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Editors

Nerve Blockade and Interventional Therapy

Springer

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Preface

An interventional therapy used in the pain clinic is the nerve block. The primary method used to acquire the skill in nerve block procedures has been to practice technique using landmarks.

However, radiography, computed tomography, and ultrasonography have recently been used to ensure accurate and safe performance of nerve blocks. These techniques allow visualization of needles and instruments using real-time images. Because the positional relationship between the needle tip and the anatomical target can be reproduced by imaging, novices can quickly and safely acquire procedural skills without relying on expertise, as required when using the landmark method.

Although Japanese pain clinic specialists are presumably highly skilled, dialogue with pain management specialists in other countries has been hampered by the lack of English language textbooks.

This English version of a Japanese textbook on interventional therapy for pain management was completed by courtesy of Springer Publishing.

We hope that this book will facilitate increased communication and exchange of knowledge with foreign students and physicians studying in Japan.

We also hope that this book will help Japanese pain clinic specialists to exchange knowledge on nerve block procedures with colleagues in other countries.

Tokyo, Japan — Kiyoshige Ohseto
Tokyo, Japan — Hiroyuki Uchino
Tokyo, Japan — Hiroki Iida

Contents

Part IV Head

Part V Neck

Part VI Shoulder and Upper Extremity

Part X Pelvis

Part XI Lower Extremity

Part XII Epidural Block

Part I

Introduction

1 Interventional Pain Treatment Using Nerve Block: Usefulness and Perspectives

Kiyoshige Ohseto and Hiroyuki Uchino

1.1 Introduction

Here, we introduce diagnostic nerve block, which is expected to become an important technique in the future, and we also describe its usefulness and perspectives. The goal of interventional treatment using nerve block is to make an accurate diagnosis of the pain and also to perform interventional therapy, such as injection of the appropriate drug in the vicinity of the nerves causing the pain, to achieve prompt pain relief. For this purpose, accurate identification of the damaged site and nerves is required. The nerve provocative test is always performed first to identify the damaged site. Second, the extent of sensory disturbance is estimated, i.e., paresthesia, from the neurological data. Moreover, if sensation in the region of pain is normal, the affected nerve is speculated based on the dermatome. On the other hand, if identification by the dermatome is difficult and the patient feels only motion pain, identification of the points of tenderness is important. The nerve causing the pain is sometimes located under the site of tenderness. First, to speculate the site of and the specific nerves causing the pain, a radiologist will sometimes be consulted for assistance in the interpretation of various diagnostic images, such as X-ray, magnetic resonance, computerized tomography, and ultrasound images. Second, a nerve block is performed to the nerve or joint site that was identified as being responsible for the pain, under fluoroscopy-guided method or ultrasound-guided method. The main aim of nerve block is to induce the same pain through the same nerves by drug injection through the block needle and then to check the disappearance of the pain by the injection of local anesthetics. This technique enables the clinician to make a functional diagnosis. The procedures of the neuroimaging and nerve block under X-ray fluoroscopy or ultrasound guidance described in this book enable neurofunctional identification of the nerves causing the pain, which has been difficult until now. Furthermore, if effective interventional treatment is performed for the targeted nerves or sites, long-term effects can be achieved. We would like all pain clinicians to become experts in the nerve block technique, by learning the procedures of each step, including diagnosis of the pain and estimation of the temporary effect of the nerve block, and then proceed to perform the interventional pain treatment to achieve favorable effects.

It is sometimes difficult to accurately characterize the pain using only pathological and morphological approaches. In such cases, functional diagnosis based on a nerve block is considered to play an important role in identifying the nerve causing the pain and its site, which could lead to a definitive diagnosis. If a diagnostic nerve block is applied for the treatment of pain that has been difficult to treat, this should lead to prompt pain amelioration.

The purpose of this book is also to assist in performing preventive analgesia and therapeutic nerve block effectively and safely. Furthermore, the most important point of this book is to open and establish new avenues for the concept of nerve block, through the introduction of accurate and safe procedures of the diverse types of diagnostic nerve block.

We sincerely hope that this book will contribute toward providing strategies of pain treatment to medical staff and patients who are interested in pain management.

1.2 Postscripts

The Japanese references are listed at the end of the Japanese (in Japanese) and relevant articles. We would like you to refer to the figures and pictures in the Japanese references.

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Interventional Treatments and Nerve Blocks

2

Kiyoshige Ohseto and Hiroyuki Uchino

2.1 Introduction

Our objective in writing this book is to describe procedural advances enabled by developments in medical technology and assistive devices. Benjamin Franklin called man a "tool-making animal," and indeed it is within our nature to continuously improve the tools we use as labor-saving or (for our purposes) medical devices.

Nerve block techniques have traditionally relied primarily on the landmark method in which surface anatomical features are used to determine the point of insertion. The practitioner's judgment and experience is then used to determine direction to target, the feeling of the inserted needle through the fingers, the feeling of needle against bone, and estimation of depth. All of these factors are taken into account along with desired efficacy and potential risks. In other words, it is an extremely demanding procedure requiring long practice and experience to master.

Advances in medical technology help evolve medical devices, including those which make nerve blocks more effective and safe than ever. For example, early-generation ultrasound devices used for guiding the needle in nerve blocks showed only fuzzy images of the needle. Recent improvements in both ultrasound and needles now show both the needle tip and surrounding anatomy clearly.

Advances in X-ray fluoroscopy-guided method have reduced radiation exposure levels while also allowing images to be analyzed in detail in bright rooms. CT-guided nerve blocks mean that the anatomy and position of the needle can be visualized in real time during the procedure. The cost of nerve blocks is in general very low; the procedure itself is the major component of the price as the drugs used are inexpensive. Total cost for a nerve block is considered lower than long-term drug treatment.

However, there are still many approaches to nerve blocks, and there is no book discussing best approaches for beginning practitioners to train with in order to attain mastery both rapidly and safely.

The Japan Society of Pain Clinicians has published interventional pain treatment guidelines, which are useful for making evidence-based choices among available interventional treatment methods, including nerve blocks.

It is our hope that this book will only prove more valuable going forward, as multicenter clinical studies and joint research projects will require a reference for selection of safe and effective standardized procedures.

Discussions of each nerve block procedure in this book are written by expert practitioners. Comments for each are then added by the supervisory editor for each section, with additional information such as technical tips and the best devices to use at each stage.

This book was also planned to serve as a reference for doctors in other countries, as well as a tool for aiding mutual understanding among practitioners and a study book for exchange students. It may also be useful for doctors traveling overseas as a tool for demonstrating and performing procedures. To fulfill all of these objectives, we are now planning a series of accompanying videos on the Internet.

Above all, we hope that this book will increase the safety and efficacy of nerve block procedures among current and future practitioners. We welcome any feedback about suggestions regarding the content of the book.

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Part II

Overview

Definition

3

Hiroki Iida

3.1 Introduction [1]

Pain is defined by the International Association for Study of Pain (IASP; 1981) as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage". Pain is also referred to in a subjective sense as a feeling, and pain is considered to exist in a patient if he/she says they have pain.

In addition, it is also necessary to define the following terms as a glossary of terms related to "pain".

3.1.1 Acute/Chronic Pain

There is currently no clear division between these terms, but they are based on the time from the onset for pain (the representative points are 3 and 6 months).

3.1.2 Nociceptive Pain

Pain that is caused by a nociceptive receptor activation with an algesic substance, activated by nociceptive stimulation and inflammation

3.1.3 Neuropathic Pain

Pain that occurs as a result of dysfunction due to nerve damage or diseases affecting the nerves

3.1.4 Psychogenic Pain

A condition where an objective physical condition explaining the cause of the pain is lacking; a mental factor is thought to be the main reason for the pain.

3.1.5 Allodynia

A condition where pain occurs in response to stimuli (nociceptive stimulation) that do not usually cause pain

3.1.6 Hyperalgesia

A state where pain perception increases after nociceptive stimulation

3.1.7 Hyperesthesia

A state with an increased sensitivity to stimulation (not limited to a specific sense)

3.1.8 Hyperpathia

A sharp pain syndrome arising from an abnormally high pain reaction to stimulation

3.1.9 Hypoesthesia

A state with a decreased sensitivity to stimulation (not limited to a specific sense)

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3.1.10 Hypoalgesia

A state where the reaction to pain stimulation decreases

3.1.11 Dysesthesia

Unpleasant abnormal sensation (whether it is initiated or induced does not matter)

3.1.12 Paresthesia

Abnormal sensation (whether it is initiated or induced does not matter) without discomfort

3.1.13 Neuralgia

Pain along nerve paths

3.1.14 Neuritis

Inflammation of the nerve

3.1.15 Neuropathy

Functional disorders or pathological changes in nerves

Reference

1. Turk DC, Okifuji A. Pain terms and taxonomies of pain. In: Fishman SM, Ballantyne JC, Rathmell JB, editors. Bonica's management of pain. 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2010. p. 13–20.

Purpose

4

Hiroki Iida

4.1 Introduction

4.1.1 Significance of the Nerve Block

A nerve block is an attractive procedure for the treatment of pain. The reason is that, while analgesics can attenuate pain, only nerve blocks can possibly eliminate pain.

The main advantages of nerve blocks are as follows:

1. The ability to determine whether a nerve is involved in the pain reported by the patient, and identification of the exact source of complicated pains (e.g., whether they are of a peripheral or central origin).
2. The ability to evaluate the role of sympathetic and/or somatosensory nerves in maintaining pain.
3. The prediction of whether nerve destruction (by alcohol or thermal applications) will be successful in the treatment of the patient's pain.
4. The nerve block itself, in some cases, can act as a radical treatment or otherwise can provide temporary remission by alleviating severe pain.

Before applying a diagnostic block, sustained reproducible pain and physical activity should be evaluated in detail. Those findings can then be assessed after the block. While the effect of the nerve block can sometimes be great, due to the possibility of serious complications associated with it (by the drugs used and by procedure itself), it is necessary to pay sufficient attention to learning the appropriate procedures. In addition, the results of destructive interventions (especially using alcohol) can be greatly beneficial, but sometimes the resulting side effects are nonreversible. Thus, it is necessary to strictly observe therapeutic indications.

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Method for Evaluating Pain

5

Hiroki Iida

5.1 Introduction

5.1.1 Pain Assessment

5.1.1.1 Basic Conception

The evaluation of pain is currently based on the presumption that the most reliable means of evaluating pain is a report from the patient about the existence of pain. An ideal pain evaluation method must be able to identify the existence of pain and track its change over time. In addition, it must fit all people regardless of age, race, religion, socioeconomic position, and mental or emotional backgrounds. There are various evaluation methods for pain, but it is not clear if one is superior. It is important that the same evaluation method is used from the beginning to the end of a treatment period since it is important to decide on courses of treatment.

5.1.1.2 Methods of Assessment [1]

Measuring Pain Intensity

1. Visual Analog Scale (VAS)
   - A patient is shown a paper with a ruler consisting of a line that is 100 mm in length.
   - It has the words "no pain" at the leftmost end and "worst pain imaginable" at the rightmost end. Patients are instructed to mark a point on the line to indicate the intensity of pain felt at the time of the evaluation.
2. Numerical Evaluation Scale (NRS)
   - NRS is similar to the VAS. On a numeric scale, numbers 0–10 are spaced evenly. "0" at the leftmost end means "no pain," and "10" at the rightmost end refers to the "worst pain imaginable." The patient indicates a number to describe his/her pain.
3. Verbal Rating Scale (VRS) and Verbal Descriptor Scales (VDS)
   - Patients describe pain intensity using a list of words such as "none," "mild," "moderate," or "severe" to describe severity from least to most.
4. Face Scale (Facial Pain Scales)
   - Generally, evaluating pain in children is difficult. However, children older than 3 years can be reliably evaluated using this scale. This scale shows six pictures of facial features, rating from smile ("no pain") to a teary face ("hurts worst"). Patients are asked to choose the picture that best expresses their pain.

Evaluation of Pain Quality

1. McGill Pain Questionnaire (MPQ)
   - The MPQ is the most frequently used multidimensional test. It was designed to consider the psychological influences on reporting and evaluating pain. This test is composed of 78 adjectives divided into 20 sets that describe the sensory, affective, and evaluative qualities of the patient's pain. The disadvantage of the MPQ is the length of time required to complete the test. In response, the short-form MPQ (SF-MPQ) was developed as an easy-to-use alternative in clinical settings that minimizes the assessment burden. The SF-MPQ scales show a strong correlation with the original MPQ scales.
2. Brief Pain Inventory (BPI)
   - In BPI, patients are asked to mark their pain location using a drawing of the human body and then to rate the severity of their pain intensity as "least," "most," or "average" in the 24 h prior to the test and at the evaluation time. In addition, they are asked to describe the effects of the pain on their daily activity. It is a useful method for monitoring the effects of pain.

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Objective Evaluation of Pain

1. Quantitative Analysis Device for Pain Perception: Pain Vision™
   - This is a method to evaluate quantitative parameters in pain intensity using a painless electric stimulation starting at the smallest electric current perception level. Pain intensity is evaluated using the current perception threshold and pain compatible electric current as parameters. It is an appropriate device to painlessly evaluate the intensity of pain for intraindividual comparison before and after pain treatment.
2. Electric Current Threshold Measuring Equipment: Neurometer™, NC3000TM
   - This provides a noninvasive functional evaluation of sensory nerve integrity. A-beta, A-delta, and C-fiber groups are selectively stimulated by currents of 200 Hz, 250 Hz, and 5 Hz, respectively. It is a useful device to detect sensory nerve damage resulting from conditions such as diabetes, sciatica, entrapment neuropathy, and radiculopathy. It also allows the determination of neurological dysfunction due to hyperesthesia and hypoesthesia, as well as monitoring the progression of nerve regeneration.

5.1.1.3 Evaluation of Pain in Elderly People

In an elderly person, appropriate pain control is particularly important to prevent long-term lying in bed and to increase daily activity, but it is often difficult to evaluate pain in this age group. This is because:

1. Aged people are more likely to underreport their pain.
2. It is difficult to convey the exact pain intensity when pain is accompanied by cognitive impairment.

In such cases, it is preferable to use easily understood methods, such as VDS or the face pain scale.

5.1.1.4 Evaluation of Pain in Children

Children younger than 3 years are rarely candidates for pain treatment through nerve blocks. However, in children older than 3 years, the self-evaluation of pain is commonly used.

Reference

1. Correll DJ. The measurement of pain: objectifying the subjective. In: Waldman SD, editor. Pain management, vol. 1. Saunders: Elsevier; 2007. p. 197–211.

Diagnosis

6

Takahisa Nishiyama and Kiyoshige Ohseto

6.1 Introduction

A general diagnosis is made on the basis of interview, physical examination, and diagnostic imaging findings. With adequate care taken to avoid overlooking red flags, certain diagnoses are ruled out. Then, as indicated, the disorder is diagnosed by nerve block results.

6.1.1 Interview

Interviews are conducted to assess chief complaints, history of the present illness, medical history, accompanying conditions, and so on in proper order. The history of the present illness needs to be ascertained in a chronological manner. For example, the features of pain due to herpes zoster change over time. The nature of this pain differs among the early stages of herpes zoster (the period having rash), that during the subsequent rash-subsidence period and that occurring several months later. Medical history should cover the histories of surgery, oral medication (particularly antiplatelet drugs, anticoagulants, steroids, immune suppressants, and so on), and allergies. For example, asthmatic patients are likely to show allergic reactions to contrast material, thus necessitating careful administration. Diabetes mellitus also involves pain due to peripheral neuritis, thus raising the risk for infection at the time of nerve block. Regarding family history and environmental factors, it is known that patients with migraine or polyhidrosis often have a positive family history and that familial turmoil, interpersonal difficulties, and the like tend to lead to psychosocial pain.

6.1.2 Physical Findings

Although attention tends to be paid to local features, physical examination should cover the entire body.

1. Sensory testing: Sensory tests can be performed quickly and are very worthwhile. For example, in cases with cervical myelopathy, leg pain can appear as the initial symptom. Systemic sensory tests may reveal sensory dysfunction in the arms as well.
   - Sensory testing methods: Sensory tests are often performed using a brush and rely on comparison with the sensory perception of the face (trigeminal nerve area). The entire body needs to be checked for reduction of perception. There is some overlapping in nerve supplies to the skin, but the presence of areas specifically regulated by individual nerves will facilitate identifying the affected site.
   - The sensory perceptions of the upper and lower extremities tend to be evaluated by comparison between the right and left sides. However, in cases in which sensory perceptions are disturbed bilaterally, comparison between the right and left sides is of little value. Comparisons should be made with the face.
2. Exercise testing: Motor functions of the extremities are evaluated with MMT (manual muscle testing). The patient needs to be instructed to walk and carry out other activities of daily living during the evaluation.
3. Reflexes and other neurological findings: Reflexes of the extremities, cerebral nerve findings, and so on are to be checked as required.

6.1.3 Diagnostic Imaging

1. *Plain X-ray*: This is appropriate for observation of bones and tissue ossification. Comparisons among different body positions (flexion, extension, standing, recumbent,

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etc.) are possible. Definitive diagnosis in a single body position is difficult.

2. *CT*: This is appropriate for observation of fracture and osseous changes. In addition to transverse and sagittal imaging, coronal and 3D imaging are also suitable.
3. *MRI*: Plain MRI provides a valid means of observing the spinal cord, nerve roots, intervertebral discs, bleeding, and so on. Fat suppression imaging should also be ordered at the same time. Coronal imaging and 3D imaging are helpful in some cases. Contrast-enhanced MRI is performed in cases suspected of having metastatic tumors.
4. *Ultrasonography*: This is appropriate for assessing soft tissue. Rib fracture or the like may be detected on occasion. Ultrasonography allows the observation of motor organs in a movie format, while joints, muscles, tendons, and so on, are moved. It can easily be performed at outpatient clinics.

6.1.4 Diagnosis Based on Nerve Block

Nerve block is not only a method of treatment but also a testing method which allows the identification of pain-affected sites (Fig. 6.1).

(Example) A case of cervical spondylotic radiculopathy: If the test on a dermatome reveals reduced sensory perception between the first and second fingers (area specific to C6) and if pain along the radial nerve is induced by the Jackson test and the Spurling test, C6 radiculopathy should be suspected. After diagnostic imaging, a C6 nerve root block is performed under ultrasound or fluoroscopy-guided method. If the needle is inserted into the vicinity of the C6 nerve root, radiating pain arises. Consistency of this radiating pain with the site of pain (chief complaint) is confirmed. If the pain can be alleviated by a local anesthetic, C6 radiculopathy can be diagnosed and its location identified. Thus, nerve block can be regarded as a method of functional diagnosis making use of sensory perception based on pain induction and relief.

The nerve block method for diagnostic purposes is selected on the basis of the illness as estimated by physical and diagnostic imaging findings. Diagnostic nerve block has therapeutic effects. Furthermore, an additional type of nerve block exerting stronger therapeutic effects is also applied in some cases.

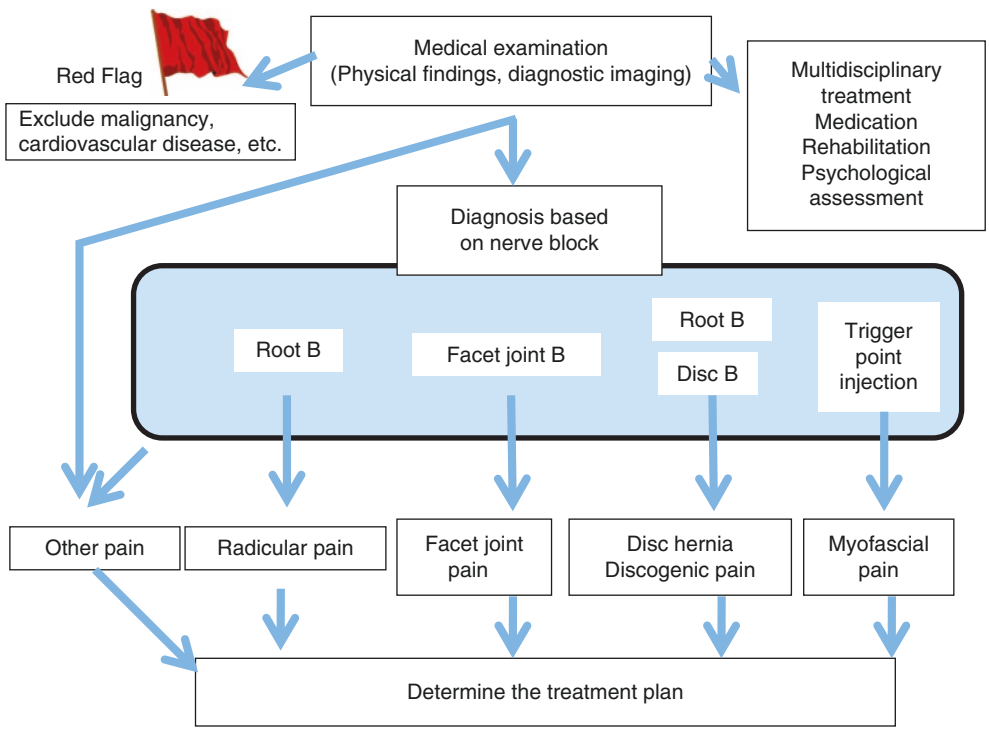

Fig. 6.1 Diagnosis flowchart of pain. Diagnosis flowchart of pain with nerve block. Nerve block is beneficial for the identification of pain-affected sites and for determining the treatment plan

Apparatus

7

Hiroki Iida and Motoyasu Takenaka

7.1 Introduction

Although complications are rare, nerve block techniques do involve the risk of serious complications. Thus, practitioners are required to prepare carefully and continuously monitor patients to prevent complications.

7.1.1 Cart

An equipment cart is essential for providing a smooth and safe nerve block. The cart should include emergency drugs and airway equipment in addition to commonly used equipment, supplies, and local anesthetics.

7.1.2 Trays

Nerve block trays are set up in a basic manner that is suitable for most nerve blocks and can be used for an efficient and successful nerve block. If possible, such trays should be customized to proceed with the block smoothly. The tray should also include items for sterilizing and draping skin, syringes without needles, and catheters. With a properly prepared tray, practitioners can concentrate and focus solely on performing the nerve block.

7.1.3 Needles and Catheters

7.1.3.1 Block Needles

Currently, several types of needles are available for peripheral nerve blocks such as pencil-point, Quincke, and short-bevel needles. The needle design can influence the risk of nerve injury. Pencil-point and short-bevel needles are less likely to cause nerve injuries and much less likely to penetrate or cut nerves compared to long-bevel needles.

Recently, new types of needles have also been developed. For radiofrequency or pulsed radiofrequency procedures, needles can be fully insulated except for their tip. Additionally, larger gauge needles suitable for passing through a catheter have been developed for continuous infusion blocks. The length of the needle is chosen depending on the neural block technique or the body type of patients (Table 7.1).

Table 7.1 Needle sizes for common nerve block procedures

Block technique	Needle length (mm)
Epidural block (cervical/thoracic/lumbar)	60–100
Intrathecal block (cervical/thoracic/lumbar)	60–100
Facet block	60–100
Gasserian ganglion block	100
Maxillary nerve block	60
Mandibular nerve block	60
Sympathetic ganglion block (thoracic/lumbar)	100–120
Celiac plexus block	100–120
Cervical plexus block	50
Interscalene brachial plexus block	25–50
Axillary brachial plexus block	25–50
Thoracic paravertebral block	90–100
Sciatic block (posterior/anterior approach)	100/150
Femoral block	50

7.1.3.2 Catheter

When continuous infusion is planned, a special needle design with larger diameters and catheters is used for the block. Some needle designs also have the ability to connect a built-in lead to a nerve stimulator. The introduction of the stimulating catheter for the continuous stimulation of a nerve provides a great advantage to practitioners.

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7.1.4 Nerve Stimulators

Nerve stimulators are very useful tools in peripheral nerve blocks and contribute greatly to successfully localizing a peripheral nerve. The operation of the machine is simple and easy, but current flow during stimulation varies depending on the device and model. Recent nerve stimulators can deliver a constant current output. Consequently, it is possible to maintain a stable current output in the presence of varied resistances. Practitioners should be familiar with how to use these techniques.

7.1.5 Radioscopy

Fluoroscopically guided nerve blocks are frequently utilized by interventional pain clinicians. The overtube and C-arm devices are most suitable as X-ray fluoroscopic devices. Using an overtube fluoroscopic device, we can cordon a wide space over the body, making it easy to operate. The C-arm fluoroscopy device is superior in reliability and safety because it allows for good perspective views from the front or lateral side. A radiopaque dye is used to clarify the location of anatomic structures and needle placement under fluoroscopy-guided method. More information on this subject is provided in Chap. 11.

7.1.6 Ultrasound

The first report regarding the use of ultrasound-guided nerve block in 1978 did not have substantial clinical impact because of the limited scope for visualization during the procedure [1]. In 1994, Kapral reported the safety and certainty of real-time ultrasound-guided approach for supraclavicular brachial plexus blocks [2].

In recent years, ultrasound machines with high-image-resolution imaging are smaller, portable, and less expensive. The ultrasound-guided approach is likely to be one of the important techniques for the practitioners of nerve blocks.

References

1. La Grange P, Foster PA, Pretorius LK. Application of the Doppler ultrasound blood flow detector in supraclavicular brachial plexus block. Br J Anaesth. 1978;50:965–7.
2. Kapral S, Krafft P, Eibenberger K, et al. Ultrasound-guided supraclavicular approach for regional anesthesia of the brachial plexus. Anesth Analg. 1994;78:507–13.

Drugs Used

8

Naomi Hirakawa

8.1 Introduction

8.1.1 Local Anesthetics

When using local anesthetics for nerve block, highly safe drugs that cause fewer adverse reactions are desirable. The indications for nerve block with local anesthetics are limited. Local anesthetics may be used to test the nerve block with neurolytics.

8.1.1.1 Basic Structure [1]

Procaine and tetracaine belong to the ester type, and lidocaine, mepivacaine, bupivacaine, ropivacaine, and levobupivacaine belong to the amide type.

8.1.1.2 Pharmacological Action

Locally administered local anesthetics are eliminated via the liver, and ester-bonded drugs are hydrolyzed. Residual drug molecules penetrate the nerve sheath, enter nerve cells, and inhibit the generation and transmission of action potentials. Local anesthetics coexist as ionic (BH^+) and nonionic (B) types in the body, and the lipid-soluble nonionic type passes through the nerve cell membrane and enters the cells. Within the cells, the ionic type increases and binds to Na^+channels on the cell membrane, which blocks Na^+ influx into cells and inhibits the generation of action potentials.

8.1.1.3 Characteristics of Local Anesthetics

The characteristics of local anesthetics used for nerve block are shown in Table 8.1 [2].

Lidocaine is described as a representative local anesthetic used for nerve block, but local anesthetics with a similar effect may be used. Local anesthetics include lidocaine (0.5–2%), mepivacaine (0.5–2%), bupivacaine (0.125–0.5%), ropivacaine (0.2–0.75%), and dibucaine hydrochloride

Table 8.1 Characteristic of local anesthetics [2]

	Molecular weight	Protein binding rate %	pKa	Patition coefficient
Ester type				
Tetracaine	264	76	8.5	221
Amide type				
Lidocaine	2234	64	7.8	43
Mepivacaine	246	77	7.7	21
Bupivacaine	288	95	8.1	346
Levobupivacaine	288	95	8.1	346
Ropivacaine	262	94	9.1	115

preparations. Since this book mainly concerns outpatient block, and as a rule patients go home, local anesthetics containing epinephrine, which can prolong the effect, are excluded from such use. The concentration and volume of local anesthetics are determined in consideration of the anesthetic type, nerve block type, expected effect, age, and general condition. It is inappropriate to use local anesthetics at a high concentration for peripheral nerve block [3]. Long-acting local anesthetics are also inappropriate for many outpatients because of the persistence of motor paralysis. A high-concentration local anesthetic may be used when it is used for block, such as trigeminal ganglion block, without a neurolytic.

8.1.1.4 Adverse Effects of Local Anesthetics

Toxicosis, allergy, and neuropathy (neuropathy may occur when the concentration is high).

8.1.2 Steroids

8.1.2.1 Action Mechanism of Steroids

Inhibition of the inflammatory changes of nerves (inhibition of inflammatory mediator production), inhibition of conduction through C fibers, inhibition of nerve reactions to nociceptive input via peripheral nociceptors, and inhibition of

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nerve excitement by direct action on the nerve cell membrane

8.1.2.2 Steroids Used for Nerve Block

Water-soluble steroids, *mainly dexamethasone*, are basically described because intra-arterial injection of particulate steroids (suspension) may cause embolism.

8.1.3 Neurolytics

The target of neurolytics is destruction of nerve fibers or cells to block the pain conduction pathway for a long time. Ethyl alcohol, phenol glycerin, and phenolated water are normally used. Neurolytics are prepared and sterilized at each facility because these are not commercially available.

8.1.3.1 Types and Action Mechanisms of Neurolytics

Ethyl Alcohol (Alcohol)

Alcohol is a representative neurolytic. Normally, 99.5% pure alcohol is used, but it is used as 50–95% for celiac plexus block. The mechanism of action of alcohol is dehydration of the nerve tissue through extraction of cholesterol and phospholipids and precipitation of lipoprotein and mucoprotein [4]. In peripheral nerves, it damages Schwann cells and axons, blocking nerve conduction. When it is injected into a ganglion, it destroys cells by coagulating and dehydrating the cytoplasm. The effect on peripheral nerves persists for 6–18 months. The duration of the effect is about 4 months when it is applied by subarachnoid administration. Since the specific gravity of alcohol (0.80) is lower than that of cerebrospinal fluid, it is necessary to place the affected side up when employing subarachnoid administration. One problem with block with alcohol is alcohol-induced neuritis, which is caused by partial destruction of the sensory nerve. Symptoms remit within 2–3 weeks in many cases, but they may persist for a prolonged period.

Phenol

Phenol destroys nerve fibers and cells through denaturation, coagulation, and precipitation of protein [4]. Phenol is dissolved with water or glycerin for use. Meningeal reactions are induced by injection of 5–8% phenolated water into the subarachnoid space, and fibrosis and hypertrophy of the arachnoid occur with increasing concentrations. The tissue changes after phenol injection are similar to those after alcohol injection and involve degeneration of the posterior funiculus and dorsal root nerve (Fig. 8.1). The characteristic effects of phenol include segmental demyelination and Wallerian degeneration. This specific neurotoxicity is observed when the nerve is exposed to a high concentration of phenol. Phenol is used to block the spinal nerves because it less often leads to neuritis compared with ethyl alcohol. When phenol is used as phenolated water and phenol glycerin, it is used at 5–10% and 10%, respectively.

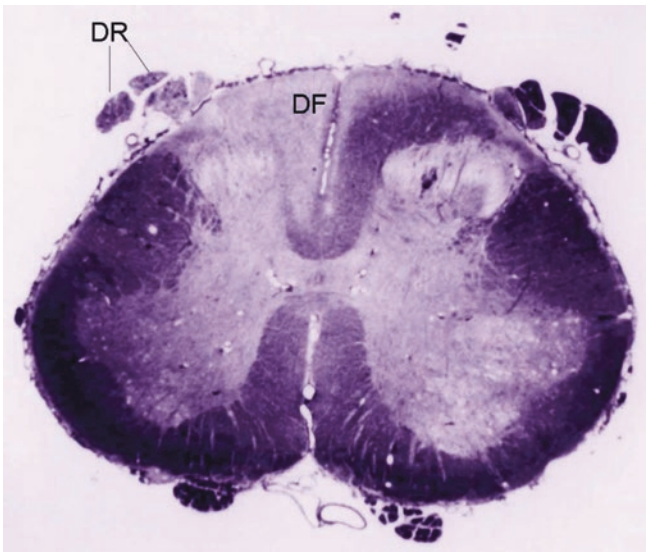

Fig. 8.1 Human spinal cord section after phenol glycerine injection (the generation of dorsal funiclus (DF) and dorsal root (DR) is observed)

Glycerin (Glycerol)

The neurolytic effect of glycerin was discovered incidentally by Hakånson, who initially reported that injection of anhydrous glycerin into the trigeminal cistern resolved trigeminal neuralgia [5]. Glycerin has since been used in the treatment of trigeminal neuralgia. Regarding the histological changes, many inflammatory cells, marked edema of myelin sheath, and axonal degeneration are observed [6].

8.1.3.2 Nerve Block with Neurolytics

The main indication for nerve block with neurolytics is cancer pain. Radiofrequency thermocoagulation is employed for nerve block to treat trigeminal neuralgia in many cases in consideration of the safety. While a long-term effect can be expected for nerve block with neurolytics, dissemination of the drug solution to an unexpected region or damage of a blood vessel feeding the spinal cord may occur. Sufficiently skilled procedures are required.

8.1.4 Contrast Medium

For contrast medium, non-ionic, water-soluble contrast medium for spinal cord, such as iohexol, is mainly used.

References

1. Berde CB, Strichartz GR. Local anesthetics. In: Miller RD, editor. Miller's anesthesia. 7th ed. Philadelphia: Churchill Livingstone; 2010. p. 913–39.
2. Whiteside JB, Wildsmith JA. Developments in local anesthetic drugs. Br J Anesth. 2001;87:27–35.
3. Wedel DJ, Horlocker TT. Nerve blocks. In: Miller RD, editor. Miller's anesthesia. 7th ed. Philadelphia: Churchill Livingstone; 2010. p. 1639–74.
4. Myers RR. Neuropathology of neurolytic agents. In: Cousins MJ, editor. Neural Blockade. 3rd ed. Philadelphia: Lippincott-Laven; 1998. p. 985–1006.
5. Hakånson S. Trigeminal neuralgia treated by the injection of glycerol into the trigeminal cistern. Neurosurgery. 1981;9:638.
6. Hara H, et al. Glycerol injection to the rat trigeminal nerve: histological and immunohistochemical studies. Acta Neurichir. 1992;119:111–4.

Neurodestruction and Stimulation Approach

9

Sei Fukui

9.1 Indications

9.1.1 Neurodestruction Using Drug Solution (Alcohol and Phenol)

For the drug solution, alcohol and phenol solutions are used. Alcohol is generally used at 99.5%. Phenol (10–15%) is prepared with glycerin and used for subarachnoid block.

9.1.2 Radiofrequency Thermocoagulation (RF)

Radiofrequency thermocoagulation is a treatment method that blocks the signaling function of nerves for a prolonged period by coagulating the target nerve of various types with radiofrequency energy. In radiofrequency thermocoagulation, 300-Hz high-frequency current emitted from the non-insulated region of the needle tip vibrates molecules around the tip and generates heat in the surrounding tissue, centering at the non-insulated needle tip, the same phenomenon as heating food by microwaves, and the heat coagulates the tissue (Fig. 9.1) [1].

The thermocoagulated lesion is wide around the non-insulated region and becomes narrow in the region beyond the needle tip, forming an oval shape centered around the non-insulated region (Fig. 9.1) [1]. Application in parallel to the target nerve is advantageous for forming a thermocoagulated lesion [1]. Since the thermocoagulated lesion is limited to a diameter of 2–4 mm, it does not markedly influence the surrounding tissue. Even if the needle tip is inserted into a blood vessel, the temperature is not elevated because vibration is unlikely to be induced in fluid. Thus, the risk of vascular injury is low.

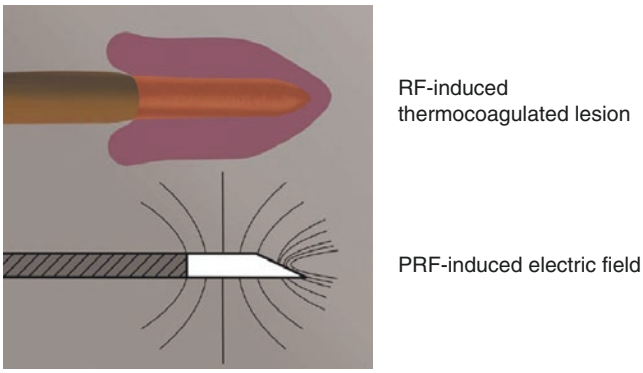

Fig. 9.1 Comparison between RF-induced thermocoagulated lesion and PRF-induced electric field. In radiofrequency thermocoagulation, the lesion is wide around the non-insulated region and narrow at the tip. Since the thermocoagulated lesion is conically shaped, with the point centering on the non-insulated region, it is desirable that the needle and target nerve are parallel. In contrast, the PRF-induced electric field is wide at the needle tip and narrow around the non-insulated region, so that it is desirable for the target nerve to be located at the needle tip. Since the PRF-induced electric field expands homogenously from the non-insulated region, the target nerve may be positioned at or parallel to the needle tip in PRF

The size of an RF-coagulated lesion is determined by the length of the non-insulated region (active tip) of the puncture needle, needle tip temperature, and coagulation time. The length of the lesion increases as the temperature of the needle tip rises.

Since the coagulated lesion is limited to the region around the non-insulated region, the treatment is relatively safe. A needle with a 4-mm non-insulated region forms a coagulated lesion with an about 2-mm diameter at 80–85 °C and about 3-mm diameter at 90–95 °C. Needles with 4- and 10-mm non-insulated regions are also available, and a needle with a 10-mm non-insulated region is used for RF of sympathetic nerve ganglions (Fig. 9.2). If it is accurately applied to the target nerve alone, the required effects are ensured, and complications are less likely to occur.

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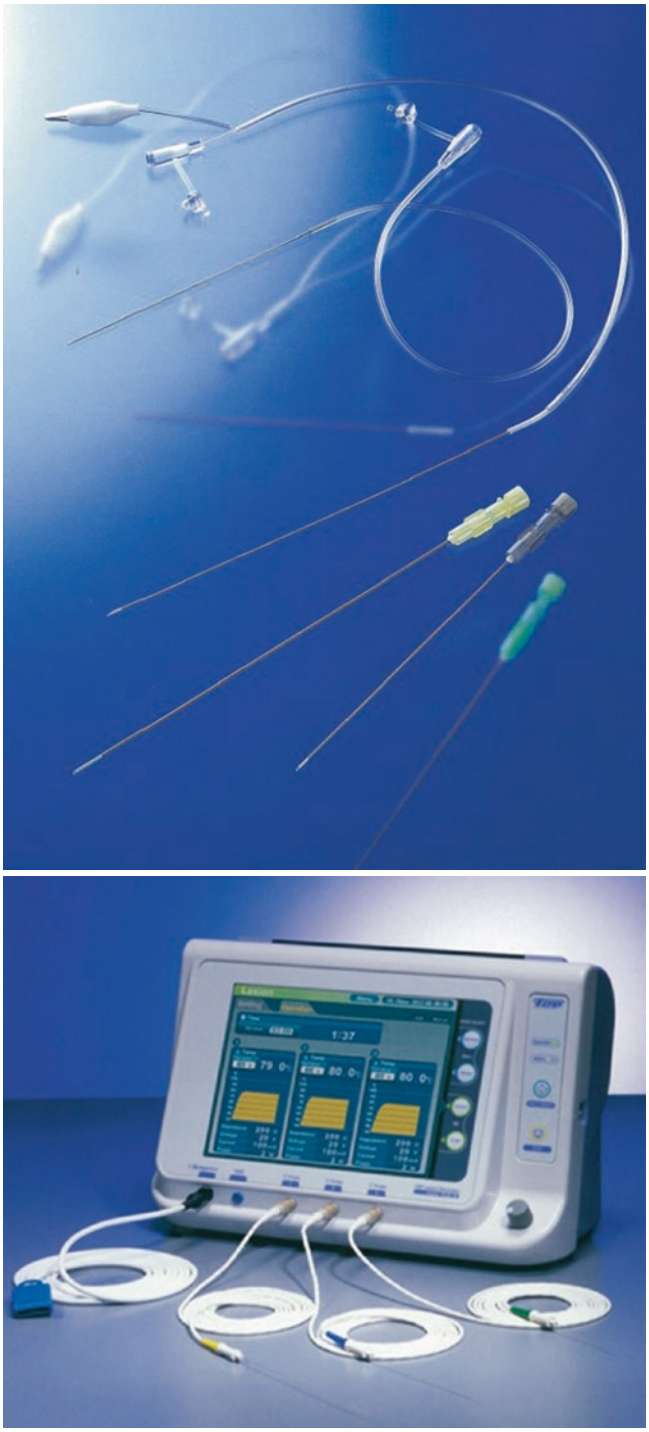

Fig. 9.2 Puncture needle and radiofrequency thermocoagulation apparatus, NT1100. Puncture needles with 4- and 10-mm non-insulated regions and radiofrequency thermocoagulation apparatus, NT1100 (St. Jude Medical, it has not been approved in Japan). Only the application time can be changed in JK3 and NT500 (St. Jude Medical), but the PRF conditions, such as the pulse width and frequency, voltage, and application time, can be freely changed in NT1100 (St. Jude Medical). In addition, NT1100 is capable of simultaneously applying electrical stimulation, radiofrequency thermocoagulation, and PRF to a maximum of three sites

9.1.3 Instruments and Nerve Block Needle

Two apparatuses are available in Japan: JK3 (Neurotherm) and NT500 (St. Jude Medical) (Fig. 9.3). The latest model of NT500 has four functions: temperature monitoring, nerve stimulation, impedance measurement, and radiofrequency generation units. For the needle, puncture needles with 4-, 7-, and 10-mm exposed tips are used (Hakko Medical and TOP Corp.). A needle is selected from those with 5-, 10-, and 15-cm lengths corresponding to the application site. Normally, a return electrode is set on the leg in high-frequency therapy.

9.1.4 Procedure of RF Therapy

A guide needle is advanced to the target nerve under fluoroscopy-guided method. When the target is a sensory nerve, the optimum position of the needle tip is confirmed by reproducing pain and muscle contraction by 50-Hz electrical stimulation of the sensory nerve and 2-Hz locomotor stimulation at 0.5 V or lower. Then, local anesthesia and the current are applied for 1–2 min at 70–90 °C. RF is safer and more useful than conventional neurodestruction, but it is essential to have an accurate and reliable technique, for which fluoroscopic guidance is necessary.

9.1.5 Pulsed Radiofrequency (PRF)

Pulsed radiofrequency (PRF) is a treatment method to reduce pain by intermittently applying a high-frequency current at 42 °C or lower, which generates an electric field at the needle tip and affects the nerve [1, 2]. Since PRF is not neurodestructive, it is applied for various types of pain as a safe, low-invasive treatment causing fewer complications.

9.1.6 Outline of PRF Therapy

PRF is a treatment method using a radiofrequency thermocoagulation apparatus and 22-G puncture needle with a 4–10-mm exposed tip. High-frequency current (50,000 Hz) is applied for 0.02 s intermittently with 0.40-s intervals for 2–6 min (Fig. 9.3). The heat decreases when the current is off, which maintains the needle tip temperature at 42 °C [2]. PRF is set to generate an electric field without enough heat to damage the nerve. Since PRF is unlikely to degenerate nerve tissue, muscle weakness, sensory disturbance, and motor paralysis are unlikely to develop. It is also applicable for patients for whom radiofrequency thermocoagulation is contraindicated and regions affected by pain induced by dorsal root ganglion and nerve impairments [2]. The electricity

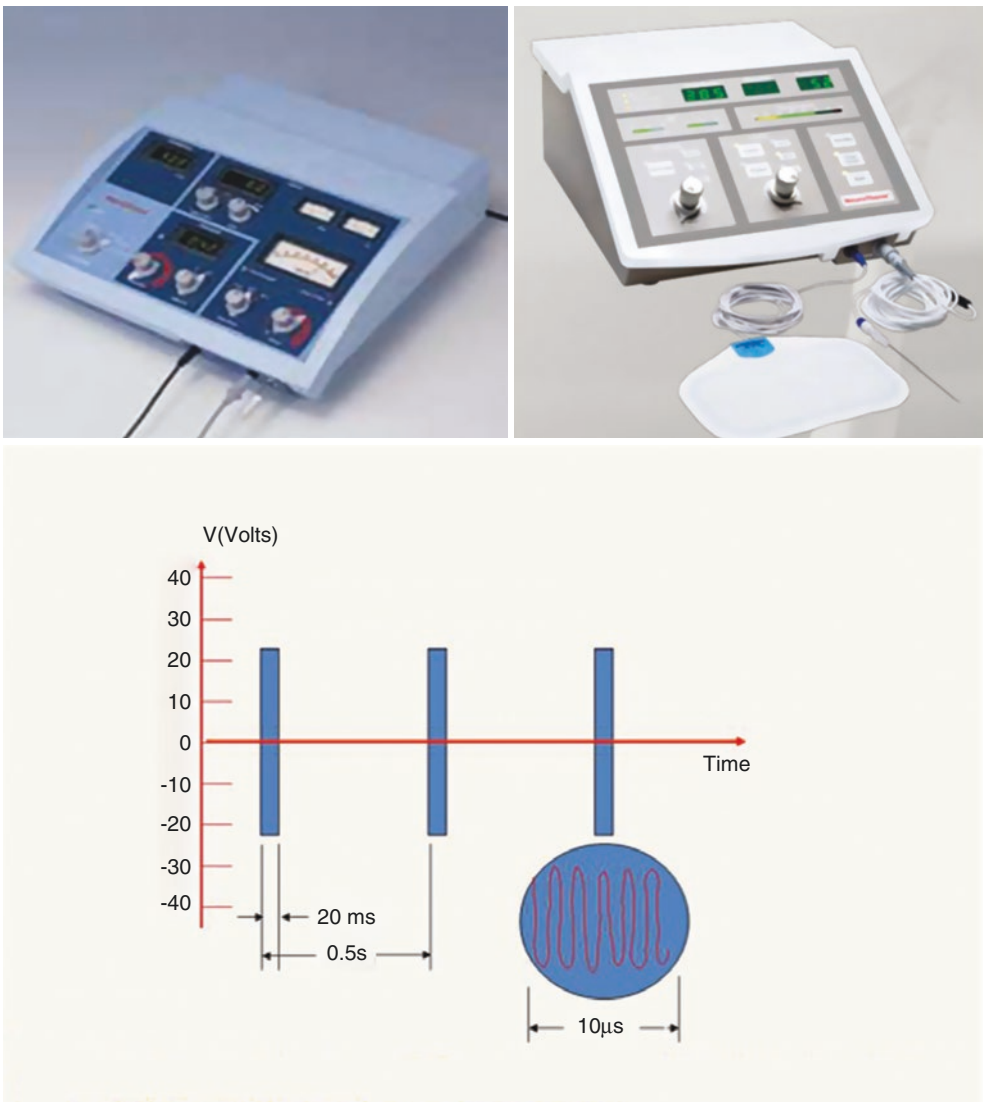

Fig. 9.3 Electrical stimulation of PRF and radiofrequency thermocoagulation apparatuses, Jk3 and NT500. JK3 and NT500, currently available for PRF in Japan, are set to intermittently apply current at a voltage of 45 V, pulse width of 0.02 s, and 2-Hz pulse frequency for 2–6 min

energizing time is generally 120 s, but it can be extended to 2–6 min depending on the application site.

The electric field of PRF homogeneously expands from the non-insulated region (Fig. 9.1). Accordingly, the optimum approach for radiofrequency thermocoagulation (RF) is setting the electrode parallel to the target nerve. For PRF, the target nerve may be positioned at the needle tip or in parallel.

9.1.7 Action Mechanism of PRF

PRF generates a markedly stronger electric field than that generated by radiofrequency thermocoagulation [1, 2]. Although the action mechanism of PRF has not been elucidated, the electric field generated at the needle tip by PRF plays an important role in the analgesic effect [2].

Regarding the main action mechanism, the following mechanisms have been reported: (1) the PRF-induced electric field inhibits the ion channel function (Na + and Ca2+ channels) in the nerve cell membrane, and (2) the PRF-induced electric field inhibits inflammatory cytokines [2]. The appropriate conditions corresponding to the application site also remain to be investigated.

References

1. Chua NH, Vissers KC, Sluijter ME. Pulsed radiofrequency treatment in interventional pain management: mechanisms and potential indications—a review. Acta Neurochir. 2011;153:763–71.
2. Gauci CA, Gauci CA. The physics of radiofrequency & pulsed radiofrequency. In: Gauci CA, editor. Manual of RF techniques. 2nd ed. Amsterdam: Flivopress; 2008.

Part III

Feature of Each Technique

Landmark Method (Blind Method)

10

Takahisa Nishiyama and Kiyoshige Ohseto

10.1 Introduction

10.1.1 What is the Landmark Method?

In the landmark method, an illustration is depicted on the body surface to serve as a landmark for needle insertion such that a nerve block can be carried out at the prescribed depth. The blind method is the landmark method in the narrower sense of the term, applied when there is no assistance provided by an imaging device of any type. Recently, nerve block under fluoroscopy-guided method, ultrasound-guided method, computed tomographic (CT-guided method), or magnetic resonance imaging (MRI-guided method) guidance has been widely used. The landmark method has also been employed for a portion of all cases undergoing nerve block. Furthermore, there are many cases in which the use of an imaging device is accompanied by direct depiction of the needle insertion point or angle on the body surface. In these cases nerve block may be performed using a mixture of the landmark method and the imaging device (Fig. 10.1). The basic feature of the landmark method is nerve block by means of three-dimensional image construction. This three-dimensional image is also needed when an imaging device is used for nerve block.

10.1.2 Characteristics of the Landmark Method

10.1.2.1 The Blind Method (the Landmark Method)

The landmark method performed without an imaging device is known as the blind method. The blind method employs no images and can be viewed as the landmark method in the narrower sense of the term. Block performed by the blind method is represented in the following types of block: (1) block at shallow points relative to the skin, (2) block difficult to perform with an imaging device, and (3) compartment block. Superficial cervical plexus block can also be performed under ultrasound-guided method, but it can be carried out rapidly with the blind method because the point of the block is not deep. Suprascapular nerve block involves block of sites difficult to identify with an imaging device. Epidural block is a type of compartment block conducted by employing the blind method. When this block is performed, the line joining the highest points of the right and left iliac crest (Jacoby's line or Tuffier's line) is estimated to be the space between the fourth and fifth lumbar vertebrae and the block is conducted at this level. This estimation of the location is correct in many patients, but this line is not always located between the fourth and fifth lumbar vertebrae (particularly in cases with scoliosis or a sixth lumbar vertebra or the like, this estimation method does not precisely reflect the interindividual difference). However, when a local anesthetic is injected into the intervertebral space, inaccuracy in the vertebral level for injection often poses little problem (although some reports have recommended performing epidural block under fluoroscopy-guided method to ensure safety).

When stellate ganglion block (SGB) is to be performed, the use of ultrasound-guided method allows visualization of the status of blood vessels and a safer block even by beginners, while monitoring the images together with the trainer physician. Meanwhile, there are many pain clinic physicians who adopt the blind method for this type of block. This is for the following reasons: (1) the target site of SGB is close to the body surface (thus allowing the block to be carried out while touching the transverse process of the cervical vertebrae with the fingers); (2) it is a type of compartment block within the longus colli muscle.

Brachial plexus block (scalene muscle method) often employed the blind method in the past, but at present,

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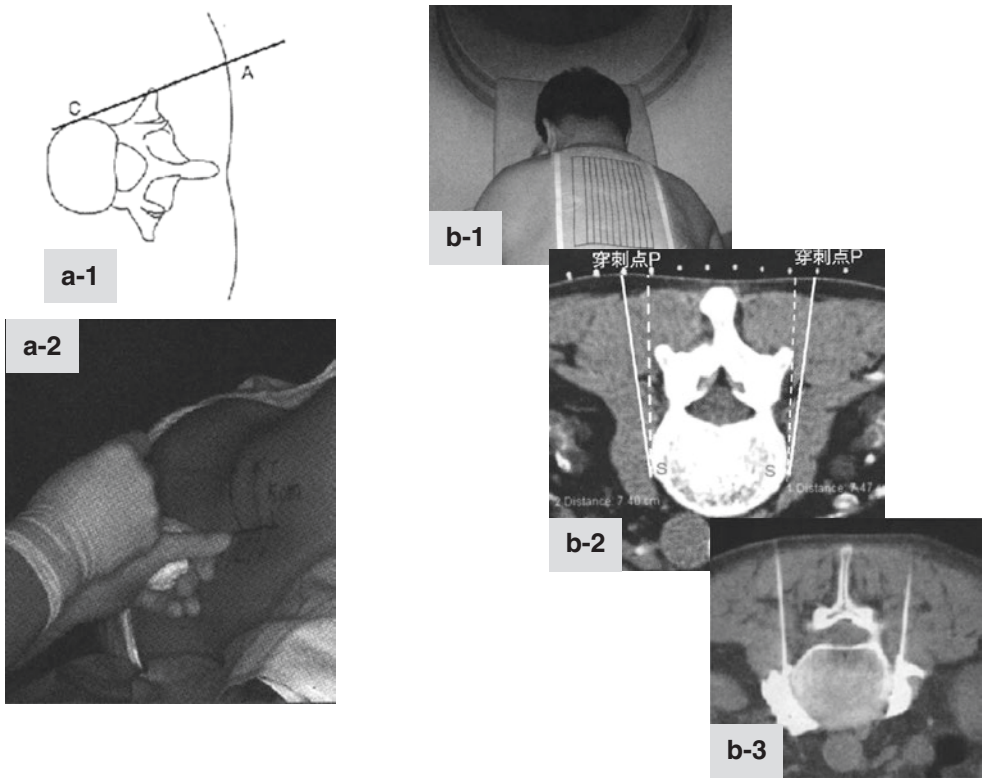

Fig. 10.1 Blind method and CT-guided method for nerve block. (**a-1**) Point and direction of needle insertion using the blind method for lumbar sympathetic ganglion block. (**a-2**) Manner of needle insertion using the blind method. (**b-1**) CT-guided sympathetic nerve block. Imaging is performed with a radiopaque marker to determine the point of insertion. (**b-2**) The angle of insertion is decided on the basis of the image obtained. (**b-3**) An illustration is depicted on the skin, and the needle is inserted while CT imaging is intermittently performed. The needle course with the CT-guided method closely resembles that with the classic blind method. It is understandable that illustrations or three-dimensional image construction is also needed for the CT-guided method. Reproduced with modifications from Pain Clinic 2011 Spring Extra Issue Vol. 21, pp. 115-120, Shinko Trading, Tokyo

ultrasound-guided method is increasingly being used for this type of block. Thus, for many types of nerve block, there is a tendency for the blind method to be replaced by a method using imaging devices (e.g., ultrasound device).

10.1.2.2 Nerve Block Under Imaging Device Guidance by the Landmark Method

Many types of nerve block are routinely carried out using the landmark method concomitantly with an imaging device. The imaging devices employed include ultrasound, fluoroscopic, and MRI devices (Table 10.1). These devices have both advantages and shortcomings. Therefore, the block occasionally requires a combination of these devices. Furthermore, the types of block possible can vary depending on the performance of the devices used. At present, the images obtained from all devices are only two-dimensional. Thus, three-dimensional image construction is needed at the time of the block. The skill required for the landmark method facilitates achieving this goal. The development of real-time ultrasound devices in the future (3D or possibly even 4D) is very likely to make three-dimensional image construction a reality.

10.1.3 Future of the Landmark Method

The illustration depicted for CT-guided sympathetic nerve block closely resembles the classic blind method. For this and other reasons, the landmark method is very likely to survive while undergoing progression and modification. When nerve block is performed, attention tends to be paid to features related to three-dimensional images (e.g., the point, direction, and depth of needle insertion). However, needless to say, non-visual information such as tactile features (i.e., the feeling when perforating the intervertebral disc, yellow ligament, fascia, or blood vessels or when touching the transverse process, vertebral body, and related structures) is also important.

Table 10.1 Landmark method and methods using imaging devices for major types of nerve block

	Landmark	Ultrasound-guided	Imaging-guided	CT-guided/MRI
Neck				
Superficial cervical plexus	○	◎	——	——
Brachial plexus	○	◎	○	——
Stellate ganglion	◎	◎	——	——
Root	X	○	◎	——
Facet joint	X	○	◎	——
Thoracolumbar				
Intercostal nerve	◎	◎	○	——
Root	X	○	◎	——
Facet joint	X	○	◎	——
Sacroiliac joint	○	◎	◎	——
Transversus abdominis plane	X	◎	X	——
Epidural	◎	○	X	——
Lumbar sympathetic ganglion	X	X	○	◎
Celiac plexus	X	X	◎	◎
Extremities				——
Radial, median, and ulnar nerves	◎	◎	——	——
Sciatic nerve	◎	◎	——	——
Shoulder joint	◎	◎	——	——
Knee joint	◎	○	——	——
Face				
Trigeminal ganglion (Gasser's)	X	X	◎	◎
Supra- and infraorbital	◎	◎	◎	——
Mental	◎	◎	◎	——
Occipital	◎	X	——	——

◎○, valid; X, impossible; ——, not feasible due to high cost and the labor required

X-ray Fluoroscopy-Guided Method

11

Hiroki Iida

11.1 Introduction

Image-guided intervention techniques are used for performing procedures with safety and accuracy. Such procedures for pain treatment can be performed for both maximizing benefit and minimizing the risks to the patient. In general, fluoroscopy using C-arm devices and ultrasound are the most commonly used forms of image-guided intervention in pain treatment. However, fluoroscopy-guided method can only recognize bones; thus, they are used only for target nerves expected in the vicinity of a bony landmark.

11.1.1 Advantages

1. The position of the needle with respect to the bony landmark can be visualized with a wide field of view in the target region allowing practitioners to correctly place needles for accurate delivery.
2. Intravascular injection can be relatively easily detected (compared to ultrasound-based techniques) using a contrast medium, and this increases the clinical efficacy, decreases possible side effects, and enhances patient safety.

11.1.2 Disadvantages [1]

1. There is the potential for adverse effects to patients and staffs, who undergo prolonged exposure to fluoroscopy. To minimize radiation exposure, the following steps can be taken: (1) intermittent use of fluoroscopy; (2) placing the image intensifier as close to the patient as possible; (3) the target region image should be kept in the center of the field, and the size of the x-ray field should be reduced as much as possible; and (4) the use of suitable shields (such as a thyroid shield and leaded gloves) could help decrease exposure to the staff.
2. Since it is necessary to imagine the three-dimensional anatomy while watching the two-dimensional X-ray images, practitioners are required to learn and develop their skill.
3. The possibility of an allergic reaction to the contrast medium commonly used during fluoroscopic procedures.

Recently some pain clinicians have started using a CT-guided method instead of fluoroscopy, which allows for a safer placement of the needle.

Reference

1. Wang LH, McKenzie-Brown AM, Hord AH. Radiation safety. Handbook of fluoroscopy-guided spinal injections. Boca Raton, FL: Taylor & Francis; 2006. p. 29–40.

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Ultrasound-Guided Method

12

Kiyoshige Ohseto, Naoto Iwase, and Hiroyuki Uchino

12.1 Introduction

12.1.1 Ultrasound-Guided Nerve Block, Ultrasound Anatomy

Ultrasound-guided nerve block allows the real-time visualization of needle placement on cross-sectional images, enabling accurate drug injection around the nerve (into the nerve in some cases). This technique is considered to be more accurate and safer than the conventional landmark-based method. The use of ultrasound-guided method improves the success rate of nerve blocks particularly in less experienced clinicians.

The time required for nerve block (including the preparation time) is usually longer in the ultrasound-guided method than in the landmark-based method. However, the time to onset of action is often shorter in the ultrasound-guided method because a local anesthetic is injected near the target nerve. In addition, the duration of effect is longer, and the rates of complications, such as accidental puncture of blood vessels and nerves, are lower in the ultrasound-guided method than in the landmark-based method [1–3].

12.1.2 Ultrasound Anatomy [4–6]

It is essential to understand how the ultrasound beam is transmitted and reflected back to the probe on the body surface and allows visualization of the body structure. Ultrasound equipment provides images by transforming the reflected waves to electric signals. Tissue that reflects ultrasound waves strongly produces a bright or hyperechoic image. Tissue that reflects ultrasound waves weakly produces a dark or hypoechoic image. Tissue that reflects no ultrasound waves produces an anechoic image.

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12.1.2.1 Nerve

Nerves are observed as hypoechoic, whereas the epineurium is observed as hyperechoic. Peripheral nerves are visualized as a cord-like structure with a hyperechoic boundary and a hypoechoic central area, although the visualization pattern can be different depending on the location. Ultrasound images of nerves and tendons show a similar appearance, but nerves do not change in terms of their shape and width, whereas tendons connect to muscles. Nerves are usually located near blood vessels.

12.1.2.2 Blood Vessel

Blood vessels are observed as hypoechoic or anechoic round or oblong structures. Veins are easily collapsible upon external pressure. Color Doppler displays blood flow, allowing discrimination between hypoechoic nerves and small blood vessels.

12.1.2.3 Muscle and Fascia

Muscles are one of the best structures suitable for ultrasound examination. Muscle fibers usually run parallel. Muscle tissue is predominantly hypoechoic, with a patchy hyperechoic appearance. The fascia is hyperechoic.

12.1.2.4 Bone

The bone surface reflects ultrasound strongly, and the bone margin appears as hyperechoic with an acoustic shadow (black) deep into it.

12.1.3 Techniques, Cautions, Equipment, and Drug Solution

As in the other nerve block procedures, preparations of oxygen administration, artificial respirator, emergency drugs, and fluid replacement among others are necessary to address potential complications. It is important for examiners to have sufficient practice to enhance their scanning and needling skills before they work with real patients.

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12.1.3.1 Probes Used for Ultrasound-Guided Nerve Block [4]

Linear Probe (5–14 MHz)
The ultrasound beams are parallel; therefore, the width of the image is equal to that of the probe.

The probe is suitable for nerves located within a depth of 3 cm and useful for the assessment of the surface structure.

Applicable nerve blocks: brachial plexus block (interscalene, supraclavicular, and axillary approaches), femoral nerve block, obturator nerve block, articular nerve block, and peripheral nerve block.

Convex Probe (2–5 MHz)
The transducer has an arch-shaped electrode pattern and displays a fan-shaped image, allowing a wider field of view. The probe is suitable for nerves located deep in tissue.

Applicable nerve blocks: lumbar plexus bock and sciatic nerve block.

Micro-Convex Probe (5–8 MHz)
The probe displays a fan-shaped image. The probe is small and can be applied to a small area of the body surface.

Applicable nerve blocks: stellate ganglion block and peripheral trigeminal nerve branch block.

Hockey Stick-Type Probe (6–13 MHz)
The probe has the same function as the linear probe. It has a length of 30 mm and a width of 6 mm. The probe has a smaller footprint (width), which is suitable for small areas such as the face.

Applicable nerve blocks: peripheral trigeminal nerve branch block and glossopharyngeal nerve block.

12.1.3.2 How to Manipulate the Probe
The angle of incidence of the ultrasound beam has a marked effect on the image quality of the target nerve. It is important to position the probe vertically to the skin but not to the nerve under the skin.

12.1.3.3 Needles for Nerve Block
Various nerve block needles with good visibility are available. A Teflon-coated needle electrode is also available. Experienced clinicians can perform ultrasound-guided nerve block using ordinary needles.

12.1.3.4 Local Anesthetics
Local anesthetics used in ultrasound-guided nerve block are the same as those used in the landmark-based technique. For pain relief, ultrasound-guided nerve block often requires a lower concentration and a smaller amount of drug than the landmark-based method [7].

12.1.3.5 Method of Puncture [8]
After the ultrasound gel is placed into a sterile bag, the probe is enclosed in the sterile bag while preventing air from entering the bag. The probe is held by the non-dominant hand.

In-Plane Technique (In-Line Technique)
The needle is passed along the long axis of the ultrasound beam. The needle is always observable, but the entire picture of the needle is not always observed. In that case, adjustment of the probe is necessary to visualize the needle tip.

Out-of-Plane Technique (Out-of-Line Technique)
The needle is advanced vertically to the long axis of the ultrasound beam. The needle is recognized as a hyperechoic (white) point, but it may not accurately indicate the position of the needle tip; therefore, observation while adjusting the probe is necessary. The position of the needle tip can be also estimated from the movement of the surrounding tissue. Beginners are recommended to use the "in-plane" technique.

12.1.4 Applicable Blocks

There are many types of nerve blocks, including stellate ganglion block, brachial plexus block (interscalene, supraclavicular, subclavicular, and axillary approaches), cervical plexus block, nerve root block, upper extremity peripheral nerve block, epidural block, thoracic paravertebral block, intercostal nerve block, femoral nerve block, obturator nerve block, sciatic nerve block (parasacral, posterior, anterior, and popliteal approaches), lower extremity peripheral nerve block, and lumbar plexus block. Intraarticular injection and subacromial bursa injection are administered to the joints including the intervertebral, shoulder, hip, and knee joints. The level of technical expertise required depends on the types of nerve blocks.

In addition, the combined use of fluoroscopy will increase the safety and efficacy of the procedure.

12.1.5 Complications [9]

The ultrasound-guided technique is safer than the landmark-based technique, although there are still potential complications and problems with skill acquisition.

12.1.5.1 Neurological Disorders
Ultrasound guidance helps avoid the direct injection of the drug to the nerve (perineurium). However, a direct injection may occur even with ultrasound guidance.

12.1.5.2 Local Anesthetic Toxicity

Injections should be given slowly, while monitoring the spread of the local anesthetics. The amount of local anesthetics should be kept to the minimum.

12.1.5.3 Intravessel Injection and Vessel Puncture

The risk of accidental vessel puncture is lower in the ultrasound-guided technique than in other techniques [2]. If it becomes difficult to differentiate a nerve from a small vessel, blood flow observation using color Doppler will reduce the risk of blood vessel puncture.

12.1.5.4 Others

Intrathecal injection, epidural cavity injection

References

1. Abrahams MS, et al. Ultrasound guidance compared with electrical neurostimulation for peripheral nerve block: a systematic review and meta-analysis of randomized controlled trials. Br J Anaesth. 2009;102:408–17.
2. Warman P, et al. Ultrasound-guided nerve blocks: efficacy and safety. Best Pract Res Clin Anaesth. 2009;23:313–26.
3. Liu SS, et al. Evidence basis for ultrasound-guided block characteristics onset, quality, and duration. Reg Anesth Pain Med. 2010;35:S26–35.
4. Stuart RM, et al. Sonography of peripheral nerve pathology. AJR. 2004;182:123–9.
5. Martinoli C, et al. Ultrasound of tendons and nerves. Eur Radiol. 2002;12:44–55.
6. Peetrons P. Ultrasound of muscles. Eur Radiol. 2002;12:35–43.
7. Koschielniak-Nielsen ZJ. Ultrasound-guided peripheral nerve blocks: what are the benefits? Acta Anaesthesiol Scand. 2008;52:727–37.
8. Grey AT. Introduction to ultrasound-assisted regional anesthesia technique. In: Hadzic A, editor. Textbook of regional anesthesia and acute pain management. New York: McGraw-Hill Medical; 2007. p. 657–61.
9. Fredrickson MJ, Kilfoyle DH. Neurological complication analysis of 1000 ultrasound peripheral nerve blocks for elective orthopedic surgery: a prospective study. Anaesthesia. 2009;64:836–44.

CT-Guided Method

13

Hiroyuki Uchino, Yukihiko Ogihara, and Kiyoshige Ohseto

13.1 Introduction

Therapeutic nerve block is one of the interventions to reduce pain. Several methods are used for nerve blocks and either local anesthetics or neurolytic agent (ethanol or glycerol) is selected. Local anesthetics are sometimes used as a trial block or diagnostic block. Neuro-destructive blocks due to neurolytic agents or radiofrequency thermocoagulation are used for sympathetic nerve block or intractable chronic pain.

To perform the safety and high-quality nerve blocks, pain clinician should have the enough anatomical knowledge and notice advantages and disadvantages of the nerve blocks. Koizuka suggested that we should realize the potential complication associated with nerve blocks that are classified as (1) nerve damage, (2) unexpected damage to the other structures or organs, (3) intravenous or intra-arterial injection of the neurolytic agents, and (4) physiological effects due to nerve block [1].

Until now, to perform the nerve blocks, so many techniques are provided as landmark method, echo-guidance method, and so on. However, it is sometimes difficult to perform the accurate needle insertion and nerve blocks with less complication, because of the anatomical distortion, deformity, and malformation. To solve these problems, image guidance can ensure safety, accuracy, and selectivity [2].

The choice of image guidance modality remains a matter of physician preference; fluoroscopy-guided method and computed tomography (CT)-guided method are the most commonly utilized methods. In this chapter, we would like to (1) provide the basic overview of CT techniques that can be valuable for sympathetic nerve block other interventional procedure, (2) show potential advantages and disadvantages of CT-guided method, and (3) discuss methods to avoid potential pitfalls.

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13.2 CT-Guided Method

CT-guided method for interventional procedure was reported in 1975 by Haaga et al. [3], who reported the CT-guided celiac plexus block. CT guidance pain intervention can perform a clear view of vital organ and vessels. It also avoids the harmful needle puncture due to the accurate placement of the needle tip for the injection of neurolytic agents. Disadvantages of conventional CT (CCT)-guided intervention are long procedure time and excessive exposure for the patient. CCT should perform the frequent scanning to confirm the optimal needle position that leads to the prolongation of procedures and considerable exposure for the patients [4]. However, generally, physicians do not require lead shielding because they usually leave the room during image acquisition. Physicians often reenter the CT room and correct the needle position. This procedure is repeated until needle reaches to the target position.

In the early 1990s, CT fluoroscopy (CTF) was developed and reported by Katada et al. for celiac plexus block [5]. CT fluoroscopy acquires dynamic and fast continuous image reconstruction and display. Patient movement is low during tube rotation. Radiation dose of continuous mode CTF is 4 times higher than conventional fluoroscopy [6]. Today, most physicians utilize quick-check CTF that is an analogous technique compared to conventional CT guidance. So, they need to protect with a lead apron, thyroid shield, and leaded glasses to minimize radiation dose during image acquisition. CTF allowed for real-time visualization of the needle, expediting the procedure and markedly reducing its overall length, partly because operators did not need to leave the scanning room [5, 7].

Multi-slice CT (MS-CT) fluoroscopy or multi-detector technology CT (MDCT) fluoroscopy allowing for easy correction of longitudinal deflection of the needle tip during insertion due to increasing the speed of acquisition [2]. This speed enables submillimeter slice thickness based on increasing the inherent spatial contrast resolution. Patient move-

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ment is low during tube rotation. In addition, some types of recent MSCT or MDCT devices provide three-dimensional views within a few minutes after scanning so that correct needle tip placement in relation to the surrounding anatomic structures and diffusion of contrast medium or neurolytic agent [8].

C-arm system has a number of disadvantages that limit its utility for low-contrast C-arm CT imaging which usually produces the nonhomogeneous images. Three-dimensional C-arm system with flat panel detector can avoid or reduce the disadvantages of image intensifier [6]. Strobel [9] suggested that the most important technical advantages of flat detector are as follows:

1. Homogeneous image quality across the entire image area resulting in distortion-free images and position-independent spatial resolution
2. High "low-contrast resolution" for good 2D soft tissue imaging performance
3. High detective quantum efficiency (DQE) across all dose levels, in particular, for CsI/aSi-based flat detectors
4. High dynamic range at all dose levels from fluoroscopy to digital subtraction angiography (DSA)
5. Tightly enclosed square or rectangular active imaging areas offering improved patient access

Acquisition of C-arm CT data is automated and it is easy to use. High-contrast C-arm CT scan sometimes uses for subtracted runs with contrast to image vascular malformations. Low-contrast C-arm scan is sometimes used to image therapy control, complication management of the head, or tumor treatment of the body. High-contrast C-arm CT scan results in significant lower dose to the patient; on the other hand, low-contrast C-arm CT scan showed similar dose compared to regular CT scans [9].

13.3 Advantages and Disadvantages of CT-Guided Nerve Blocks

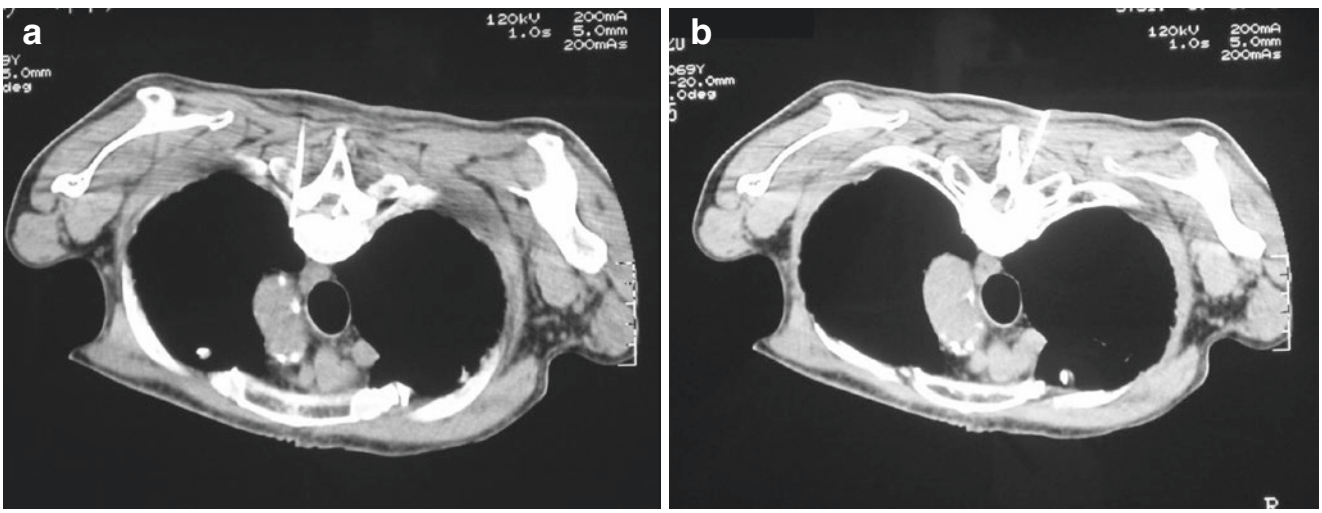
The advantages of CT-guided method are to get the greater anatomical detail that could facilitate accurate needle trajectory planning. CT guidance also provides the direct visualization of entire needle trajectory and surrounding soft tissue and bone and can apply for various types of nerve blocks. MDCT can also reduce the insertion time to get the correct position for nerve blocks. Confirmation of exact needle position can perform without use of contrast media by CT fluoroscopy.

Disadvantages of CT-guided method are as follows: (1) Longer on-table procedure time and greater radiation exposure both to the patients and physician occur compared to conventional fluoroscopy. (2) Utilization of CT guidance requires access to a CT scanner that might be less accessible compared to conventional fluoroscopy. (3) Patient motion and adjustment of needle trajectory is easily changed by conventional fluoroscopy guidance compared to CT guidance [10, 11].

13.4 Indications of CT-Guided Nerve Block

Indications of CT-guided nerve block are of various types as follows:

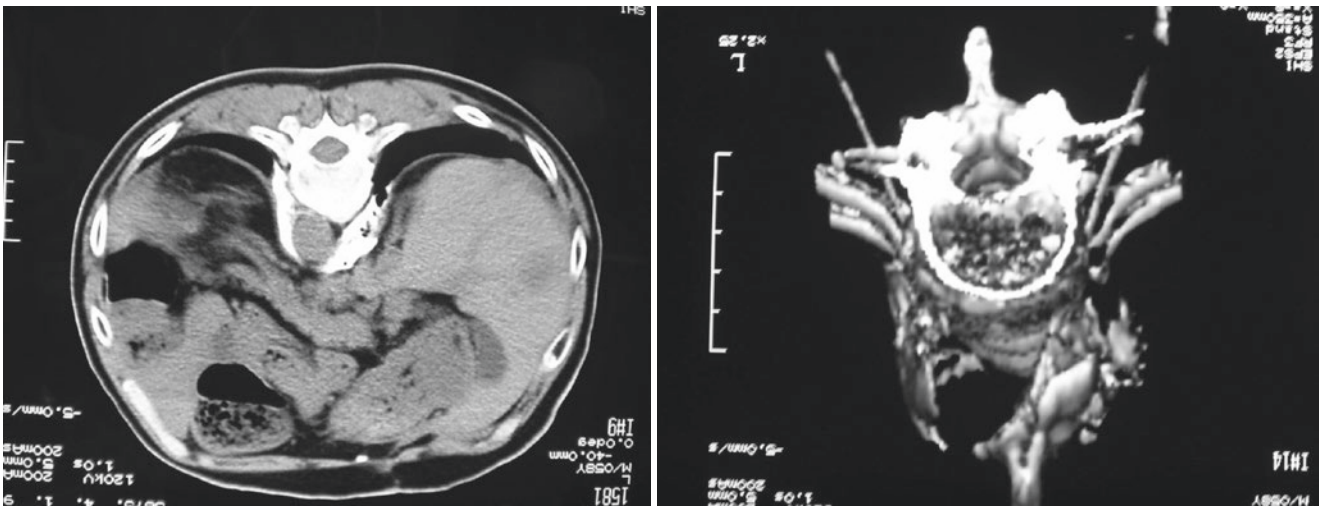
1. Sympathetic nerve block (Fig. 13.1, 13.2, and 13.3)
2. Gasserian ganglion block



Needle trajectory after thoracic sympathetic nerve block

Deviation of the needle into the subarachnoid space

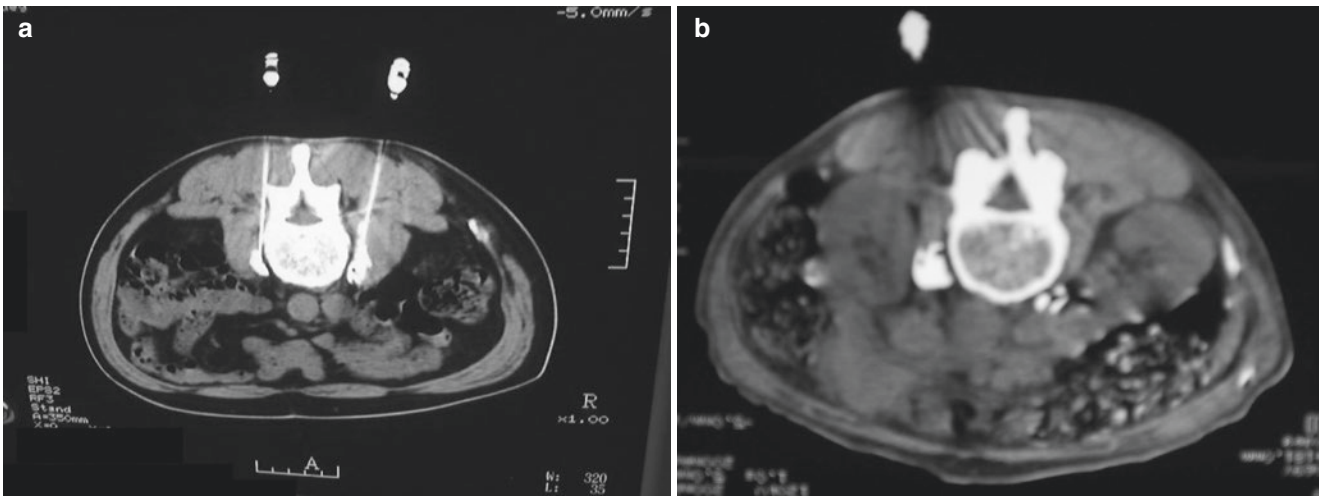
Fig. 13.1 CT-guided thoracic sympathetic nerve block. Computed tomography-guided view during thoracic sympathetic nerve block. CT image obtained with the patient in prone position shows the bilateral posterior intercostal Th2–3 or Th3–4) approach to compartment that includes sympathetic nerve (**a**). Deviation of the needle should be avoided to prevent the complication (**b**)



The spread of injectate after CPB

Assessment of the spread of injectate by 3DCT

Fig. 13.2 Celiac plexus block (CPB) and splanchnic nerve block under CT guidance. Computed tomography-guided view during splanchnic nerve block. CT image obtained with the patient in prone position shows the bilateral paravertebral approach to the compartment that includes splanchnic nerve (**a**). 3DCT reconstruction is also available to assess the spread of injectate



The spread of injectate after lumbar sympathetic nerve block

Fig. 13.3 CT-guided lumbar sympathetic nerve block. Computed tomography-guided view during lumbar sympathetic nerve block. CT image obtained with the patient in prone position shows the bilateral paravertebral approach to the compartment that includes lumbar sympathetic nerve (**a**, **b**)

3. Vertebral disc decompression
4. Radio-frequency thermocoagulation
5. Epidural injection

13.5 Key Point of Technical Procedure

The important essence to succeed CT guidance nerve blocks are as follows [10]:

1. Establish the patient comfortable position and best position for the operator.
2. Reduce the radiation dose during preliminary CT to decide the target anatomy.
3. Use CT fluoroscopy.
4. Wear lead drapes.
5. Decide the needle placement and trajectory to use the gantry laser light guide.
6. Avoid continuous mode CTF.
7. Use limited post-procedural CT except serious complications such as cement leak during CT-guided vertebroplasty.

13.6 Complications

CT guidance nerve blocks also induce the complication as follows:

1. Motor nerve injury
2. Organ injury (pneumothorax, liver, kidney, thoracic duct, colon, and rectal injury)
3. Spinal injury
4. Bleeding by vessel injury
5. Infection
6. Vertigo and hypotension due to sympathetic nerve block
7. Urinary retention and diarrhea due to sympathetic nerve block
8. Compensatory sweating due to sympathetic nerve block

References

1. Curatolo M, Bogduk N. Diagnostic and therapeutic nerve blocks. In: Fishman SM, Ballantyne JC, Rathmell JP, editors. Bonica's management of pain. 4th ed. Philadelphia: Lippincott; 2010. p. 1401–14023.
2. Koizuka S, Nakajima K, Mieda R. CT-guided nerve block: a review of the features of CT fluoroscopic guidance for nerve blocks. J Anesth. 2014;28(1):94–101.
3. Haaga JR, Reich NE, Havrilla TR, Alfidi RJ. Interventional CT scanning. Radiol Clin N Am. 1977;15(3):449–56.
4. Silverman SG, Tuncali K, Adams DF, Nawfel RD, Zou KH, Judy PF. CT fluoroscopy-guided abdominal interventions: techniques, results, and radiation exposure. Radiology. 1999;212(3):673–81.
5. Katada K, Kato R, Anno H, Ogura Y, Koga S, Ida Y, Sato M, Nonomura K. Guidance with real-time CT fluoroscopy: early clinical experience. Radiology. 1996;200(3):851–6.
6. Granfors PR, Albagli D, Tkaczyk JE, et al. Performance of a flt-panel cardiac detector. In: Medical imaging, vol. 2001. San Diego, CA: Physics of Medical Imaging; 2001. p. 77–86.
7. Sarti M, Brehmer WP, Gay SB. Low-dose techniques in CT-guided interventions. Radiographics. 2012;32(4):1109–19.
8. Koizuka S, Saito S, Tobe M, Sekimoto K, Obata H, Koyama Y. Technical communication: percutaneous radiofrequency mandibular nerve rhizotomy guided by high-speed real-time computed tomography fluoroscopy. Anesth Analg. 2010;111(3):763–7.
9. Strobel N, Meissner O, Boese J, Brunner T, Hoheisel BHM, Lauritsch G, Nagel M, Pfister M, Rührnschopf E-P, Scholz B, Schreiber B, Spahn M, Zellerhoff M. Klaus Klingenbeck-Regn. In: Reiser MF, Becker CR, Nikolaou K, Glazer G, editors. 3D imaging with flat-detector C-arm systems. Berlin Heidelberg: Multislice CT Springer; 2009. p. 33–51.
10. Hoang JK, Yoshizumi TT, Toncheva G, Gray L, Gafton AR, Huh BK, Eastwood JD, Lascola CD, Hurwitz LM. Radiation dose exposure for lumbar spine epidural steroid injections: a comparison of conventional fluoroscopy data and CT fluoroscopy techniques. AJR Am J Roentgenol. 2011;197(4):778–82.
11. Timpone VM, Hirsch JA, Gilligan CJ, Chandra RV. Computed tomography guidance for spinal intervention: basics of technique, pearls, and avoiding pitfalls. Pain Physician. 2013;16(4):369–77.

ME-Guided Method

14

Sei Fukui

14.1 Introduction

14.1.1 MR-Guided Nerve Block

Using open MRI, MR fluoroscopy-guided nerve block can be performed, such as facet block, medial branch block of the dorsal ramus, and intervertebral disc block (Fig. 14.1).

14.1.2 Indication

MR-guided nerve block is markedly advantageous for the treatment of articular and neural cysts. Percutaneous laser disc decompression to treat lumbar disc herniation can also be safely performed.

14.1.3 Instruments

Open MRI apparatus and MR-compatible nerve block needle. Currently, MR-compatible apparatuses which are usable at pain clinics are MR-compatible puncture needles and laser therapy equipment. For laser therapy, an MR-compatible 18-G 15- or 20-cm puncture needle (Cook Medical) and laser Nd: YAG laser apparatus (SLT Japan) are used.

14.1.4 MR-Guided PLDD

MR fluoroscopy-guided percutaneous laser disc decompression (PLDD) is markedly advantageous for the treatment of lumbar disc herniation. Its procedure is described below.

Patients can return to their daily lives earlier after PLDD, as opposed to long-term after care with other treatments. On the other hand, the indication has to be strictly followed to prevent complications.

A patient is placed on an MR fluoroscopy table in a prone position with a pillow positioned under the abdomen. After attaching the coil, the patient enters an open MRI apparatus. Cross-sectional images of the target intervertebral disc are acquired in the sagittal plane. Based on horizontal sectional images, the puncture site and direction through which a puncture needle exclusive for MR reaches the target are investigated. Using these results, the doctor targets the center of the intervertebral disc or a slightly posterior lateral site in the direction of hernia protrusion (Fig. 14.2) as an MR-guided insertion site.

Based on navigation displayed in the MR image, intervertebral disc puncture is applied in parallel to the intervertebral region while monitoring real-time sagittal and horizontal images, and the guide needle is advanced toward the target (Fig. 14.2). Arrival of the puncture needle to the target site and the accuracy of insertion are confirmed by T1- and T2-weighted imaging [1] (Fig. 14.2). An 18-G puncture needle is visualized as about 4–5 times thicker than the actual size on MR fluoroscopy due to the effect of magnetic susceptibility.

The inner cylinder is removed after the puncture needle reaches the target, and the laser fiber is inserted into the needle until the fiber is about 5-mm exposed out of the tip of the titanium needle. Using the laser radiation device, laser radiation is tested at a low output (10 W). After confirming that the radiation has not induced nerve irritation, vaporization of the disc herniation with laser radiation is initiated while monitoring the T1-weighted MR fluoroscopic image. One-second radiation pulses at 10–15 W at one-second intervals are set, and the nucleus pulposus is vaporized by a total of about 600–800 J laser radiation. Laser radiation is applied while confirming that the patient has no issues, especially nerve root irritation.

The laser tip temperature of PLDD can reach several hundred degrees, and regions with a temperature rise are detected as low-intensity regions on T1-weighted imaging.

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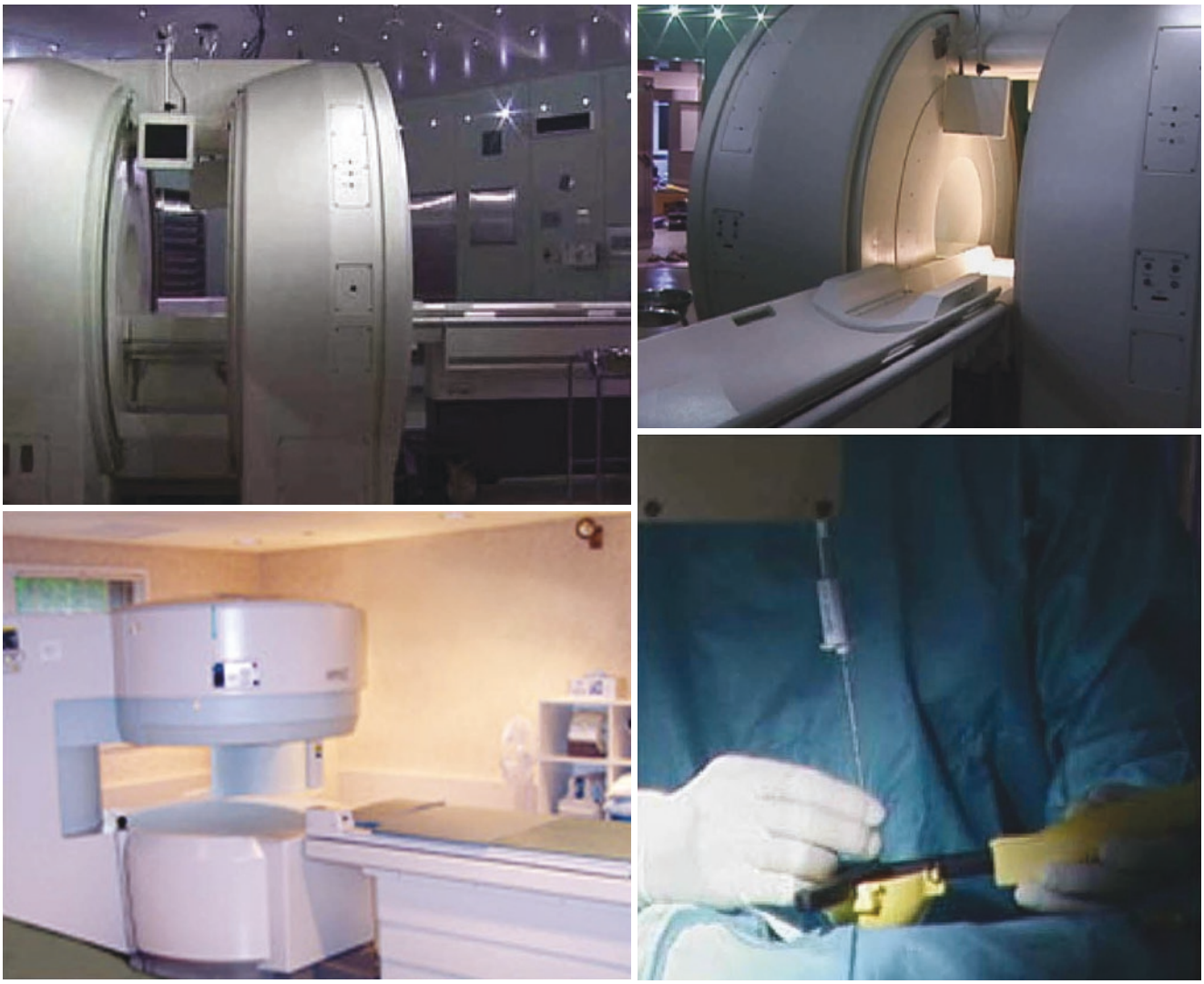

Fig. 14.1 Open MRI apparatuses and insertion using an auxiliary tool. Open MRI apparatus, SIGNA SP/1 of GE (upper left); Open MRI apparatus of Hitachi (lower left). Vertical open MRI apparatuses have an open structure appearing as two vertically standing doughnut rings, and the operator stands between the rings. A bed can be placed longitudinally (upper left) and also perpendicularly (upper right). Needle insertion using an auxiliary tool for open MRI apparatus (lower right)

A low-intensity region is observed at the needle tip after the initiation of laser radiation, and the region expands with an increase in the radiation dose (Fig. 14.2). The tissue temperature distribution can be observed based on changes in the MR intensity. Laser irradiation can be applied accurately and safely by monitoring the temperature distribution in the MR images during laser radiation (Fig. 14.3).

Temperature rise and gas production occur in the nucleus pulposus due to laser radiation-induced vaporization and coagulation necrosis. Since the laser-vaporized region shows a high intensity (Fig. 14.3), the range of hernia vaporization can be evaluated by MR imaging [1]. Observation of the laser-vaporized region and tissue temperature during laser radiation facilitate its accurate and safe application.

To improve the outcome of PLDD and safely apply it without complications, the total laser radiation dose is important as an index of the completion of laser radiation. The radiation dose is determined by the patient's subjective symptoms and range of vaporization gas on MRI. To safely apply it, the total dose to complete laser radiation is set at 600 J. Since excess radiation is likely to cause complications, the maximum dose is set at about 800 J.

14.1.5 Complications

Possible complications include discitis, vertebral body endplate disorder, nerve root injury, facet arthrosis associated

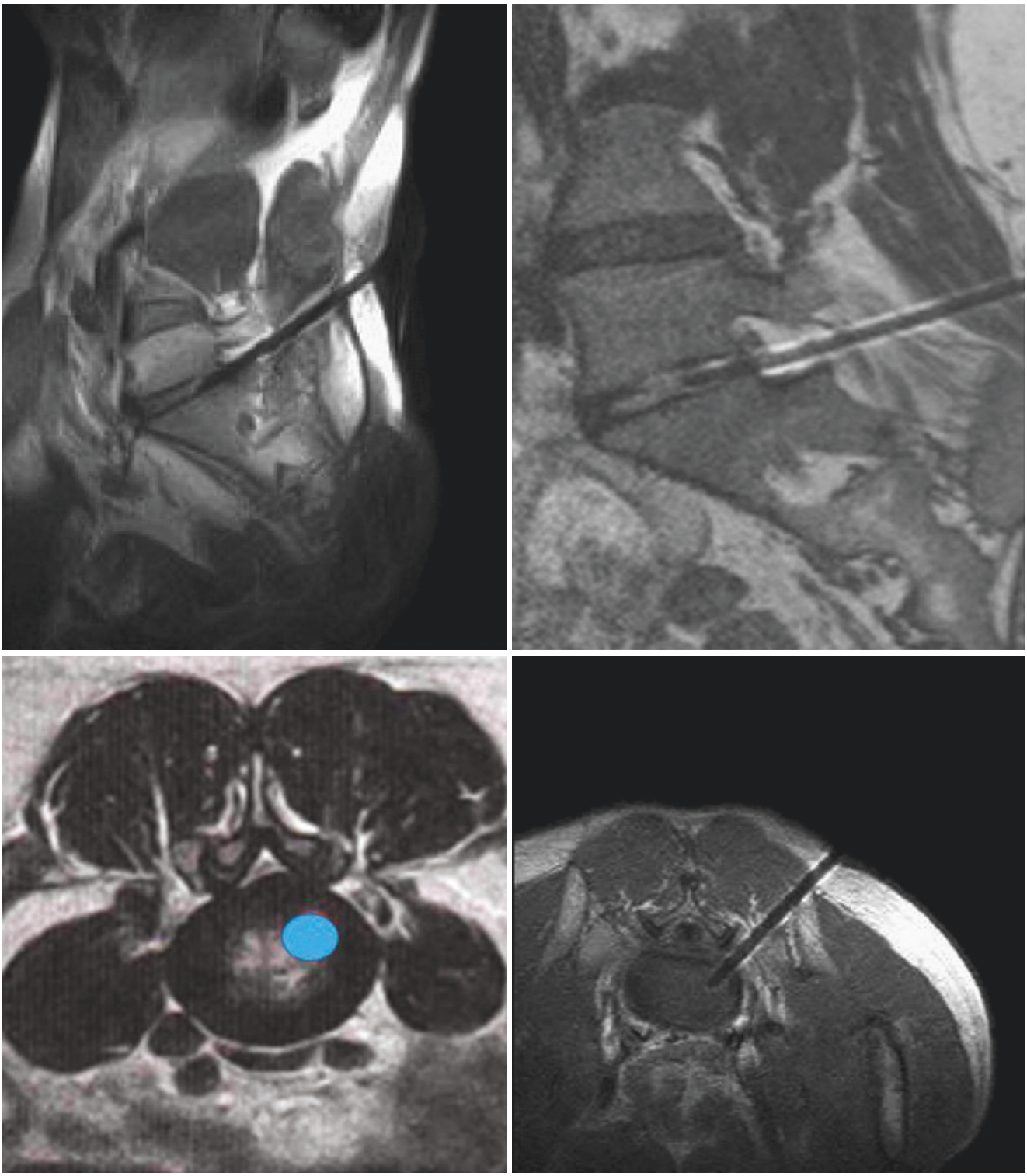

Fig. 14.2 MR fluoroscopy-guided intervertebral disc puncture. An MR-compatible 18-G needle was advanced toward the target site at the lower left of the dorsal region on the herniated side while monitoring the sagittal and horizontal images of MR fluoroscopy. An 18-G puncture needle is visualized about 4–5 times thicker than the actual size on MR fluoroscopy due to the effect of magnetic susceptibility, but it does not interfere with disc decompression

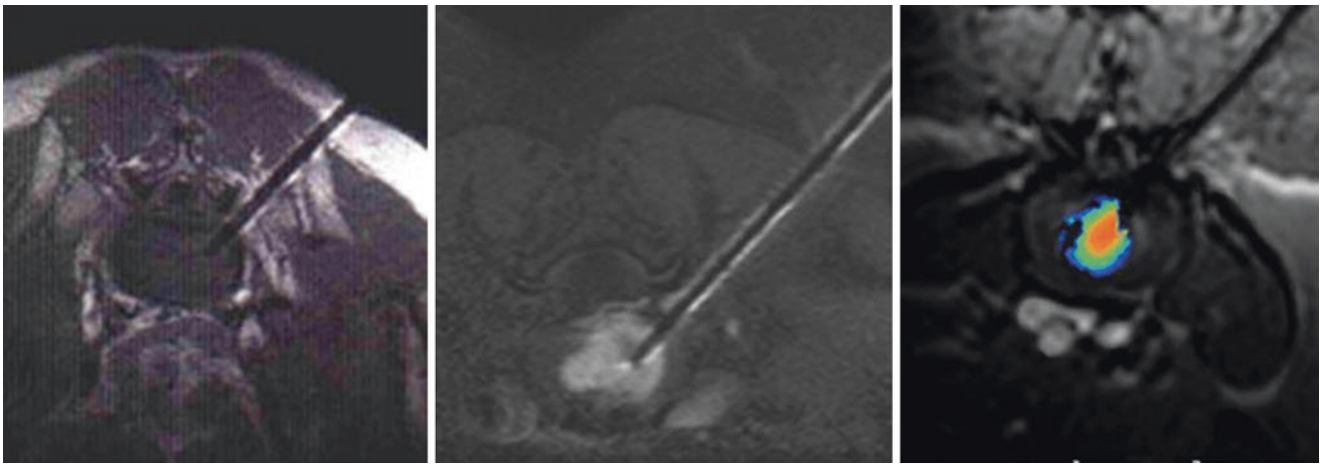

Fig. 14.3 Actual MR fluoroscopy-guided percutaneous laser disc decompression. Laser vaporization of disc herniation was initiated under MR fluoroscopy. Intraoperative temperature mapping image (middle). Vaporization was advanced while monitoring the MR fluoroscopic images and temperature (right)

with excess radiation-induced narrowing of the intervertebral disc, spondylitis, epidural abscess, and nerve injury.

Endplate disorder can be prevented by inserting the needle parallel to the intervertebral region and adjusting the radiation conditions. For infection control, intravenous drip infusion and oral administration of antibiotics 30 min before or during treatment are essential.

Reference

1. Streitparth F, Hartwig T, Walter T, De Bucourt M, Putzier M, Strube P, Bretschneider T, Freyhardt P, Maurer M, Renz D, Gebauer B, Hamm B, Teichgräber UK. MR guidance and thermometry of percutaneous laser disc decompression in open MRI: an initial clinical investigation. Eur Radiol. 2013;23:2739–46.

Part IV

Head

Trigeminal Nerve Block

15

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15.1 Indications

Typical trigeminal neuralgia, facial herpes zoster and postherpetic neuralgia, malignant tumor-associated headache/facial pain

15.2 Anatomy [1]

The trigeminal nerve comes out from the lateral side of the pons as motor and sensory roots. The sensory root expands into the trigeminal ganglion, and the motor root accompanies the sensory root inferiorly. Trigeminal ganglion divides into the three branches: the ophthalmic nerve, the maxillary nerve, and the mandibular nerve. And the motor fibers are only distributed to the mandibular division (Fig. 15.1).

15.2.1 Ophthalmic Nerve (First Branch)

The ophthalmic nerve passes through the superior orbital fissure and reaches the orbit and divides into three branches: the frontal, nasociliary, and lacrimal nerves. The frontal nerve divides into the supraorbital nerve and the supratrochlear nerve. The supraorbital nerve passes through the supraorbital notch and runs up forehead. The supratrochlear nerve comes out from the orbit inside of the ophthalmic nerve and distributes to the forehead and the nasal root. The nasociliary nerve supplies branches to the mucous membrane of the nasal cavity. The lacrimal nerve provides sensory innervations for the lacrimal grand and lateral upper eyelids.

15.2.2 Maxillary Nerve (Second Branch)

The maxillary nerve goes out of the cranial cavity from the foramen rotundum in the greater wing of the sphenoid bone. It branches the zygomatic nerve and main root becomes the infraorbital nerve; it passes through the infraorbital foramen and distributes in the nasal wing and upper lip.

15.2.3 Mandibular Nerve (Third Branch)

The mandibular nerve goes out of the cranial cavity from the foramen ovale in the greater wing of sphenoid bone. It branches the auriculotemporal nerve and buccal nerve then becomes mental nerve. The mental nerve passes through the mental foramen and innervates lower lip. The mandibular nerve sends motor fibers to the masticatory muscle.

15.3 Instruments and Drug Solutions

15.3.1 Nerve Blocks

1. 5 mL syringe
2. 1 mL syringe
3. 25–27-G 13mm needle
4. 22-G 40mm needle
5. 1% mepivacaine (or 1% lidocaine)
6. 2% mepivacaine (or 2% lidocaine)
7. 0.5% chlorhexidine gluconate +70% isopropanol

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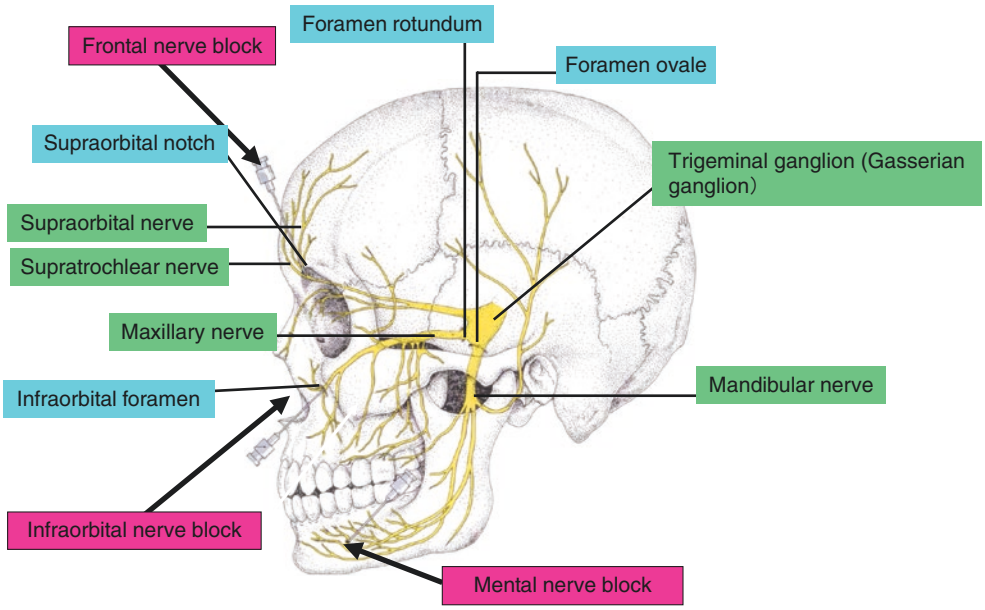

Fig. 15.1 Trigeminal nerve anatomy

8. Sterilized cotton swabs
9. Forceps
10. Petri dish
11. Pair of sterilized gloves
12. Sterilized cut gauze (20 × 20 cm)

15.3.2 Permanent Chemical Blocks

1. 99.9% sterilized ethanol

15.3.3 Ultrasound-Guided Method

1. Ultrasound generator/monitor
2. Micro-convex-type or a linear-type probe covered with a sterilized probe cover

15.3.4 RFT (Radiofrequency Thermocoagulation)

1. 22-G 54.99 mm guiding + lesioning needles
2. Radiofrequency lesion generator
3. Disposable reference electrode
4. Surgical drapes

15.4 Procedures and Techniques

15.4.1 Frontal Nerve Block

15.4.1.1 Landmark Method

1. Position: supine position
2. Procedure

The operator stands on the head side of the patient. The puncture site is on the supraorbital margin of 2–3 cm temporal to the midline of the face. The supraorbital notch can be touched at the point (Fig. 15.2a). Insert the needle vertically to the skin at the point and administer 0.3–0.5 mL of local anesthetics on the bone. Touch the upper edge of the orbit from below to prevent the needle from slipping into the eye ball during the procedure.

When using a neurolytic agent, hold the needle at the same point after injecting the local anesthetics and confirming sensory loss in the affected area without any complications, and then administer 0.5 mL of pure ethanol.

When performing RFT procedure, use a 22-G 54 mm guiding needle and lead it to the supraorbital foramen. When paresthesia is obtained, deliver 50–100 Hz 0.2 V electrical stimulation. If the stimulation evokes paresthesia in the forehead where the patient suffers from neuralgia, inject 0.5 mL of local anesthetics. After confirming anesthesia in the affected area without any complications, apply a 70–90 °C 120 s thermal lesioning.

15.4.1.2 Ultrasound-Guided Method

Place a linear-type probe or a hockey stick-type probe transversely on the same location of the landmark procedure. There is the supraorbital notch showed as the dent of the bone (Fig. 15.2b). Lead the needle from outside to the notch on the transverse plane, and then administer the local anesthetics or perform the RFT procedure.

15.4.2 Infraorbital Nerve Block

15.4.2.1 Landmark Method

1. Position: supine position
2. Procedure

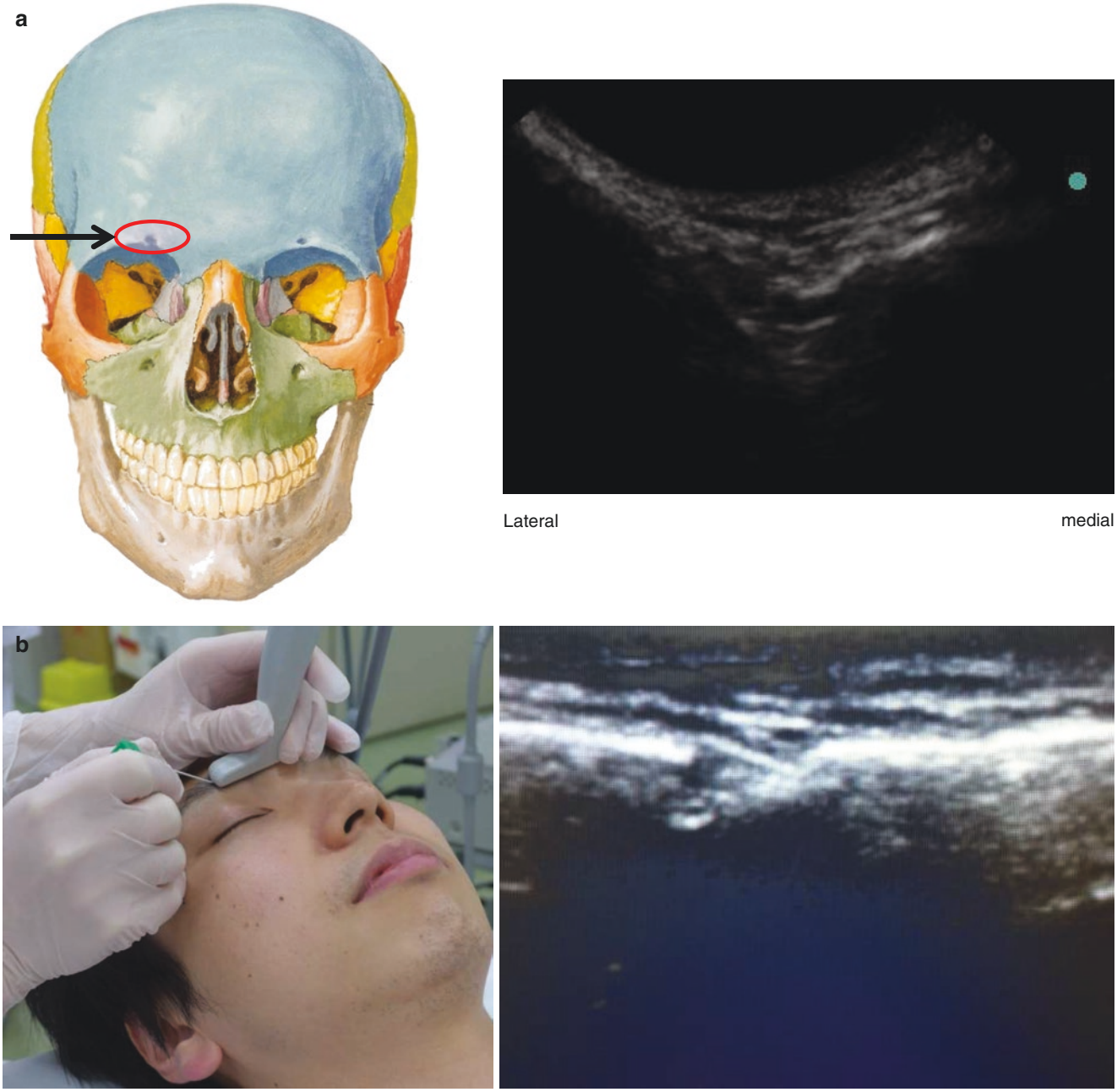

Fig. 15.2 (**a**) Location of supraorbital notch. (**b**) Supraorbital nerve block

The infraorbital foramen is located about 12 mm under the lower margin of the orbit and 30 mm lateral to the midline of the face (Fig. 15.3a). The puncture site is 10 mm lateral to the superior edge of the nasal wing. After infiltration anesthesia around the puncture site by a small amount of 1% mepivacaine, advance the block needle to the infraorbital foramen. When the needle touches the infraorbital nerve, the patient will complain of paresthesia, and then administer 0.2–0.5 mL of 2% mepivacaine. The length of the infraorbital canal is only about 10 mm, so it is not recommended to insert the needle further than 10 mm. During the procedure, keep the lower edge of the orbit detected with a finger to keep out the needle from orbit.

In case of using a neurolytic agent or RFT, just follow the same way as the supraorbital nerve block.

15.4.2.2 Ultrasound-Guided Method

Place a linear-type or a hockey stick-type probe sagittally on the same location of the landmark procedure. There is the infraorbital foramen showed as the dimple of the bone. Lead the needle from caudal to the foramen, and then administer the local anesthetics or apply the RFT procedure (Fig. 15.3b).

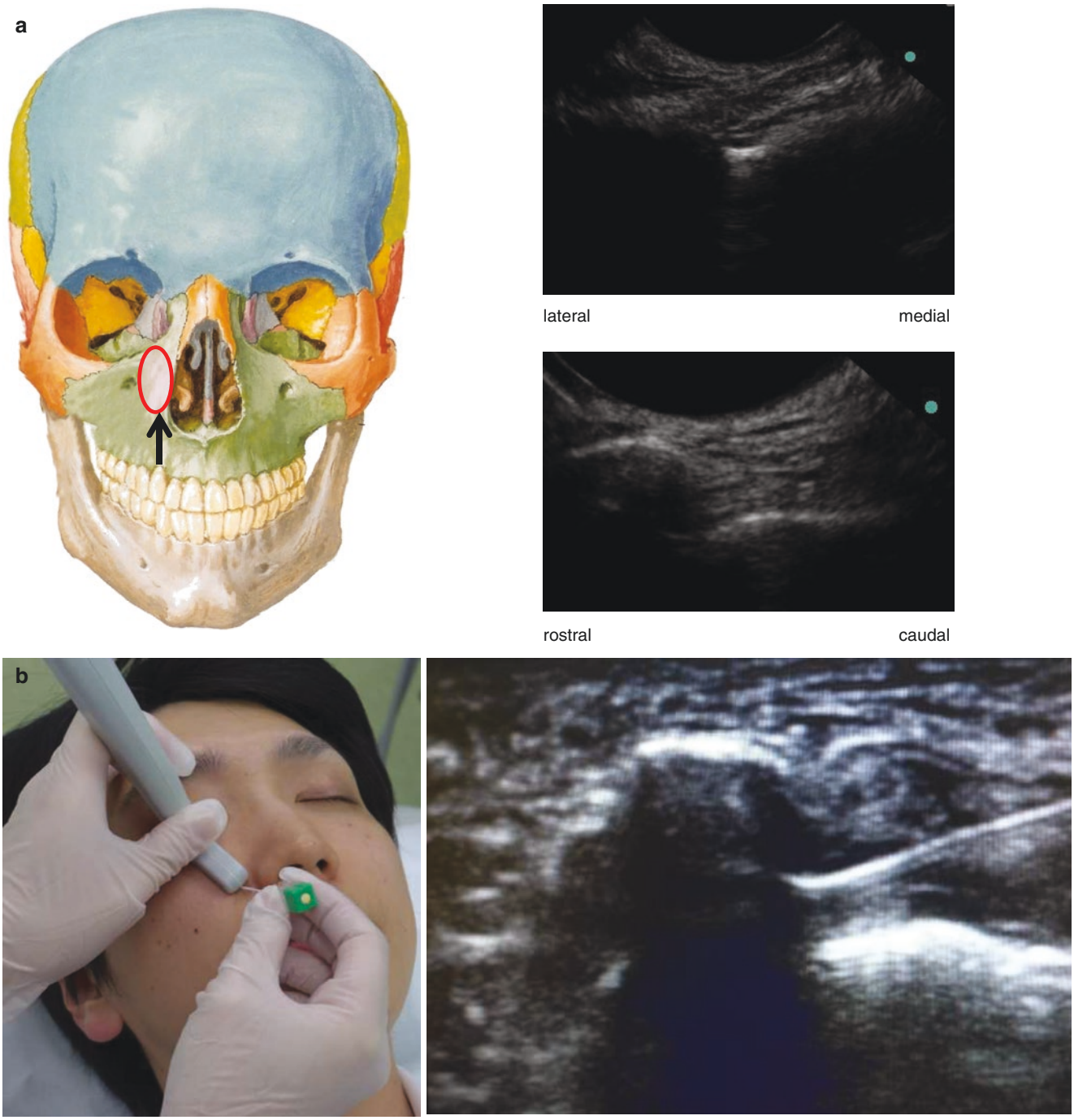

Fig. 15.3 (**a**) Location of infraorbital foramen. (**b**) Infraorbital nerve block

15.4.3 Mental Nerve Block

15.4.3.1 Landmark Method

1. Position: supine position
2. Procedure

The mental foramen is located at 2 cm caudal from the corner of mouth, and it opens toward outside (Fig. 15.4a). Puncture site is 1 cm lateral and 1 cm cephalad from the mental foramen. After infiltration anesthesia around the puncture site by a small amount of 1% mepivacaine, advance the block needle to the mental foramen. When the needle touches the mental nerve, the patient will complain of paresthesia, and then administer 0.2–0.5 mL of 2% mepivacaine.

In case of using a neurolytic agent or RFT, just follow the same way as the supraorbital nerve block.

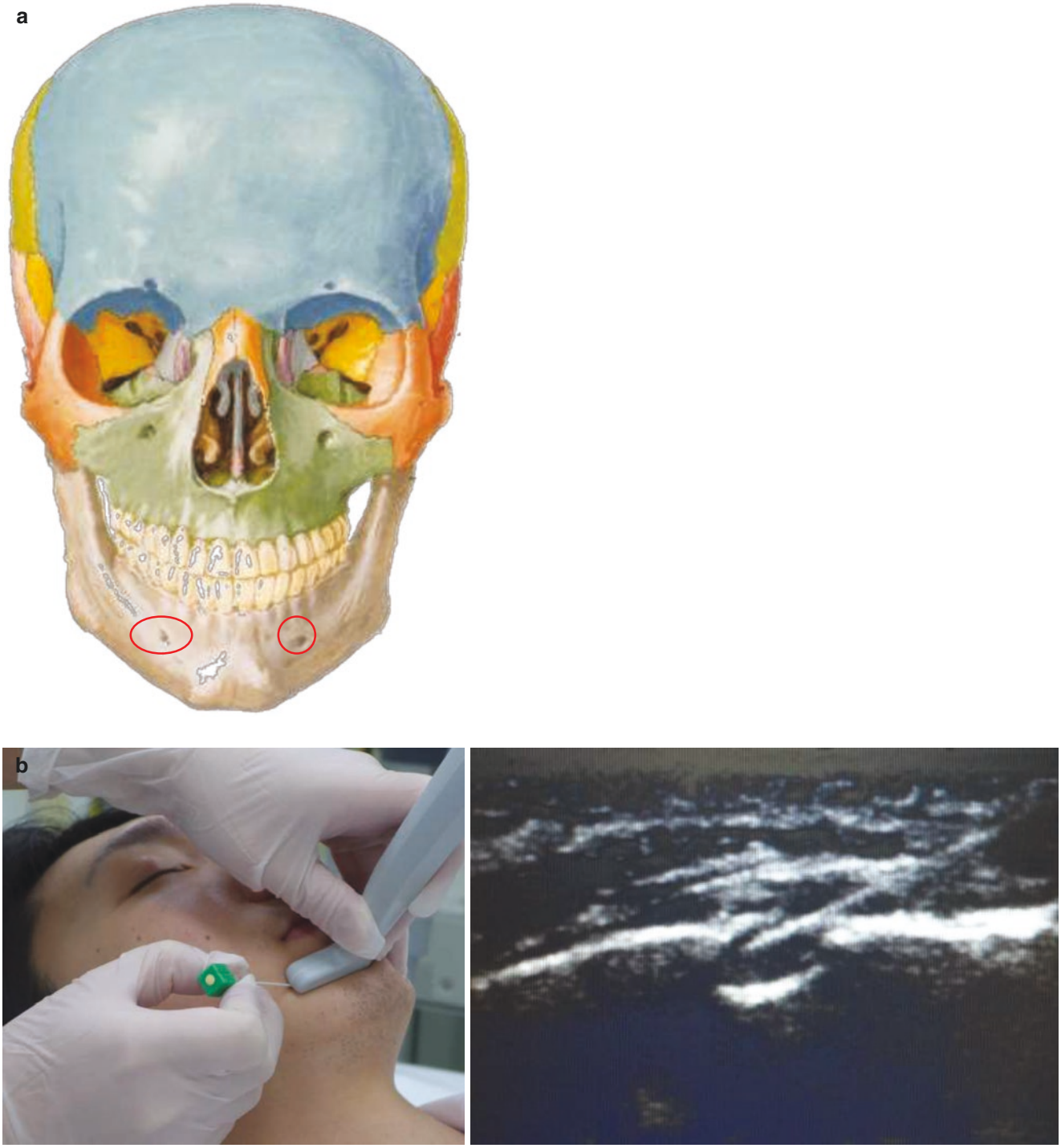

Fig. 15.4 (**a**) Location of mental foramen. (**b**) Mental nerve block

15.4.3.2 Ultrasound-Guided Method [2]

Ultrasound-guided technique is exclusively used in extraoral approach of the mental nerve block. Palpate the mental foramen according to the description in the landmark method. Place the linear-type or the hockey stick-type probe on the line connecting the mental foramen and the puncture site of landmark method. There is the mental foramen showed as the dimple of the bone. Lead the needle from the outside to the foramen under ultrasound guidance, and then administer the local anesthetics or apply the RFT procedure (Fig. 15.4b).

15.4.4 Maxillary Nerve Block: All the Methods are Performed with Fluoroscopic Guidance

15.4.4.1 Lateral Extraoral Method [3, 4]

1. Position: supine position with the face inclines 30–45° toward the unaffected side
2. Procedure

The puncture site is about 3.0 cm medial from the tragus cartilage and about 5 mm caudal from the inferior margin of the zygomatic arch. The insertion direction is a line connecting the puncture site and outer canthus, and the needle is inserted at 110° against the skin surface (Figs. 15.5 and 15.6). After infiltration anesthesia around the puncture site, advance a 22-G 60–70 mm needle toward the outer canthus. The needle will reach the greater wing of sphenoid bone in 4 cm, and then the needle is slightly pulled back and advanced downward again. When the needle tip hits the nerve, radiating pain develops in the nasal ala, upper lip, and lower orbit; the depth is about 5 cm, and then 0.4–0.5 mL of local anesthetic is administered using a 1 mL syringe. When using a neurolytic agent, hold the needle at the same point after injecting the local anesthetics and confirming sensory loss in the affected area without any complications for 15 min, and then administer 0.5 mL of pure ethanol.

15.4.4.2 Complications

Hemorrhage (swelling of the buccal region, hemorrhage into the orbit), visual impairment (needle insertion into the orbit causes ocular trauma and optic nerve injury), oculomotor nerve disorder

Since complications are likely to occur when the needle position is too deep, sufficient attention should be paid to this procedure especially before applying neurolytic block.

15.4.5 Mandibular Nerve Block [4]

15.4.5.1 Landmark Method; Lateral Approach

The puncture site is about 30 cm medial from the tragus cartilage and just below the inferior margin of the zygomatic arch (Figs. 15.7 and 15.8). After infiltration anesthesia to the puncture site, a 22-G 6 cm block needle is vertically inserted into the skin. The needle reaches the lateral pterygoid plate of the sphenoid bone in about 4 cm from the skin. Advancing the needle slightly posterosuperior direction on the bone, radiating pain develops in the lower lip and tongue apex; the depth is about 4.5 cm from the skin.

15.4.5.2 Approach Under Fluoroscopy-Guided Method

Lateral Approach: Submentovertical View

The face is placed in the midline position with neck fully extended. The X-ray is 30° tilted toward the caudal side to demonstrate where the foramen ovale is (Figs. 15.9 and 15.10b). The puncture site is about 3.0 cm medial from the tragus cartilage and about 5 mm caudal to the inferior margin of the zygomatic arch. After infiltration anesthesia, insert a block needle vertically to the skin, and then advance the needle toward the foramen ovale. Radiating pain develops in the lower lip and tongue apex when the needle gets close to the foramen ovale (Fig. 15.9). In case the needle tip enters the foramen ovale, Gasserian ganglion is blocked; when radiating pain develops in the lower jaw, the absence of the needle insertion in the foramen ovale is confirmed using a contrast medium. After injecting 0.5 mL of local anesthetic (lateral approach), narcosis of only the third branch is to be confirmed.

Anterior Approach: Anteroposterior Oblique View

The patient is placed in a supine position with the neck slightly extended and the head is 15° inclined toward the

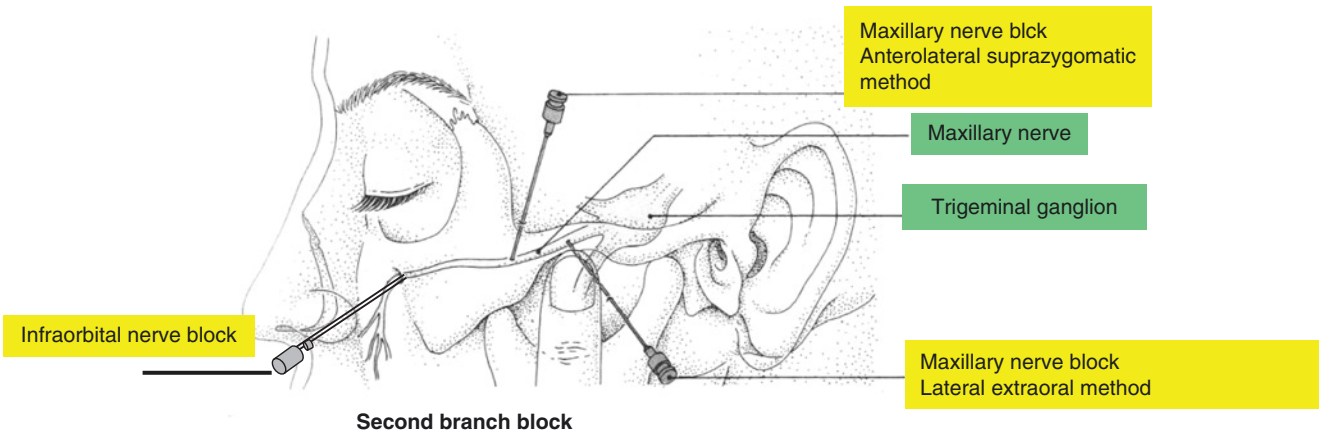

Fig. 15.5 Second branch block

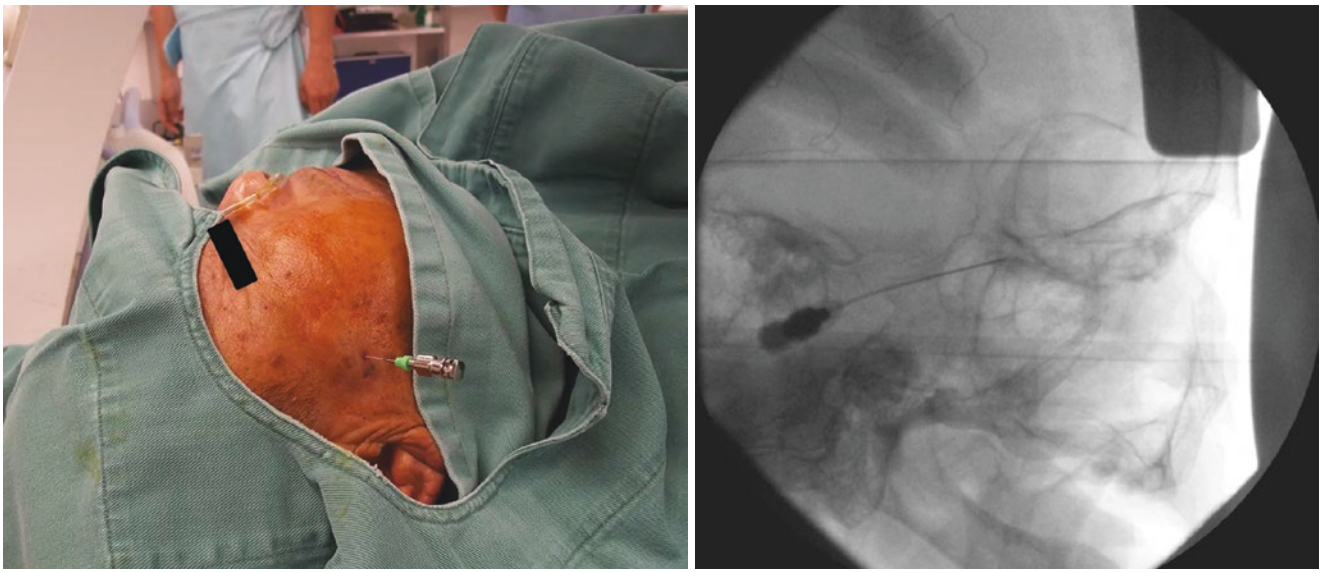

Fig. 15.6 Maxillary nerve block (lateral extraoral method)

Fig. 15.7 Mandibular nerve block

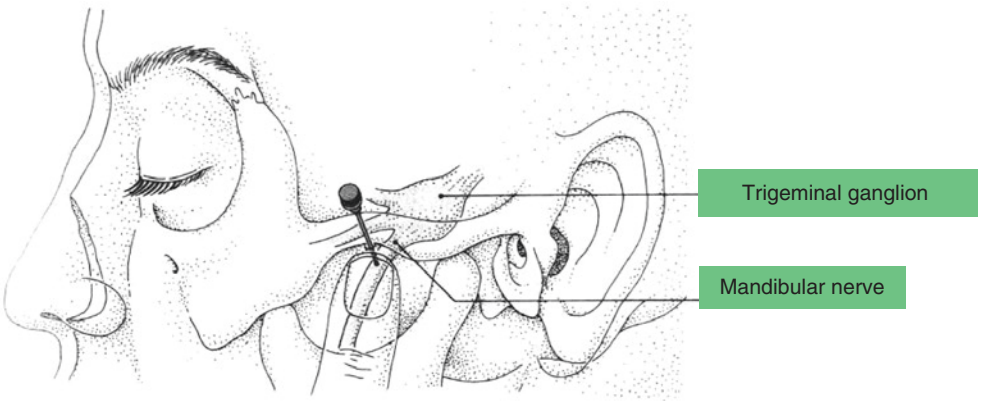

Fig. 15.8 Mandibular nerve block

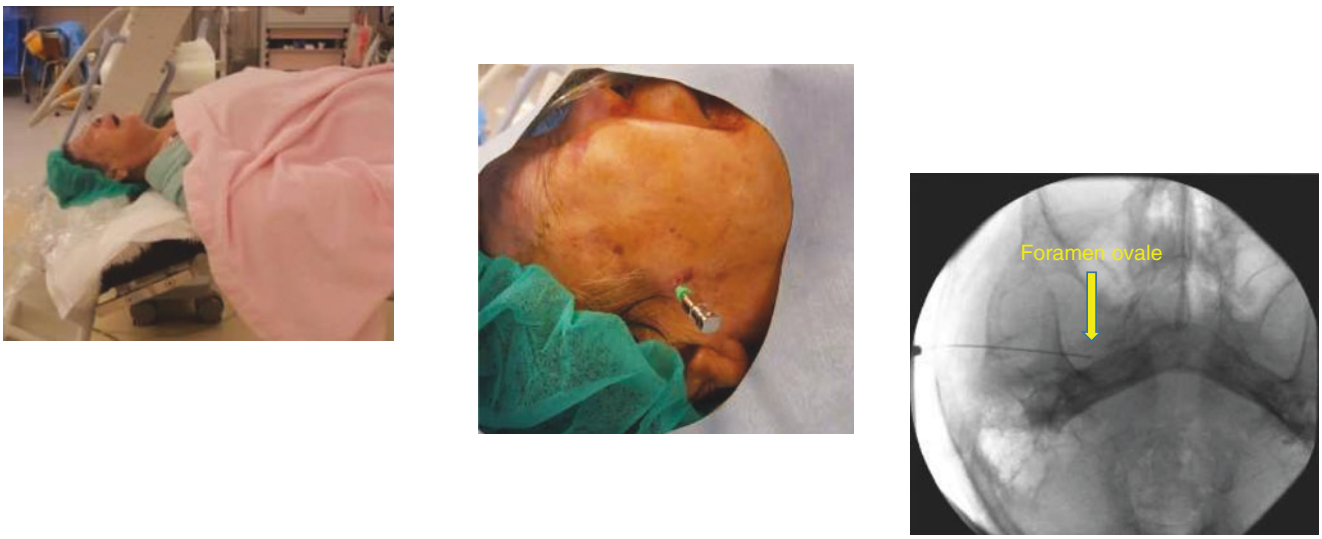

Fig. 15.9 Mandibular nerve block (submentovertical view)

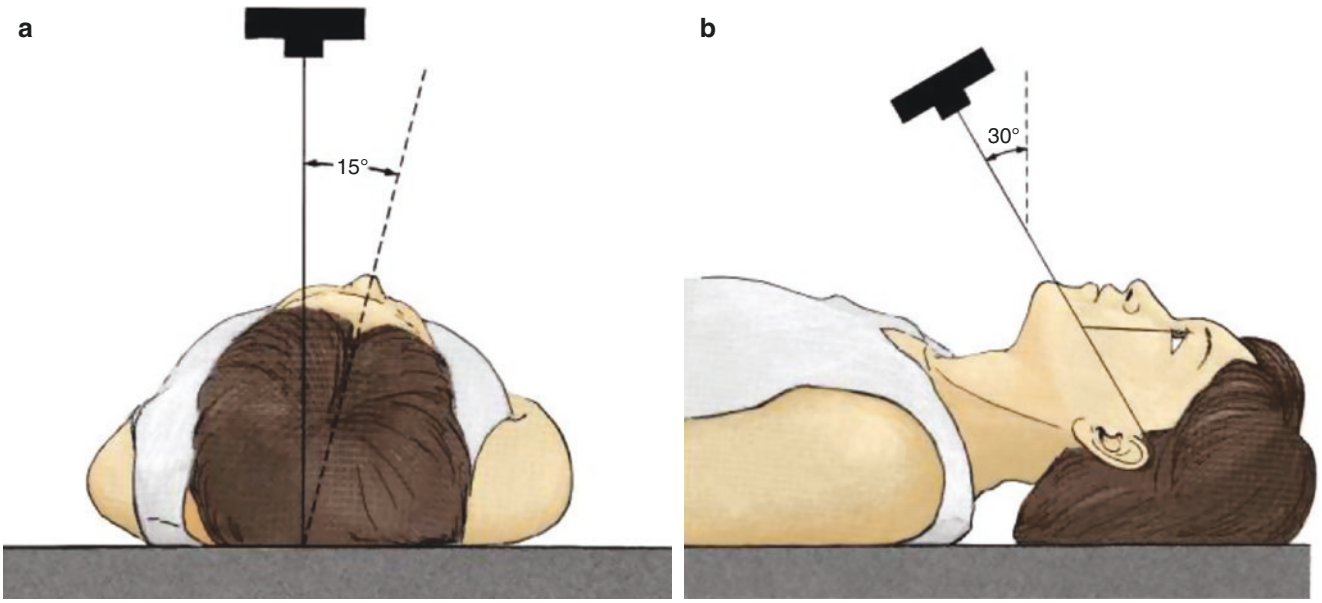

Fig. 15.10 Patient position. (**a**) Anterior approach: anteroposterior oblique view. (**b**) Lateral approach: submentovertical view

unaffected side (Fig. 15.10a). The X-ray tube is 15–20° inclined toward the caudal side in the oblique position to identify the foramen ovale (Fig. 15.10b). The puncture site is about 3 cm lateral to the corner of the mouth. After infiltration anesthesia, a 22-G 10-cm block needle is advanced toward the lower wall of the foramen ovale. When radiating pain develops in the lower jaw, the absence of the needle insertion in the foramen ovale is confirmed using contrast medium. After injecting 0.5 mL of local anesthetic (lateral approach), narcosis of only the third branch is to be confirmed. When the needle tip enters the foramen ovale, the procedure becomes Gasserian ganglion block.

In all methods, 0.5 mL of local anesthetic is injected, and 0.5 mL of anhydrous ethanol is injected after confirming that narcosis occurs only in the third branch.

Since the mandibular nerve contains the motor branch, the masticatory muscle strength may decrease after block.

15.4.5.3 Complications

Hemorrhage/hematoma, maxillary nerve or ophthalmic nerve block (when the needle position is too deep), alcoholic neuritis, masticatory muscle paralysis, facial palsy (it is readily caused by the lateral approach), insertion into the

eustachian tube (causes earache, vertigo, nausea), Gasserian ganglion block (when the needle is inserted into the foramen ovale).

References

1. Moore KL, Dalley AF. Chapter 7. Head, nerves of face, Clinically oriented anatomy. 5th ed. Philadelphia: Lippincott Williams& Wilkins; 2006. p. 939–46.
2. Michalek P, Donaldson W, McAleavey F, Johnston P, Kiska R. Ultrasound imaging of the infraorbital foramen and simulation of the ultrasound-guided infraorbital nerve block using a skull model. Surg Radiol Anat. 2013;35:319–22.
3. Poore TE, Carney FMT. Maxillary nerve block: a useful technique. J Oral Surgery. 1973;31:749–55.
4. Seltsam JH. Mandibular and maxillary anesthesia. Cal Med. 1956;65:406–12.

Gasserian Ganglion Block (Percutaneous Radiofrequency Trigeminal Rhizotomy)

16

Yoshikazu Naganuma

16.1 Introduction

Trigeminal neuralgia (TN) is a rare cranial nerve dysfunction which causes lightning-like pain attack in the face and disables the sufferers from normal daily activities such as eating, speaking, and brushing the teeth. The causes of TN are neurovascular compression, tumors, multiple sclerosis, and others. In some cases no abnormalities are detected.

There exist only four methods for the treatment of TN: oral medication (carbamazepine), microvascular decompression (MVD), nerve blocks and gamma knife surgery (GKS). Since each method has both positive and negative features, the priority should be given to pick up the suitable choice for the patient among the four. The fact that neuralgia is evoked by slight local sensory stimulation of the skin surface leads to the idea that induction of numbness acts as potent treatment [1–4]. RF-TR is developed to diminish sensory conduction by partial denervation of the Gasserian ganglion (Figs. 16.1).

16.2 Indication

RF-TR is definitely indicated for the treatment of trigeminal neuralgia. TN can be classified into two categories: classical and symptomatic. The use of ablative technics are limited to classical TN. Observation of the nature of pain whether it is periodical or continuing, sharp or dull, and responsive to carbamazepine or not is of very importance.

The indication of RF-TR should be based on the symptoms not on the MRI study.

The RF-TR described here is to treat TN of mandibular division and maxillary division of posterior superior alveolar branch, zygomaticofacial and zygomaticotemporal branches. TN of frontal and infraorbital regions should be covered by peripheral technics.

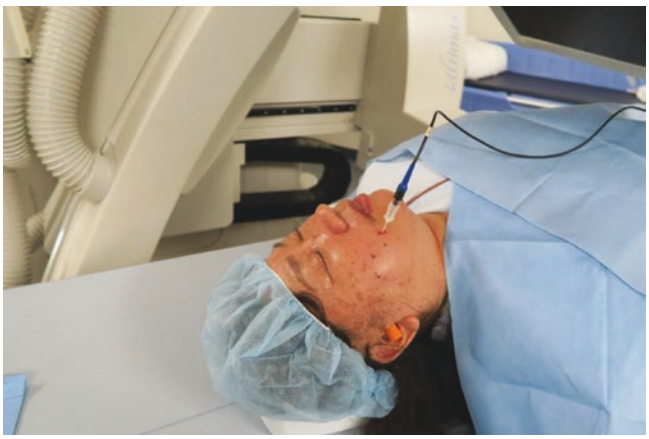

Fig. 16.1 Under X-ray monitoring Gasserian ganglion is punctured via foramen ovale

16.3 Anatomy

Trigeminal nerve derives from anterior pons and consists of large sensory root and small motor root. Sensory root expands at apex of the petrous part and forms trigeminal ganglion.

Trigeminal ganglion is divided into three branches: ophthalmic nerve, maxillary nerve, and mandibular nerve. Mandibular branch travels through the foramen ovale to the lower jaw and tongue. Motor root runs beneath the sensory root, does not enter the ganglion, mixes with the sensory branch after passing the foramen ovale. Chorda tympani, the branch of facial nerve, carries gustatory sensation enters the mandibular nerve at the level of pterygoid muscle.

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16.4 Instruments and Drug Solutions

1. Radiofrequency lesion generator.
2. 97 mm cannula with 4mm uninsulated tip with lesioning electrode (Sluyter-Meheta Kit).
3. 5 mL syringe with 25 gauge needle filling local 1% mepivacaine for insertion site.
4. 1 mL syringe with 2% mepivacaine for lesioning.
5. Metric rule.
6. Two pairs of hemostat forceps.
7. Inactive disperse pad.
8. C-arm fluoroscopic apparatus.
9. Contrast dye when necessary, gauze, cotton, surgical drapes, 0.5% chlorhexidine gluconate alcohol solution, 18 gauge needle, 21 gauge needle.

16.5 Anesthesia and Preoperative Procedure

1. Routine blood analysis, check hemostatic status.
2. Routine medication such as antihypertensive agents and antidepressants.
3. Fasting 4 h prior to operation.
4. Intravenous catheterization with heplock.
5. Preemptive antibiotic infusion.
6. Propofol for intravenous anesthesia.
7. Cardiorespiratory monitoring.
8. Premedication when necessary.

16.6 Procedures and Techniques

16.6.1 Operative Procedure

16.6.1.1 Preparation

The patient lies supine on fluoroscopic table with his/her head slightly lowered. The use of safety belt is advised in case the patient reacts to painful procedure. The entry point is sterilized by 0.5% chlorhexidine gluconate alcohol solution. The head, the chest, and the skin around the entry point are covered by surgical sheets. Inactive disperse pad is attached to the leg. Connect electrode with radiofrequency lesion generator. Antibiotic is infused intravenously prior to the operation.

16.6.1.2 Visualization of the Foramen Ovale (Fig. 16.1)

The patient lies on fluoroscopic table with his/her chin slightly up; turn the head 20–30 degrees toward contralateral side. Monitoring the fluoroscopic view, X-ray tube is tilted caudo-cranially so that foramen ovale can be seen like the moon over the horizon of pyramidal eminence between coronoid process and maxillary sinus.

16.6.1.3 Mandibular Division Lesioning (Fig. 16.2)

While monitoring foramen ovale by tunnel vision, mark the entry point which is slightly lateral to the foramen. The point is infiltrated with 1% mepivacaine using 25 gauge needle. Insert 97 mm cannula toward the upper edge of the foramen ovale until the tip touches the skull base. The puncture point is in center to bottom of the foramen, and the direction of the cannula is along the short axis of the oval.

Measure the depth from surface of the skin to the foramen using metric scale. Propofol is injected via intravenous catheter; the dosage is depending on the body weight and the age of the patient.

Note that the method described here is different from the ones reported by famous authors like Sweet WH [1], Tew JM and Taha J [3].

The electrode is inserted into the cannula; then start motor and stimulation with 3 Hz in frequency and 0.3 V in voltage. As soon as the patient falls asleep, the mandibular nerve is punctured. When the needle tip enters the nerve, rhythmical jaw movement is observed.

Then in order to avoid motor weakness, advance the needle slowly until the masseter movement disappears. The distance from the edge of foramen to the motor inactive point is approximately 1.5 cm. C-arm is rotated to check location of the needle laterally. The tip should not be deeper than the level of clivus and CSF should not flow out either.

16.6.1.4 Lesioning

0.2–0.3 mL of 2% mepivacaine is injected via cannula. Check if sensory response is lost as normally the patient is awaken around this point of the procedure. Start lesioning slowly at the beginning to the maximum of 90°C ranging from 60 to 120 s depending on the severity of the disease. As soon as local anesthetic is injected, the patient develops facial numbness and does not respond to any thermal stimulation if the cannula tip is in appropriate position.

16.6.1.5 Maxillary Division Lesioning (Fig. 16.3)

In targeting maxillary division, entry point should be lateral to the one marked in mandibular division lesioning. Sometimes the cannula skims coronoid process. After hitting the cannula tip to the edge of foramen ovale, the patient's head is neutralized with his/her neck extended to the maximum; then tilt C-arm caudad to observe basal view of the skull. Check if the direction of the cannula is

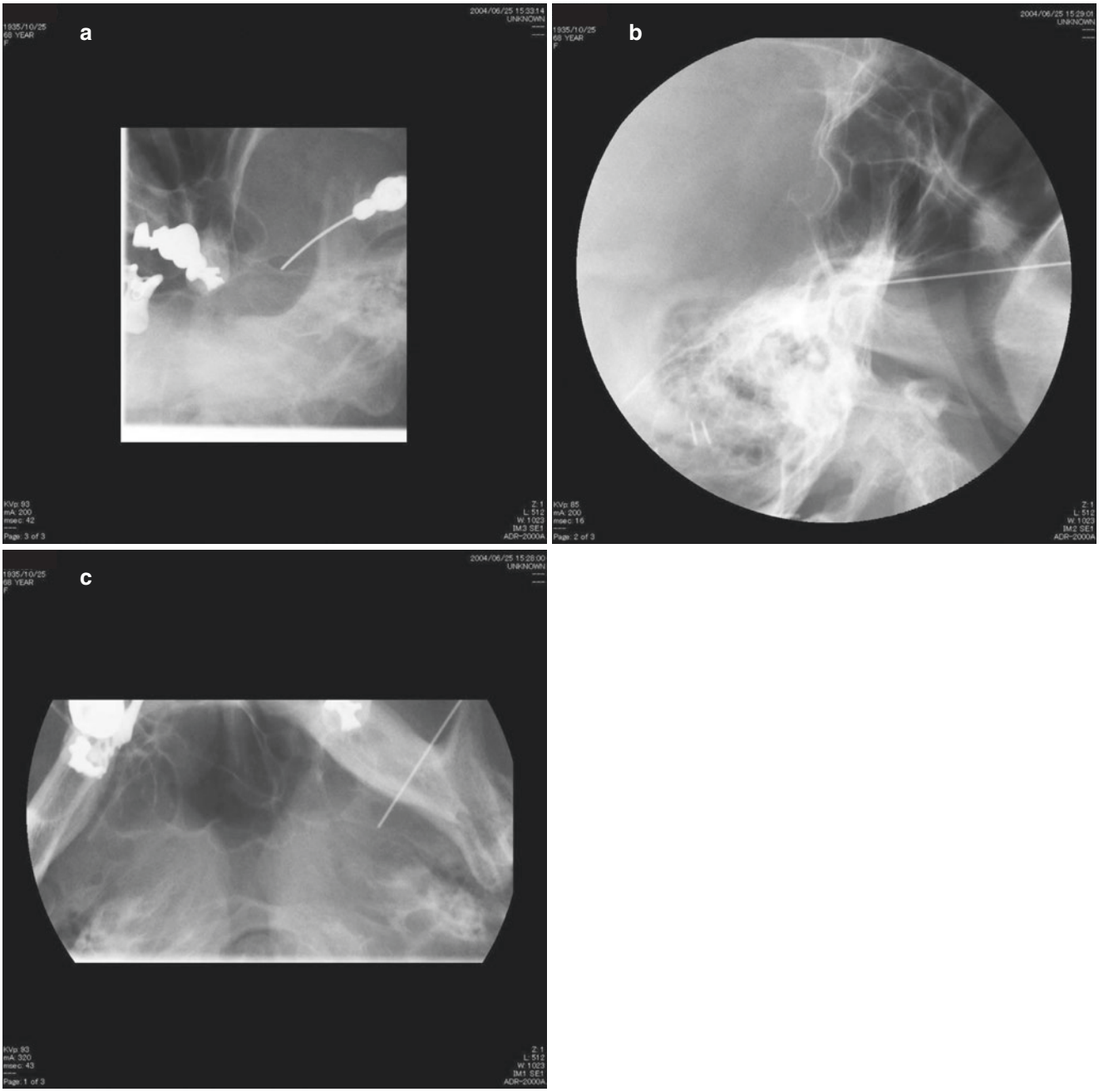

Fig. 16.2 Treatment of the mandibular branch of TN. (**a**) Anterior-posterior oblique view. (**b**) Lateral view. (**c**) Basal view

medial to the short axis of the oval. Advance the cannula the same way as described in targeting maxillary division. As soon as the masseter loses response to electrical stimulation, rotate C-arm to gain lateral view of the skull. Push the cannula forward slowly 3-5 mm behind the clivus level. Again the tip should not pass the clivus line and CSF should not be seen either. Thermal lesioning is started after injecting 0.2–0.3 mL of 2% mepivacaine.

16.7 Postoperative Care

After RF-TR the patient is required to take bed rest for at least 1 h and then allowed to start oral diet. NSAIDs is given in case headache takes place on operative side temple. Overnight observation is necessary to make sure that the patient is free from infection. A week later the neurological status is examined on outpatient basis.

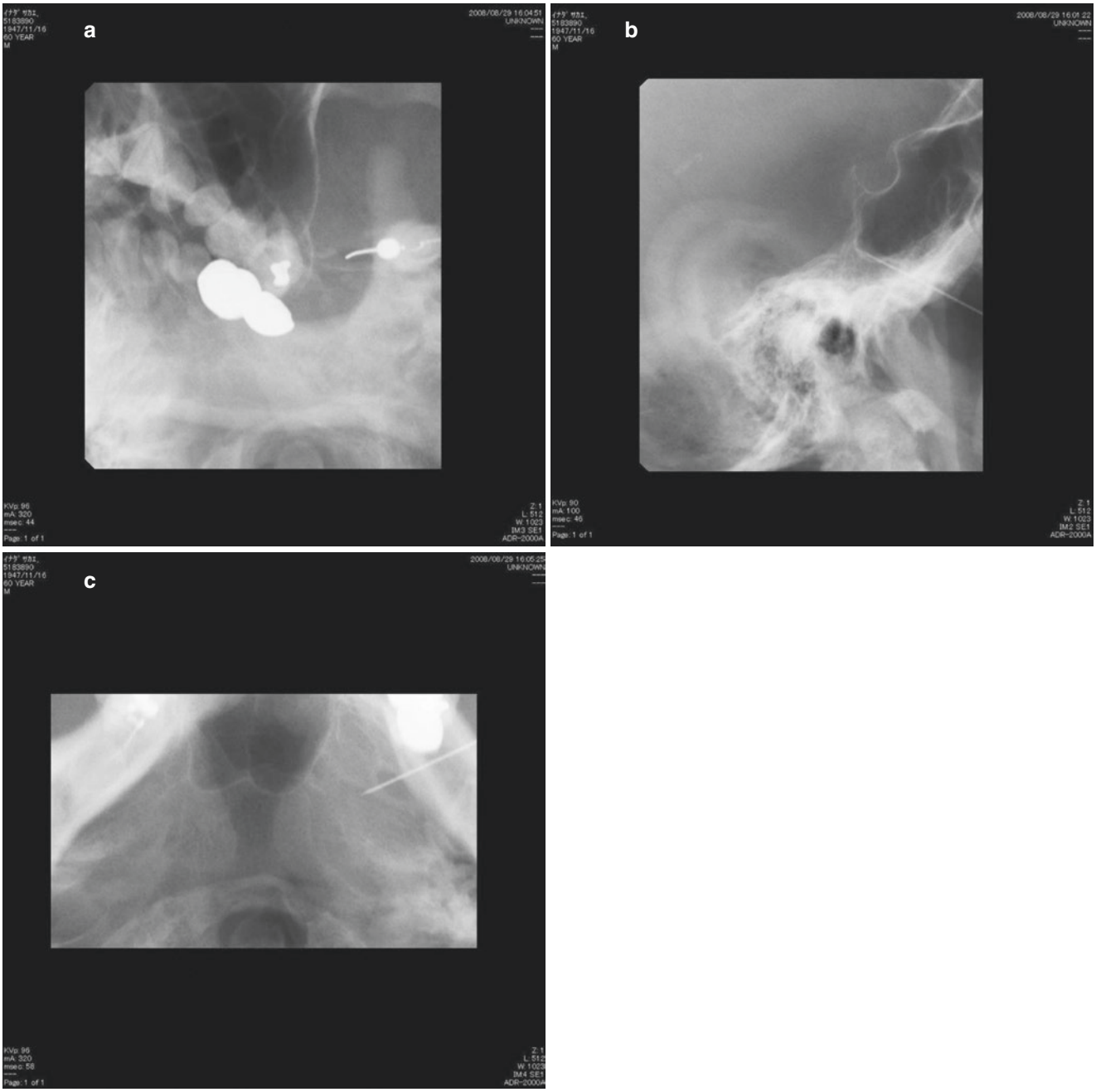

Fig. 16.3 Treatment of the maxillary branch of TN. Note the needle tip is more medial and deeper than that of mandibular branch treatment. (**a**) Anterior-posterior oblique view. (**b**) Lateral view. (**c**)Basal view

16.8 Effect of RF-TR

Normally after RF-TR patients can enjoy carbamazepine-free painless period for 2–3 years. If the patient is a carbamazepine responder, painless period will be elongated. RF-TR is effective for the cases either MVD or GSK or both were ineffective, and repeated treatment is possible.

16.9 Complications

Facial numbness (common)
Masseter weakness (rare)
Gustatory impairment
Painful dysethesia
Loss of corneal reflex (very rare)

References

1. Sweet WH, Wepsic JG. Controlled thermocoagulation of Trigeminal ganglion and rootlets for differential destruction of pain fibers: Part 1. Trigeminal neuralgia. J Neurosurg. 1974;40:143–56.
2. Sanders M, Henny CP. Result of selective percutaneous controlled radiofrequency lesion for treatment of trigeminal neuralgia in 240 patients. Clin J Pain. 1991;8:23–7.
3. Taha JM, Tew JM Jr. Comparison of surgical treatments for trigeminal neuralgia: reevaluation of radiofrequency rhizotomy. Neurosurgery. 1996;38(5):865–71.
4. Kanpolat Y, Savas A, Bekar A, Berk C. Percutaneous controlled radiofrequency trigeminal rhizotomy for rhe treatment of idiopathic neuralgia: 25-year experience with 1600 patients. Neurosurgery. 2001;48(3):524–32.

Glossopharyngeal Nerve Block

17

Hidekimi Fukui

17.1 Glossopharyngeal Nerve Block

Glossopharyngeal nerve block is performed to treat glossopharyngeal neuralgia in which severe paroxysmal pain occurs in the tongue base and the pharynx as well as deep in the ear. These disorders are associated with pain with relatively long remission phases, and there are cases in which it is possible to go through the pain attack phase with repeated use of oral spraying of a local anesthetic/application procedure or nerve block by pharmacological therapy and a local anesthetic. The nerve block procedures are divided into oropharyngeal and lateral cervical region procedures.

17.2 Indications

Glossopharyngeal neuralgia is sometimes difficult to distinguish from trigeminal neuralgia affecting the third branch. Typically, glossopharyngeal neuralgia is caused mainly by vascular compression of the glossopharyngeal nerve. Symptomatic glossopharyngeal neuralgia is caused, for example, by tumors, inflammation, and an elongated styloid process.

17.3 Anatomy (Fig. 17.1)

The glossopharyngeal nerve is a mixed nerve which carries motor fibers and parasympathetic fibers in addition to sensory fibers. Sensory fibers are distributed in the tympanic cavity, mastoid cells, auditory canal, tonsils, uvula, part of the pharynx, the posterior one third of the tongue, carotid sinus, and carotid body. Motor and parasympathetic fibers are distributed in the stylopharyngeal muscle and parotid gland, respectively.

The glossopharyngeal nerve emerges from the dorsal side of the olives of the medulla oblongata, passes through the jugular foramen with the vagus and accessory nerves, and exits the cranial cavity. It gives off the tympanic nerve which distributes in the tympanic plexus and otic ganglion and then the carotid sinus nerve, descends between the internal carotid artery and internal jugular vein and through the internal side of the styloid process and stylopharyngeus and the external side of vagus and accessory nerves, passes through the inferior end of the lateral stylopharyngeus, and distributes around the tongue base.

The styloid process projects inferiorly and anteriorly from the inferior surface of the temporal bone, from which the styloglossus, stylohyoid, and stylopharyngeus originate.

There are individual differences in the length of the styloid process, and the line connecting the gonial angle and the mastoid just crosses the tip of the styloid process.

17.4 Instruments and Drug Solutions

17.4.1 Oral Spraying of a Local Anesthetic/Application Procedure

Sprayer for a local anesthetic or cotton swab, 4% lidocaine solution or 8% lidocaine spray, tongue depressor.

17.4.2 Oropharyngeal Procedure

23G 60 mm disposable needle, 1 mL syringe, 1–2% lidocaine, 0.75% ropivacaine, disinfectants.

17.4.3 Lateral Cervical Region Procedure

25G 25–32 mm block needle, 2.5 or 5 mL syringe, 1–2% lidocaine.

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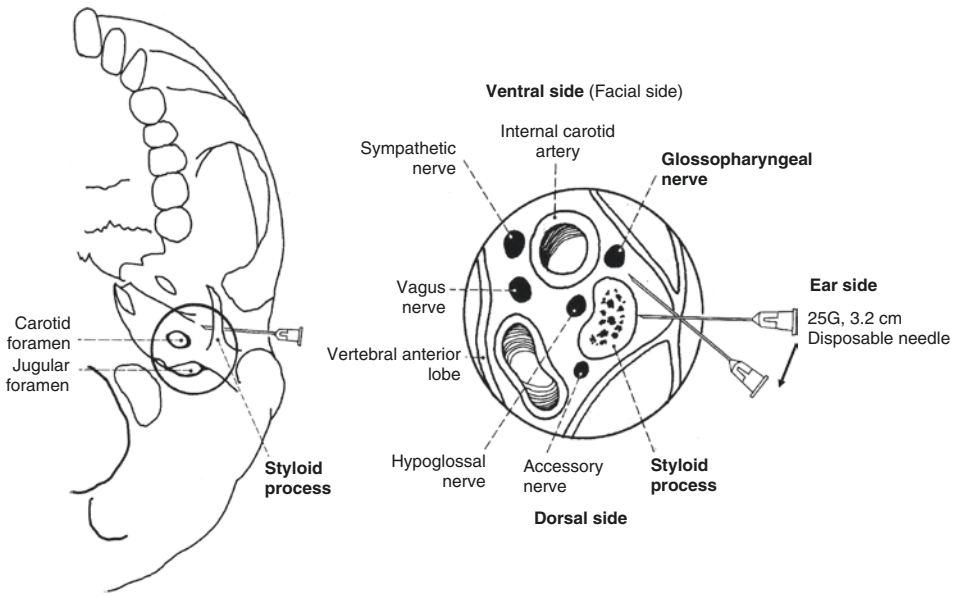

Fig. 17.1 Anatomy

Use of ultrasound: Diagnostic ultrasound imaging systems, linear-type probe, ultrasonic set.

17.5 Procedures and Techniques

The nerve destruction procedure was omitted here, taking safety into consideration.

17.5.1 Oral Spraying of a Local Anesthetic/ Application Procedure

This is the procedure by which local anesthetic is sprayed or applied onto sites such as the pharynx and larynx. As it can be performed easily and safely, this is the procedure that should initially be tested.

In the sitting position, the tongue is depressed by the tongue depressor, a local anesthetic is sprayed on, or a cotton swab moistened with a local anesthetic is applied to the anterior and posterior palatine arches. Then, the tonsil and tongue base are treated in the same manner. Chemicals and saliva accumulated in the mouth are forcibly expelled or absorbed by cotton balls.

17.5.2 Oropharyngeal Procedure

This is the procedure for blocking the tonsillar branch and ramus lingualis of the glossopharyngeal nerve in the inferior pole of the palatine tonsil. First, with the subject in the sitting position, the tongue is depressed by the tongue depressor. The insertion point in the tonsillar branch is determined to be located 0.5 cm outside of the inferior margin of the anterior palatine arch of the affected side. From the insertion point, the block needle is advanced about 1 cm toward the posterolateral wall of the inferior pole of the palatine tonsil. After ensuring that there is no backflow of blood, based on adequate suctioning, 0.5 mL of a local anesthetic is injected. For the block in the ramus lingualis, the needle is advanced about 1.5 cm toward the tongue base from the contact point between the palatine arch and the lateral margin of the tongue on the affected side. After ensuring that there is no backflow of blood, in the aforementioned manner, 0.5 mL of a local anesthetic is injected.

17.5.3 Lateral Cervical Region Procedure (Fig. 17.1)

This is the procedure for blocking the path of the glossopharyngeal nerve that exits the jugular foramen toward the stylopharyngeus in the anterolateral styloid process. While the subject is in the supine position, a shoulder pillow is inserted, and the face is turned toward the unaffected side if at all possible. The needle tip is then advanced from the auricle of the affected side toward the neck. Next, by palpation and ultrasound, the anterior margin of the mastoid and mandibular angle of the mandibular rami are confirmed. Then, following construction of a figure, draw a line connecting the two ends, and mark its midpoint. The insertion point is defined as the midpoint of the line connecting the mastoid and the mandibular rami. Under the skin of the insertion point (within 5 mm), administer an extremely small amount of a local anesthetic. Under ultrasound guidance, while confirming the styloid process, insert the needle by aiming to place the 25G 25–32 mm block needle on the styloid process.

The styloid process is present in a much shallower area than expected. There are cases in which it is impossible to confirm

the styloid process under ultrasound guidance. In such a case, it is not recommended to blindly insert/extract the needle or change its position as the vagus nerve, accessory nerve, hypoglossal nerve, facial nerve, sympathetic nerve, internal carotid artery, veins, and other important structures are located around the styloid process. All of these are present in deeper positions than the styloid process, allowing the needle tip to hit the styloid process. When the needle tip hits the styloid process, withdraw the needle by 3–5 mm, and next advance the needle anterosuperiorly toward the anterior process by about 5 mm by sliding it along the anterior margin of the styloid process. Remove the inner cylinder of the block needle, and after confirming by suction with a syringe that no blood is withdrawn, slowly inject 0.5–1 mL of 1% lidocaine. When the styloid process cannot be confirmed in any of the possible ways attempted, confirm the internal carotid artery under ultrasound guidance before reaching it, ensure that there is no backflow of blood, and administer a slow injection in the same manner.

It is not recommended that a neurolytic agent be used or that a high-frequency thermocoagulation procedure be applied in this lateral cervical region because, as described above, there are many important nerves and blood vessels that can potentially be damaged.

As above, in those cases in which the local anesthetic and drug therapy are not effective, take into consideration referral to the neurosurgery department after detailed examinations by MRI and other appropriate modalities.

17.6 Complications

17.6.1 Oral Spraying of a Local Anesthetic/ Application Procedure

As a high concentration of local anesthetic is used, local anesthetic intoxication can occur with excessive use, and difficulty swallowing is experienced when the unaffected side is also blocked.

17.6.2 Oropharyngeal Procedure

Pharyngeal muscle paralysis leading to deviation toward the unblocked side of the posterior pharyngeal wall during vocalization is a potential complication. Disappearance of the gagging reflex due to pharyngeal and laryngeal paresthesia is also possible. Other complications include gustatory anesthesia at the tongue base and dysphagia of solids.

17.6.3 Lateral Cervical Region Procedure

There are many important nerves and blood vessels in the vicinity of the path of the glossopharyngeal nerve that exits the jugular foramen toward the stylopharyngeus.

In this procedure, once a local anesthetic reaches these nerves, the corresponding nerve paralysis occurs transiently, and various side effects can manifest thereafter: hoarseness, pharyngeal and laryngeal paresthesia, dysphagia, deviation to the paralyzed side of the tongue, facial paralysis, high blood pressure, tachycardia, Horner's syndrome, hematoma, bleeding, larynx puncture, etc.

As circulatory system side effects occasionally occur after glossopharyngeal nerve block, allow the patient to rest for at least 30 min, and continuously check for vitals by attaching a blood pressure monitor and a pulse oximeter. The possibility of bradycardia warrants special caution.

The procedures in this chapter refer to Naganuma [1] and Hosokawa [2].

References

1. Naganuma Y. Glossopharyngeal nerve block. In: Nerve block method. 2nd ed. Tokyo: Igakusyoin; 2000. p. 40–2. (in Japanese).
2. Hosokawa T. Glossopharyngeal nerve block. Pain Clinic. 2011;32:S55–62. (in Japanese)

Editors' Comment

18

Kiyoshige Ohseto, Hiroyuki Uchino, Yukihiko Ogihara, and Hiroki Iida

18.1 Head Pain Comment (Treatment for Trigeminal Neuralgia)

The following four strategies are the commonly applied treatments for trigeminal neuralgia: drug therapy, nerve block, surgery (microvascular decompression), and γ knife radiosurgery. The first-choice treatment is drug therapy using carbamazepine. However, for patients whose pain is not controlled despite administration of the drug and those who are allergic to the drug, one of the remaining three treatment strategies is selected. Among these strategies, nerve block is effective even in emergencies and is performed to block the peripheral trigeminal nerve branches. Young patients and those who request surgery are referred for surgery. When nerve block is performed, the main principle is to control the pain combined with small doses of drugs. Moreover, when pain recurs in patients treated with other treatment strategies, nerve block is the last choice.

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Part V

Neck

Occipital Nerve Block (Landmark, Ultrasound-Guided)

19

Hiroyuki Nishie

19.1 Introduction

19.1.1 What Is An Occipital Nerve Block?

Occipital nerve blocks are used to treat various forms of headache. The three nerves that comprise the posterior occipital nerve are the greater occipital nerve, the third occipital nerve, and the lesser occipital nerve. The greater occipital nerve is a posterior branch of C2 that innervates the skin at the posterior part of the scalp (Fig. 19.1). The third occipital nerve is a posterior branch of C3. The lesser occipital nerve is a C2–C3 anterior branch and is part of the cervical plexus. A greater occipital nerve block is typically performed at a site on the occipital bone using a conventional land-marking method; however, an ultrasound can enable more proximal implementation [1]. As mentioned, the lesser occipital nerve is a C2–C3 anterior branch and will be discussed in the section related to the cervical plexus block; however, we will focus on the landmark method for this type of block. A third occipital nerve block is seldom used to treat headaches and will be omitted here. Therefore, the description that follows relates to greater (landmark and ultrasound-guided) and lesser (landmark) occipital nerve blocks.

19.2 Indications

19.2.1 Indications for Occipital Nerve Blocks

Occipital nerve blocks are used to treat various types of headache. Procedures involving the use of only local anesthetic, steroids, pulsed radiofrequency, and so forth are known. A greater occipital nerve block may be done alone or may be combined with a lesser occipital nerve block; literature should be consulted with each.

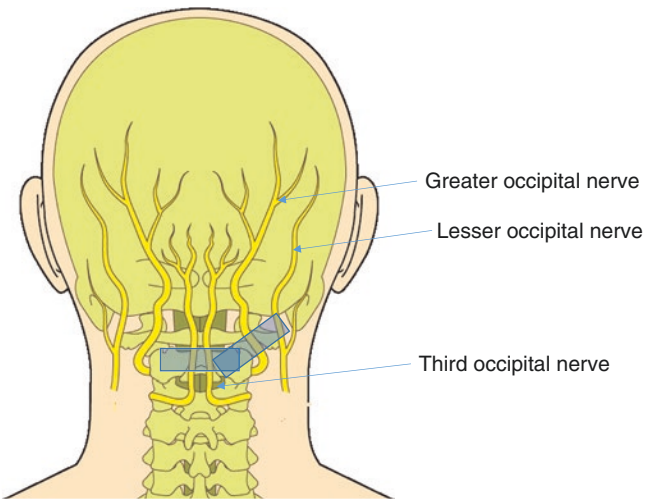

Fig. 19.1 Locations of the greater occipital nerve, the lesser occipital nerve, and the third occipital nerve

- Recurrent cluster headache [2]
- Chronic cluster headache (steroid + local anesthetic) [2]
- Occipital neuralgia (pulsed radiofrequency) [3]
- Migraine [4]
- Chronic daily headache [5]
- Cervical headache [6]
- Traumatic cervical syndrome [7]
- Post-dural-puncture headache

19.2.2 Patients Requiring Careful Attention [8]

- Patients who are pregnant. In particular, steroids are teratogenic and are to be avoided as much as possible. Lidocaine is used as a local anesthetic in these patients.
- Patients with a history of allergies to local anesthetics.
- This procedure could lead to low or high blood pressure in the elderly.
- Careful attention should be paid to patients with a history of vagal reflex or syncope.
- Patients with defects of the occipital bone.

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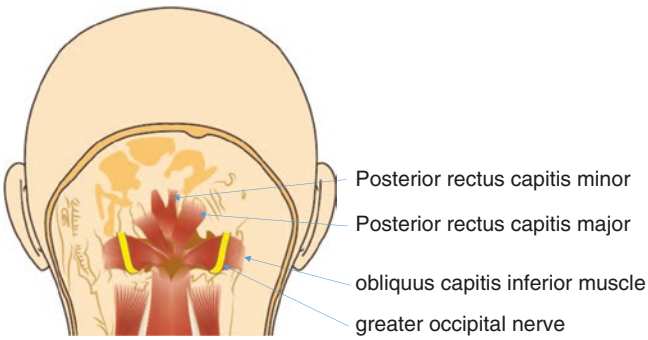

Fig. 19.2 Positional relation of the greater occipital nerve and oblique capitis inferior muscle

- Patients with a bleeding tendency.
- The risk of hair loss should be considered if steroids are being used.

19.3 Anatomy (Figs. 19.1 and 19.2)

The greater occipital nerve is a posterior branch of the second cervical nerve that ascends diagonally between the obliquus capitis inferior muscle and the semispinalis capitis. The nerve then passes through the trapezius and the semispinalis capitis, in a position close to the occipital bone. The greater occipital nerve is responsible for providing sensation to the scalp in the posterior portion of the head. The lesser occipital nerve is an anterior branch of C2–C3 cervical nerve and rises through the posterior margin of the sternocleidomastoid muscle; it conveys sensation to the scalp lateral to the portion innervated by the greater occipital nerve and posterior to the greater auricular nerve. The third occipital nerve is a posterior branch of the C3 that issues a branch at the C2–C3 facet joint and then issues a sensory branch for the suboccipital area [9].

19.4 Instruments and Drug Solutions

1. Ultrasound use set.
2. Syringe (5 or 10 mL) (for local anesthetic, 1–1.5 mL per nerve).
3. Puncture needle (landmark method: 25 G disposable needle; ultrasonic method: 25 G Cathelin needle)

19.5 Procedures and Techniques

19.5.1 Procedure for Greater Occipital Nerve Block

Using the landmark method, a block is done at a shallow site on the occipital bone. With ultrasound, the block is more proximal, ascending through the obliquus capitis inferior muscle.

19.5.2 Landmark Method

The occipital nerve is found at a position one-third inward from the line connecting the occipital external protuberance and the mastoid process. As an alternative landmark, another method is to contact the occipital artery with a finger and aim inward. The method of puncturing with the landmark approach involves first inserting the needle up to 3–4 mm, pulling back slightly, checking that there is no backflow of blood, and then injecting 1.0–1.5 mL of local anesthetic.

19.5.3 Ultrasound-Guided Method (Fig. 19.3)

Near the hairline on the back of the neck, a probe is applied to the midline to identify the characteristic C2 spinous process at the level of its bifurcation. Shifting outwardly by about 2.5 cm, the outside is probed at an angle to the side of the head, to seek out the splenius capitis muscle and the semispinalis capitis. The obliquus capitis inferior muscle is deep in the semispinalis capitis, and the occipital nerve is found between them.

19.5.4 Lesser Occipital Nerve Block: Landmark Method

The occipital protuberance and the mastoid process are connected with a line, as with a greater occipital nerve block. The lesser occipital nerve is located one-third outward. The injection is done similarly to that with the greater occipital nerve block.

19.5.5 Complications

Local anesthetic intoxication: This occurs when the local anesthetic is injected into a blood vessel. Injection is done slowly only after fully checking that there is no backflow of blood. Careful attention is also needed because of the possibility of its falling when the injection is delivered to a patient in a seated position.

Decreased blood pressure: The concentration of the local anesthetic requires careful attention [8]. It is first implemented in a supine position, not a seated position.

Hematoma, infection: Care must be taken during blocks at proximal areas. Efforts need to be made for a careful and thorough operation.

Nerve injury: If the patient feels an intense pain during the puncture, the needle should not be advanced further.

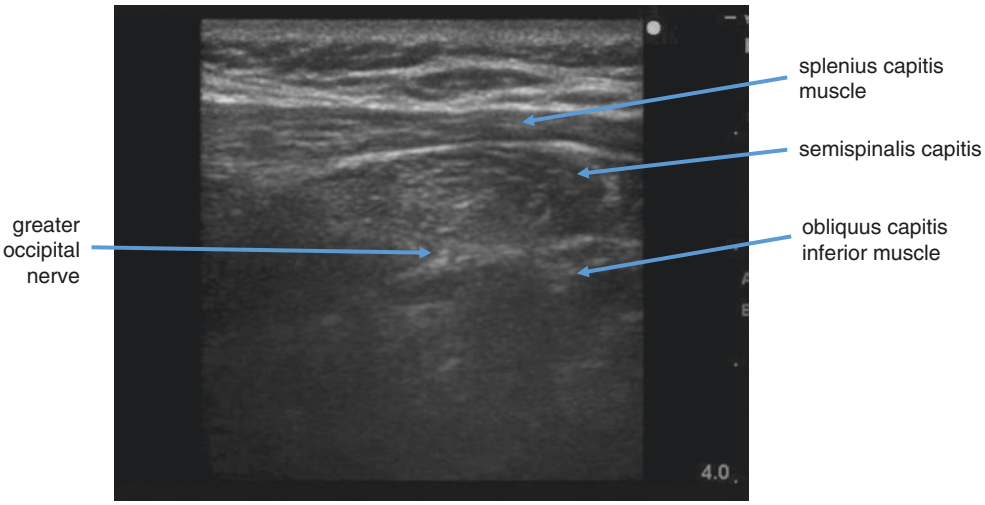

Fig. 19.3 Ultrasound image of the greater occipital nerve

Steroid side effects: Hair loss and depigmentation require attention.

Epidural or spinal injection

Spinal cord injury

References

1. Greher M, Moriggl B, Curatolo M, Kirchmair L, Eichenberger U. Sonographic visualization and ultrasound-guided blockade of the greater occipital nerve: a comparison of two selective techniques confirmed by anatomical dissection. Br J Anaesth. 2010;104(5):637–42.
2. Ambrosini A, Vandenheede M, Rossi P, et al. Suboccipital injection with a mixture of rapid- and long-acting steroids in cluster headache: a double-blind placebo-controlled study. Pain. 2005;118(1–2):92–6.
3. Vanderhoek MD, Hoang HT, Goff B. Ultrasound-guided greater occipital nerve blocks and pulsed radiofrequency ablation for diagnosis and treatment of occipital neuralgia. Anesth Pain Med. 2013;3(2):256–9.
4. Ashkenazi A, Matro R, Shaw JW, Abbas MA, Silberstein SD. Greater occipital nerve block using local anaesthetics alone or with triamcinolone for transformed migraine: a randomised comparative study. J Neurol Neurosurg Psychiatry. 2008;79(4):415–7.
5. Saadah HA, Taylor FB. Sustained headache syndrome associated with tender occipital nerve zones. Headache. 1987;27(4):201–5.
6. Naja ZM, El-Rajab M, Al-Tannir MA, Ziade FM, Tawfik OM. Occipital nerve blockade for cervicogenic headache: a double-blind randomized controlled clinical trial. Pain Pract. 2006;6(2):89–95.
7. Naja Z, Al-Tannir M, El-Rajab M, Ziade F, Baraka A. Nerve stimulator-guided occipital nerve blockade for postdural puncture headache. Pain Pract. 2009;9(1):51–8.
8. Blumenfeld A, Ashkenazi A, Napchan U, et al. Expert consensus recommendations for the performance of peripheral nerve blocks for headaches--a narrative review. Headache. 2013;53(3):437–46.
9. Finlayson RJ, Etheridge JP, Vieira L, Gupta G, Tran de QH. A randomized comparison between ultrasound- and fluoroscopy-guided third occipital nerve block. Reg Anesth Pain Med. 2013;38(3):212–7.

Phrenic Nerve Block

20

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20.1 Introduction

Phrenic nerve block is used occasionally to diagnose and treat hiccups.

20.2 Indication

Phrenic nerve block is one of the treatment approaches for hiccups.

20.3 Anatomy (Fig. 20.1)

The phrenic nerve starts from C3, C4, and C5, runs vertically down the anterior scalene and then toward the medial border from the lateral border, passes in front of the subclavian artery and behind the brachiocephalic artery, and enters into the thoracic cavity. The phrenic nerve controls the movement of the diaphragm and the pleural and peritoneal sensations.

The center of the reflex arc for hiccups is the phrenic nerve and the respiratory center in the brain stem. The efferent pathway is composed of the phrenic nerve, the glottis, and the accessory muscles of respiration. The afferent pathway has not been identified but involves the vagus nerve, the phrenic nerve, and the thoracic sympathetic nerves.

20.4 Procedures and Techniques

The landmark method is available. See Ref. [1].

20.4.1 Ultrasound-Guided Method

Lay the patient in the dorsal position with his face to the unaffected side. Find the sternocleidomastoid and the anterior scalene with the linear probe. The phrenic nerve is easily found at the level where the brachial plexus is shown between the scalene muscles. Perform the nerve block at this level [2].

Complications: intravascular injection, pneumothorax, recurrent nerve paralysis, brachial plexus block, and Horner's syndrome

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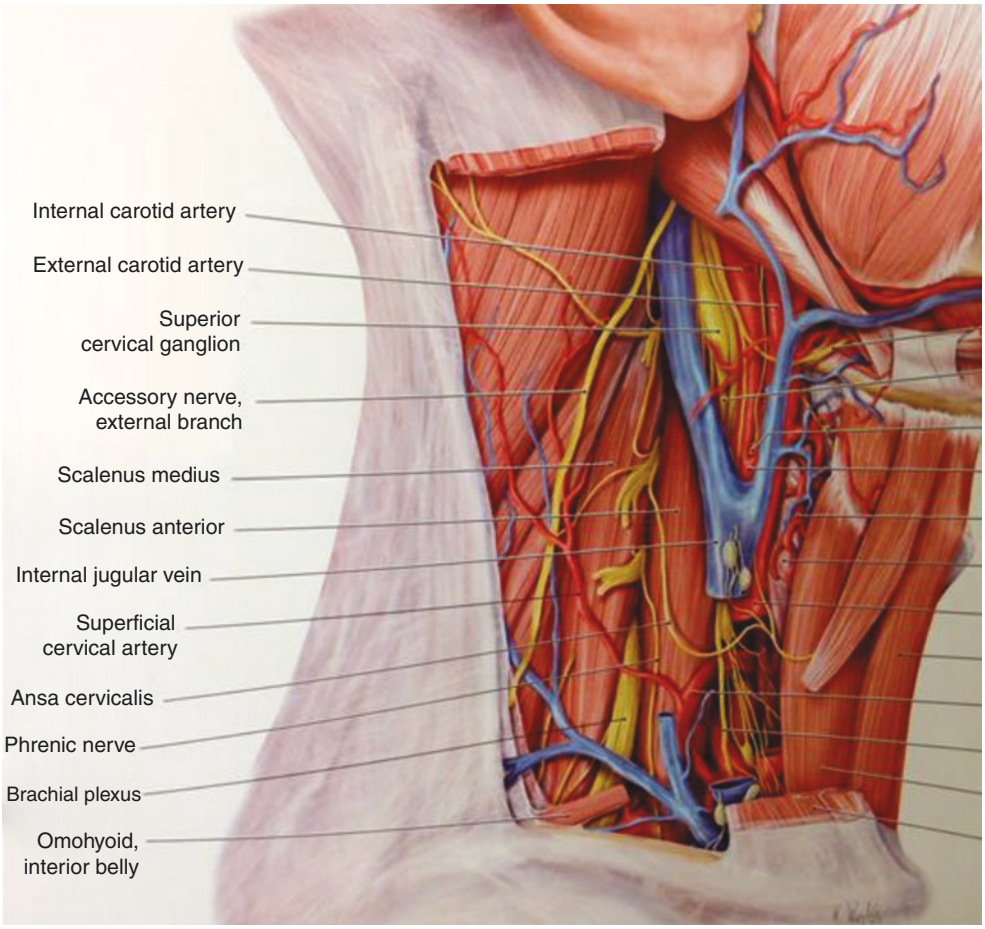
Fig. 20.1 Anatomy



References

1. Ohseto K, et al. Pain clinic - nerve block. Tokyo: Igakushoin; 2000. p. 139–41. (in Japanese)
2. Ohseto K, et al. X-ray fluoroscopy. In: Ultrasound and CT—guided, nerve block. Tokyo: Igakushoin; 2009. p. 264–5. (in Japanese).

Superficial Cervical Plexus Block (Landmark, Ultrasound-Guided)

21

Hiroyuki Nishie

21.1 Introduction

21.1.1 What is a Superficial Cervical Plexus Block?

The superficial cervical plexus block is a technique of blocking the greater auricular, lesser occipital, transverse cervical, and supraclavicular nerves, which are peripheral branches of C1–C4. Although this procedure is mainly performed as anesthesia for neck surgery, it may also be indicated for pain related to shingles or similar disorders. The superficial cervical plexus block can be completed via either a landmark method or an ultrasound-guided method; however, the procedures vary slightly. Both methods can be performed at relatively shallow locations around the sternocleidomastoid muscle, and both approaches are simple and effective.

21.2 Indications [1]

- Neck surgeries (thyroid surgery [2], median cervical cyst enucleation, and lymph node dissection)
- Shingles pain (combined with a stellate ganglion block) [3]
- Neck pain due to malignancy, etc.

21.3 Anatomy (Fig. 21.1) [1]

The superficial cervical plexus is a sensory nerve formed by anterior-branching divisions of the C1–C4 spinal nerves. These anterior branches include the greater auricular, lesser occipital, transverse cervical, and supraclavicular nerves, which send sensory afferents to innervate the skin of the anterior neck, lateral neck, pinnae, shoulders, acromioclavicular joints, clavicle, and elsewhere. All four nerves emerge from the posterior margin of the sternocleidomastoid muscle. The greater auricular nerve (C2, C3), which is the largest of the superficial cervical plexus, comes out from the posterior margin of the sternocleidomastoid muscle, divides into an anterior and posterior branch, and innervates the front and back of the pinnae. The lesser occipital nerve rises toward the head and innervates the scalp and cervical region of the retroauricular surface. The transverse cervical nerve (C2, C3) crosses the middle of the neck and innervates the anterolateral surface of the neck going from the mandible to the sternum. Lastly, the supraclavicular nerve (C3, C4) runs caudally under the platysma within the posterior triangle of the neck and divides into three branches.

21.4 Instruments and Drug Solutions

1. Ultrasonic set
2. Syringe (5 mL)
3. Puncture needle (landmark method, 25-G disposable needle; ultrasonic method, 23−25-G Cathelin needle)

21.5 Procedures and Techniques

21.5.1 Superficial Cervical Plexus Block Technique

With the classical landmark method, a local anesthetic is injected subcutaneously at the posterior margin of the sternocleidomastoid muscle (method 1) [3] (“×” in Fig. 21.1). By

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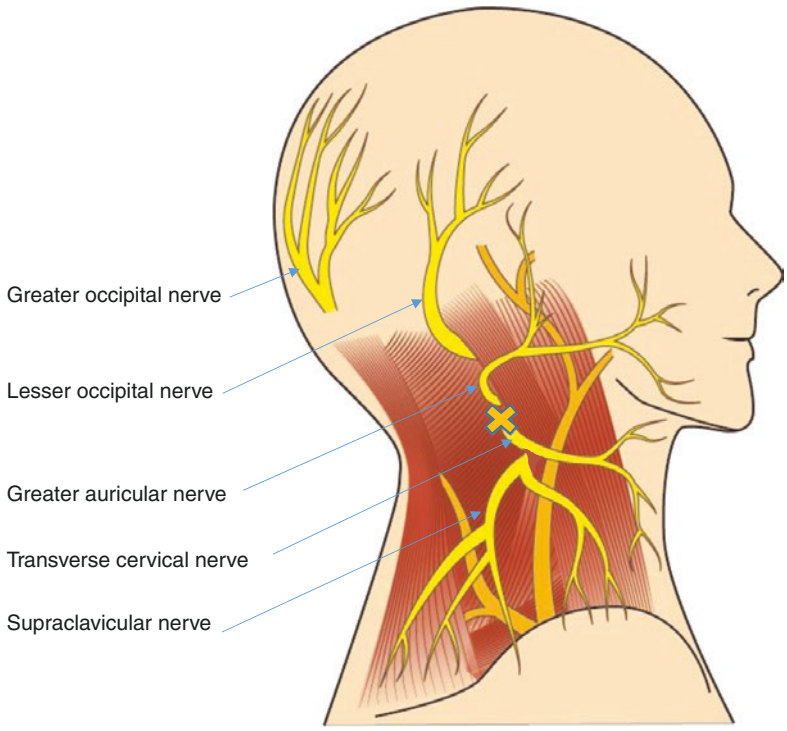

Fig. 21.1 The anatomy of the superficial cervical plexus block with the landmark method. A local anesthetics is injected subcutaneously at the margin of the sternocleidomastoid muscle (cross)

contrast, the ultrasound-guided method involves injecting a local anesthetic between the deep cervical fascia (prevertebral layer) and the shallow cervical fascia, which is a deep layer of the sternocleidomastoid muscle [4] (method 2) ("×" in Fig. 21.2). In the latter approach, the drug reportedly enters through the deep cervical fascia to result in a deep cervical plexus block [5], making the definitions of a superficial cervical plexus block and a deep cervical plexus block ambiguous. A method where an injection is made between the superficial cervical fascia and the deep cervical fascia may be expressed as an intermediate cervical plexus block [2]. However, it has been suggested that the superficial muscle fascia might not exist [6]. Here, we define method 1 as a landmark-based superficial cervical plexus block (landmark method) and method 2 (intermediate) as an ultrasound-based superficial cervical plexus block (ultrasound-guided method).

21.5.2 Landmark Method

To perform this method, it is important to have an understanding of the anatomy of the body's surface. The body is in a supine position, with the head turned to the unaffected side. The sternocleidomastoid muscle and external jugular vein, which rise to the surface when the head is slightly lifted, are checked over. The puncture point is made 1.5–2.0 cm cranial from the intersection of the sternocleidomastoid and the external jugular vein. The method of puncture should be substantially subcutaneous in nature. After a suction test, 3–5 mL of local anesthetic is injected. When the needle is in the proper position, the local anesthetic is known to rise swiftly through the posterior margin of the sternocleidomastoid muscle [3]. The local anesthetic more readily spreads cranially if the caudal side of the puncture point is held down with the finger of an individual that is not performing the actual injection.

21.5.3 Ultrasound-Guided Method (Fig. 21.2)

A superficial cervical plexus block is thought to produce the same effects regardless of whether ultrasound-guided method or the landmark method is used [7]. The body posture should be in either a lateral supine position or a semi-lateral supine position, the latter being achieved by placing a pillow under the back while the affected side faces up. A linear probe is then used to check the ultrasonic image at the level of C4. Checking C4 entails checking the C6 anterior tubercle, with its characteristic form. From there, it is easy to gradually slide the probe cranially toward C5 and then to C4. The needle is inserted with the in-plain approach. Due to the shallow position of the cervical plexus, it is better to angle the needle down, inserting it about 1 cm away from the probe. The needle is then advanced between the shallow cervical fascia covering the

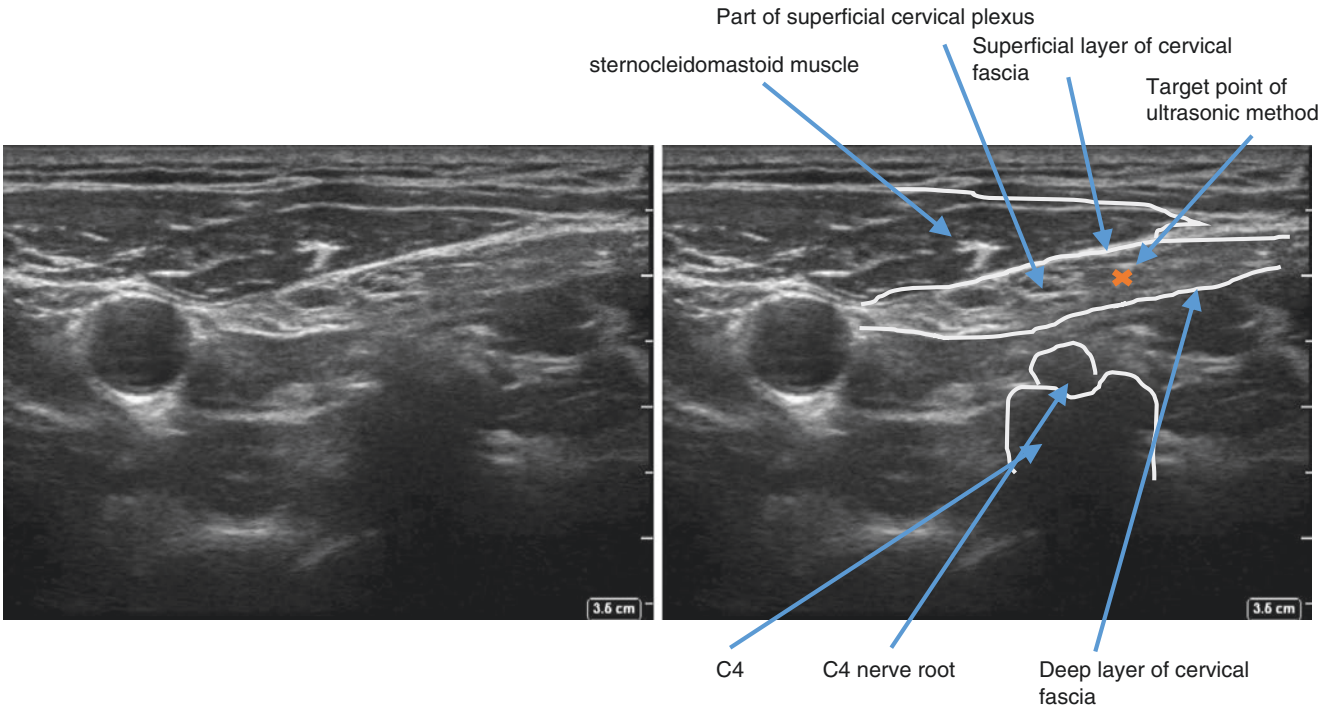

Fig. 21.2 Ultrasound image of the superficial cervical plexus. Cross indicates target point

inner surface of the sternocleidomastoid muscle and the deep cervical fascia covering the outer surface of the middle scalene. Local anesthetic is injected, and its spread between the fascia is checked.

21.6 Complications

Local anesthetic intoxication can occur when its blood concentration rises rapidly and is caused by injection of the local anesthetic into a blood vessel. This can be prevented by checking the injection of the local anesthetic.

Hematoma can form from the vascular puncture and poses a risk of causing airway constriction. There should be ample compression if backflow of blood is observed with suction.

Nerve injury: If the patient feels an intense pain during the puncture, the needle should not be advanced further.

References

1. Vloka JD, Tsai T, Hadzic A. Cervical plexus block. In: Textbook of regional anesthesia and acute pain management; 2007.
2. Egan RJ, Hopkins JC, Beamish AJ, Shah R, Edwards AG, Morgan JD. Randomized clinical trial of intraoperative superficial cervical plexus block versus incisional local anaesthesia in thyroid and parathyroid surgery. Br J Surg. 2013;100(13):1732–8.
3. Higuchi H, Masuda Y, Oseto K, et al., editors. Cervical plexus blocks pain clinic nerve blocks. 2nd ed; 2000. p. 77–84. (in Japanese).
4. Herring AA, Stone MB, Frenkel O, Chipman A, Nagdev AD. The ultrasound-guided superficial cervical plexus block for anesthesia and analgesia in emergency care settings. Am J Emerg Med. 2012;30(7):1263–7.
5. Pandit JJ, Dutta D, Morris JF. Spread of injectate with superficial cervical plexus block in humans: an anatomical study. Br J Anaesth. 2003;91(5):733–5.
6. Nash L, Nicholson HD, Zhang M. Does the investing layer of the deep cervical fascia exist? Anesthesiology. 2005;103(5):962–8.
7. Ramachandran SK, Picton P, Shanks A, Dorje P, Pandit JJ. Comparison of intermediate vs subcutaneous cervical plexus block for carotid endarterectomy. Br J Anaesth. 2011;107(2):157–63.

Stellate Ganglion Block

22

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22.1 Introduction

22.1.1 What is Stellate Ganglion Block?

Stellate ganglion block (SGB) is a compartment block technique in which a local anesthetic is injected into a cervical sympathetic ganglion, stellate ganglion (SG), and the region around it to block the SG, cervical sympathetic trunk, and sympathetic pre- and postganglionic fibers contained in the compartment. The effect of SGB includes sympathetic block-induced facial flush on the blocked side, skin temperature elevation in the innervated region, nasal obstruction, stopping sweating, and Horner's syndrome. In this chapter, the landmark, ultrasound-guided, and fluoroscopic methods are described.

22.1.1.1 Indications

Stellate ganglion block is indicated for craniofacial, neck, shoulder, and upper limb pain and other non-painful diseases [1].

1. Craniofacial pain: Atypical facial pain, symptomatic trigeminal neuralgia (neuropathic pain after tooth extraction), herpes zoster, postherpetic neuralgia, migraine, cluster headache, and tension headache
2. Neck, shoulder, and upper limb pain: Cervical intervertebral herniation, cervical spondylosis, posttraumatic cervical syndrome, thoracic outlet syndrome, upper limb CRPS, phantom limb pain, Raynaud's disease, herpes zoster, and postherpetic neuralgia
3. Others: Peripheral facial nerve palsy and occlusion of retinal blood vessels and others

22.2 Anatomy [2, 3]

In the cervical sympathetic nervous system, the superior cervical ganglion (SCG), middle cervical ganglion (MCG), vertebral ganglion (VG), and stellate ganglion (SG) are present in this order from the cranial side [2] (Fig. 22.1).

SG represents the union of the inferior cervical ganglion and first and second thoracic ganglia [2]. The frequency of observing these as SG markedly varies (70–100%) among reports. Normally, SG is present with the nerve trunk in the compartment at the first thoracic vertebral level at which the longus colli muscle gradually becomes thin. MCG is present near the sixth cervical vertebra (C6), to which puncture is normally applied, and MG or VG is present at the seventh cervical vertebral (C7) level. However, the positional relationship among the sympathetic ganglions markedly varies, and MCG and VG may be absent in some cases. SG is present below the subclavian artery and forms the subclavian loop (Ansa subclavia) in many cases [2].

The transverse view of the neck at the C6 level, which is important for ultrasound-guided SGB, is shown in Fig. 22.2. The cervical vertebrae and muscles around it are surrounded by the prevertebral layer of the deep cervical fascia. The drug solution injection site for SGB, the longus colli muscle, is also located in this prevertebral layer. The longus colli muscle attaches to the anterior vertebral surfaces from the fifth cervical to third thoracic vertebra, and the cervical sympathetic nerve is distributed along the ventral side of the longus colli muscle.

The original version of this chapter was revised.
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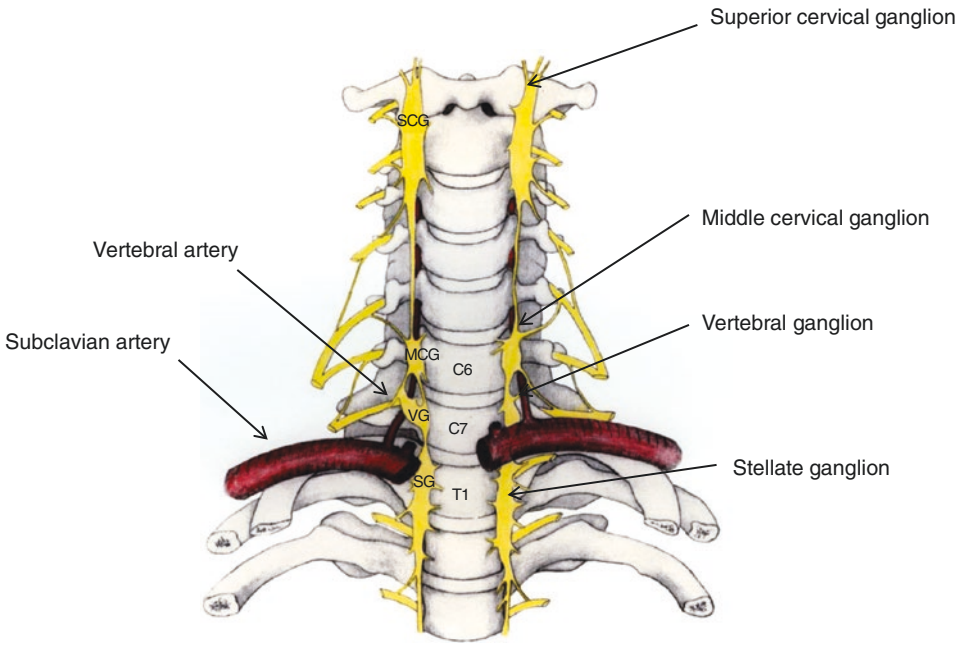

Fig. 22.1 Anatomy of the cervical sympathetic ganglion

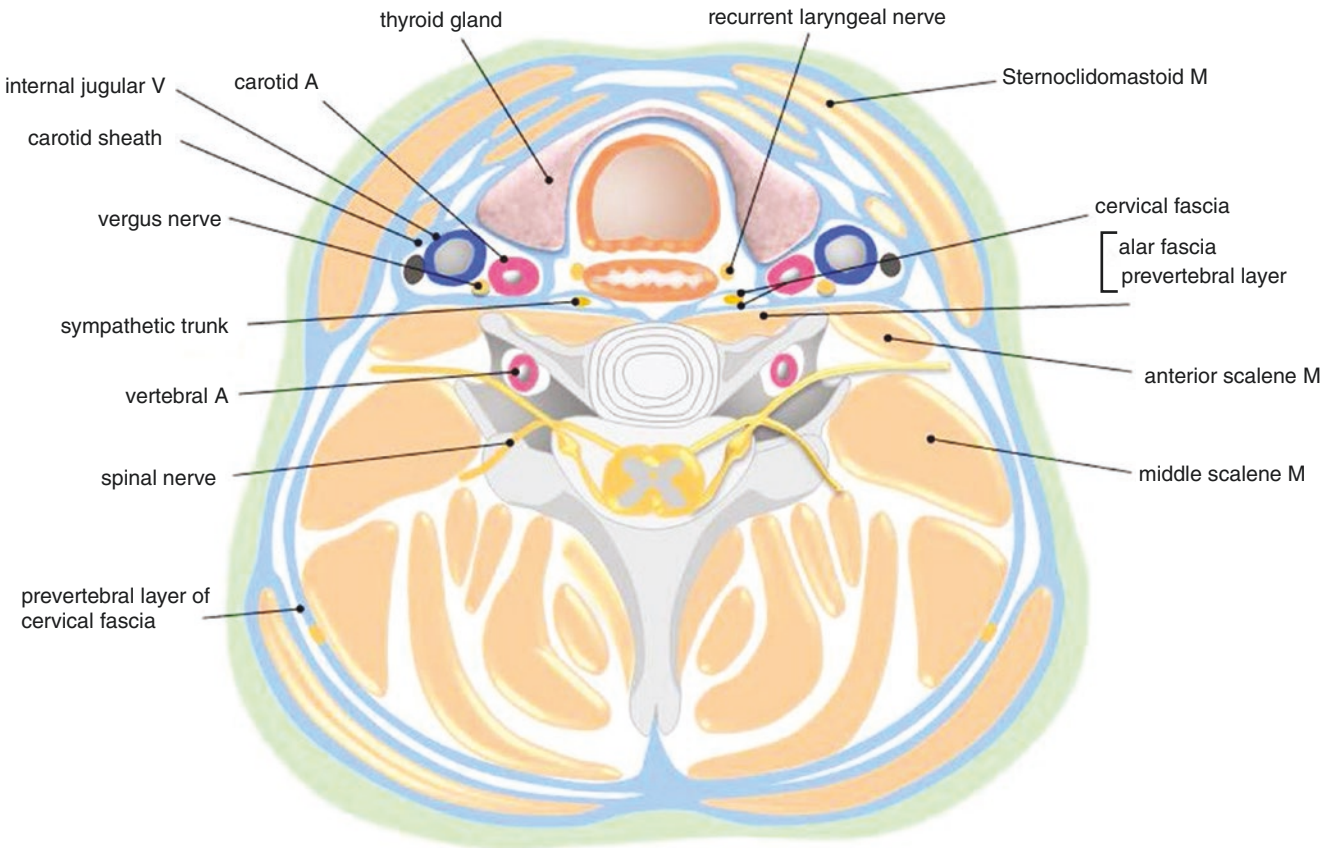

Fig. 22.2 Transverse section at C6 level quoted from Pain Clinic 29 1459–1465, 2008

Generally, SGB is applied at the C6 level. At this level, the cervical sympathetic trunk (CST) is present slightly medial to the anterior tubercle and anterior to the longus colli muscle. The longus colli muscle is covered with the deep cervical fascia, and this is divided into the alar fascia and prevertebral layer. Regarding the relationship between the sympathetic nerve and fascia, SG is distributed between the two very thin fasciae. To apply ultrasound-

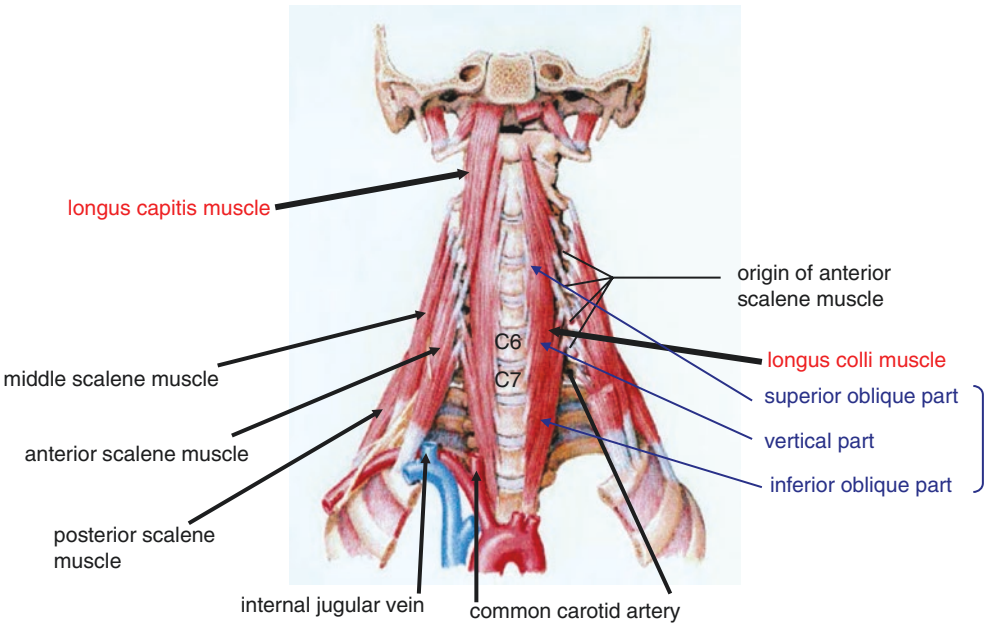

Fig. 22.3 Anatomy of the muscle of the neck: longus capitis muscle and longus colli muscle

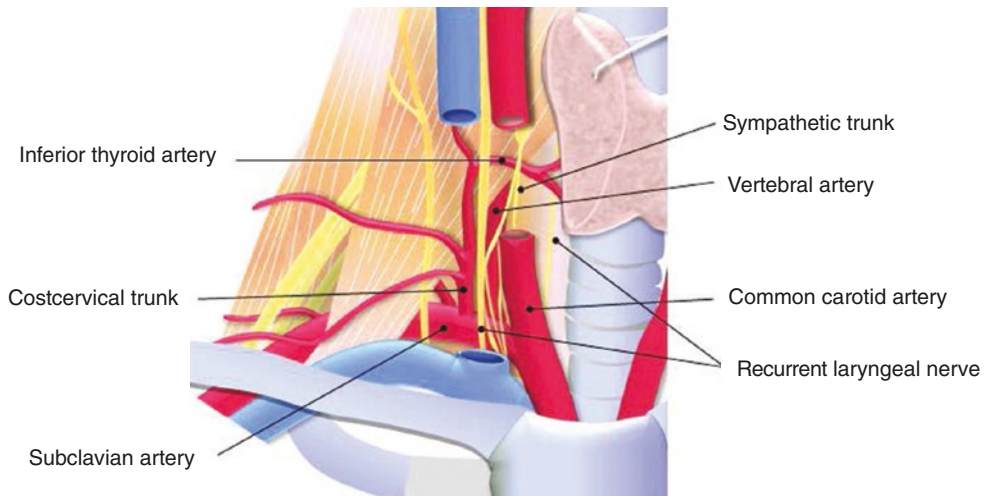

Fig. 22.4 Sympathetic trunk and inferior thyroid artery (quoted from Pain Clinic 29: 1459–1465, 2008)

guided SGB, the needle is advanced into the longus colli muscle below the deep cervical fascia. The longus colli muscle is divided into the superior oblique, vertical, and inferior oblique regions (Fig. 22.3). Regarding the landmark method, Yamamuro et al. reported that, when puncture is applied to C6 to obtain an effect in the upper limbs, it is important to puncture the central region of the base of the C6 transverse process, at which the inferior oblique region of the longus colli muscle is present [4]. The longus colli muscle is the longest muscle among those present at the C3–T3 level, and it is located on the medial side. The distal side of the muscle comes close to the vertebral body, and the medial margin is located anterior to the vertebra at the C6 level. The longus colli muscle is an important element for SGB to succeed. In recent ultrasound-guided SGB, the diffusion of drug solution in the longus colli muscle is visible, which should increase the success rate.

Normally, the vertebral artery (VA) enters the vertebra through the C6 transverse foramen, but an exceptional entrance through the upper vertebral level has been observed [5, 6]. It is necessary to confirm the distribution of the vertebral artery at the C6 level when ultrasound-guided SGB is applied. However, the ascending cervical artery and inferior thyroid artery branching from the thyrocervical artery present anterior to the transverse process are considered to cause complications of SGB involving blood vessels, such as vascular puncture, rather than the vertebral artery (Fig. 22.4) [7, 8].

22.3 Points for Applying SGB

Before applying SGB, the reason for its necessity for treatment and possible complications should be explained using documents, and consent should be obtained, in which an emergency system should be prepared for late-onset

complications developing after patients go home and a contract address should be recorded. Since SGB may cause serious complications requiring emergency treatment because of its anatomical characteristics, it has to be performed at a site where oxygen inhalation, artificial respiration, and the securing of vascular access can be performed and emergency medicines can be prepared. SGB should be performed by a specialized physician capable of applying resuscitation. After blocking, sufficient observation for about 20–30 min is necessary. The durations of pressing and rest are extended as needed. The patient is allowed to go home after fully confirming the absence of abnormality.

22.4 Instruments and Drug Solutions

Needle: A 23–25-G injection needle with a 25–32-mm length, local anesthetic (1% mepivacaine or 1% lidocaine), 5 mL syringe

22.5 Procedures and Techniques

22.5.1 Landmark Method (Paratracheal Method) [9]

Drug solution: Three to ten milliliters of a local anesthetic is administered.

Needle: A 23–25-G injection needle with a 25–32-mm length is used. Long needles are not used.

Posture: The patient is placed in the supine position with slight retroflexion of the head, protruding the jaw.

Puncture: After sufficient disinfection of the region to be blocked, puncture is applied employing the paratracheal method. The soft tissue between the sternocleidomastoid muscle and trachea is pressed laterally with the index and middle fingers to palpate the anterior tubercle of the transverse process of the sixth cervical vertebra (C6) (Fig. 22.5). Application at the C6 level is recommended for safety. When the base of the transverse process is hit by the needle, it is carefully aspirated while retaining the syringe and needle carefully so that the needle tip is not moved. After confirming the absence of the reflux of blood, a small volume (0.5–1.0 mL) of the local anesthetic is injected, followed by reconfirming the absence of blood reflux, and the drug solution is slowly injected. After injection, the operator places an index finger tip at the inserted site and removes the needle. The punctured site is firstly pressed with the operator's index finger tip, and then the patient's finger on the opposite side is guided to the punctured site, and the patient presses the site for about 5 min.

22.5.2 Fluoroscopy-Guided SGB

To apply SGB under fluoroscopy-guided method, there are anterior and posterior approaches. In the posterior approach, puncture is applied at the first to second thoracic vertebral (T1–2) level.

Drug solution: The same local anesthetics as those for the landmark method are used.

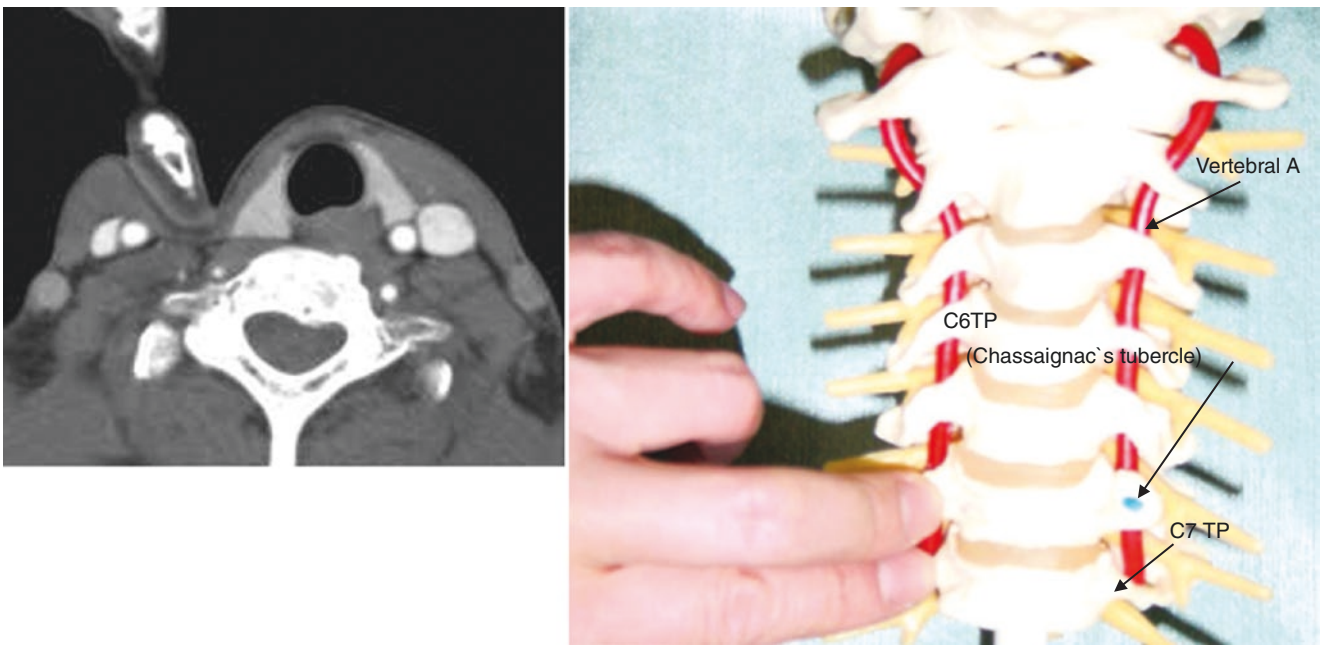

Fig. 22.5 Landmark technique

Water-soluble contrast medium

Needle: For the anterior approach, the same needles as those for the landmark method (paratracheal method) are used. For the oblique method, Abdi et al. recommend 25-G spinal needles, but the applied site can be sufficiently reached with a 24-G, 32-mm injection needle.

For the posterior approach, 22-G 10-cm block needles are used.

22.5.2.1 Anterior Approach

Paratracheal method: Puncture is applied similarly to that in the landmark method. The X-ray tube is tilted by about 15° in the cauda-cranial direction, setting the reference at the C6 transverse process (Fig. 22.6a). After puncture, contrast medium is injected. It diffuses along the longus colli muscle (Fig. 22.6b). After confirming that it was not injected into a blood vessel, the local anesthetic is injected.

Oblique method [10]: In a supine position with a low pillow under the shoulder, the head is slightly turned toward the healthy side. The X-ray tube is set at an oblique position of 30° in the right anterior oblique direction (RAO) (Fig. 22.7a).

Setting the insertion point at the C7 uncinate process-vertebral body transitional region using forceps, the needle is inserted toward the base of the C7 uncinate process (Fig. 22.7b), and, when it hits the bone, 1–2 mL of contrast medium is injected. After observing the diffusion of contrast medium along the longus colli muscle (Fig. 22.7c) and confirming that it was not injected into a blood vessel, the local anesthetic is injected.

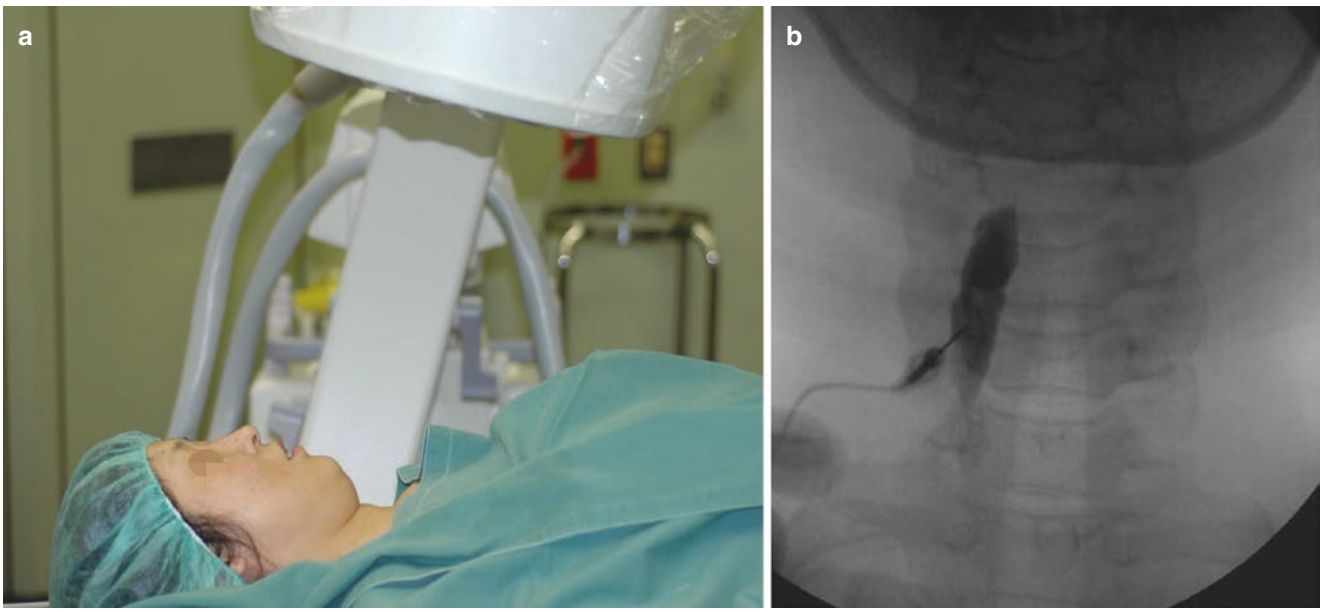

Fig. 22.6 Fluoroscopic technique (anterior approach: paratracheal method). (**a**) posture of the patients and the angle of the X-ray tube. (**b**) contrast image of the longus colli muscle

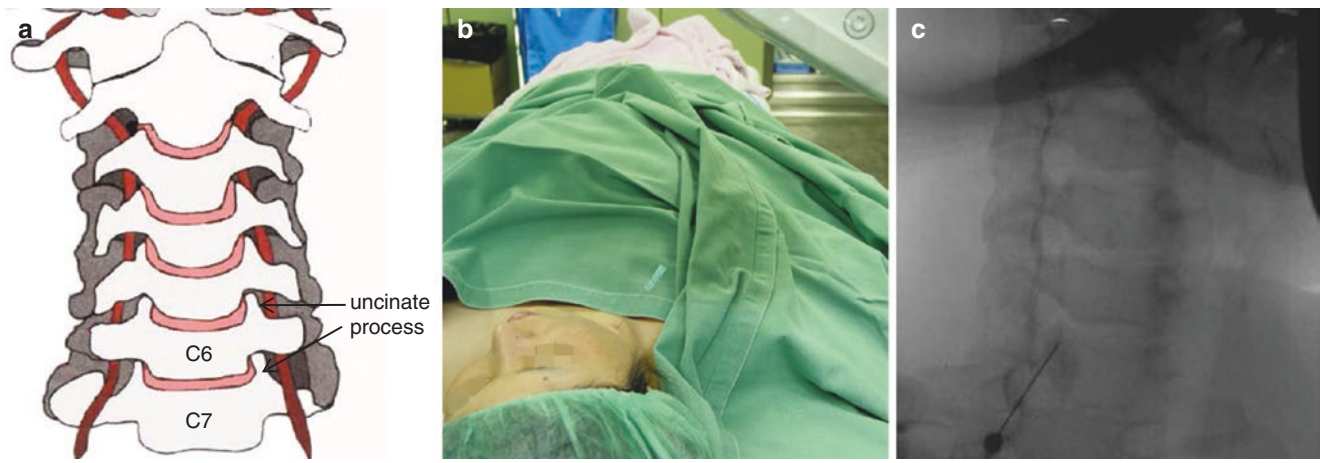

Fig. 22.7 Anterior approach (anterior oblique technique). (**a**) anatomy of the uncinate process of C6, C7 vertebra. (**b**) posture of the patient and the angle of the X-ray tube. (**c**) contrast image

22.5.2.2 Posterior Approach [11]

When a neurolytic is used, the posterior approach is more appropriate than the anterior approach.

Both upper limbs are elevated in a prone position, and a pillow is placed under the thoracoabdominal region to make the T1–2 vertebrae parallel and set the X-ray tube vertical to it (Fig. 22.8a).

The insertion point is set at 4 cm lateral to the spinous process of T1–T2 (Fig. 22.8b). Local infiltration anesthesia is applied, and the needle is advanced to a site lateral and anterior to the target vertebra. When the needle tip hits the bone, it is slightly pulled back and advanced in a slightly lateral anterior direction. It is slipped below the transverse process to be positioned lateral and anterior to the vertebra. Contrast medium is injected, and, after observing its diffusion, 5–7 mL of the drug solution is injected. When a neurolytic is used, 2–3 mL of phenol solution is injected 20 min after the test block.

22.5.3 Ultrasound-Guided SGB [12, 13]

Since Shibata et al. [12] reported ultrasound-guided SGB (U-SGB) using a micro convex probe in 2007, U-SGB has gradually become widely performed because it is considered significantly more reliable and safer than the landmark method.

22.5.3.1 Technique Using a Linear Probe (Fig. 22.9)

Drug solution: 35 mL of 1% mepivacaine or lidocaine

Needle: A 23- or 25-G Cathelin needle (echogenic block needle)

Firstly, a short-axis view of the cervical spine is obtained. The C6 level is confirmed and visualized based on the shape of the transverse process, and the needle is inserted into the longus colli muscle present at the base of the transverse process anterior to the vertebra. The needle passes through the region between the anterior tubercle of the C6 transverse process and internal jugular vein and reaches the longus colli muscle. After confirming that the needle tip is present in the longus colli muscle, drug solution is slowly injected. Injection is continued while observing that the longus colli muscle is being swollen by the injection on the display.

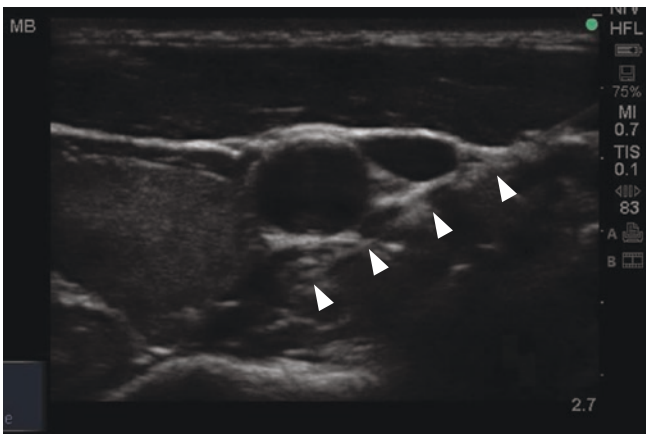

Fig. 22.9 US-guided SGB with liner transducer

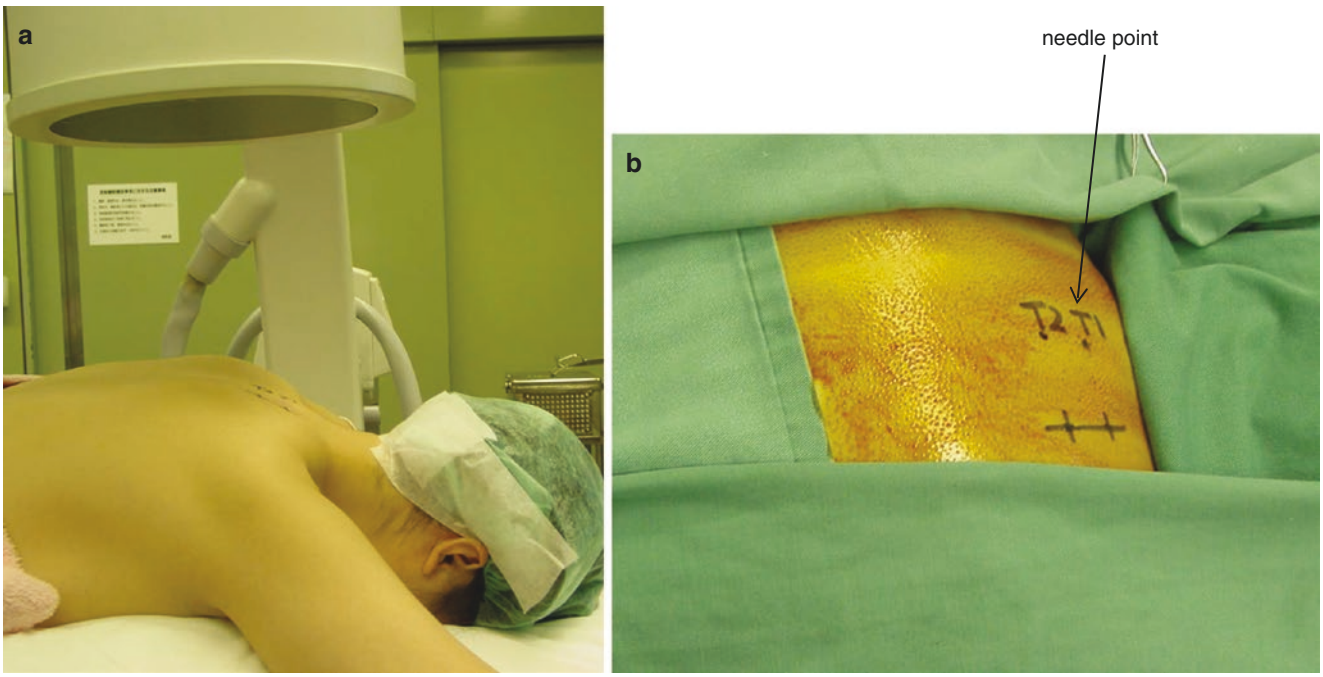

Fig. 22.8 Posterior approach

Since the anterior tubercle of the C6 transverse process is present in the needle insertion pathway, setting the needle insertion angle may be difficult in some cases. In such cases, the probe is slightly moved toward the cranial side to remove the anterior tubercle from the display, which makes securing the insertion pathway to the longus colli muscle easier. The presence of the internal jugular vein in the puncture pathway cannot be avoided in some cases, for which the internal jugular vein may be inevitably penetrated by the needle to inject drug solution into the longus colli muscle.

22.5.3.2 Technique Using a Micro Convex Probe

The region observed in the short axis view using a linear probe is visualized with a micro convex probe (Fig. 22.10). Similarly to observation using a linear probe, the C6 vertebra over the anterior tubercle of the transverse process can be observed, and the longus colli muscle anterior to it and the thyroid, common carotid artery, and internal jugular vein anterior to the longus colli muscle can be confirmed. The common carotid artery anterior to the longus colli muscle is moved laterally with the finger or probe and pressed with a micro convex probe at the moved site, which secures a safe insertion pathway from the skin to the longus colli muscle, as shown in Fig. 22.11.

U-SGB using a micro convex probe is a longus colli muscle puncture method similarly to SGB employing the landmark method: The common carotid artery present in the puncture pathway is moved laterally. In SGB employing the landmark method, the common carotid artery is moved laterally with the second and third fingers of the non-dominant hand to confirm the anterior tubercle of the C6 transverse process. This procedure is performed using a micro convex probe in this technique. On actual puncture, a 25-G, 25-mm injection needle is used. The puncture site is identified, referring to the C6 transverse process, and the common carotid artery is moved to the lateral side of the probe. Since the thyroid is also moved medially with pressing, puncture can be applied either on the lateral or medial side of the probe. Puncture through the lateral side is shown in Fig. 22.12. It is difficult to move the common carotid artery in some rare cases. In such cases, the insertion pathway can be secured by moving the artery medially by pressing it with the probe, but the longus colli muscle is inevitably punctured through the internal jugular vein because this vein is present anterior to the muscle.

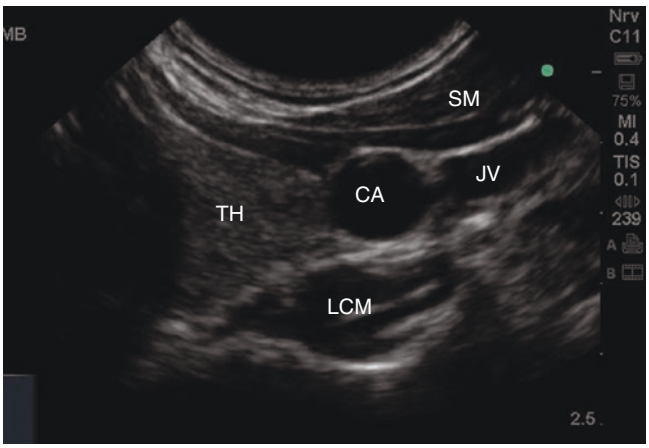

Fig. 22.10 Ultrasonographic image of the neck at C6 level with micro convex transducer

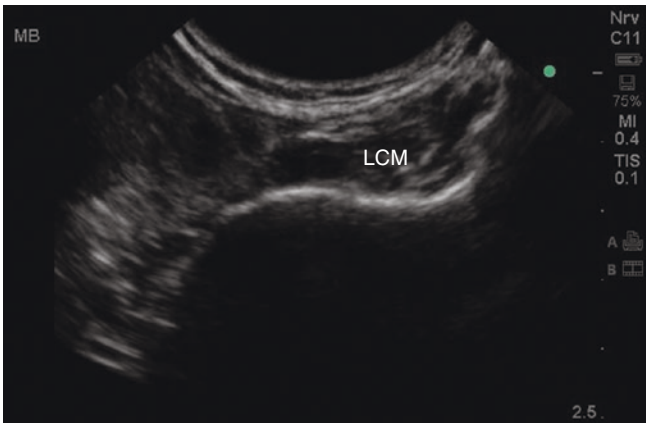

Fig. 22.11 Neck was pressed with transducer and common carotid artery is moved laterally

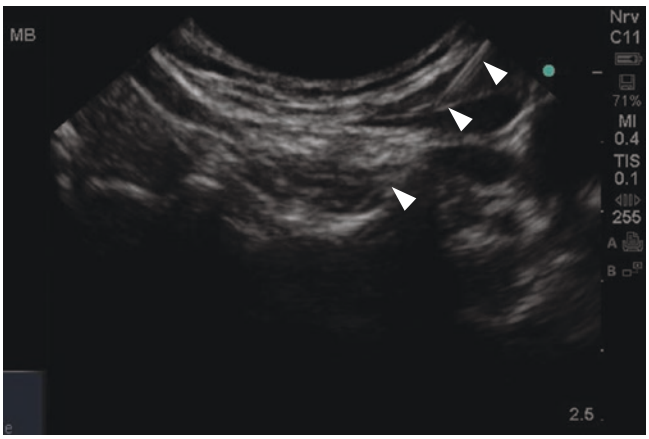

Fig. 22.12 Needling into longus colli muscle (triangle: needle line)

22.6 Complications

22.6.1 Early-Onset Complications

Recurrent nerve paralysis (hoarseness), brachial plexus palsy (muscle weakness and numbness of the upper limb), intravascular injection (carotid artery and jugular vein: toxication with local anesthetic, vertebral artery: loss of consciousness),

esophageal puncture, injection into the epidural space, and subarachnoid injection (dyspnea and respiratory arrest)

22.6.2 Late-Onset Complications

Pneumothorax, retropharyngeal hematoma (dyspnea), vertebral osteomyelitis, discitis, retropharyngeal abscess. Retropharyngeal hematoma may be fatal.

References

1. Brevick H, Cousins MJ, Löfström JB. Sympathetic neural blockade of upper and lower extremity. In: Cousins MJ, Bridengaugh PO, editors. Neural blockade in clinical anesthesia and management of pain. 3rd ed. Philadelphia: Lippincott-Raven; 1998.
2. Totoki T, Morimoto A, Taniguchi Y, Hirakawa N, Taniguchi T, Mineta Y, Kato T, Harano K. Anatomy of the stellate ganglion. J Jpn Soc Pain Clinicians. 1994;1:3–11. (in Japanese)
3. Hirakawa N. Anatomy and function of stellate ganglion. Pain Clinic. 2014;35:149–57. (in Japanese)
4. Yamamuro M, Eba Y, Kaneko T, Yasuda A, Fudeta H. Stellate ganglion block at the sixth cervical vertebra. (2). A study of technique. Pain Clinic. 1991;12:507–12. (in Japanese)
5. Yamaki K, Saga T, Hirata T, Sakaino M, Nohno M, Kobayashi S, Hirao T. Anatomical study of the vertebral artery in Japanese adults. Anat Sci Int. 2006;81:100–6.
6. Hong JT, Park DK, Lee MJ, Kim SW, An HS. Anatomical variations of the vertebral artery segment in the lower cervical spine; analysis by three-dimensional computed tomography angiography. Spine. 2008;33(22):2422–6.
7. Narouze S. Beware of the "serpentine" inferior thyroid artery while performing stellate ganglion block. Anesth Analg. 2009;109:289–90.
8. Huntoon MA. The vertebral artery is unlikely to be the sole source of vascular complications occurring during stellate ganglion block. Pain Pract. 2010;10:25–30.
9. Wakasugi B, Mochida N. Effective stellate ganglion technique. Pain Clinic. 2007;28:478–86. (in Japanese)
10. Abdi S, Zhou Y, Patel N, Saini B, Nelson J. A new and easy technique to block the stellate ganglion. Pain Physician. 2004;7:327–31.
11. Waldman SD. Chapter 29 Stellate ganglion block: posterior approach. Atlas of interventional pain management. Philadelphia: Waldman SD, WB Saunders; 1998. p. 104–7.
12. Shibata Y, Fujiwara Y, Komatsu T. A new approach of ultrasound-guided stellate ganglion block. Anesth Analg. 2007;105(2):550–1.
13. Akashi N, Park K. Technique of ultrasound-guided stellate ganglion block. Pain Clinic. 2014;35:163–70.

Brachial Plexus Block (Landmark, Ultrasound-Guided, and Fluoroscopy-Guided Methods)

23

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23.1 Introduction

Brachial plexus block (BPB) is useful in the treatment of painful conditions of the neck, shoulder, and upper extremities. The following section describes BPB methods (landmark method, fluoroscopy-guided method, and ultrasound-guided method).

BPB can be performed by treatment agent injection on the brachial plexus, which consists of C5–T1, and it can also be performed by blocking the autonomic and somatic nerves. For the management of pain (neck and shoulder pain and upper-limb pain), there is no need for an injection into the intraneural nerve for anesthesia and muscle relaxation. The following section will discuss the landmark, fluoroscopy-guided, and ultrasound-guided methods.

23.2 Indication

1. Neck pain, shoulder pain, upper extremity pain (e.g., cervical spondylosis, cervical spondylitis radiculopathy, cervical disk herniation, zoster associated pain)
2. Peripheral artery disease of upper extremities

Great care must be taken when performing BPB in cases of nerve disorders (e.g., complex regional pain syndrome).

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23.3 Anatomy (Fig. 23.1)

Upper-extremity sensory and motor performance is commonly regulated by the brachial plexus, which mainly consists of anterior branches of C5–T1 spinal nerves. Brachial plexus are through between anterior scalene muscle and middle scalene muscle. Brachial plexus, subclavian artery/vein, and clavicular artery/vein wrap consist of prevertebral fascia.

This block local anesthetic is injected in this region [1–3]. Actually, this region can be checked by ultrasound.

23.4 Instruments and Drug Solutions

1. Needle: 23 gauge, 6 cm disposable needle (blunt Coudé needle)
2. Treatment agents: local anesthetics and steroids (Fluoroscopy-guided: water-soluble, nonionic contrast)
3. Syringe: 10 mL syringe

23.4.1 RF/PRF—Additional Equipment

99 mm radiofrequency thermocoagulation needle
Electrode

23.4.2 Equipment

Ultrasound-guided: sterile cover, extended tube, sterile jelly
Fluoroscopy-guided: forceps, C-arm
Nerve-stimulated: Nerve stimulator, stimulator needle

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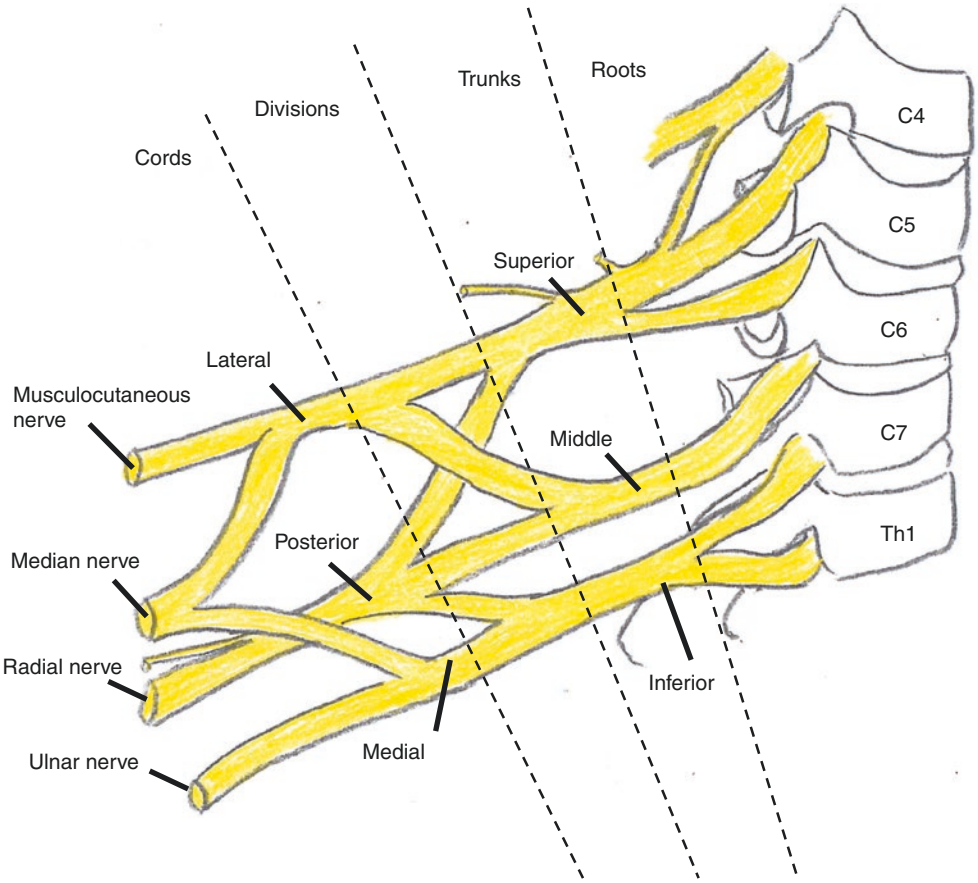

Fig. 23.1 Anatomy

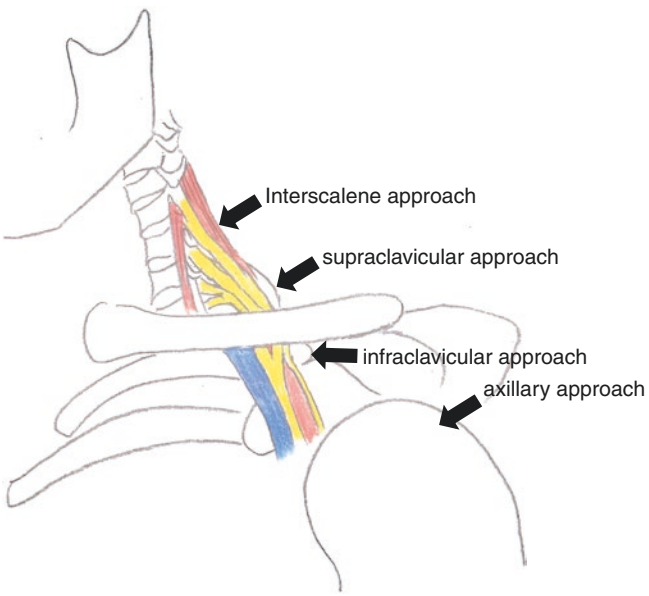

Fig. 23.2 Some approach techniques

23.5 Procedures and Technique

23.5.1 Landmark Method

There are several approaches or techniques (Fig. 23.2). The interscalene and axillary approaches are safer and easier than the supraclavicular afnd infraclavicular approaches using the landmark techniques.

23.5.1.1 Interscalene Approach

BPB can be performed by injection at the site covered by fascia between the anterior scalene muscle and middle scalene muscle. The point of injection is the posterior to sternocleidomastoid muscle and the same of cricoid cartilage position (Winnie point). It is easier to perform by pushing between the anterior scalene muscle and middle scalene muscle region to achieve radiated paresthesia in the upper limb and then make the injection at the brachial plexus point. To stimulate radiation pain, it must be confirmed to recall blood test before injection. Treatment agents should be injected slowly and gently.

23.5.1.2 Axillary Approach

Place the patient's upper extremity into outer rotation, 90° flexion forearm. Touch the attached point between the pectoralis major and latissimus dorsi to find the axillary artery pulse; the most recommended point is the inner center side region.

23.5.2 Fluoroscopy-Guided Method

23.5.2.1 Procedure

Have the patient lie in a supine position and place the patient's head on a pillow. It can be also to get some lateral position on puncture side. Fluoroscopic imaging must be sure in the center position across the first and second ribs.

Locate the puncture location (center position where the first and second ribs cross and a higher position of the clavicle bone are recommended) using forceps (Fig. 23.3). The syringe and treatment agents must be prepared in advance; injection is done on the first rib under fluoroscopy. Check the monitor and the recall blood test. Evaluate the patient's condition during treatment agent injection (mix of local anesthetics and contrast). An extension tube can also be used. Obtain an image of the middle scalene muscle with contrast (Fig. 23.4) [4].

23.5.3 Ultrasound-Guided Method

There are also many ultrasound-guided approaches for BPB [5, 6]. The safest technique is the interscalene muscle approach. This section will recommend the outer middle scalene muscle as the point of injection.

23.5.3.1 Procedure

Lay the patient in a semilateral position on the puncture side by setting a pillow behind the back. Get down position of clavicle to get more space for nerve block.

Insert the probe into a region two to three fingers from the head side between the clavicle bone and the lateral side of the sternanocleidomastoid muscle (Fig. 23.5). If it cannot reach the brachial plexus, place the probe on the upper clavicle bone and then obtain an image of the subclavian artery and an image of a low echoic circle like a grape (this is the brachial plexus nerve). Get the probe into head position approach until get the image of three trunks (superior, middle, inferior trunk) (Fig. 23.6a).

Get the plane of probe from outer side (in plain) through the needle to middle scalene muscle (Fig 23.6b). Obtain the recall blood test on this position. Until the needle puncture of the middle scalene muscle fascia is confirmed, a small amount of anesthetics can be injected. The last confirm is performed, treatment agents can be injected.

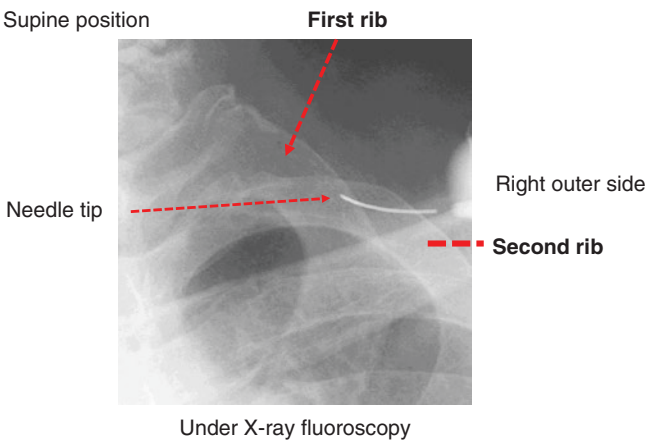

Fig. 23.3 Fluoroscopic image

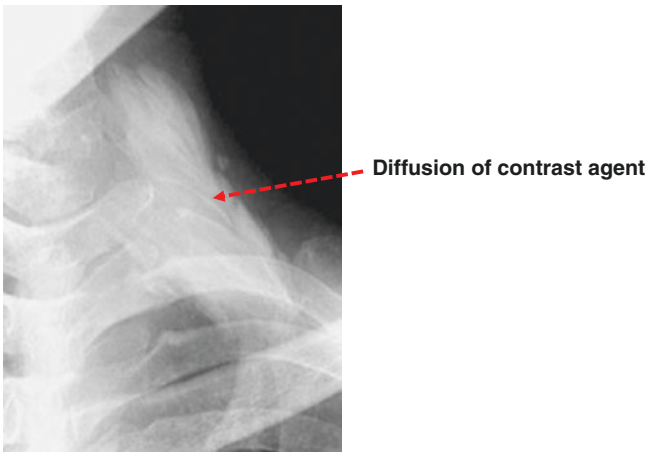

Fig. 23.4 The image of middle scalene muscle with contrast

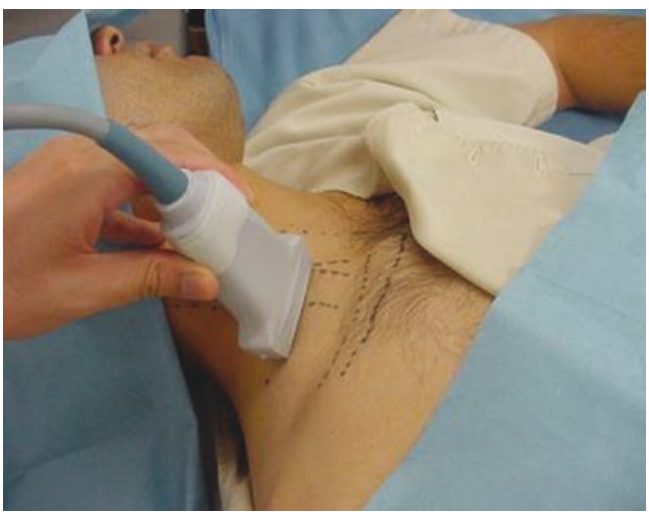

Fig. 23.5 Position

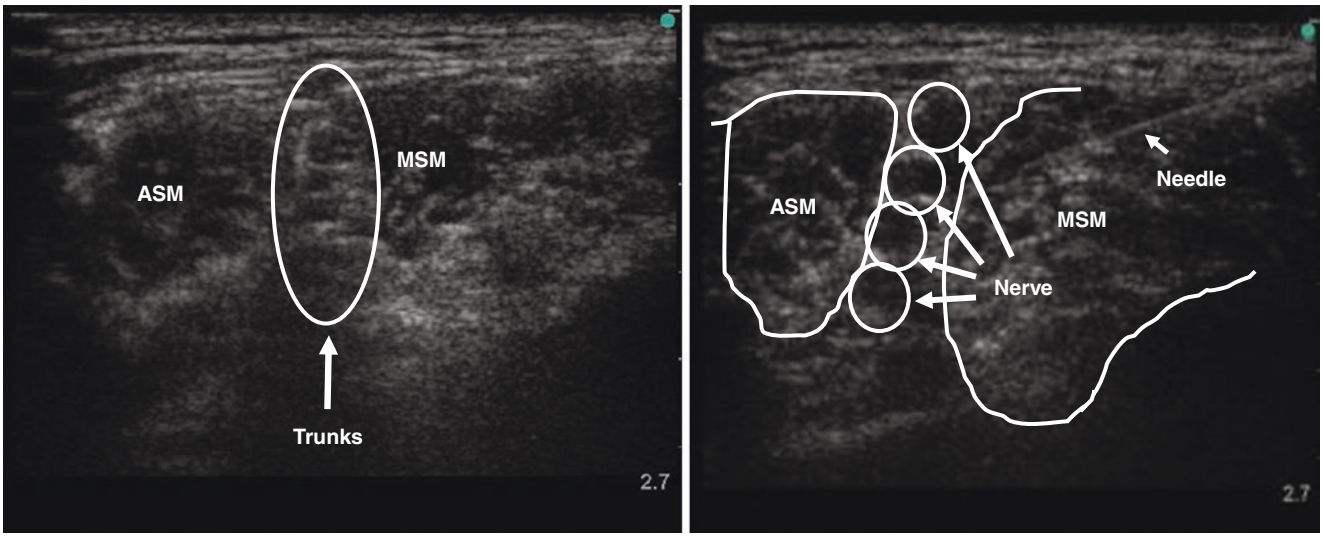

Fig. 23.6 Ultrasound image of the brachial plexus and surrounding structures. *ASM* Anterior scalene muscle, *MSM* Middle scalene muscle

At this stage, an image of the treatment agents spreading between the brachial plexus and middle scalene muscle can be taken.

23.6 Complications

Diaphragm paralysis is the most common complaint. Following nerve blockage, Hb saturation must be checked.

Hematoma: following vessel puncture, hematoma can occur, which could be the result of airway obstruction. If the recall blood test is positive, press the puncture region approximately.

Injection into vessel: Local anesthetic systemic toxicity may occur within minutes of injection of the treatment agents. (e.g., convulsion, unconsciousness).

Nerve injury may occur if the nerve is punctured directly. It must be change the position of needle puncture when high resistance of injection.

ETC: Epidural puncture, subarachnoid puncture, and pneumothorax may occur.

References

1. Yuda Y. Brachial plexus block under fluoroscopic guidance. Curr Ther. 1992;10:2317–23. (in Japanese)
2. Tatushima M, Shiotani M. Brachial plexus block. Medical Postgraduates. 1997;8:236–40. (in Japanese)
3. Tatushima M, Karasawa H. Nerve block under flurorscopic guidance brachial plexus block, pain clinic. 2nd ed. Tokyo: Igaku-shoin; 2000. p. 222–4. (in Japanese)
4. Nishiyama M, Naganuma K, Amaki Y. A new approach for brachial plexus block under fluoroscopic guidance. Anesth Analg. 1999;88:91–7. (in Japanese)
5. Perlas A, Chan VWS, Simons M. Brachial plexus examination and localization using ultrasound and electrical stimulation. Anesthesiology. 2003;99:429–35.
6. Marhofer P, Greher M, Kapral S. Ultrasound guidance in regional anaesthesia. Br J Anaesth. 2005;94:7–17.

Editors' Comment

24

Kiyoshige Ohseto and Hiroyuki Uchino

24.1 Neck Comment

The landmark (blind) method for brachial plexus block is currently not recommended in pain clinics because of its rather frequent association with complications. However, the landmark method is helpful for identifying the optimum site for needle insertion, as viewed from the skin surface, and for determining the needle tip direction. The ultrasound-guided brachial plexus block is easier for beginners than the landmark technique if they marked the ideal needle insertion point on the skin surface in advance.

The ultrasound-guided method provides visualization of the nerve and vessels allowing local anesthetic injection into the brachial plexus; in addition, brachial plexus block can be simply performed at the bedside. On the other hand, the disadvantages of this technique include inability to visualize local anesthetic injection into small vessels and to clearly show the extent of local anesthetic spread in a craniocaudal direction.

In contrast, fluoroscopy-guided brachial plexus block uses local anesthetic mixed with contrast media, allowing real-time confirmation of contrast media spreading and of anesthetic injection into the vessels. This fluoroscopy-guided method allows injection of a high concentration and a large volume of local anesthetics during surgery and in patients with severe pain. The disadvantage of this technique is X-ray exposure.

24.2 Neck Comment in Acraniocaudal Direction

When treating the neck, the ultrasound-guided method allows the performance of nerve blocks. Using this method, a majority of nerve blocks can be more safely performed in a shorter time than using previously used landmark- and fluoroscopy-guided methods. For brachial plexus block, the ultrasound-guided method particularly allows physicians to inject drug solutions directly into the painful nerves at the bedside.

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Part VI

Shoulder and Upper Extremity

Suprascapular Nerve Block

25

Yuko Yonekawa

25.1 Introduction

Suprascapular nerve block is used for pain in and around the shoulder joints. It is also a useful adjunctive therapy in exercise treatment because the suprascapular nerve has sensory and motor branches. The efficacy of the simple nerve block is increased when used in combination with other nerve blocks.

25.2 Anatomy

The suprascapular nerve starts from C5 to C6 and branches out from the superior trunk of the brachial plexus. It runs in the outward and posteromedial direction, dorsal to the venter inferior musculi omohyoidei with the suprascapular vessels, and branches out the superior articular branch before passing under the superior transverse scapular ligament at the scapular notch and entering into the supraspinous fossa. The superior articular branch runs outward at the base of the coracoid process, branches out into the periosteum and the coracoclavicular ligament, runs outward between the back of the coracoid process and the supraspinous muscle, and divides into a branch ending in the coracohumeral ligament and the superior capsule of the shoulder joint and another branch ending behind the subacromial bursa and the acromioclavicular capsule. The main trunk divides into a motor branch at the supraspinous muscle before dividing into the inferior articular branch. Both branches pass under the inferior transverse scapular ligament at the lateral margin of the base of the scapular spine and enter into the infraspinous fossa. Then the motor branch runs inward to the infraspinous muscle, and the inferior articular branch runs inferiorly to the back of the shoulder joint capsule.

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25.2.1 Indications

Scapulohumeral periarthritis, shoulder joint pain, omarthritis, infiltrating malignant tumor in the shoulder joint, and others.

25.3 Instruments and Drug Solutions, Procedures and Techniques

25.3.1 Landmark Method

The patient is placed in the sitting position. The physician stands behind the patient. The needle insertion site is where the gap is felt by the index finger when pinching the scapular spine and the clavicle with the thumb and the middle finger (Fig. 25.1). Insert a 6 cm 23 G Cattelan needle vertically

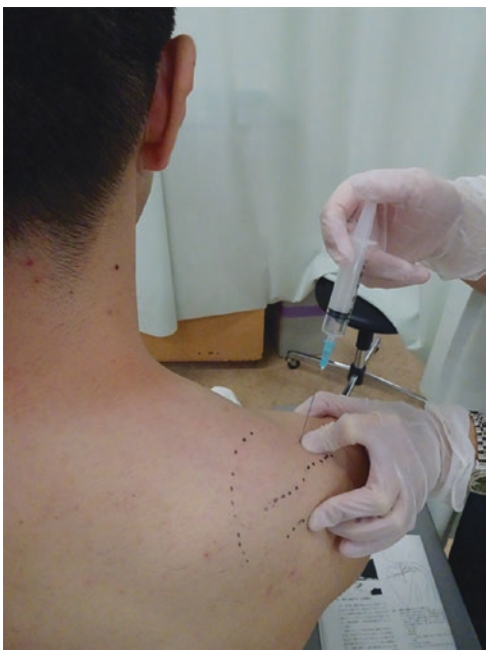

Fig. 25.1 The physician stands behind the patient. The needle insertion site is where the gap is felt by the index finger when pinching the scapular spine and the clavicle with the thumb and the middle finger

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4–5 cm deep. Inject 1% carbocaine 10 mL when the needle tip reaches the supraspinal bone.

25.3.2 Ultrasound-Guided Method

The patient is placed in the sitting position. The physician stands behind the patient. Place the ultrasound monitor in front, on the right. Place a linear probe sagittally in the center front of the shoulder blade to find the pleura at about 4 cm deep. Move the probe outward to confirm the position away from the lung. The probe should be parallel to the shoulder blade and the spine. Move the probe in the cephalad direction to find the suprascapular fossa. The supraspinous muscle will be found below the suprascapular fossa. Move the probe outward to find the scapular notch. The suprascapular nerve will be found as a hyperechoic mass under the transverse scapular ligament in the scapular notch. Insert a needle toward the nerve by using the parallel method.

Complications

Pneumothorax, hematoma, nerve damage, and toxic.

Dorsal Scapular Nerve Block (Landmark Method)

26

Kumiko Hida

26.1 Introduction

A dorsal scapular nerve block is performed for pain in the neck, shoulder, and interscapular region. This technique involves injecting a local anesthetic into trigger points (tender points, palpable nodules) located on the line of the dorsal scapular nerve.

26.2 Indications

A dorsal scapular nerve block is performed for pain in the neck, shoulder, and interscapular region.

Shoulder-arm-neck syndrome, cervical spondylosis, cervical disc herniation, cervical-spinal canal stenosis, posttraumatic cervical syndrome, periarthritis humeroscapularis.

26.3 Anatomy [1]

The dorsal scapular nerve, a dorsal branch of the brachial plexus, is derived mostly from C5. The nerve pierces the middle scalene muscle and travels in the posterior direction between the scalenus posterior muscle and the serratus posterior superior and levator scapulae muscles to innervate the rhomboid major and minor muscles and occasionally the levator scapulae muscles (Fig. 26.1). The nerve has purely motor function, serving the rhomboid muscles and, partially, the levator scapulae muscle.

26.4 Instruments and Drug Solutions

Needle: A 25G 25mm needle or A 27G 19 mm needle.

Local anesthetic: 5–10 mL of 1% lidocaine.

26.5 Procedures and Techniques [2, 3]

The procedures were performed with the patient in the sitting or supine position.

The needle was inserted perpendicular to the skin at the target points that were tender points or taut bands of the running portion of the dorsal scapular nerve. The needle was advanced into the muscle until a palpable or visible local twitch response was provoked. The lidocaine solution was injected and the needle was then retracted. Confirmation of the radiating pain is not always necessary. As a guide, insertion depth is 1.5–2.5 cm, and the solution volume is 0.5–2 mL at any single point.

26.6 Target Points

26.6.1 The Middle Scalene Muscle (Fig. 26.2)

Dorsal edge of the central position of the sternocleidomastoid muscle toward the unaffected side, patient in the supine position.

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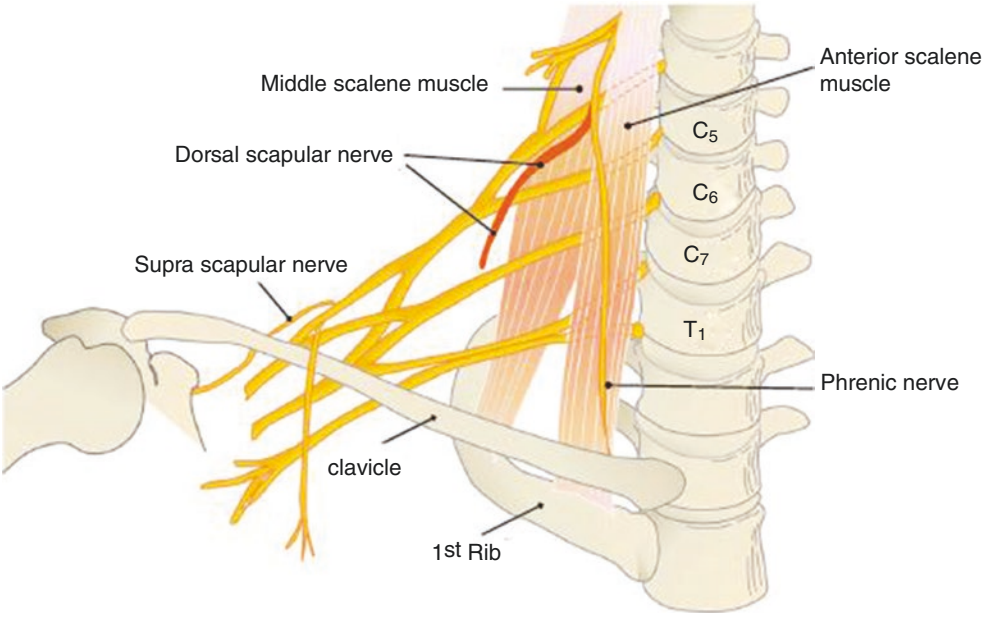

Fig. 26.1 Course of the dorsal scapular nerve

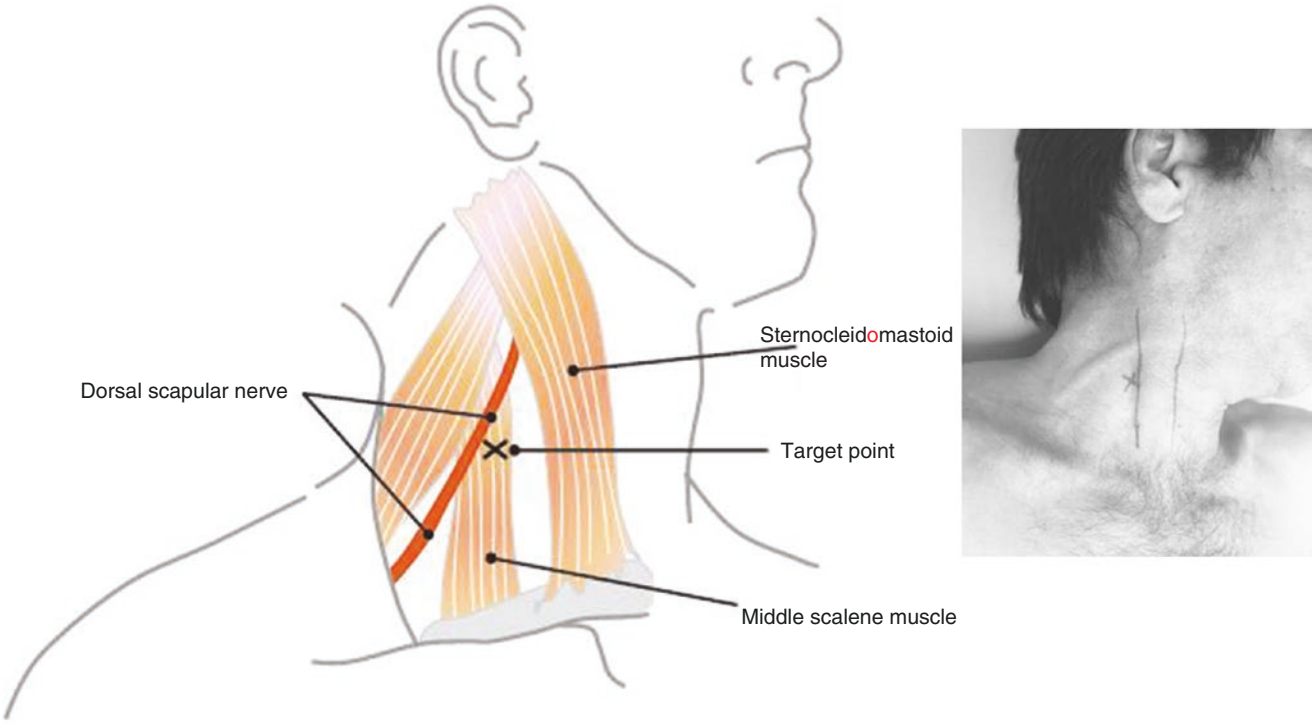

Fig. 26.2 Target point: the middle scalene muscle

26.6.2 The Levator Scapulae Muscle (Fig. 26.3)

Approximately 6 cm outside of the Th1,2 spinous process, patient in the sitting position.

26.6.3 The Rhomboid Muscle Minor (Fig. 26.3)

Sitting position, midpoint of the spinous process and medial margin of the middle scapula; patient in the sitting position.

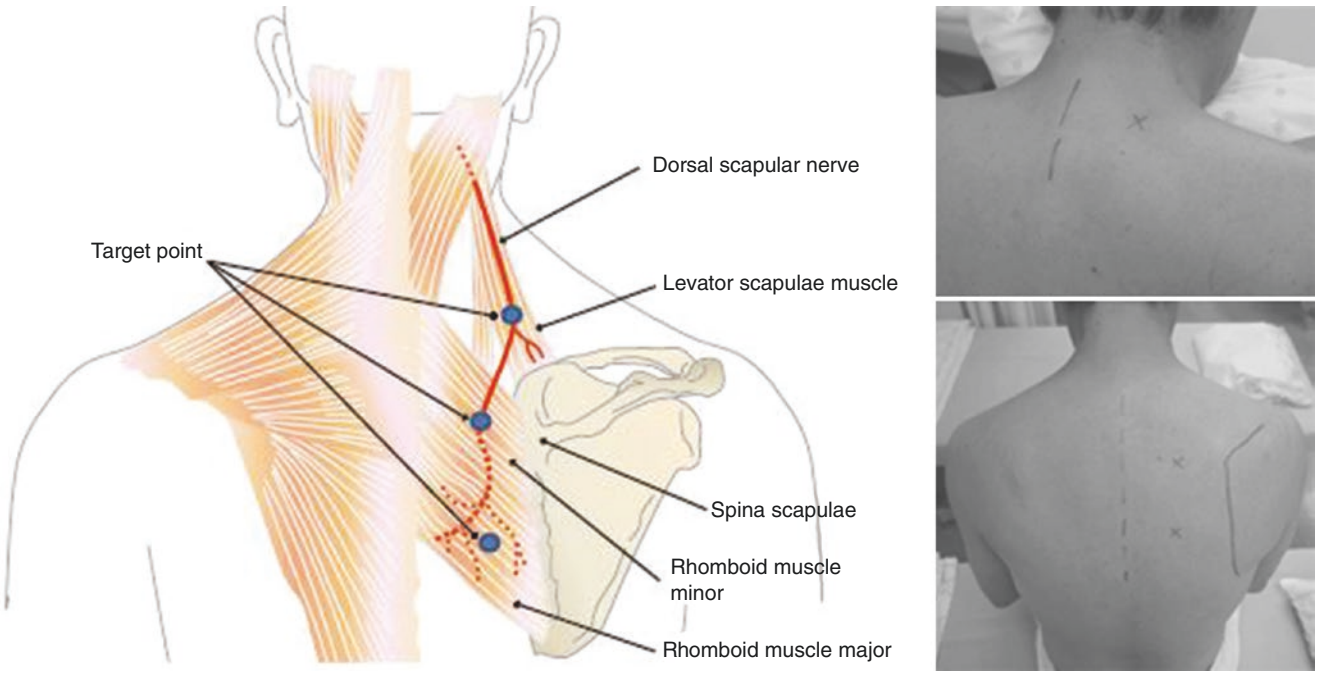

Fig. 26.3 Target point: the levator scapulae muscle and rhomboid muscle

26.6.4 The Rhomboid Muscle Major (Fig. 26.3)

Intermediate portion of the spinous process and the spina scapulae of the medial margin of the scapula, patient in the sitting position.

26.7 Complications

Nerve injury, pneumothorax, bleeding, cervical root block, cervical spinal block.

References

1. Haim H, Urban BJ. Dorsal scapular nerve block: Description of thchnique and report of a case. Anesthesiology. 1993;78:361–3.
2. Date H, Oseto K. Peripheral nerve block at the cervical/back area. 2nd ed. Pain Clinic Nerve Block. Tokyo, Igakushoin: Bunkichi Wakasugi; 2000. (in Japanese)
3. Fukuuchi K, Nakagawa M, Higa S. Dorsal scapular nerve block. Pain Clinic. 2011;32:S329–34. (in Japanese)

Axillary Nerve Block (Ultrasound-Guided Method)

27

Yasuyuki Shibata and Michael J. Barrington

27.1 Axillary Nerve Block

The axillary nerve can be blocked on the posterior surgical neck of the humerus where this nerve runs around together with the posterior humeral circumflex vessels (PCHV) (Fig. 27.1).

The deltoid is cut open to expose the teres minor and the axillary nerve. The right side of the image is the shoulder and the left is the arm. LoHTB, long head of triceps brachii; LaHTB, lateral head of triceps brachii; PCHA, posterior circumflex humeral artery; D, deltoid; Tm, teres minor

27.2 Indications

Surgical: shoulder surgery

Pain medicine: shoulder pain

27.3 Anatomy

The axillary nerve (C5, C6) is a branch of the posterior cord of the brachial plexus. This nerve provides motor innervation of the deltoid, the teres minor, and the long head of the triceps brachii. In addition, it provides sensory innervations of the shoulder joint and the skin covering the inferior region of the deltoid muscle on the arm.

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27.4 Instruments and Drug Solutions

Needle: 5 cm, 21 guage insulated needle

Probe: a linear 38 mm, high-frequency probe (6–13 MHz)

Local anesthetic solutions: 5–10 mL of ropivacaine 0.2–0.5% or levobupivacaine 0.2–0.5% for anesthesia and pain medicine

27.5 Procedures and Technique

The patient is placed in a sitting position with the arm to be blocked adducted or in a lateral decubitus position with the side to be blocked uppermost [1–3].

1. Place a linear transducer on the posterior aspect of the arm to visualize the humeral shaft longitudinally.
2. Slide the transducer cephalad following the humeral shaft until the humeral head comes to the image. The transition part between the humeral head and shaft is the surgical neck of the humerus.
3. Identify the axillary nerve and the PCHV on the surgical neck (Fig. 27.2).
4. Insert a needle from the cranial end of the probe, and place the tip of the needle just cranial to the PCHV.
5. Once a motor response of the deltoid is elicited at a current of 0.5 mA, local anesthetic is injected after a negative aspiration test.

27.6 Complications and Side Effects

- Patients who have received an axillary nerve block cannot abduct their shoulder because of the weakness of the deltoid.
- There is a risk of the PCHV injury.

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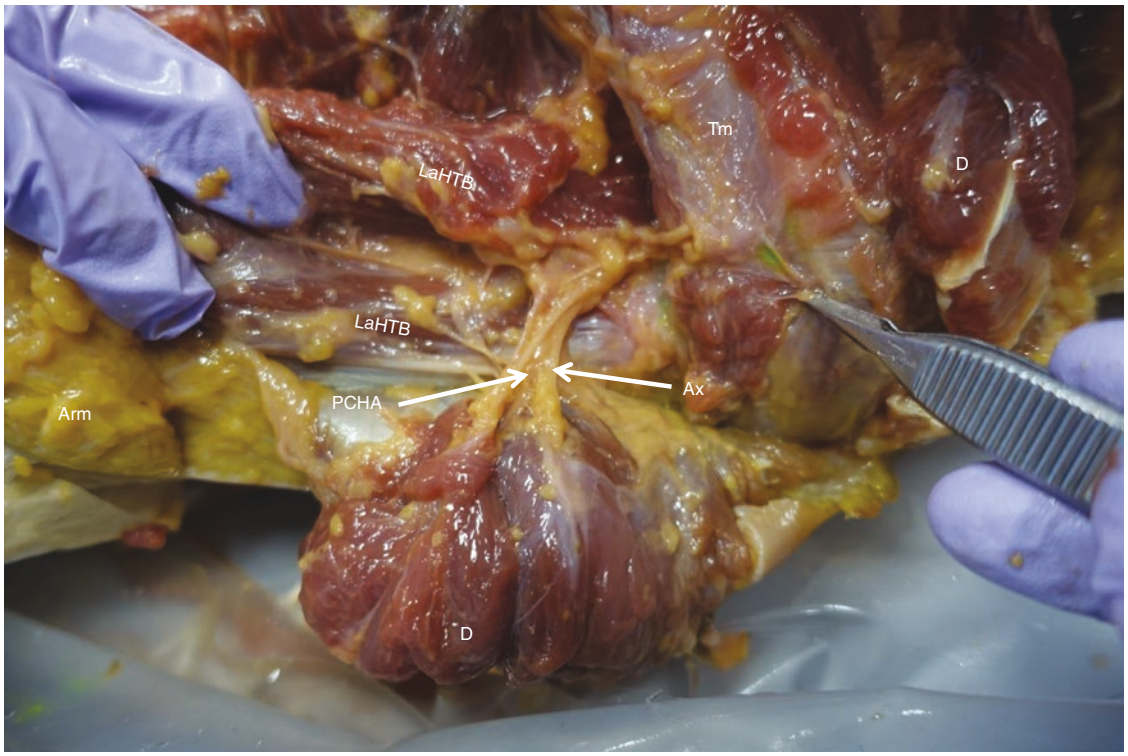

Fig. 27.1 Posterior view of the right shoulder

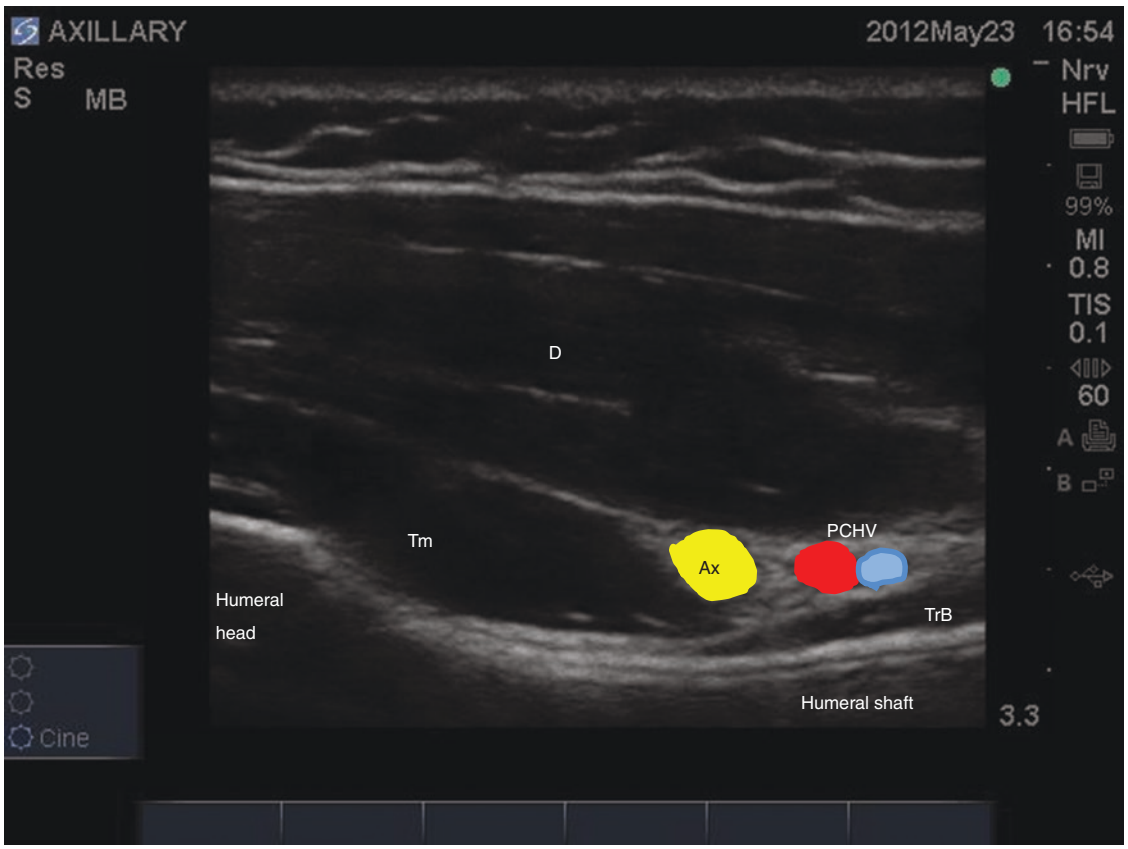

Fig. 27.2 Ultrasound image of the posterior surgical neck. *Ax* axillary nerve, *D* deltoid, *PCHV* posterior circumflex humeral vessels, *Tm* teres minor, *TrB* triceps brachii

References

1. Rothe C, Asghar S, Andersen HL, Christensen JK, Lange KH. Ultrasound-guided block of the axillary nerve: a volunteer study of a new method. Acta Anaesthesiol Scand. 2011;55:565–70.
2. Kim YA, Yoon KB, Kwon TD, Kim DH, Yoon DM. Evaluation of anatomic landmarks for axillary nerve block in the quadrilateral space. Acta Anaesthesiol Scand. 2014;58:567–71.
3. Rothe C, Lund J, Jenstrup MT, Lundstrom LH, Lange KH. Ultrasound-guided block of the axillary nerve: a case series of potential clinical applications. Acta Anaesthesiol Scand. 2012;56:926–30.

Peripheral Nerve Block of Upper Limb

28

Ryohta Nishiyama and Hiroyuki Uchino

28.1 Introduction

28.1.1 Peripheral Nerve Block of Upper Limb

The peripheral nerves of the upper limb are the radial, the median, and the ulnar nerves that originate from the brachial plexus. These nerves are sometimes blocked individually based on the dermatome that corresponds with the pain anatomically [1].

28.2 Indications

1. Adaptations are treatment of pain disease of each nerve.
2. Differential diagnosis of nerves that causes pain.
3. Treatment of carpal tunnel syndrome.
4. Treatment of entrapment neuritis.
5. Rescue block of the brachial plexus block.
6. Surgery of the hand.
7. Treatment of pain of finger ulcers and upper limb peripheral portion.

28.3 Anatomy

The brachial plexus (plexus brachialis) is a somatic nerve plexus formed by intercommunications among the ventral rami (roots) of the lower four cervical nerves (C5–C8) and the first thoracic nerve (T1). The plexus, depicted in the images below, is responsible for the motor innervation of all of the muscles of the upper extremity, with the exception of the trapezius and levator scapula [1]. The brachial plexus, which is composed between the C5 and Th1 spinal nerves, differentiates five endings nerves near the axillary artery. The radial nerve is winding the humerus in a spiral (radial nerve groove), down between triceps and humerus, and divides into shallow branch and deep branch in the elbow. The median nerve accompanies along the outer surface of brachial artery, crosses on the inside before reaching the elbow joint, and falls within the flexor retinaculum descends in the connective tissue of the superficial flexor after the surface for forearm. The ulnar nerve descends the inside biceps groove, leading to the forearm through the ulnar nerve groove in the elbow, and accompanies along the inside of ulnar artery (Fig. 28.1a). The structure view of a cross section at the upper arm-forearm is shown in Fig. 28.1b, c.

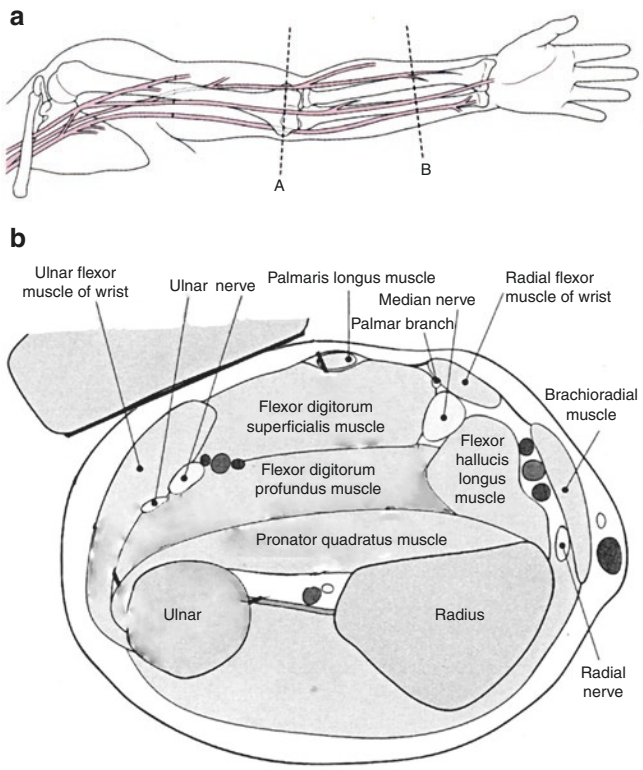

Fig. 28.1 (**a**) Run of peripheral nerve in the upper limb (radial, median, ulnar nerve). Broken line A: (Panel b) is cross-sectional view on this line. Broken line B: (Panel b) is cross-sectional view on this line. (**b**) Sectional view at elbow joint level. (**c**) Sectional view at the forearm distal third level

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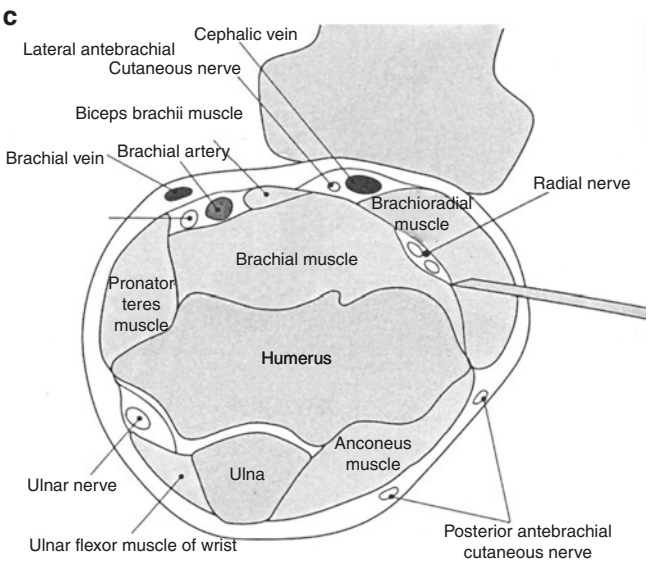

Fig. 28.1 (continued)

28.4 Instruments and Drug Solutions

- High-frequency (10–15 MHz), hockey stick-type linear probe
- 25G × 25 mm needle or 27G 19 mm, 10 mL syringe (0.75% ^^ropivacaine 5 mL + 0.5% lidocaine 5 mL)

28.5 Procedures and Techniques

28.5.1 Position and Orientation of Probe and Depiction and Location of Puncture

Extend the upper limbs and rotate the upper arm and forearm to visualize the target nerve. Draw the cross-sectional target nerve (short axis). The ultrasonic probe and a linear probe (narrow footprint, 10–15 MHz) can make close contact to the skin surface [2, 3].

The optimal sites for each nerve block are shown below.

The radial nerve: it locates in front of the elbow (Fig. 28.1b). By frontal scanning of the linear probe, we can depict them below the fascia of brachioradialis. Shallow and deep branches of radial nerve are possible to block.

The median nerve and the ulnar nerve: 5 cm range before and after the center of forearm (Fig. 28.1b). By frontal scanning of the linear probe, it exists between the flexor digitorum superficialis muscle and the flexor digitorum profundus muscle. It is possible to block two nerves simultaneously by a single approach.

28.5.2 Ultrasonic Neuroimaging

Peripheral nerves change the formation of the cross section according to the structure of surroundings such as accompanying muscles and blood vessels. The peripheral nerve at the upper arm and forearm is depicted as a spindle-like and is wrapped by a high echogenic nerve sheath. The internal structure shows characteristic image of the low echogenicity and honeycomb shape. If it is difficult to distinguish it from a blood vessel or a tendon, it is able to distinguish by compression with a probe or presence of blood flow by color Doppler.

28.5.3 Ultrasonic-Guided Needle Insertion

1. Prior to insert, image evaluation should be performed with ultrasound-guided method waves to determine the insertion portion. Direction of the needle insertion is advanced parallel to the echo beam, and this method is able to draw the entire needle (in-plane needle approach) (Fig. 28.2). Parallel method needs the long penetration distance, and obese patients need long needles. On the other hand, the approach distance of the needle is the shortest in the method that advances perpendicularly to the echo beam (out-of-plane needle approach). Because it is difficult to confirm the position of the tip, there is a possibility of puncturing nerves and blood vessels.
2. After skin disinfection, wrap the probe with a sterilized cover. By moistening with sterile water or preventing entry of air between the probe and the skin to maintain the quality of the ultrasonic image.

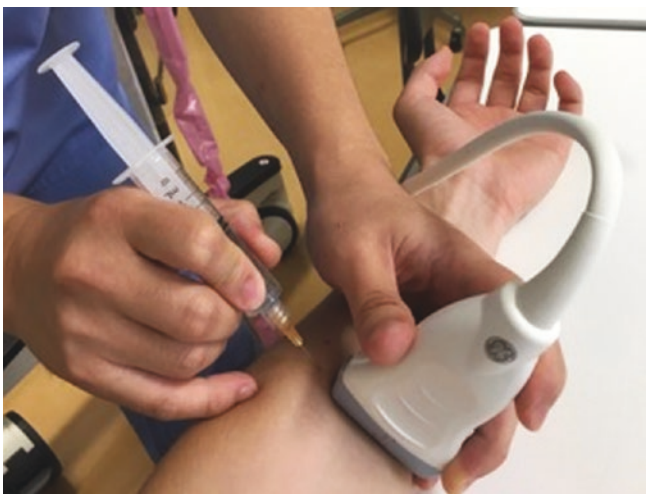

Fig. 28.2 Ulnar nerve block procedure at the left forearm. Use a linear probe. The probe is perpendicular to the running of the nerve (short axis image), and the block needle is inserted parallel to the probe (in-plane needle approach). For the actual procedure, the probe is covered with the sterile cover

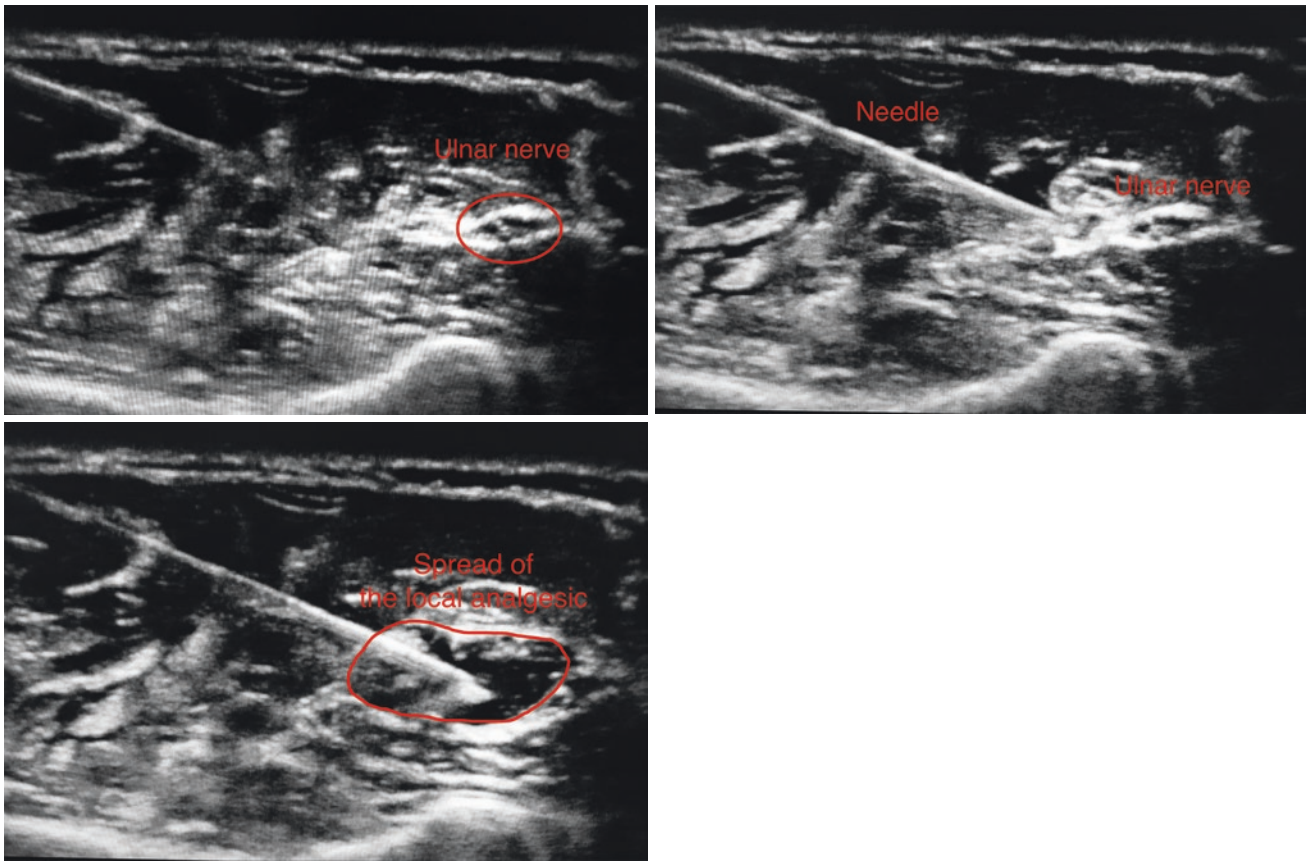

Fig. 28.3 Ultrasound image of the ulnar nerve block (spread of the local analgesic). Slow infusion of the local anesthetics is able to confirm the spread of low echo region around the nerve. If the nerve is wrapped with the liquid, the drawing of the neural structure becomes more clear

3. Advance the needle tip close to the nerve slowly while making sure not to lose sight of both the target nerve when the block needle is drawn subcutaneously. If the insertion angle is close to parallel to the skin surface, the needle tip can be easily visualized.
4. If the local analgesic can infiltrate to the nerve surroundings, the effect is certain, and the time of drug action is quick (Fig. 28.3). As an effective method, the tip of the needle is guided to the gap of the fascia through which the nerve runs, and inject local analgesics little by little while viewing the ultrasonic image. At this time, if the direction of the bevel of the needle is faced toward the nerve side, it is easy to adjust the direction.

28.6 Complications

28.6.1 Puncture of Artery

Need to control the tip of the needle to avoid arteries accompanying the nerve. In case of hematoma (under the fascia, observable as a low-absorbing area expanding around the blood vessel), resume operation after the compression. Patients with a bleeding tendency may have peripheral neuropathy and hematoma, so we need to perform careful procedure. In addition, even if there is no vascular puncture on the image, always check the absence of backflow by aspiration to prevent systemic toxicity of local anesthetic injection.

28.6.2 Injury of the Nerve

After inducing the tip of the needle into the tissue around the nerve by ultrasonic image, inject the local analgesic. It is not necessary to touch the block needle into the nerve directly. However, squeezing surrounding tissue by injection of local analgesic may complain of radiation pain. In this case, pull out the tip of needle slightly, and inject the local analgesic. If nerve injuries are suspected, inject local analgesics with a steroid or administer nonsteroidal anti-inflammatory drugs.

28.6.3 Infection

Prevention of infection is necessary, because the tunnel of subcutaneous tissue is able to be a trigger. Wrap the probe with a sterile cover and puncture with wearing a sterile gloves. It is always necessary to disinfect before and after puncture. If it is judged that there is a possibility of infection after puncture, consideration of antibiotic administration is also necessary.

References

1. Date H, Ohseto K. Upper limb peripheral nerve block: pain clinic—nerve block. Tokyo: Igaku-Shoin Ltd; 2000. p. 106–16. (in Japanese)
2. Komatsu T, Satou Y, Seo N, Hirota K. Ultrasound guided area anesthesia, kokuseido, 2007. (in Japanese).
3. McCartney CJ, Xu D, Cnstantinescu C, et al. Ultrasound examination of peripheral nerves in the forearm. Reg Anesth Pain Med. 2007;32:434–9.

Shoulder

29

Yosuke Usui

29.1 Introduction

1. Glenohumeral joint block is a procedure in which a local anesthetic and hyaluronic acid are injected into the joint to treat shoulder pain and its range of motion limitations.
2. When the drug solution injected into the glenohumeral joint using a posterior approach does not flow to the anterior part of the capsule, a diagnosis of stenosis of the glenohumeral joint capsule is made. When the drug solution flows into the subacromial or subcoracoid bursa, a diagnosis of a complete rotator cuff tear is made.
3. When pain develops in the acromion only when the glenohumeral joint is placed in the position of abduction with internal rotation, drug injection into the subacromial bursa is effective.

29.2 Indications

1. Injection into the glenohumeral joint: frozen shoulder, complete rotation cuff tears
2. Injection into the subacromial bursa: subacromial bursitis

29.3 Anatomy (Fig. 29.1)

1. The shoulder anatomy is shown as a four-layer structure.
2. The first layer is the glenohumeral joint capsule (first shoulder joint); the second layer consists of the supraspinatus, infraspinatus, teres minor, and subscapularis muscles (rotator cuff); the third layer consists of the subacromial, subcoracoid, and subdeltoid bursae (second shoulder joint); and the fourth layer is the deltoid muscle.

29.4 Instruments and Drug Solutions

1. For glenohumeral joint capsule injection: 22G Cattelan needle
2. For subacromial bursa injection: 21G short needle
3. For each injection: mepivacaine (maximum dose: 0.25%, 20 mL) and hyaluronic acid

29.5 Procedures and Techniques

29.5.1 Glenohumeral Joint Injection

29.5.1.1 Landmark Method: Anterior Approach—Supine Position

1. The needle is inserted to the depressed part on the medial side of the humeral head and 1 fingerbreadth lateral and caudal to the coracoid.
2. When the needle tip is at the coracoacromial ligament, resistance is felt.
3. The needle tip is advanced, and when it reaches the inside of the joint capsule, the resistance disappears.

29.5.1.2 X-Ray Fluoroscopy-Guided Method: Anterior Approach—Supine Position

1. The needle is advanced toward the space between the humeral head and glenoid cavity, avoiding the coracoid.
2. When the needle tip reaches the inside of the joint capsule, resistance disappears.
3. The location of the needle tip is confirmed by contrast medium injection. Subsequently, the drug solution is injected.
4. When necessary, shoulder pumping is performed.

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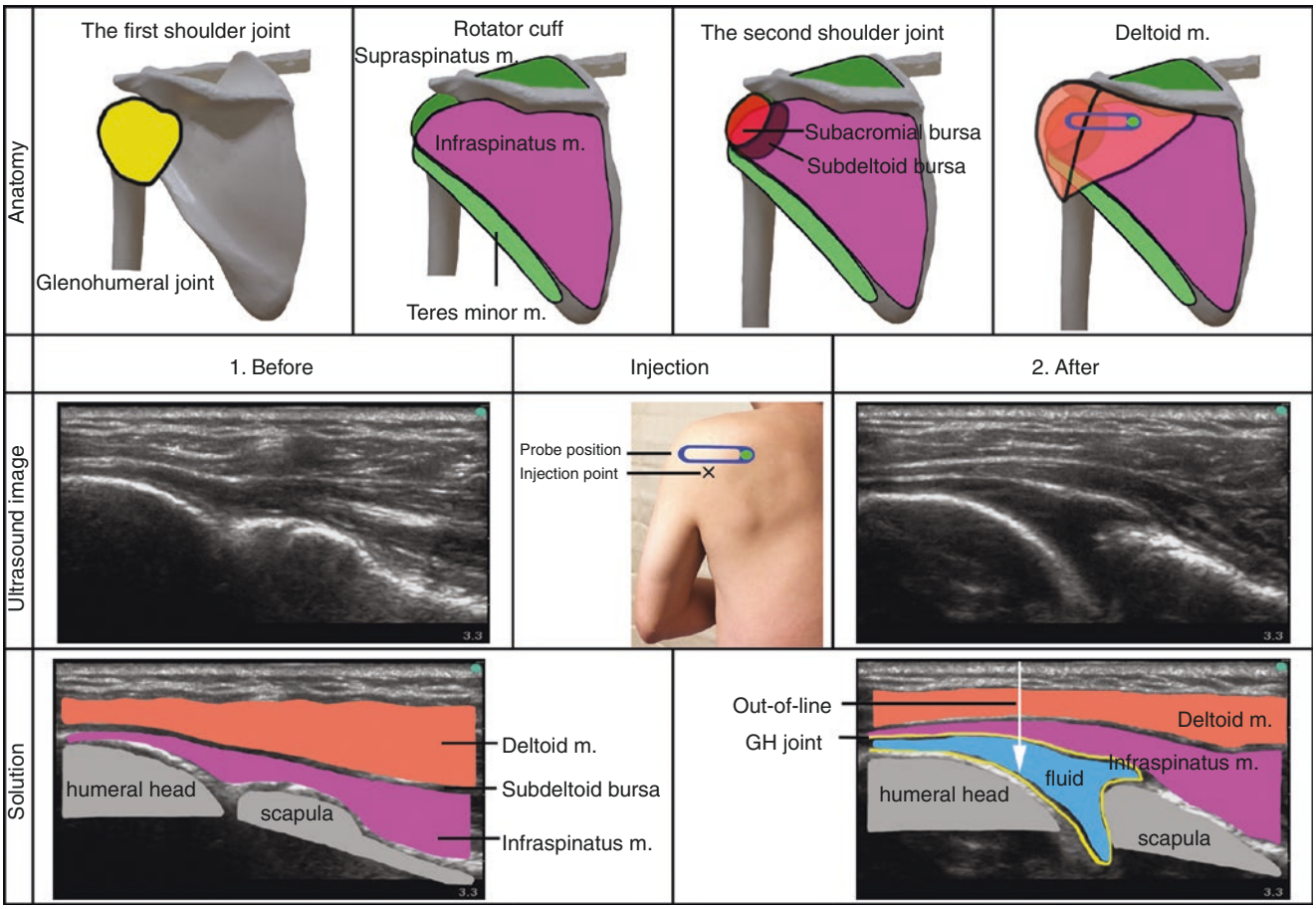

Fig. 29.1 Glenohumeral joint injection. (1) The probe is placed parallel to the caudal side of the scapular spine, allowing the visualization of the humeral head and infraspinous fossa. (2) When the needle, which was advanced using the out-of-plane approach, penetrates the deltoid and infraspinatus muscles, entering the joint space, resistance disappears. (3) When the drug solution volume exceeds 10 mL, the joint capsule is distended

29.5.1.3 Ultrasound-Guided Method: Posterior Approach—Sitting Position (Fig. 29.1)

1. The shoulder joint is internally rotated, and the probe is placed parallel to the caudal side of the scapular spine using a posterior approach, allowing the visualization of the humeral head and infraspinous fossa. When the needle advanced using the out-of-plane approach penetrates the deltoid and infraspinatus muscles, reaching the inside of the joint capsule, resistance disappears. When the drug solution volume exceeds 10 mL, the joint capsule is distended.

29.5.2 Subacromial Bursa Injection

29.5.2.1 Landmark Method: Lateral Approach—Sitting Position

1. The shoulder joint is extended, and the acromion is touched.
2. The needle is inserted inferior to the acromion.
3. When the needle tip is at the deltoid muscle, resistance is felt.
4. The needle tip is advanced with resistance, and when it reaches the inside of the subacromial bursa, the resistance disappears.

29.5.2.2 Ultrasound-Guided Method: Lateral Approach—Sitting Position (Fig. 29.2)

1. The shoulder joint is extended, and the probe is placed between the acromion and greater tuberosity, allowing the visualization of the deltoid and supraspinatus muscles.
2. When the needle tip advanced using the in-plane approach reaches the inside of the subacromial bursa between the deltoid and supraspinatus muscles, resistance disappears.
3. Adhesions of the bursa were dissected using the injection pressure.

29.6 Complications

Bleeding, infection, nerve damage, and pain enhancement

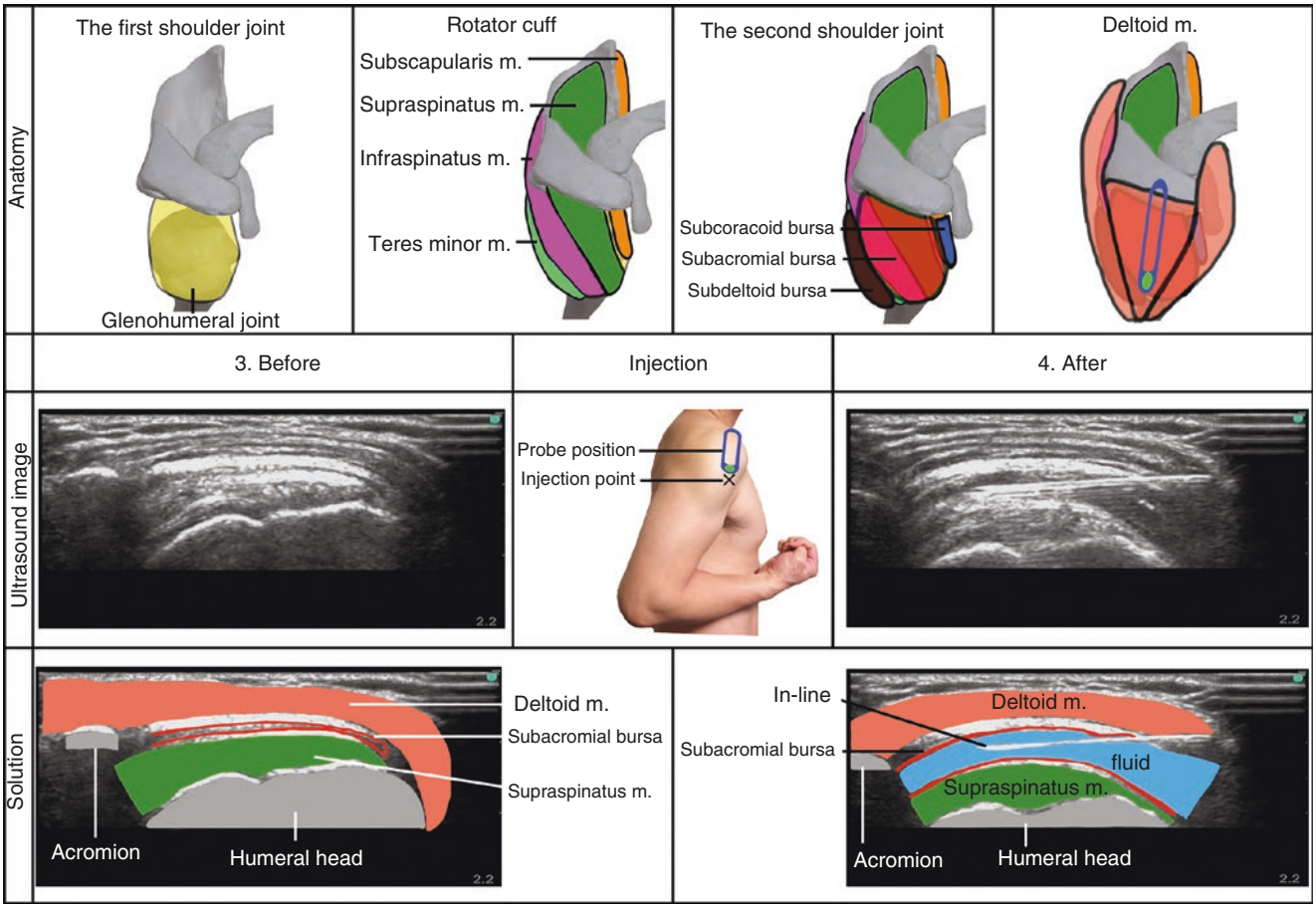

Fig. 29.2 Subacromial bursa injection. (1) The probe is placed between the acromion and greater tuberosity, allowing the visualization of the deltoid and supraspinatus muscles. (2) When the needle tip advanced using the in-plane approach reaches the inside of the subacromial bursa between the deltoid and supraspinatus muscles, resistance disappears. (3) Adhesions of the bursa were dissected using the injection pressure

Shoulder Joint Block and Pumping (X-Ray-Guided)

30

Hiroaki Yamagami

30.1 Introduction

30.1.1 What Is Shoulder Joint Pumping?

Shoulder joint pumping is a procedure to intra-articularly repeat irrigation/aspiration by injecting contrast agent, local anesthetic, and saline into the joint.

30.2 Indication

Periarthritis scapulohumeralis, subacromial bursitis, rotator cuff (partial) tear, calcific rotator cuff tendinitis, bicipital tenosynovitis, contracture of the joint of the shoulder region, and impingement syndrome. Shoulder joint pumping is indicated in patients with a long period of limited range of motion and with no pain relief even if the shoulder joint block or the trigger point injection was performed.

30.3 Anatomy (Fig. 30.1)

Two types of shoulder joints are related to the shoulder joint block. The first is the glenohumeral joint, which is the shoulder joint in a narrow sense, and the articular surface is unified with the joint capsule. The joint capsule starts from the synovial cavity of the acetabular in the anterior and starts from the acetabular lip in the posterior with both reaching the same anatomical neck of the humerus. The inner surface is covered by the synovium, and the outer surface is unified with the rotator cuff. The second is called the second shoulder joint but is a functional joint configuring the lateral side of the glenohumeral joint. It is the area where the rotator cuff and the greater tubercle pass through, and the subacromial bursa allows a smooth, gliding movement. The disorder that causes obstruction in the second shoulder joint is called impingement syndrome.

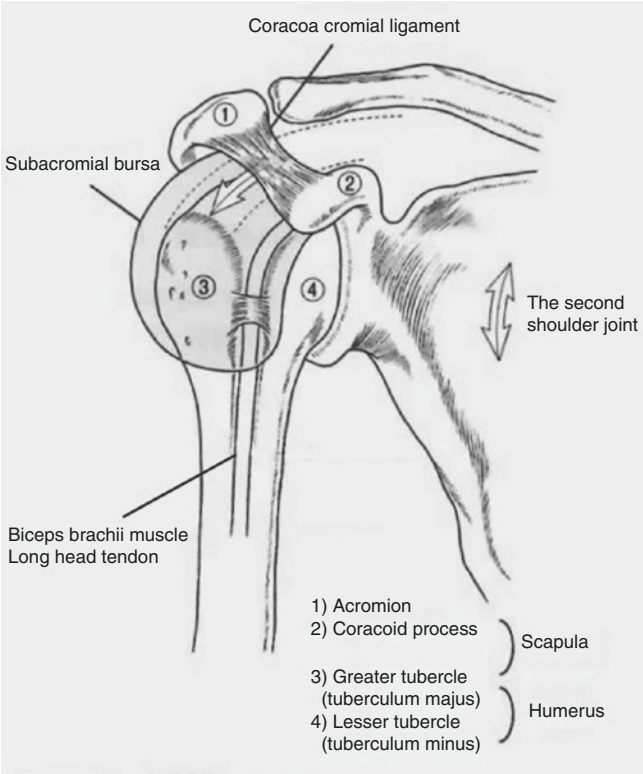

Fig. 30.1 Anatomy of the shoulder joint

30.4 Instruments and Drug Solutions

(i) 5 mL syringe (1% lidocaine 5 mL)
- 5 mL syringe (saline 5 mL)
- 2.5 mL syringe (iohexol 2.5 mL) (2 syringes at the time of shoulder joint pumping)
- Hyaluronic acid syringe
- 2.5 mL syringe (aqueous dexamethasone 2 mg + 1% lidocaine 2 mL)

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(ii) 23–25 G × 6 cm disposable needle
(iii) Disinfection set (extension tube (at the time of the shoulder joint pumping))
- Practice of procedure
- Under X-ray fluoroscopy

30.5 Procedures and Technique

30.5.1 Posture and Photography

A patient should be in the supine position, and a pillow is not necessarily required. Press the upper extremities onto the trunk, and laterally rotate the upper arms to expand the joint space (make the palms face the top) (Fig. 30.2).

Fluoroscopic point: The X-ray fluoroscopic direction should be vertical; slightly tilt the X-ray tube to the cranial side in order to make the interval between the acromion and the humerus wide.

Photographic point: At the time of the contrast radiography of the shoulder joint capsule, shoot the frontal view in position of medial rotation, lateral rotation, and elevation.

30.5.2 Puncture and Drug Injection

Under the clavicle shadow, the puncture site should be determined by hitting forceps onto the site where the shadows of the acetabular and the epiphysis cross (Fig. 30.3). While locally anesthetizing (1–2 mL) the joint skin and the subcutaneous using a 23–25G × 6 cm needle, puncture intra-articularly. Aiming at the area that looks like a triangle surrounded by the upper acetabular and the upper epiphysis helps you perform the procedure easily. Feeling resistance from the subscapularis muscle tendon and the joint capsule, keep advancing the nerve block needle until it enters the shoulder joint capsule. For difficult cases, you may hit the humeral head. Contrast with 2.5–5 mL of iohexol and waste the contrast agent after shooting, if possible. Only for the shoulder joint block, you can perform with a 23–25 G × 6 cm needle. At this time, inject drug solution (hyaluronic acid or 2 mL of 1% lidocaine), and complete this procedure (Fig. 30.4) [1].

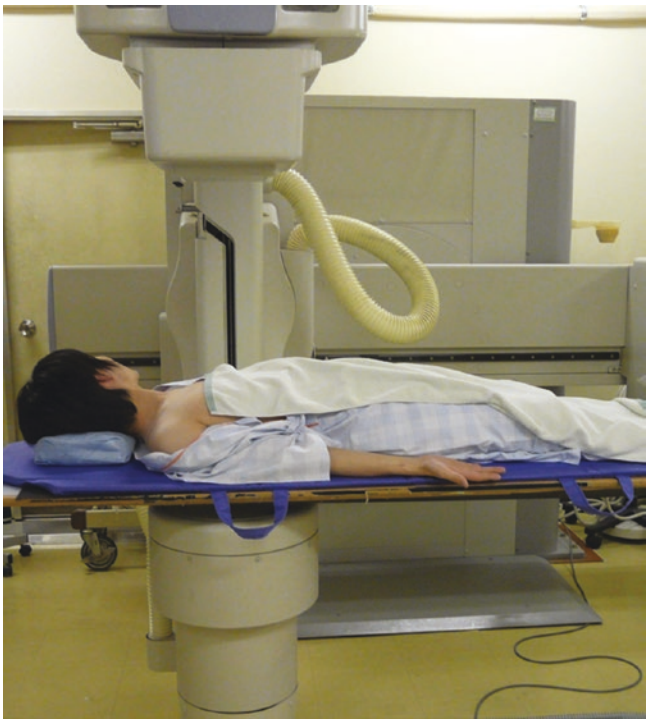

Fig. 30.2 Posture and X-ray fluoroscopic direction

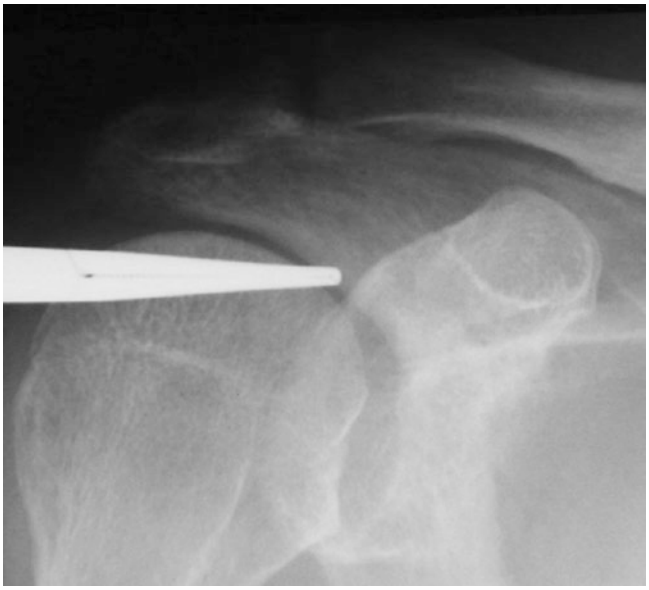

Fig. 30.3 Puncture site at the time of shoulder joint imaging

Inject 10–15 mL of saline (or 0.5% lidocaine). For shoulder joint pumping, use a large needle 23G or larger because higher injection pressure works more effectively. Connect an extension tube to the needle, and repeat infusion/wasting 3–5 times (Fig. 30.5). When the joint capsule bursts, resulting in low resistance no matter how much you inject, the patient should not be indicated for pumping.

For patients complaining of pain caused by high infusion resistance, combine the brachial plexus block with the C4–C5 nerve root block. After pumping, the range of motion improves passively and automatically, so perform abduction, lateral rotation, flexion, and so on. For the patient where improvement of the range of motion is small, perform manipulation. Perform the suprascapular nerve block, the axillary nerve block, the brachial plexus block, and the subacromial bursa block, and then pas-

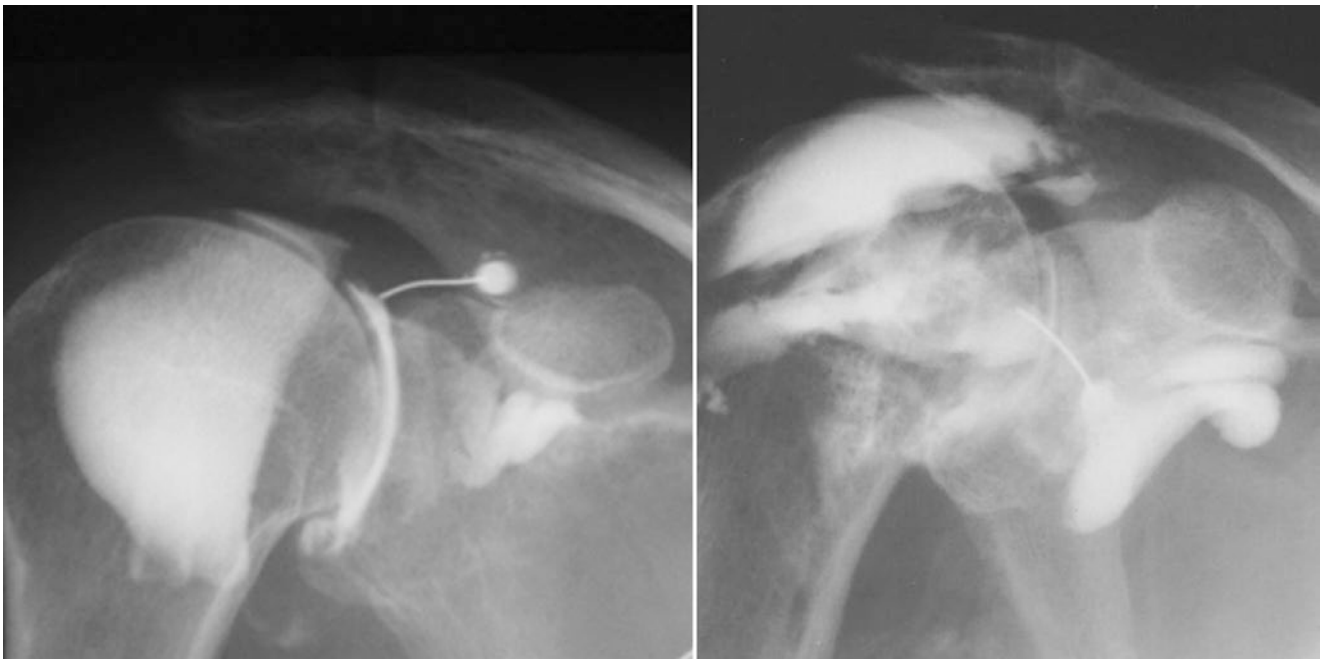

Fig. 30.4 Shoulder joint imaging (glenohumeral joint). (Left) Normal shoulder joint imaging. (Right) Shoulder joint imaging of rotator cuff tear

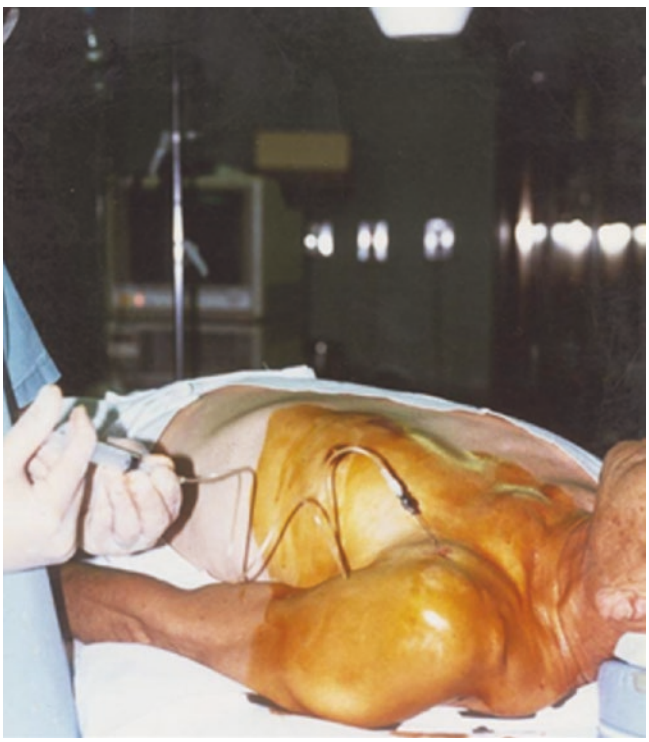

Fig. 30.5 Practice of shoulder joint pumping

sively perform flexion/abduction of the shoulder joint several times after approximately 10 min. Finally, inject the drug solution and complete the procedure.

30.6 Complications

Infection prophylaxis is important. Adequate disinfection of the operative field and intraoperative thorough cleaning are necessary. For patients complicated by compromised disorders, such as diabetes, perform the preoperative antibiotic regimen.

Pain: When articular internal pressure increases, the patient may complain of severe pain at infusion. Combine the intravenous infusion with a brachial plexus block and an epidural block with analgesics.

Reference

1. Yamagami H, Shiomi Y. Shoulder joint block and pumping. In: Ohseto K, editor. Nerve block method under fluoroscopy. Tokyo: Igaku-shoin; 2009. p. 163–5. (in Japanese).

31 Radiofrequency Thermocoagulation of Shoulder Articular Branches (X-Ray-Guided)

Hiroaki Yamagami and Yukiyo Shiomi

31.1 Introduction

What is radiofrequency thermocoagulation of the articular branches of the shoulder?

Radiofrequency thermocoagulation of the articular branches of the shoulder is a procedure that can relieve pain for long time.

31.2 Indications

This procedure is indicated for pain caused by prolonged periarthritis scapulohumeralis and partial rotator cuff injury, as well as for refractory omarthritis on which the trigger-point injection, intra-articular injection, and joint pumping have only a transient effect, recurring immediately.

31.3 Anatomy (Figs. 31.1 and 31.2)

The articular capsule of the shoulder is predominantly innervated by the suprascapular nerve for the upper anterior surface and the upper posterior surface and by the axillary nerve for the lower anterior surface and the lower posterior surface. The suprascapular nerve arises from the superior trunk of the brachial plexus. It reaches the superior border of the scapula from the anterior surface and passes the scapular notch to reach the supraspinous fossa. There, it ramifies the muscular branch into the supraspinatus muscle and the articular branch into the upper shoulder joint, the anterior part. Furthermore, the suprascapular nerve runs over the spine of the scapula into the infraspinous fossa. There, it ramifies the muscular branch into the infraspinatus muscle, and the articular branch into the posterior surface of the shoulder joint. It runs with the posterior humeral circumflex artery, passing the anterior part of the subscapularis muscle, and ramifies the articular branch into the anterior surface of the shoulder joint. From there, it enters

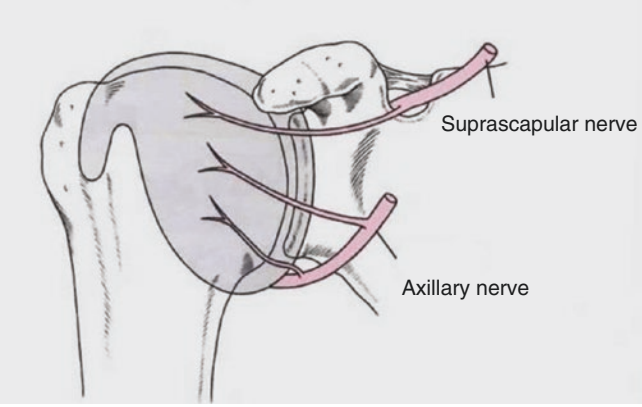

Fig. 31.1 Anterior surface innervation in the right shoulder joint

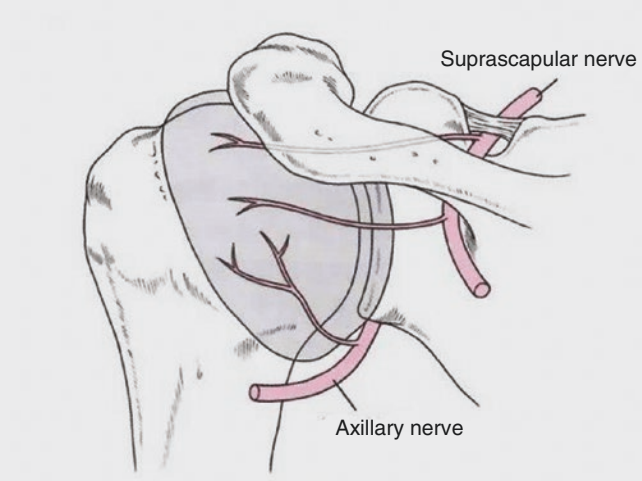

Fig. 31.2 Posterior surface innervation in the right shoulder joint

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the square cavity (cavity surrounded by the teres minor muscle at the inferior border for the superior side, the humeral cervix for the lateral side, the long head of the triceps brachii muscle for the medial side, and the teres major muscle superior border for the inferior side) and ramifies the articular branch into the shoulder joint posterior surface in the square cavity. Moreover, it divides into the deep branch and the superficial branch. The superficial branch provides the muscular branch into the teres minor muscle, which becomes the upper lateral cutaneous nerve in the periphery. The deep branch innervates the deltoid muscle. In the articular capsule of the shoulder, the subscapular nerve is distributed over the joint anterior surface, as well as the branch of the lateral pectoral nerve on the superior surface. It is common for every articular branch to run on the glenoid fossa peripheral labium ossis.

31.4 Instruments and Drug Solutions

Needle: 25G 2.5 cm needle +5 mL syringe (1% lidocaine for local anesthesia), 22G 9.7 cm (exposed tip 4 mm) Sluijter needle
Syringe: 2.5 mL syringe (lidocaine), 5 mL syringe
Agents: 0.5–2% lidocaine
Radiofrequency thermocoagulation set

31.5 Procedures and Techniques

For desensitization of the anterior surface of the shoulder joint, perform in the supine position. For desensitization of the posterior surface, perform in the prone position. A patient should be in a slightly oblique presentation to adjust the articular surface of the shoulder joint.

31.5.1 Frontal Approach

A patient should be in the supine position, and puncture from the lower coracoid process. On the lateral side of the upper acetabular joint space on the coracoid process base, search for the area where recurrent pain is reported by stimulating at approximately 50 Hz and 0.5 V. Visualize the site where recurrent pain was reported, and confirm that the site is not a blood vessel or in the joint capsule. Then inject 0.5 mL of 1–2% lidocaine, and perform the radiofrequency thermocoagulation at 80–90 °C [1, 2].

31.5.2 Posterior Approach

A patient should be in the prone position, and puncture from the posterior. On the lateral side of the upper acetabular joint space, search for the area where recurrent pain is reported by stimulating at approximately 50 Hz and 0.5 V. Visualize the site where recurrent pain was reported, and confirm that the site is not a blood vessel or in the joint capsule. The subsequent procedure is similar to the above (Figs. 31.3 and 31.4) [1, 2].

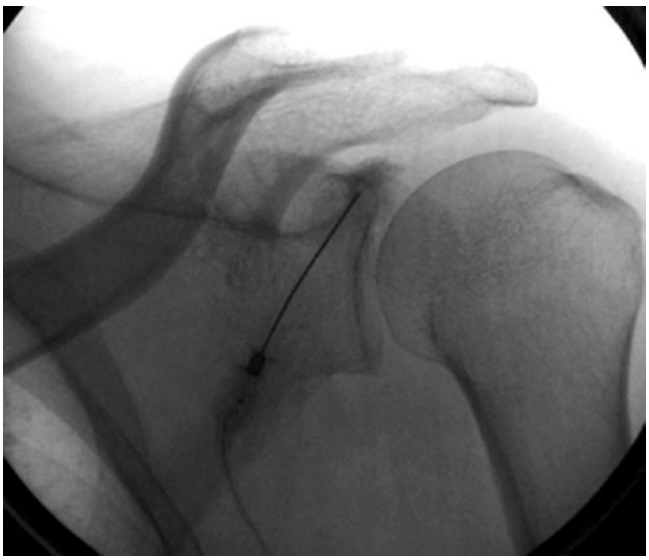

Fig. 31.3 X-ray photograph of the radiofrequency thermocoagulation of the articular branch of the right shoulder (posterior approach)

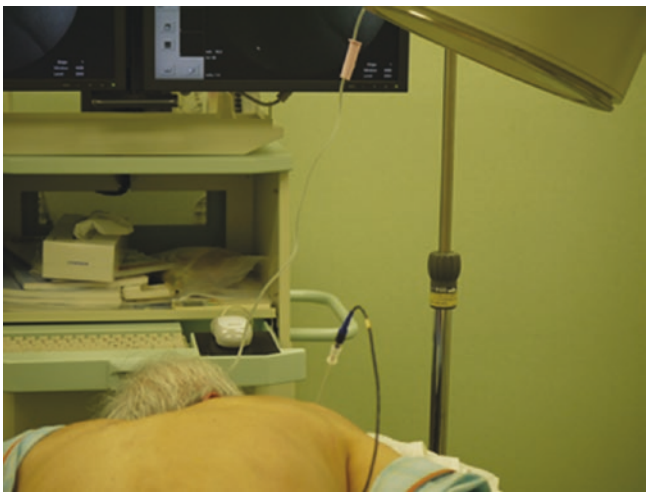

Fig. 31.4 Practice of the radiofrequency thermocoagulation of the articular branch of the right shoulder (posterior approach)

31.6 Complications

Radiofrequency thermocoagulation of the articular branches of the shoulder has few risks of causing sensory disturbance and muscle weakness because it is performed for the peripheral articular branches. In addition, arthresthesia is thought to be multi-innervated by multiple articular branches. Thus, even if the thermocoagulation is performed on a single branch, it has little possibility of causing a Charcot joint. Therefore, we consider radiofrequency thermocoagulation of the articular branches of the shoulder as a relatively safe procedure. However, acupuncture-site pain and possible infection remain as a risk.

References

1. Yamagami H, Fukushima T, Yanaidani F. Radiofrequency thermocoagulation for refractory omarthralgia. Pain Clinic. 2002;23: 969–74. (in Japanese)
2. Ohseto K. Radiofrequency thermocoagulation of peripheral nerve. In: Wakasugi B, editor. Pain clinic—nerve block method. 2nd ed. Tokyo: Igaku-shoin; 2000. p. 263–7. (in Japanese).

Elbow

32

Yosuke Usui

32.1 Introduction

1. Steroid injections into the lateral humeral epicondyle at the attachment site of the **common** extensor tendon of the forearm have short-term effects on tennis elbow.
2. However, steroid injection therapy, unless used in combination with physical therapy, does not have long-term effects and is associated with a high recurrence rate. Therefore, stretching of the extensor carpi radialis brevis (ECRB) and muscle training of the biceps brachii are important.

32.2 Indications

1. Tennis elbow (lateral epicondylitis).
2. Pain develops in the lateral humeral epicondyle when the wrist is extended against resistance in forearm pronation.

32.3 Anatomy (Fig. 32.1)

1. The radial nerve divides into the deep and superficial branches near the supinator.
2. The forearm extensors except the ECRB and extensor carpi radialis longus (ECRL) are innervated by the deep branch of the radial nerve after its passage through the supinator.
3. The ECRB and ECRL are innervated by the radial nerve before its passage into the supinator.
4. The superficial branch of the radial nerve runs along the radial artery, is covered by the brachioradialis, and innervates the radial side of the forearm and dorsum of the hand.
5. The biceps brachii, brachialis, and supinator act to supinate the forearm, while the pronator teres and pronator quadratus act to pronate the forearm.
6. A cause of lateral epicondylitis is ECRB shortening and hardening.
7. The ECRB is relaxed in supination and tense in pronation.
8. When the wrist is flexed, the ECRB attaching to the lateral humeral epicondyle is stretched, causing pain in this epicondyle.

32.4 Instruments and Drug Solutions

1. A 25-G short needle.
2. 1% mepivacaine (1 mL) and steroid.

32.5 Procedures and Techniques

32.5.1 Landmark Method

1. With the elbow slightly flexed and pronated in the supine position, the radial head is confirmed.
2. A depression **slightly central to the radial head** is palpated.
3. This site is punctured, and injection flow without resistance is confirmed.
4. The needle is advanced until it hits against the tender point of the lateral humeral epicondyle.

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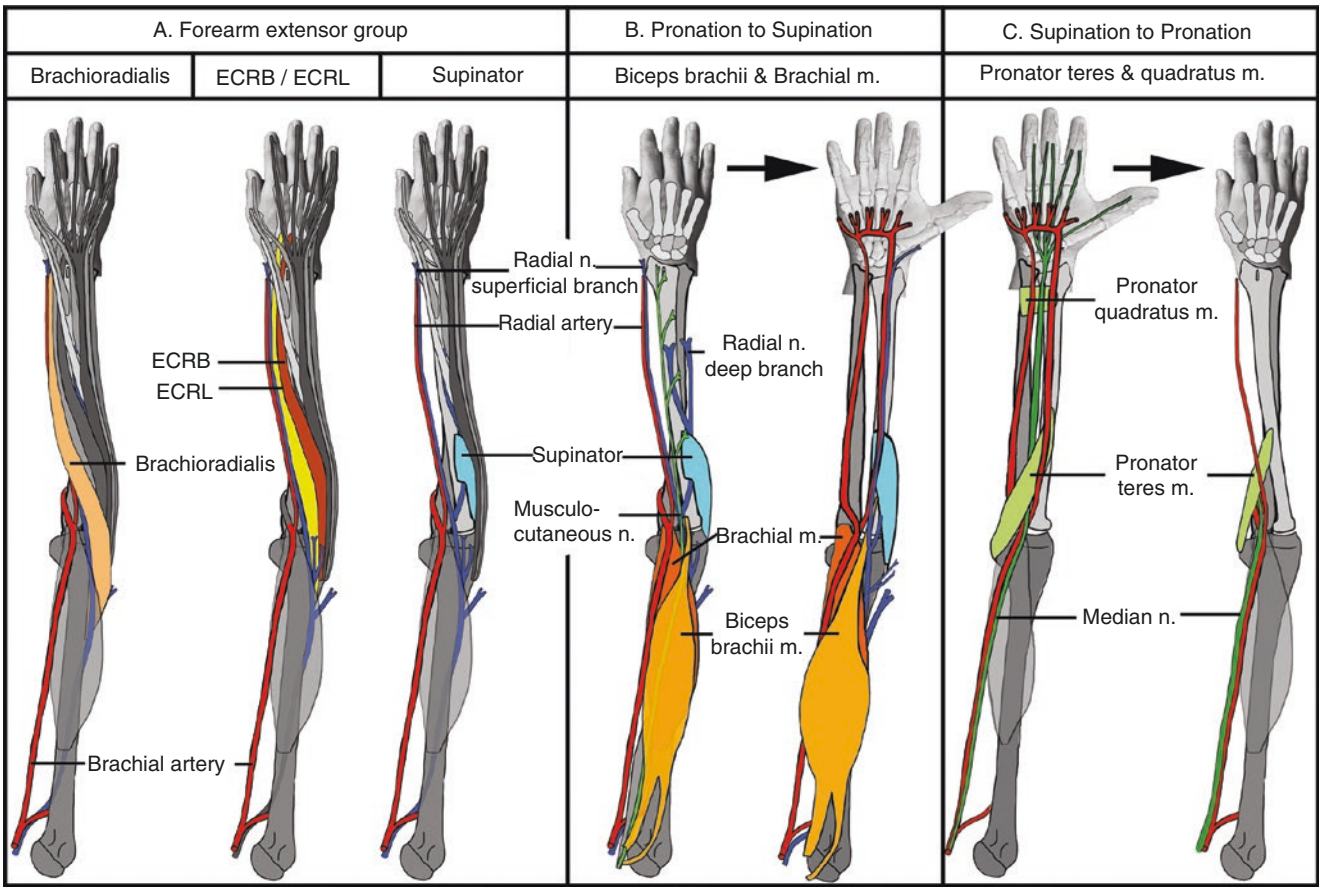

Fig. 32.1 Anatomy of the forearm. (1) The radial nerve divides into the deep and superficial branches near the supinator. (2) The forearm extensors except the ECRB and extensor carpi radialis longus (ECRL) are innervated by the deep branch of the radial nerve after its passage through the supinator. (3) The ECRB and ECRL are innervated by the radial nerve before its passage into the supinator. (4) The superficial branch of the radial nerve runs along the radial artery, is covered by the brachioradialis, and innervates the radial side of the forearm and dorsum of the hand. (5) The biceps brachii, brachialis, and supinator act to supinate the forearm (B). (6) The pronator teres and pronator quadratus act to pronate the forearm (C)

32.5.2 Ultrasound (US)-Guided Method (Fig. 32.2)

1. Sitting position.
2. **In front of the screen**, the affected shoulder joint is abducted, the elbow joint is extended, and the forearm is pronated.
3. The probe is placed on the long axis of the lateral humeral epicondyle and radial bone and rotated 90° around the lateral humeral epicondyle.
4. The needle is advanced using the in-plane approach to the attachment site of the ECRB on the lateral humeral epicondyle.

32.6 Complications

1. Frequent steroid injections at the muscle attachment site should be avoided since healing can be delayed.

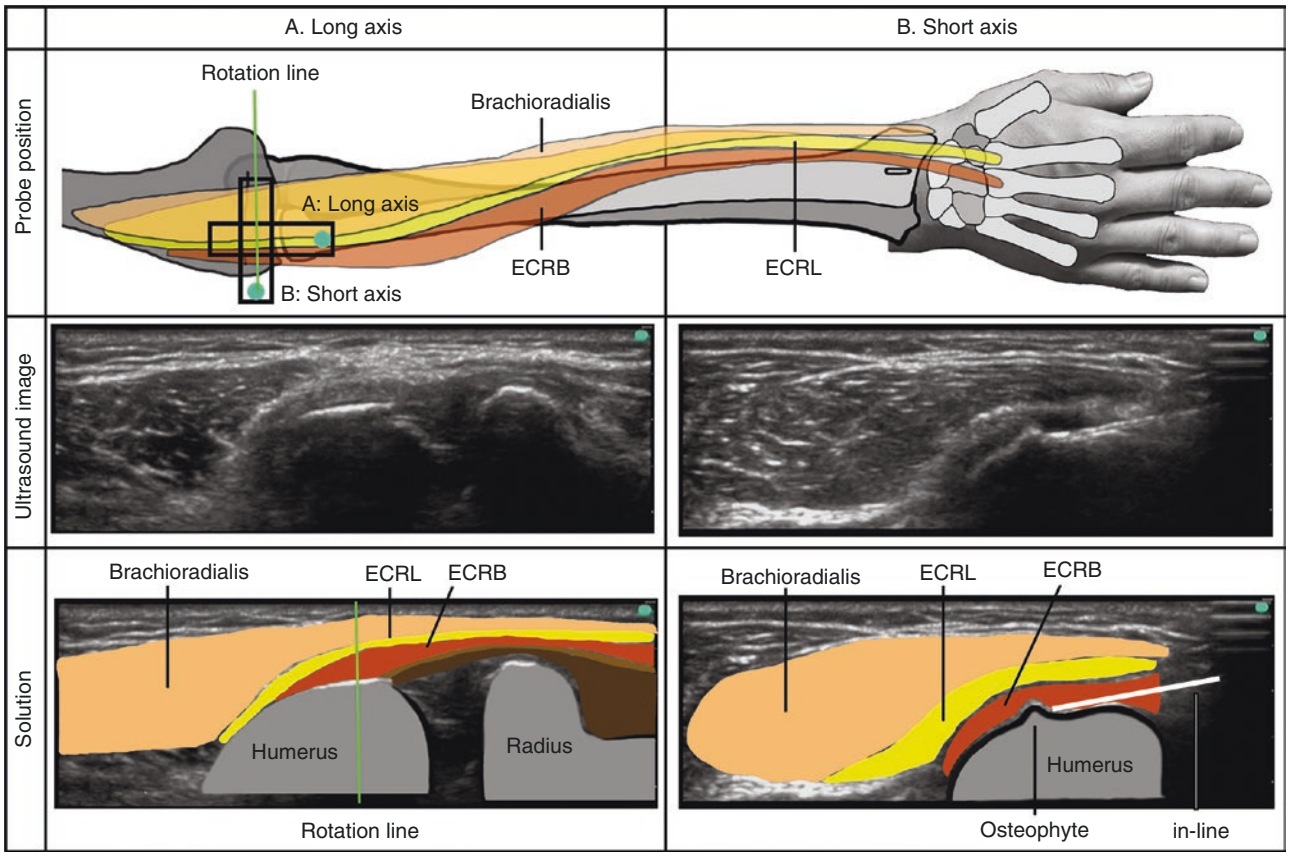

Fig. 32.2 Injection into the extensor carpi radialis brevis. (1) **In front of the screen**, the affected shoulder joint is abducted, the elbow joint is extended, and the forearm is pronated. (2) The probe is placed on the long axis of the lateral humeral epicondyle and radial bone and rotated 90° around the lateral humeral epicondyle. (3) The needle is advanced using the in-plane approach to the attachment site of the ECRB on the lateral humeral epicondyle

Hand

33

Yosuke Usui

33.1 Introduction

1. Among diseases with wrist pain as the chief complaint, De Quervain's disease, which is tenosynovitis involving the first extensor compartment, thumb carpometacarpal osteoarthritis, which involves the articulation between the trapezium and the first metacarpal bone of the thumb, and carpal-tunnel syndrome, which is median nerve entrapment damage, are described.

33.2 Indications

1. De Quervain's disease: Inject into the first compartment when pain is provoked by stretching the tendons of the abductor pollicis longus and extensor pollicis brevis.
2. Thumb carpometacarpal osteoarthritis: Inject into the carpometacarpal joint of the thumb when pain is provoked by compressing the anatomical snuffbox.
3. Carpal-tunnel syndrome: Inject into the carpal tunnel when pain is provoked by compressing the transverse carpal ligament.

33.3 Anatomy (Figs. 33.1 and 33.2)

1. The tendons of the abductor pollicis longus and extensor pollicis brevis are contained in the first compartment over the radial styloid process, the tendons of the extensor carpi radialis longus and extensor carpi radialis brevis in the second compartment on the radial side of Lister's tubercle, the tendon of the extensor pollicis longus in the third compartment on the ulnar side of Lister's tubercle, the tendons of the extensor digitorum and extensor indicis in the fourth compartment, the tendon of the extensor digiti minimi in the fifth compartment, and the tendon of the extensor carpi ulnaris in the sixth compartment.
2. The median nerve passes between the ulnar and radial heads of the pronator teres on the peripheral side of the elbow joint and then travels between the flexor digitorum profundus and flexor digitorum superficialis in the forearm.
3. It emerges on the ventral side of the flexor digitorum superficialis on the central side of the wrist and passes between the transverse carpal ligament and flexor digitorum superficialis.
4. Stenosing tenosynovitis in the first compartment containing the tendons of the abductor pollicis longus and extensor pollicis brevis is De Quervain's disease.
5. Degenerative disease of the joint consisting of the trapezium and the first metacarpal bone of the thumb is thumb carpometacarpal osteoarthritis.
6. Entrapment neuropathy of the median nerve passing immediately below the transverse carpal ligament is carpal tunnel syndrome.

33.4 Instruments and Drug Solutions

1. A 27-G needle.
2. 1% mepivacaine (1 mL) and steroid.

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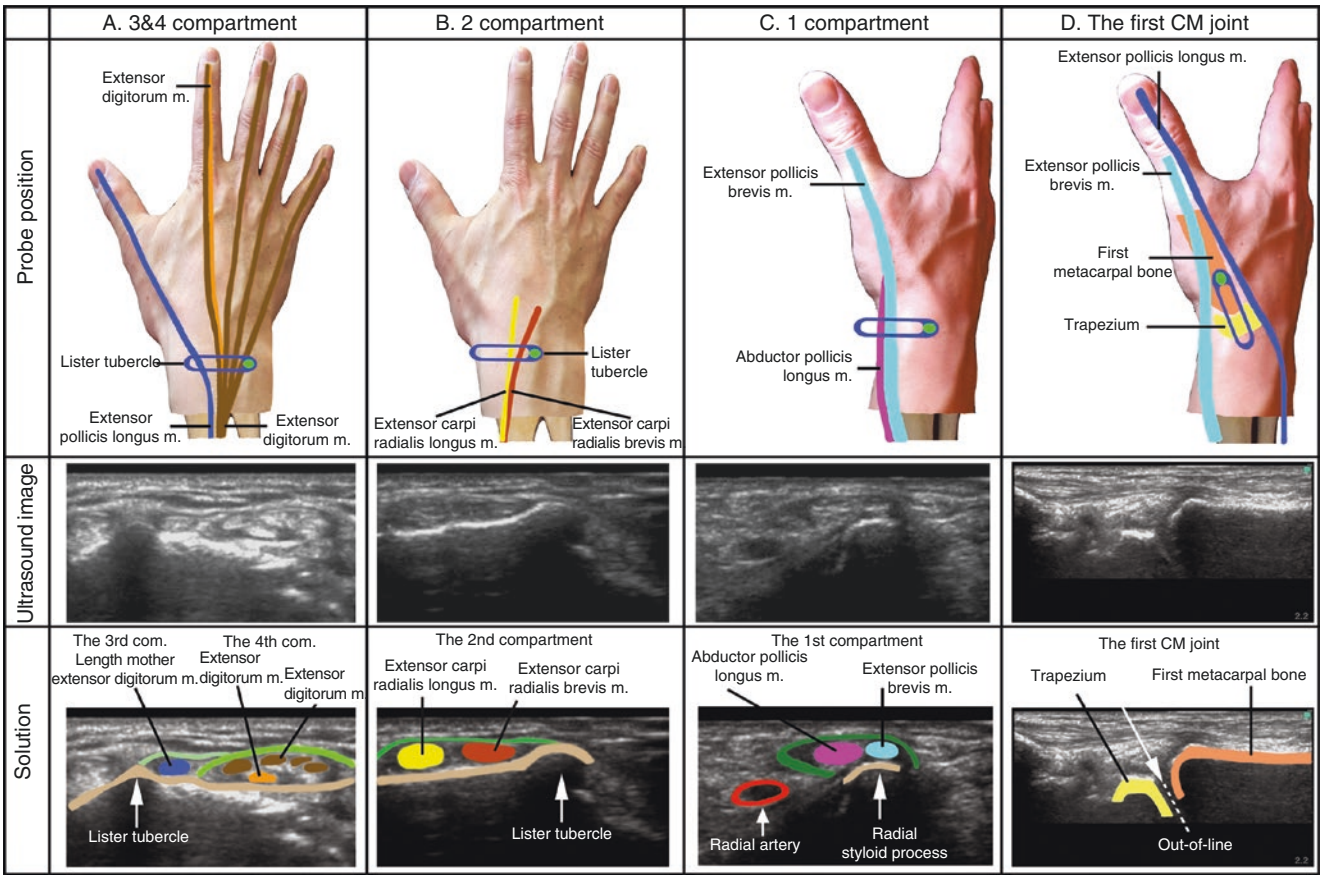

Fig. 33.1 US images of the dorsum of the hand. (1) The third compartment on the ulnar side of Lister's tubercle contains the tendon of the extensor pollicis longus, while the fourth compartment contains the tendons of the extensor digitorum and extensor indicis (**a**). The second compartment on the radial side of Lister's tubercle contains the tendons of the extensor carpi radialis longus and extensor carpi radialis brevis (**b**), while the first compartment over the radial styloid process contains the tendons of the abductor pollicis longus and extensor pollicis brevis (**c**). (2) The joint formed by the trapezium and first metacarpal bone, situated deep in the anatomical snuffbox bordered by the tendons of the extensor pollicis brevis and extensor pollicis longus, is the carpometacarpal joint (**d**)

33.5 Procedures and Technique

33.5.1 De Quervain's Disease

33.5.1.1 Landmark Method

1. The tendons of the abductor pollicis longus and extensor pollicis brevis over the radial styloid process are palpated, and the needle is advanced to the peri-tendon area.

33.5.1.2 Ultrasound (US)-Guided Method (Fig. 33.1c)

1. The probe is placed on the short axis of the styloid process, and the needle is advanced to the first compartment.

33.5.2 Thumb Carpometacarpal Osteoarthritis

33.5.2.1 Landmark Method

1. The carpometacarpal joint of the thumb deep in the anatomical snuffbox is palpated, and the needle is advanced.

33.5.2.2 US-Guided Method (Fig. 33.1d)

1. The probe is placed between the trapezium and first metacarpal, and the needle is advanced to the carpometacarpal joint.

33.5.3 Carpal Tunnel Syndrome

33.5.3.1 Landmark Method

1. The needle is advanced from a site proximal to the wrist flexion crease into the carpal tunnel.

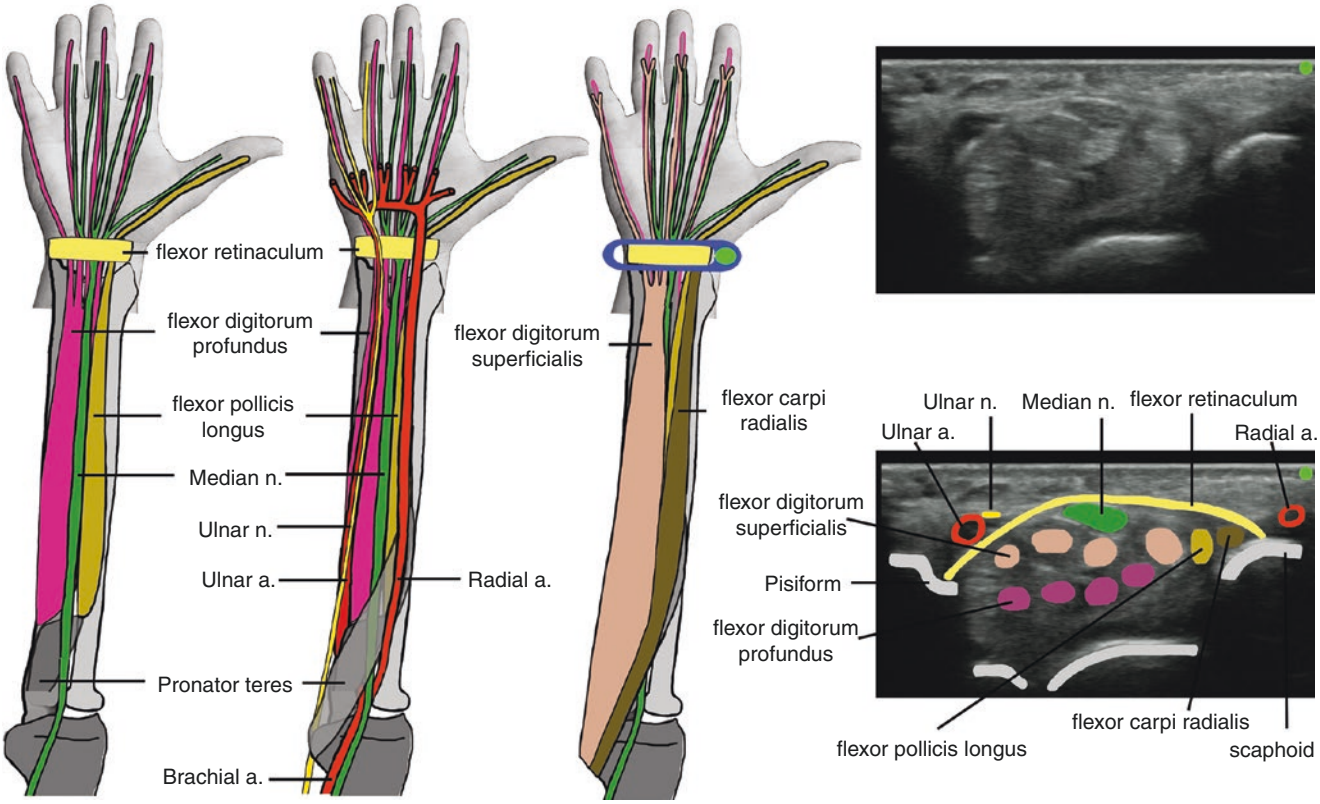

Fig. 33.2 US images of the carpal tunnel. (1) The median nerve passes between the ulnar and radial heads of the pronator teres on the peripheral side of the elbow joint and then travels between the flexor digitorum profundus and flexor digitorum superficialis in the forearm. (2) It emerges on the ventral side of the flexor digitorum superficialis on the central side of the wrist and passes between the transverse carpal ligament and flexor digitorum superficialis

33.5.3.2 US-Guided Method (Fig. 33.2)

1. The probe is placed between the pisiform and the tubercle of the scaphoid, and the needle is advanced to a site between the transverse carpal ligament and median nerve.

33.6 Complications

Bleeding, infection, neuropathy

Comment

34

Hiroaki Yamagami and Yukiyo Shiomi

34.1 Shoulder and Upper Extremity

The ultrasound-guided method is becoming a widely adopted technique to inject drug solutions into the joints of the shoulders, upper extremities, and other parts. In addition, pre-scanning provides images of the intraarticular anatomy of the shoulder and upper extremity joints and facilitates diagnosis. Direct injection of drug solutions into the injured sites identified through pre-scanning immediately results in analgesia, which leads to an improved range of motion.

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Part VII

Thorax and Back

Intercostal Nerve Block

35

Ryota Hamada, Syuhei Matuoka, Kiyoshi Hatakeyama, and Kiyoshige Ohseto

35.1 Introduction

35.1.1 Intercostal Nerve Block

Intercostal nerve block is a form of compartment block, in which drug solution is injected into a neurovascular sheath composed of blood vessels, i.e., arteries and veins, and intercostal nerves. Thoracic nerves originating from a point where the root emerges from the intervertebral foramen and ranging as far as the distal end of the thoracoabdominal area can be blocked. Intercostal nerve block techniques (landmark, ultrasound-guided, and X-ray fluoroscopically-guided) are relatively easy to perform and are applicable to patients receiving treatment at outpatient clinics. However, when physicians familiar with the anatomy perform semipermanent intercostal nerve block with injection of a minimal volume of neurolytic drug solution or high-frequency thermocoagulation, it is essential to carry out the block procedure meticulously and mainly under X-ray fluoroscopy-guided method.

35.2 Indications

Herpes zoster, postherpetic neuralgia, trauma (e.g., rib fracture), intercostal neuralgia, post-thoracotomy pain, thoracic disc herniation, ossification of the yellow ligament, and malignant diseases (e.g., metastasis of cancer to the ribs).

35.3 Anatomy

After thoracic nerves emerge from the intervertebral foramen, they are called intercostal nerves. These thoracic nerves first send a gray communicating branch to the thoracic sympathetic trunk on the anterolateral sides of the vertebral bodies. Then, the nerves divide into the ventral and dorsal rami. The dorsal ramus penetrates the erector spinae muscles and controls the skin and muscles of the back, whereas the ventral ramus, which is the intercostal nerve, controls the majority of sensations on the thoracoabdominal wall.

The intercostal nerves, together with the intercostal arteries and veins, pass through a triangular space formed by the parietal pleura and the innermost intercostal muscle on the thoracic side, the internal intercostal muscle (membrane) and the external intercostal muscle on the skin side, and the upper and lower ribs on the cranial and caudal sides (Fig. 35.1). The angle of the rib refers to the portion where it suddenly turns anterolaterally after extending posterolaterally from the thoracic vertebra. Because the rib forms an angular protrusion, this angle is an easy site at which to palpate the rib under the skin. When intercostal nerve block is performed by the landmark technique, the angle of the rib is a good landmark because the rib is most palpable around this site.

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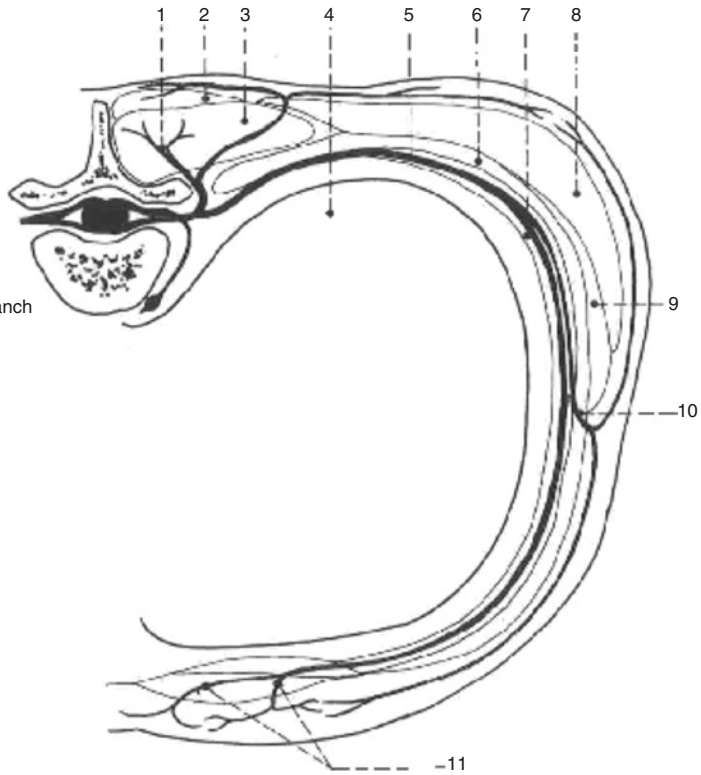

Fig. 35.1 Route of the intercostal nerve: coronal section (Cited from Tatsuo Sakai 2010) [2]

35.4 Instruments and Drug Solutions

1. 23- to 25-G, 25- to 42-mm disposable needle.
2. 2- to 5-mL syringe.
3. Local anesthetics.
4. Neurolytic drug: 5–10% phenol solution.
5. Kit for high-frequency thermocoagulation and pulsed high-frequency stimulation and kit for X-ray fluoroscopic guidance.

35.5 Procedures and Techniques

35.5.1 Position

When a patient is placed in the prone position with a pillow maintained under the thoracoabdominal area, the right and left scapulae are gently separated to facilitate the puncture. When intercostal nerve block is performed in the area extending cranially from the fifth rib, it is preferable to perform the block under X-ray fluoroscopic or ultrasound guidance because the scapula interferes with detection of the angle of the rib. When the pain is severe, the block can be performed with the patient placed in the lateral decubitus position. If the patient holds a large pillow during the procedure, the scapulae will be sufficiently separated laterally so that puncture will likewise be facilitated. When pain is localized to the precordia, intercostal nerve block may be performed in this area. In such an event, the patient is placed in the supine position with the upper limb of the affected side raised.

35.5.2 Methods

35.5.2.1 Landmark Method

While the rib is palpated around its angle, the insertion site is set at the lower margin of the rib. This area is the most appropriate site for the block, for the following reasons: at this site, the rib is thick, and the costal groove is wide and deep, which makes pneumothorax occurrence unlikely. The skin at the insertion site is pulled cranially until the site is above the rib. A physician places a needle on the rib, memorizes the depth, and then allows the needle to "walk" (Fig. 35.2). While the inner cylinder of the syringe is pushed hard, the needle is slid along the margin of the rib and slowly inserted by approximately 3–5 mm in the caudal direction. When resistance to the inner cylinder or the needle tip is decreased, the needle is in the triangular space. Even when resistance is minimal or undetectable, the needle insertion should not exceed 5 mm. If suction does not result in reflux of blood, 1–2 mL of a local anesthetic can be injected.

35.5.2.2 Ultrasound-Guided Method

The ultrasound-guided technique can be adequately performed with a linear probe and a 23- to 25-G, 2.5- to 4.2-cm needle. To perform this technique, the distance between the insertion site and the targeted intercostal space should be made as short as possible. When the intercostal space is deep, the linear probe should likewise be positioned at an appropriate depth.

As for the procedure of this technique, the probe is attached vertically to the rib to estimate the distance to the

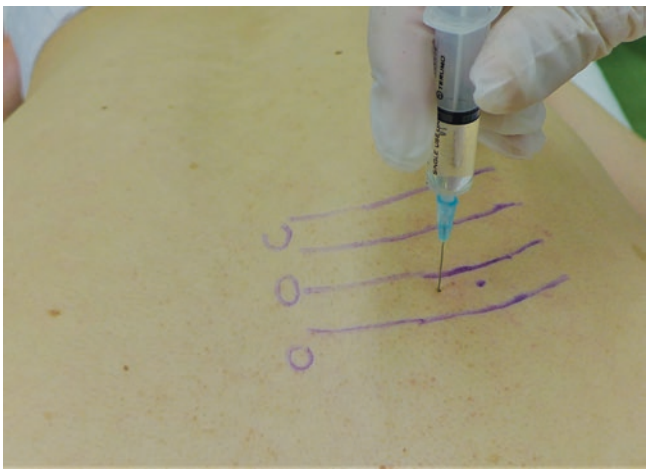

Fig. 35.2 The needle is inserted from the lower part of the rib. While pressure is applied to the syringe, the needle tip is "walked" forward and slid on the rib until reaching its lower margin. When resistance to the syringe is decreased, drug solution is injected

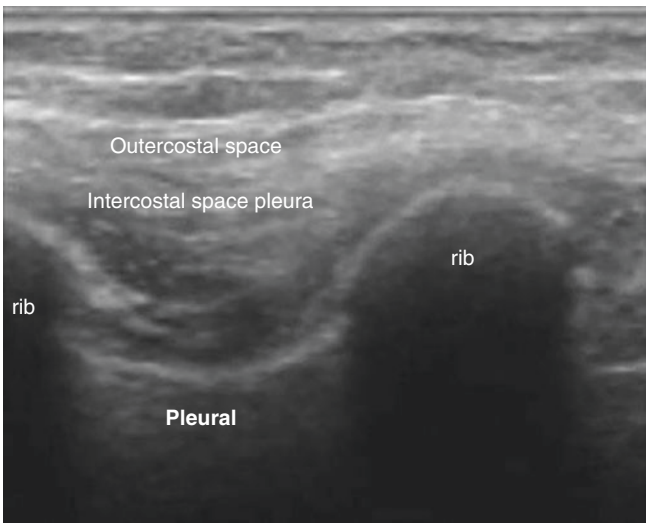

Fig. 35.3 Ultrasonographic image

pleura. The needle is inserted from the caudal side by the parallel technique and advanced between the internal and innermost intercostal muscles without puncturing the intercostal artery (Fig. 35.3). After confirmation of the absence of blood reflux, 1–2 mL of drug solution is injected. It should be confirmed that the drug solution flows directly below the internal intercostal muscles to immerse the pleura.

The PECS I and II blocks are peripheral nerve blocks devised as easy postoperative analgesic techniques for precordial surgery. Local anesthetics are injected between the pectoralis major and minor muscles for the PECS I block and between the pectoralis minor and serratus anterior muscles for the PECS II block (Fig. 35.4). Because these techniques are simple and produce analgesia in a wide area of the precordia, they have attracted attention in recent years [1].

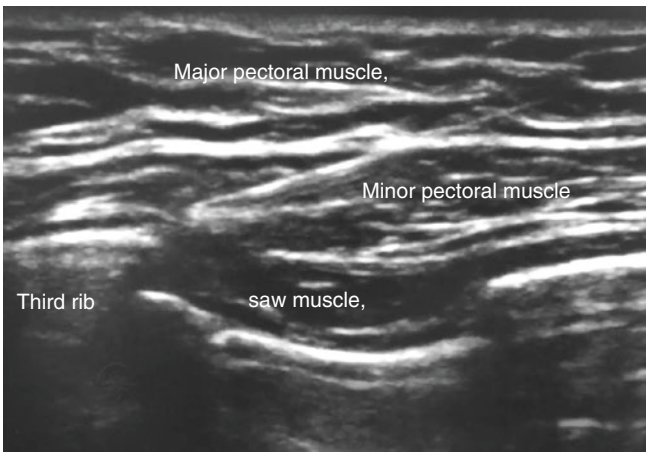

Fig. 35.4 PECS block. Major pectoral muscle, pectoralis muscle, anterior saw muscle. Major pectoral muscle, minor pectoral muscle, anterior saw muscle, third rib

35.5.2.3 X-Ray Fluoroscopy-Guided Method

In order to perform intercostal nerve block that is certain or at a diagnostically specific site, the X-ray fluoroscopically-guided method is recommended. With this technique, the insertion site is the lower margin of the targeted rib as with the landmark method.

Under X-ray fluoroscopy-guided method, the needle is temporarily attached to the lower margin of the rib and then inserted into the intercostal groove toward the dorsal side. At this point, it is also important to advance the needle by not more than 5 mm from the lower margin of the rib. At a site where resistance is decreased, contrast medium is injected. If the needle is located at the correct site, injection of approximately 0.5–1 mL of an appropriate contrast medium will produce an image of the targeted compartment. This contrast-enhanced image shows flow of the contrast medium along the neurovascular sheath toward the peripheral and central portions of the targeted compartment (Fig. 35.5).

When the muscle layer is not clearly depicted, the dye frequently spreads along the parietal pleura. In such an event, the needle should not be advanced further.

In addition, when the subcutaneous or fatty tissue is thick, as in obese patients, the insertion site is set at the center of the rib. If visualization of the needle is maintained at a point under X-ray fluoroscopic guidance with slow advancement, the needle will safely reach the center of the rib.

There is another technique in which the needle tip is attached to the costal process and slid along the lower margin of the costal process.

35.5.2.4 Continuous Catheterization

Continuous intercostal nerve block was recently developed as a postoperative analgesic technique for acute-phase responses. Paraspinal block and intercostal never block employing continuous intercostal catheterization are considered to be effective analgesic techniques for use after thoracotomy and laparotomy. When the needle is advanced according to the

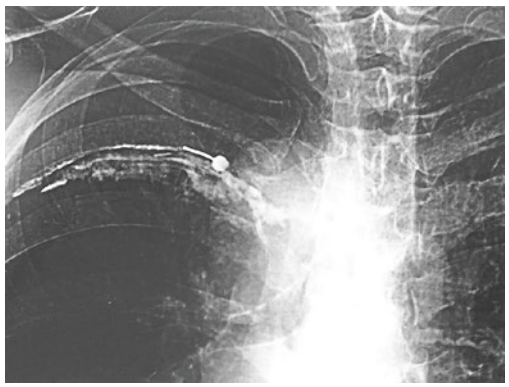

Fig. 35.5 Image of a neurovascular sheath

intercostal nerve block procedure, it reaches a site between the internal intercostal fascia and the parietal pleura. When a local anesthetic is injected between these membranes toward the spine, it reaches the same layer as that reached by paraspinal block. By placing a catheter at this site, paraspinal block with a continuous intercostal approach can be performed. It is appropriate to regard this technique as paraspinal nerve block carried out employing an intercostal approach [3, 4].

35.6 Complications

35.6.1 Pneumothorax

The incidence rate, which varies in the literature, is approximately 1%. When intercostal nerve block is carefully performed, pneumothorax very rarely occurs. The important points include performing the block around the angle of the rib, advancing the needle by not more than 5 mm, and firmly fixing the needle during drug solution injection. The ultrasound guidance allows confirmation of the location of the pleura, while the X-ray fluoroscopic guidance confirms that of the needle tip by employing contrast medium.

35.6.2 Puncture of Blood Vessels

When the landmark technique is used, blood vessels are highly likely to be punctured. It is important to inject drug solution after the absence of blood reflux has been fully confirmed.

35.6.3 Local Anesthetic Toxicity

Injection of anesthetics into the neurovascular sheath requires caution because blood concentrations tend to be higher than those of anesthetics injected employing other block techniques.

35.6.4 Peripheral Neuritis

Peripheral neuritis may occur when nerves are blocked with 99.5% alcohol. X-ray fluoroscopic guidance is thus essential when administering neurolytic drugs.

35.6.5 Thoracic Sympathetic Nerve Block

When more than 2 mL of drug solution is injected into an intercostal space by the block techniques performed around the angle of the rib, imaging studies may show flow of the drug solution onto the anterior surfaces of the intervertebral bodies along blood vessels.

35.6.6 Epidural Block and Subarachnoid Block

If the amount of drug solution injected into each intercostal space is approximately 2 mL, even flow of a portion of the drug solution into the epidural or subarachnoid space will not cause problems. Although drug solution injected around the spine may flow through the dural cuff into the subarachnoid space, this is rarely problematic because the amount of injected drug solution is small.

References

1. Blanco R, et al. The ‘pecs block’: a novel technique for providing analgesia after breast surgery. Anaesthesia. 2011;66:847–8.
2. Chan VWS, et al. Analgesic and pulmonary effects of continuous intercostals Nerve block following thoracotomy. Can J Anaesth. 1991;38:733–9.
3. Dryden CM, et al. Efficacy of continuous intercostals bupivacaine for pain relief after thoracotomy. Br J Anaesth. 1993;70:508–10.
4. Burns DA, et al. lntercostally placed paravertebral catheterization: an alternative approach to continuous paravertebral blockade. Anesth Analg. 2008;107:339–41.

Thoracic Paravertebral Block (Ultrasound Guidance Technique)

36

Yasuyuki Shibata

36.1 Introduction

36.1.1 Thoracic Paravertebral Block

Thoracic paravertebral block (TPVB) is the technique of injecting local anesthetic into the thoracic paravertebral space (TPVS) where the spinal nerves emerge from the intervertebral foramina.

36.2 Indications

Surgical: Thoracotomy, mastectomy, nephrectomy, inguinal hernioplasty, etc.

Pain medicine: Herpes zoster, postthoracotomy pain, postmastectomy pain, etc.

36.3 Anatomy

The TPVS is a wedge-shaped space located on either side of the vertebral column, bounded above and below the heads and necks of adjoining ribs. The anterolateral wall is formed by the parietal pleura, while the posterior border is formed by the superior costotransverse ligament running from the inferior aspect of the transverse process above to the superior aspect of the neck of the rib below. The superior costotransverse ligament is laterally continuous with the internal intercostal membrane. The base is formed by the posterolateral aspect of the vertebral body and the intervertebral foramen (Fig. 36.1). The TPVS communicates medially with the epidural space through the intervertebral foramen, laterally with a part of the intercostal space (to be precise, the space is surrounded by the parietal pleura below and the internal intercostal membrane above, which has not been named anatomically; here, we call this space "the intercostal neurovascular space"), anteriorly with the contralateral paravertebral space via the prevertebral and epidural space, and inferiorly with the retroperitoneal space posterior to the fascia transversalis via the medial and lateral arcuate ligaments. The TPVS is divided into anterior and posterior compartments, namely, the anterior extrapleural paravertebral compartment and the posterior subendothoracic paravertebral compartment, by the endothoracic fascia, a fibroelastic structure. The endothoracic fascia touches the parietal pleura. Therefore, there is actually no thickness in the extrapleural paravertebral compartment. The subendothoracic paravertebral compartment almost occupies the TPVS. The sympathetic trunk is located anterior to the endothoracic fascia, while the intercostal nerves and vessels are located posterior to it.

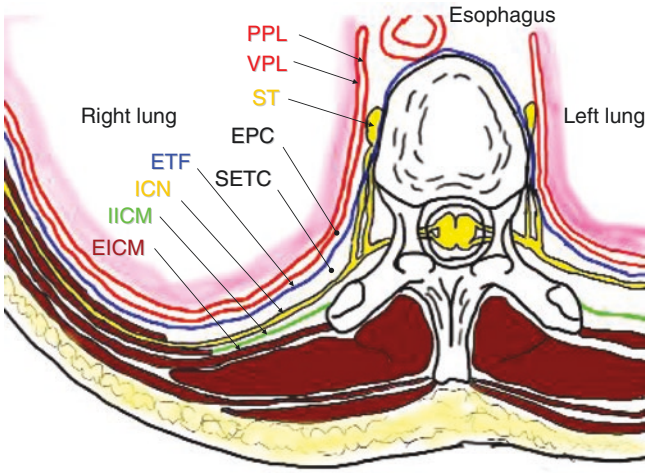

Fig. 36.1 Anatomy of the thoracic paravertebral space. *PPL* parietal pleura, *VPL* visceral pleura, *ST* sympathetic trunk, *EPC* extrapleural compartment, *SETC* subendothoracic compartment, *ETF* endothoracic fascia, *ICN* intercostal nerve (anterior rami of spinal nerve), *IICM* internal intercostal membrane, *EICM* external intercostal muscle

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36.4 Instruments and Drug Solutions

Needle: An 8 cm, 17-gauge Tuohy needle for continuous paravertebral block or an 8 cm, 19-gauge Tuohy needle for single injection paravertebral block

Probe: A linear 38 mm, high-frequency probe (6–13 MHz), a micro-convex prove (5–8 MHz), a convex probe

Solutions: 15–20 mL of ropivacaine 0.2–0.5% or levobupivacaine 0.2–0.5% for anesthesia and pain medicine

36.5 Procedures and Techniques

The patient is placed in a lateral decubitus position with the side to be blocked uppermost. The prone position is also useful for unskilled practitioners to stabilize the probe on the patient's back.

Transverse scan with the intercostal approach for single-shot TPVB [1]:

1. A probe is placed in a transverse plane on the rib at the selected level, just lateral to the spinous process. The horizontal view of the rib is visualized as a hyperechoic line with posterior acoustic shadowing.
2. The probe is moved caudally into the intercostal space between adjacent ribs. The inferior part of the transverse process is visualized as a hyperechoic convex line with posterior acoustic shadowing. The apex of TPVS is visualized as a wedge-shaped hypoechoic space surrounded by the hyperechoic line of the pleura below and the internal intercostal membrane above (Fig. 36.2). The apex of the TPVS communicates laterally with the intercostal neurovascular space.
3. After skin and probe preparation, local anesthetic is infiltrated into the skin and the subcutaneous tissue. A 20-gauge Tuohy needle is inserted in a lateral-to-medial direction from the outer edge of the probe with the bevel facing the probe using an in-plane approach.
4. Advance the needle until the needle tip penetrates the internal intercostal membrane just lateral to the transverse process. A slight pop sensation can be felt when the needle tip penetrates the internal intercostal membrane.
5. After a negative aspiration test for blood, 15–20 mL of local anesthetic is injected into the TPVS slowly.
6. The pleura is seen being pressed ventrally during local anesthetic injection (Fig. 36.3).

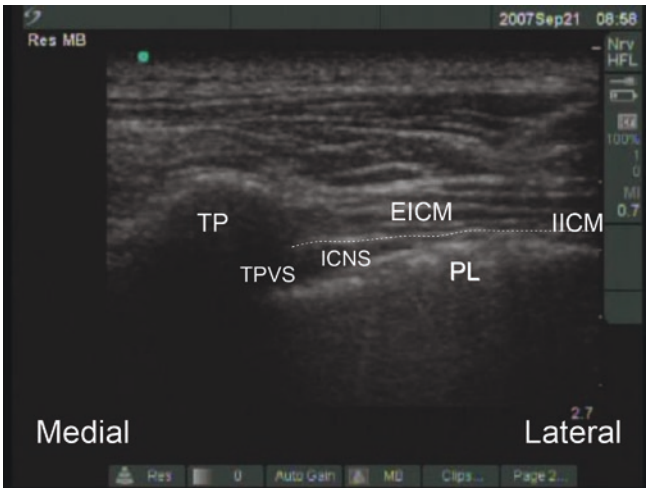

Fig. 36.2 Transverse view of the thoracic paravertebral space. *TP* transverse process, *EICM* external intercostal muscle, *IICM* internal intercostal membrane (dotted line), *PL* pleura, *TPVS* thoracic paravertebral space, *ICNS* intercostal neurovascular space

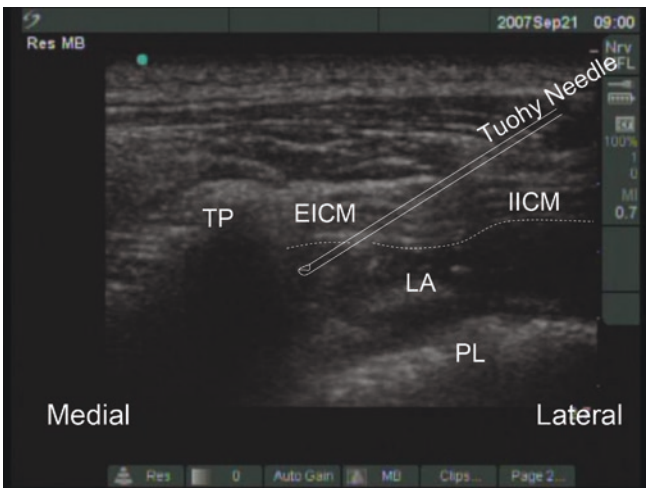

Fig. 36.3 Transverse view of the thoracic paravertebral space after local anesthetic injection. *TP* transverse process, *EICM* external intercostal muscle, *IICM* internal intercostal membrane (dotted line), *LA* local anesthetic, *PL* pleura

36.6 Complications

The complications such as bradycardia, hypotension, intercostal vessel puncture, pleural puncture, pneumothorax, and local anesthetic toxicity are rare but can be considered [2]. A Tuohy needle is safer than other types of needle because the curve side of the needle tip is facing to the internal intercostal vessels and the parietal pleura during the procedure.

References

1. Shibata Y, Nishiwaki K. Ultrasound-guided intercostal approach to thoracic paravertebral block. Anesth Analg. 2009;109:996–7.
2. Pace MM, Sharma B, Anderson-Dam J, Fleischmann K, Warren L, Stefanovich P. Ultrasound-guided thoracic paravertebral blockade: a retrospective study of the incidence of complications. Anesth Analg. 2016;122(4):1186–91.

Thoracic Sympathetic Ganglion Block

37

Hidekimi Fukui

37.1 Introduction

Thoracic sympathetic ganglion block is a nerve block procedure that produces effects such as analgesia, increased blood flow, increased skin temperature, and cessation of sweating without affecting the somatic nerve that dominates both sensory and motor functions.

In performing the thoracic sympathetic ganglion block procedure, after needle puncture into the thoracic sympathetic trunk and sympathetic ganglion that travels on the lateral side of the thoracic spine, a neurolytic agent is injected as a neurodestructive procedure, or a high-frequency thermocoagulation procedure is carried out. As the sympathetic trunk (ganglion) is distant from the body surface but close to important organs, it is necessary to carry out this procedure under X-ray fluoroscopy-guided method or CT fluoroscopy-guided method.

37.2 Indications

Intractable pain occurring in areas ranging from the upper limbs to the thoracodorsal and thoracoabdominal regions.

Pain and pathological states induced by sympathetic nerve excitement are especially suitable for this technique.

If remission of these conditions is not obtained within approximately 6 months, employing conservative therapy, such patients are candidates for nerve block.

Representative primary diseases to which nerve block is applicable.

Complex regional pain syndrome (CRPS).

Peripheral vascular disease (arteriosclerosis obliterans, Buerger's disease, Raynaud's disease, collagen disease, etc.)

Post-herpetic neuralgia,

- Hyperhidrosis (palm, axilla).
- Although it is occasionally performed to treat hyperhidrosis (palm and axilla) for the purpose of sweating cessation, compensatory sweating is inevitable, such that applicability is determined after providing a sufficient explanation.

37.3 Anatomy

Neighboring anatomy necessary for the block.

Mainly the nerve trunk is targeted for the block as thoracic sympathetic ganglia are adjacent to the thoracic sympathetic trunk, and their positional relationships to ganglia, vertebral bodies, and intervertebral disks are not clear (Fig. 37.1). The thoracic sympathetic trunk runs in costovertebral joints at the superior level, slightly behind the thoracic spine centered at the medial level, and in the lateral center of the thoracic spine at the inferior level (Fig. 37.2). They are present in pairs on the left and right sides, and sympathetic afferents and efferents communicate with spinal cord nerves via communicating branches.

Sympathetic afferents project into the spinal cord from the dorsal root through gray rami communicantes from the spinal nerve or white rami communicantes via the sympathetic trunk from sympathetic ganglia (celiac plexus, superior hypogastric plexus, etc.) formed by afferent fibers from the viscera.

Sympathetic efferents travel into the sympathetic trunk through white rami communicantes from the lateral horn (intermediolateral nucleus), their corresponding postsynaptic neurons at the sympathetic trunk or sympathetic ganglia are projected into spinal nerves through gray rami communicantes, and they thereby carry out sympathetic regulation of the target organs.

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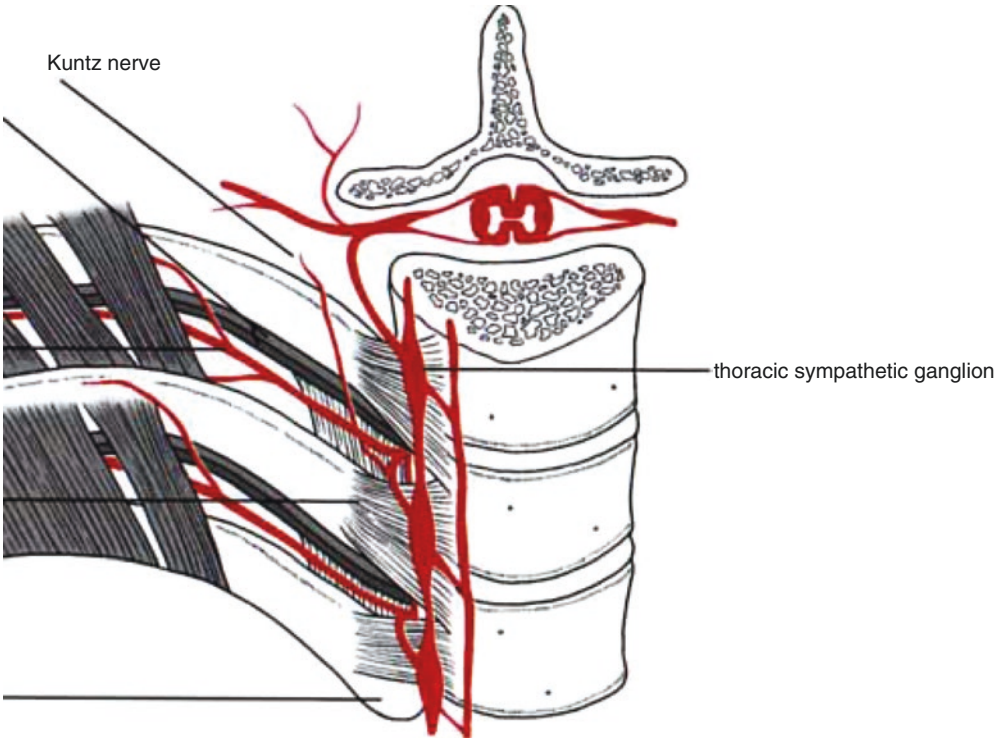

Fig. 37.1 Costal bone spinal cord thoracic sympathetic ganglion

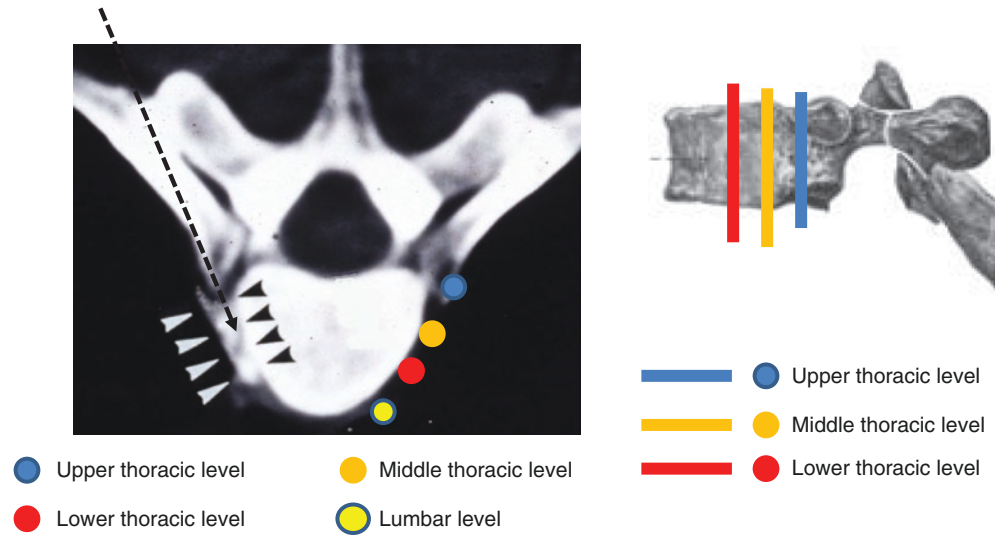

Fig. 37.2 Insertion, direction, and position of the needle. Position of the thoracic sympathetic trunk and the target position of the needle tip in the X-ray view of the thoracic spine. Upper thoracic level: 1/3 posterior to the center of the vertebral body in the lateral X-ray view. Mid-thoracic level: slightly posterior to the center of the vertebral body in the lateral X-ray view. Lower thoracic level: the center of the vertebral body in the lateral X-ray view

The needle puncture must be performed carefully as the sympathetic trunk is located close to important organs including the lungs, arteries (intercostal artery and thoracic aorta), veins (intercostal vein, azygos vein, hemiazygos vein), and nerves (recurrent laryngeal nerve and phrenic nerve).

37.4 Instruments and Drug Solutions

1. 22 gauge 10–14 cm disposable block needle.
2. 25 gauge 25 mm and 23 gauge 60 mm Cattelan needle (for local anesthesia).
3. Three 5 mL syringes (one for local anesthesia, one for contrast agent, one for neurolytic agent).

   - One 10 mL syringe (for test injection: local anesthetic plus contrast agent).
   - For local anesthesia: 1% lidocaine.
   - For contrast agent: Non-ionic contrast agent (iohexol).
   - For test injection: 2% lidocaine plus non-ionic contrast agent (1:1).

4. 99.5% alcohol or 10% phenolated water.
5. High-frequency thermocoagulation set.

- Insulated needle with 4–10 mm non-insulated portion at the tip (about 10–14 cm).

37.5 Procedures and Techniques

Position for the block.

With the subject in the prone position, the dorsal part, on which the procedure is to be performed, is placed horizontally to the fluoroscopy table.

Placing the chest on a pillow narrower than shoulder width facilitates performing the needle puncture as it increases the distance between the left and right shoulders.

37.5.1 When Carried Out Under X-Ray Fluoroscopy-Guided Method [1]

With the aid of X-ray fluoroscopy-guided, adjust the tube bulb or the body positon to align the vertebral end plate of the target along one straight line. Draw a line (a line parallel to the body axis) at 4–5 cm outside of the posterior midline (spinous process). The point at which this line intersects with a line along the vertebral body end plate (a line perpendicular to the body axis) is defined as the insertion point (Fig. 37.3). The site of puncture is disinfected in combination with routine scrubbing.

Under X-ray fluoroscopy, move the needle tip from the vertebral arch to the lateral margin of the vertebral arch, as in the case for the nerve root block, and advance the needle tip further to reach the lateral side of the thoracic spine after sliding it along the lateral margin. In the middle of the process, advance the needle around the intervertebral foramen carefully, so as to avoid hitting the nerve root.

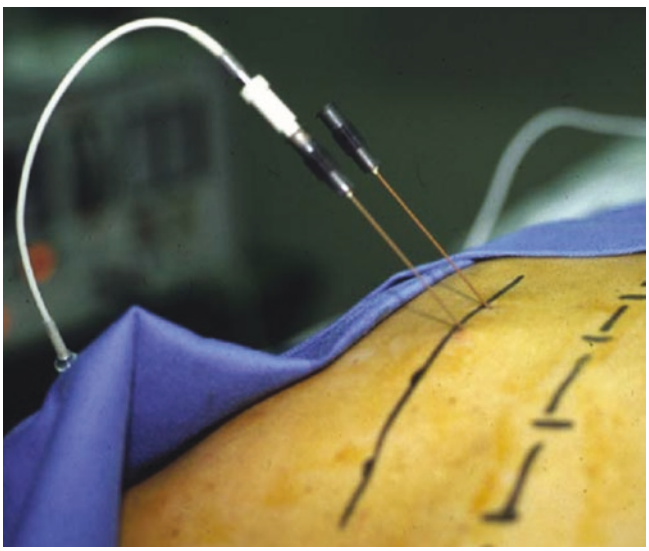

Fig. 37.3 Positions of thoracic sympathetic ganglion block and needle insertion point

The needle tip often encounters the posterior margin of the vertebral body and cannot be inserted any further. In this case, pull the needle out slightly, and after changing the direction of the bevel, advance it to the lateral part of the vertebral body in front.

When the needle tip hits the lateral part of the vertebral body, advance it to the target positions (Fig. 37.2). When the bevel is directed inward or outward as necessary, it can be advanced without leaving the vertebral body.

Inject a small amount of the contrast agent alone, and ensure that the agent pools around the outer margin of the vertebral body in the frontal X-ray view of the thoracic spine and within 1/3 posterior to the center of the vertebral body in the lateral view (Fig. 37.2). If the contrast agent disappears quickly, this confirms that the needle tip is located in a blood vessel or bone. It is then necessary to change the position of the needle tip. Thereafter, inject the mixture of a local anesthetic and a contrast agent, as in the case with single use of the contrast agent, and confirm the appearance of appropriate contrast images. In addition, ensure that the agent does not flow into the areas ranging from the nerve root, the intercostal nerves, the intervertebral foramen, the lungs, and the anterior area (esophagus, recurrent laryngeal nerve, phrenic nerve) (Fig. 37.4). It is necessary to carefully confirm whether the patient has abnormal reactions (such as a bad feeling and low blood pressure), disturbance of movement of the extremities, and Horner sign in the upper-middle thoracic spine. When the needle tip is well positioned but the distribution of the contrast agent is not appropriate, it is recommended that only the high-frequency thermocoagulation procedure be carried out. However, its nerve block effect is smaller than that produced by the neurolytic agent. If there are no problems as regards these issues, inject a small amount of neurolytic agent or perform the high-frequency thermocoagulation procedure. If there is no problem with the patient's condition after injection (or after the high-frequency thermocoagulation procedure), the block is terminated. After returning to the room, the patient should remain at rest in the prone position for at least 1 h.

37.5.2 When Carried Out Under CT-Guided Method (Fig. 37.5)

The multi-slice CT device is set to simultaneously monitor the three screens showing the head, center, and tail sides. Place the marker at the target level of the vertebral body, capture CT images and determine the distance from the posterior midline (spinous process), for insertion, on the screen (Fig. 37.4). Draw a line running through the optimal

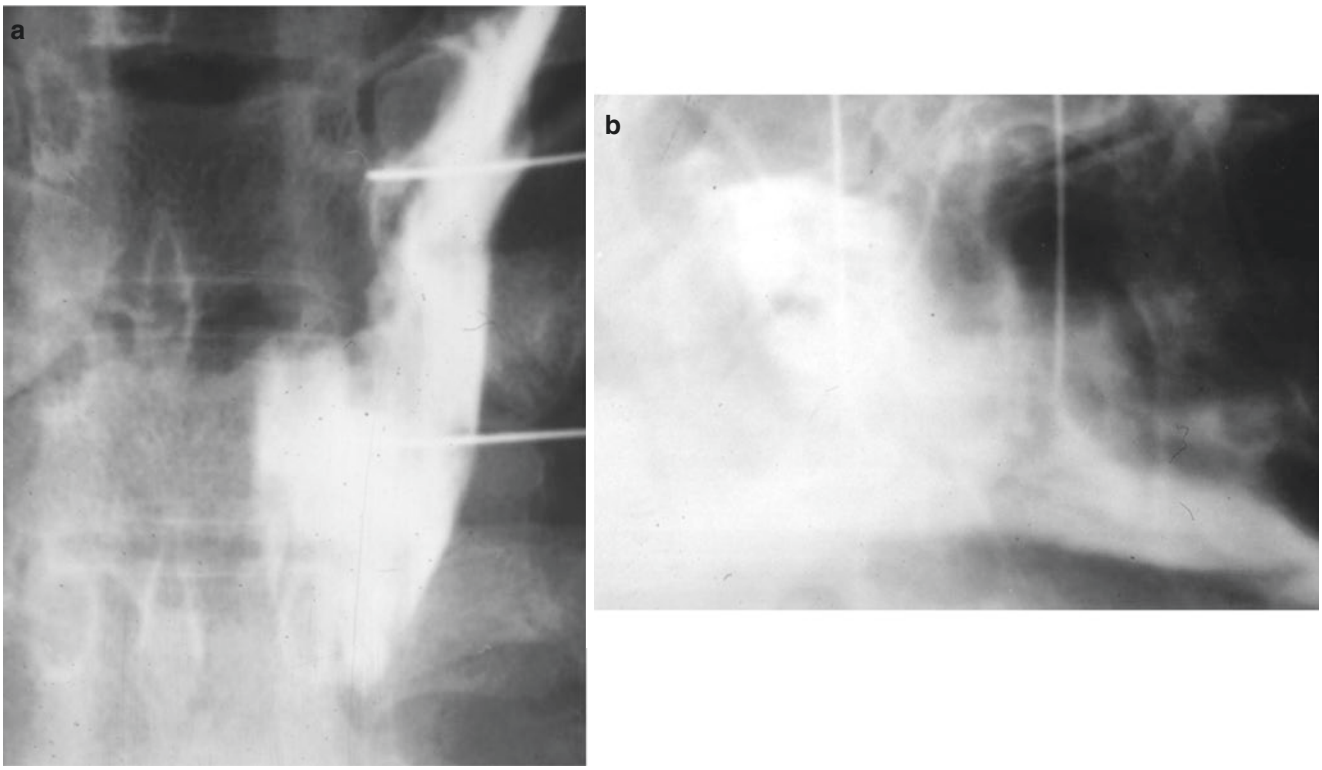

Fig. 37.4 A contrast agent, as in the case with single use of the contrast agent, and confirm the appearance of appropriate contrast images. (**a**) Front view (**b**) lateral view

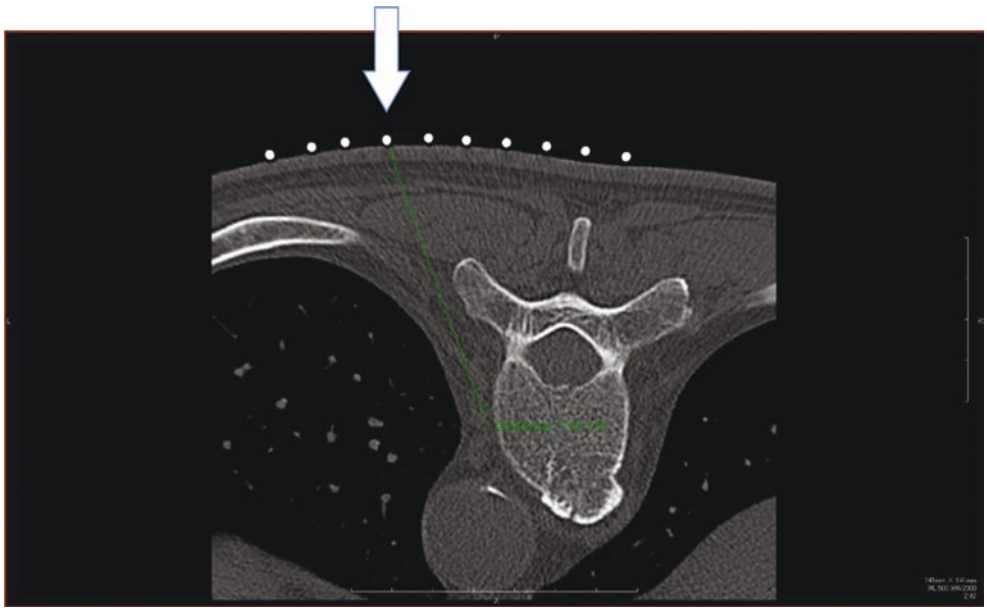

Fig. 37.5 Thoracic sympathetic ganglion nerve block under CT guided

marker for the insertion point and in parallel with the body axis. The insertion point is defined as the intersection point between this line and the optimal cross-section level for insertion (the level at which the infrared beam is emitted in the CT device). With real-time CT fluoroscopy-guided, slowly perform the needle puncture to the target positon of the needle tip. In order to maintain the necessary contact with the vertebral body, it is important to perform the needle puncture by confirming the sense of mild to moderate resistance at the time of insertion. (Other procedures are carried out according to [1] when carried out under X-ray fluoroscopy-guided).

37.5.3 In the Case of IVR-CT (Interventional Radiology-CT-Guided Method) Use

This procedure utilizes an integral device combining CT and angiography. At the first capture of CT images, as described above, measure the distance from the posterior midline (spinous process) and the distance between the insertion point and the target position after determining the insertion point on the image. After applying an optimal marker for the insertion point, the procedure is carried out according to [1] when carried out under X-ray fluoroscopy. Under some circumstances, when the length of the inserted needle approaches the pre-measured distance between the insertion site and the target position, fine adjustment is possible by capturing the CT image again. Under X-ray fluoroscopy, advance the needle tip to the appropriate position and inject the contrast agent and confirm positional accuracy, inject the mixture of the local anesthetic and the contrast agent, and by capturing CT images, confirm the appearance of appropriate contrast images as in the case for the contrast agent alone. If there are no problems as regards these issues, inject a small amount of a neurolytic agent or perform the high-frequency thermocoagulation procedure.

By using this device, it is possible to plan the needle puncture after first capturing the CT image and thereby avoid the risk of puncturing organs such as the aorta, kidneys, and urinary tract which are not easily distinguishable by conventional fluoroscopy alone. Immediately after recognition that the needle tip is clearly not in the right position, it is possible to capture the CT image with the subject lying on the same bed and perform the block by injecting the pharmacological agents more safely and accurately.

37.6 Complications [2]

37.6.1 Pneumothorax

For this block, in principle, the patient needs to be managed with hospitalization. Furthermore, pneumothorax is distinguishable on plain chest X-ray and CT images. Make an effort at early detection by conducting detailed follow-up in the ward.

37.6.2 Vessel Puncture

In the event of vessel puncture, inject a contrast agent to distinguish among relevant structures. Manage this event by changing the position of the needle.

If the contrast agent flows into the punctured vessel even after the positon of the needle has been changed, treatment should be administered employing only the high-frequency thermocoagulation procedure.

37.6.3 Horner Signs

Until injection of a neurolytic agent after the local anesthetic has been injected, distinguish between ptosis and congestion by examining both eyes.

When the Horner sign appears, conduct only the high-frequency thermocoagulation procedure or set a neurolytic agent injection volume below 0.5 mL.

37.6.4 Radiculitis, Neuritis

Caution is necessary when the contrast agent flows in the vicinity of the intercostal nerve and nerve root. Until injection of a neurolytic agent after the local anesthetic has been injected, examine cutaneous sensation in the dermatome area at the site of application. When decreased sensation is observed, conduct only the high-frequency thermocoagulation procedure.

37.6.5 Others

Caution is necessary as events such as esophageal puncture and tracheal puncture may occur.

37.6.6 Target Points

1. The new X-ray fluoroscopy device, still capable of constructing CT-like images (cone-beam CT), has recently been developed and is useful for confirming the puncture and the contrast agent spread.

References

1. Ohseto K. Contrast radiography and effects of thoracic sympathetic ganglion block:anatomical analysis. J Anesth. 1991;5:132–41.
2. Ohseto K. Efficacy of thoracic sympathetic ganglion block and prediction of complication: clinical evaluation of the anterior paratracheal and posterior paravertebral approaches in 234 patients. J Anesth. 1992;6:316–31.

Endoscopic Thoracic Sympathectomy

38

Yoichiro Abe

38.1 Introduction

Sustained sympathetic hypertonia has long been considered an aggravating factor for chronic pain. Hyperhidrosis in the palms, armpits, or soles is believed to be caused by inherent hypersensitivity to sympathetic activation. We started to treat our patients with endoscopic thoracic sympathectomy (ETS) instead of the traditional thoracic sympathetic ganglion block in January 1994. Over 2000 patients have been treated with ETS to date.

The surgical technique, the indications, and the complications of ETS are described below.

38.2 Indications

38.2.1 Hyperhidrosis

38.2.1.1 Palmer and Facial Hyperhidrosis, Some Cases of Erythromania

ETS is indicated for patients with inherent palmer hyperhidrosis interfering with their social functioning. ETS is considered if other conservative treatments (drug therapy, aluminum chloride, iontophoresis, stellate ganglion block, botulin injection to the palm) are inadequate. Erythromania may be psychological (autonomic) caused by mental strain and accompanying palpitations or it may be thermal, occurring when the person moves from a cold place to a warm place. ETS is effective for psychological erythromania but not for thermal erythromania. A thorough preoperative interview as well as counseling and psychological assessment by a psychotherapist or a psychiatrist will be required since there may be underlying psychiatric disorders.

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38.2.1.2 Neuropathic Pain in the Upper Limbs (CRPS)

ETS may be performed to relieve symptoms of CRPS if the sympathetic nerve is significantly involved in the neuropathic pain in the upper limbs. Nii and colleagues stated that the indications of ETS for neuropathic pain should be carefully considered because the efficacy decreases over time. An early sympathetic nerve block is recommended since the treatment outcome is better in patients treated early than in those treated later. However, the treatment of CRPS requires drugs, rehabilitation, and psychological follow-up because surgery alone will be insufficient.

38.2.1.3 Peripheral Circulatory Disorders of the Upper Limbs

Peripheral circulatory disorders of the upper limbs, such as Buerger's disease, arteriosclerosis obliterans (ASO), and Raynaud's disease are good indications for ETS to promote pain relief and ulcer healing. We frequently perform ETS in patients resistant to drug therapy and nerve blocks.

38.2.1.4 Angina

The sympathetic nerve is activated by pain to increase the heart rate, resulting in myocardial ischemia and increased pain from angina, becoming a vicious cycle. ETS prevents this cycle by causing bradycardia to reduce the heart strain and blocking the cardiac branch to relieve pain. However, the efficacy often decreases with progression of the underlying disorder. ETS is also reported to be effective for Wolf-Parkinson-White (WPW) syndrome.

38.2.1.5 Chronic Abdominal Pain

ETS is performed on the mid to lower thoracic sympathetic nerve to reduce pain associated with chronic pancreatitis. However, recurrence at about 6 months is likely due to progression of the symptoms or involvement of other pain circuits.

K. Ohseto et al. (eds.), *Nerve Blockade and Interventional Therapy*, https://doi.org/10.1007/978-4-431-54660-3_38

38.3 Anatomy

See Chap. 37: "Thoracic Sympathetic Ganglion Block."

38.4 Instruments and Drug Solutions

Literature reference

38.5 Procedures and Techniques

38.5.1 Surgical Technique (Fig. 38.1)

ETS is an endoscopic procedure to sever, remove, or use a clip to block the sympathetic trunk or ganglion. Hughes performed the first ETS in the lower chest in 1942 [1, 2]. Our ETS procedure includes single access to the sympathetic nerve using a urological resectoscope (Fig. 38.2), with two-port access with excellent hemostats such as harmonic scalpels, a narrow Autosuture port (about 2 mm) requiring no incision, and blocking the sympathetic nerve with a 5 mm titanium clip (clipping; Fig. 38.3). The advantage of the clipping procedure is the clip can be surgically removed later in patients with compensatory sweating.

38.5.2 Resection Level and Anatomy of the Sympathetic Nerve

T2 to T5 sympathetic innervation includes the hands (T2), upper arm, forearms and hands (T3), and armpits (T4 and T5). The nerve block is generally performed at T2 or T3.

38.6 Complications

38.6.1 Complications of ETS: Prevention and Treatment

Complications of ETS may occur during or after the procedure. Postoperative complications are especially problematic.

38.6.2 Compensatory Sweating

Sweating in the abdomen, back, buttocks, and/or lower limbs may be significantly increased. Thorough preoperative informed consent is necessary.

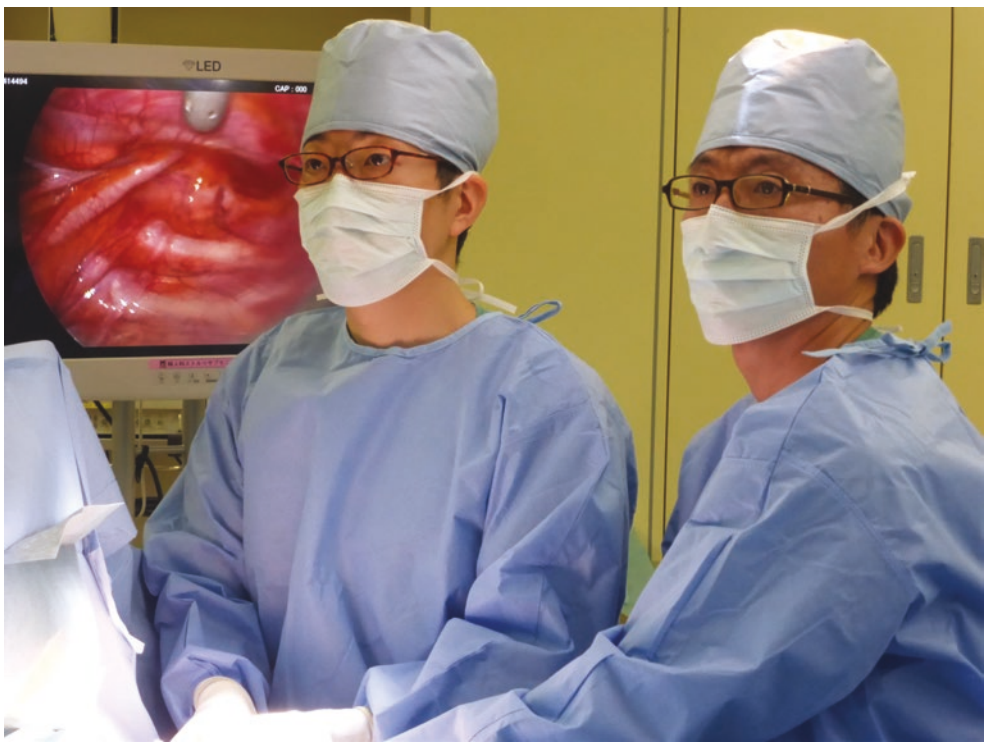

Fig. 38.1 Intraoperative photo during ETS

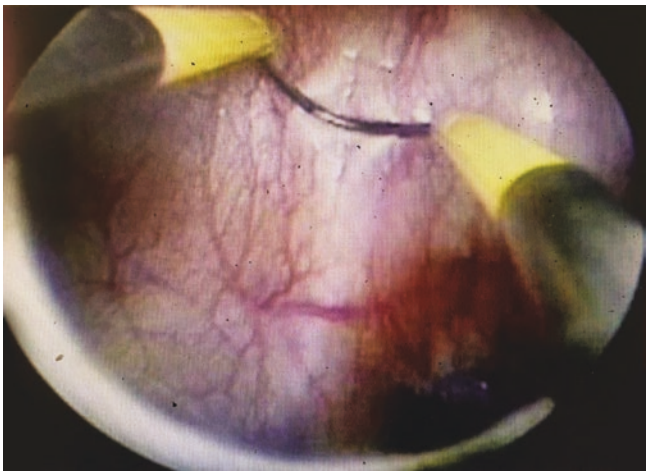

Fig. 38.2 The sympathetic nerve using a urological resectoscope

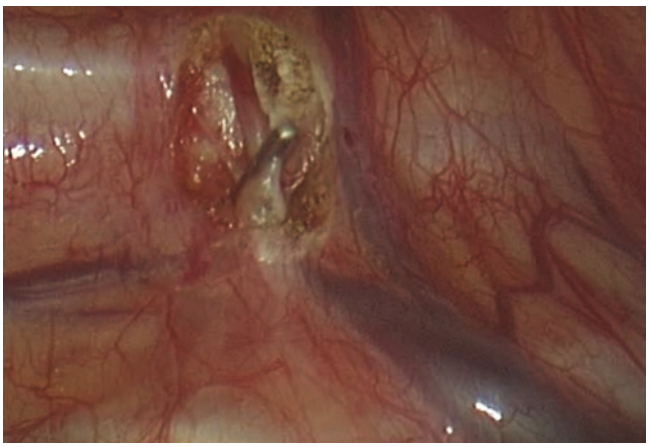

Fig. 38.3 Blocking the sympathetic nerve with a 5 mm titanium clip

38.6.3 Gustatory Sweating

Gustatory sweating may increase after ETS. Some patients may start sweating in the face as soon as they start eating.

38.6.4 Other

Some patients have unidentified complaints due to failing to cope with compensatory sweating. The complaints may include unexplainable fever, intolerance to coldness/hotness, disappearance of the senses of smell and taste, eczema in the arms, and inadequate vascular constriction in the arms. Some patients may complain about general malaise.

38.6.5 Comment

The ETS technique and the indications and the complications of ETS are described. Patients need to be thoroughly informed of the treatment and give consent because compensatory sweating is always expected despite the treatment efficacy. If the physician takes time and carefully informs the patient of what to expect, ETS will be a useful treatment to improve the patient's quality of daily life.

References

1. Samuelsson H, Claes G, Drott C. Endoscopic electrocautery of the upper thoracic sympathetic chain: a safe and simple technique for treatment of sympathetically maintained pain. Eur J Surg Suppl. 1994;(572):55–7.
2. Wettervik C, Claes G, Drott C, Emanuelsson H, Lomsky M, Radberg G, Tygesen H. Endoscopic transthoracic sympathicotomy for severe angina. Lancet. 1995;345(8942):97–8.

Editor's Comment

39

Kiyoshige Ohseto

39.1 Thorax and Back Comment

The nerve block for the posterior aspect of the thoracic spine can be safely performed using an interventional radiology-computed tomography (IVR-CT) device, which combines computed tomography (CT) guidance and radiography and other devices. However, as the sympathetic nerves located in the upper thoracic spinal region are situated over the rib sections that are anatomically distant from the thoracic vertebrae, achieving the effect of sympathetic nerve block in the upper thorax is difficult. Therefore, endoscopic thoracic sympathectomy, in which sympathetic nerves are resected under direct thoracoscopic view, achieves immediate and long-term effects.

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Part VIII

Abdomen and Back

Celiac Plexus Block and Splanchnic Nerve Block (X-Ray Fluoroscopy-Guided, CT-Guided)

40

Toshio Itabashi, Rikako Yamada, and Hiroyuki Uchino

40.1 Introduction

40.1.1 What Is Celiac Plexus Block and Splanchnic Nerve Block

Celiac plexus block and splanchnic nerve block are nerve blocks for relief of pain originating from the upper abdominal viscera (e.g., the pancreas, stomach, liver, and gallbladder) by injecting local anesthetics or neurolytic agents into the celiac plexus or splanchnic nerves (Fig. 40.1). The position of the needle tip differs between these blocks. For celiac plexus block (in a limited sense), the needle tip is positioned in front of the crura of the diaphragm (ventral side), and the celiac plexus anterior to the aorta is blocked. For splanchnic nerve block, the needle tip is positioned at the back of the crura of the diaphragm (dorsal side), and the splanchnic nerves within the retrocrural space surrounded by the crura of the diaphragm, anterior surfaces of vertebral bodies, and aorta are blocked. Meanwhile, because drug solution injected even for splanchnic nerve block passes through aortic hiatus to spread into the abdominal cavity and frequently reaches the celiac plexus, there is also a view that splanchnic nerve block is regarded as periaortic sympathetic nerve block. While the splanchnic nerve block technique is mainly performed at many facilities, selection of this technique is assumed to be based on this view.

40.2 Indications

Celiac plexus block and splanchnic nerve block are indicated for upper abdominal and back pain caused by cancer of the upper abdominal viscera. The indications include not only cancer pain but also benign intractable pain due to pancreatitis and other conditions.

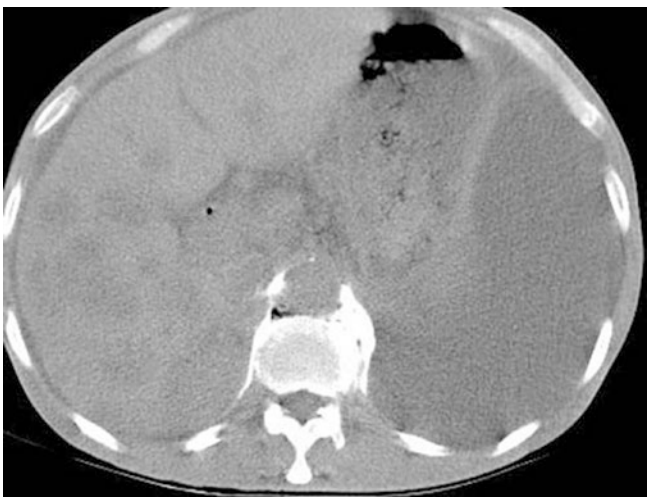

Fig. 40.1 CT image after splanchnic nerve block

40.3 Anatomy

The afferent fibers from the upper abdominal viscera enter the celiac ganglia in the celiac plexus and pass through the splanchnic nerves (greater, lesser, and least splanchnic nerves), sympathetic trunk, and white communicating branches to enter the dorsal roots. Then, the fibers reach the spinal cord dorsal horns and further ascend through the spinal ventrolateral funiculus. The celiac ganglia contain the fibers from the upper abdominal viscera, which include the stomach, liver, gallbladder, pancreas, spleen, and kidneys. Thus, the application of these techniques is effective for treating pain originating from these organs. The celiac plexus is located in an area surrounded by the kidneys, adrenal glands, liver, and pancreas in front (ventral side) of the abdominal aorta and the crura of the diaphragm at the level from the twelfth thoracic (Th12) vertebral body to the first lumbar (L1) vertebral body. The splanchnic nerves consist of the greater splanchnic nerve composed of the thoracic ganglia Th5–Th9 and the lesser splanchnic nerve composed of the thoracic ganglia Th10–Th11. These nerves are located in

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the retrocrural space surrounded by the crura of the diaphragm and vertebral bodies at the back (dorsal side) of the abdominal aorta and the crura of the diaphragm. Before the application of the blocks, it is necessary to perform abdominal computed tomography (CT) or other imaging studies to assess whether the retrocrural space is maintained.

40.4 Instruments and Drug Solutions

- 21G 1cm block needle.
- 23G 6cm needle.
- 5 mL, 10 mL syringe, 5 mL glass syringe.
- Local anesthetics, nonionic contrast media, neurolytic agent.
- Radioscopy set, IVRCT set.

40.5 Procedures and Techniques [1–6]

40.5.1 Precautions for the Techniques and Their Application

To treat decreased blood pressure, venous access should be obtained before the application of the techniques. There are various approaches, including not only the posterior approach from the back but also the intraoperative anterior approach. Under the X-ray fluoroscopy-guided method, the lateral approach to vertebral body and trans-intervertebral disc approach, which are techniques to approach from the posterior aspect, are frequently used. Moreover, an approach under the guidance of interventional radiology CT (IVRCT-guided method) is also performed because IVRCT facilitates grasping the anatomical positional relationship of each organ and is safe. In recent years, many attempts are made to apply the nerve blocks under the endoscopic ultrasound-guided method.

40.5.2 Paraspinal Approach Under the X-Ray Fluoroscopy-Guided Method

Lateral approach to vertebral body (lateral position): When the needle is inserted from the left side rather than the right side, the retrocrural space becomes smaller because the abdominal aorta is located toward the left side, and drug solution is more likely to spread to both the right and left sides. For insertion from the left side, a patient is placed in the lateral position with the right side down. The insertion point is above 1/3 of the cranial part of the L1 vertebral body at the upper border of the intervertebral foramen at 6–7 cm externally from the acantha. When the needle is inserted at a point 7 cm or more externally from the acantha, there is a risk of renal puncture. An operator should slowly advance the block needle while trying to keep it at the midpoint of the anterior-posterior diameter of the vertebral body. If the center of the vertebral body is aimed, there is a possibility to puncture the lumbar artery or vein. When the block needle touches the lateral surface of the vertebral body, the needle is slightly pointed to the outside to be kept attached to the bone and advanced to the anterior border of the vertebral body. Then, the block needle is further advanced slowly by the loss-of-resistance method using physiologic saline. Loss of resistance is achieved at the anterior border or in front of the vertebral body. If resistance remains, the needle may be attached to the abdominal aortic wall. While the block needle is retrieved, an area with no resistance should be reconfirmed. When loss of resistance is achieved, 5 mL of a contrast medium or an injection mixture of a contrast medium and local anesthetic is injected, and the spread of contrast medium is checked. The contrast-enhanced imaging findings appear as a wedge shape which is broad at the anterior aspect of the vertebral body and tapers to the caudal side on the lateral image and an h-like shape which covers the spinal column and spreads to the right and left sides of the spinal column on the front image. A contrast medium may sometimes spread to the anterior surface of the abdominal aorta. After the absence of a contrast medium either flowing into blood vessels, organs, or intervertebral foramen or clearly moving synchronously with respiration is confirmed, 10–15 mL of a local anesthetic is injected.

40.5.3 Trans-intervertebral Disc Approach Under the X-Ray Fluoroscopy-Guided Method

Trans-intervertebral disc approach: The insertion level is between the TH12 and L1 vertebral bodies or between the L1 and L2 vertebral bodies. Before performance, the condition of the retrocrural space is checked on CT images, and the level with a wider retrocrural space should be selected. This approach is frequently performed at the level between the L1 and L2 vertebral bodies. The axis of X-ray fluoroscopy is adjusted to align with the anterior-posterior diameter at the cranial side of the vertebral body at the caudal side of the insertion level. The insertion point should be at a point on the line extended from the anterior-posterior diameter and 4–6 cm externally from the acantha. The block needle is inserted at approximately 50° from the skin and slowly advanced toward the intervertebral disc between the vertebral bodies to be treated. When the block needle enters the intervertebral disc and is advanced to the point approxi-

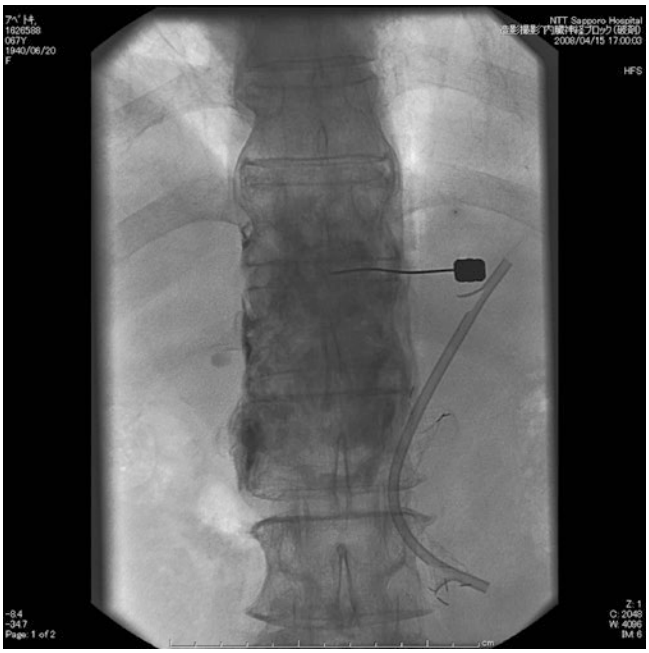

Fig. 40.2 Trans-intervertebral disc approach under the X-ray fluoroscopy-guided method. The needle tip is positioned close to the midline on the front image after loss of resistance

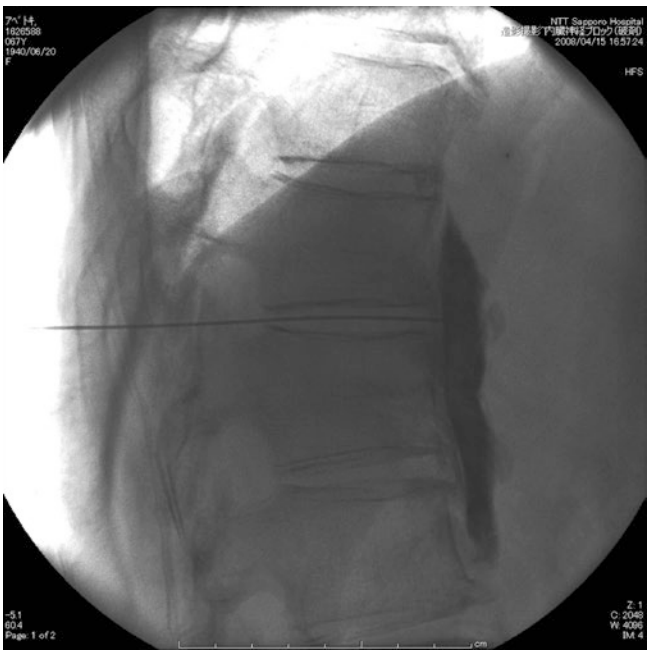

Fig. 40.3 Trans-intervertebral disc approach under the X-ray fluoroscopy-guided method. The needle tip is in front of the intervertebral disc on the lateral image after a contrast medium is injected

mately 1/4 of the proximal end of the right-to-left diameter of the intervertebral disc on the front image, the position of the needle tip is confirmed on the lateral image. The block needed is further advanced slowly by the loss-of-resistance method using physiologic saline. When the needle tip is positioned close to the midline on the front image (Fig. 40.2) and in front of the intervertebral disc on the lateral image after loss of resistance, 5 mL of a contrast medium or an injection mixture of a contrast medium and local anesthetic is injected (Fig. 40.3). When contrast-enhanced image findings show that the contrast medium covers the spinal column and spreads to both side of the spinal column on the front image and spreads to the ventral side of the vertebral body on the lateral image, a local anesthetic is injected in the same manner.

40.5.4 Trans-intervertebral Disc Approach Using IVRCT-Guided

With a patient in the prone position, a few vertebral bodies above and below the insertion level are imaged by CT, and the level of a vertebral body where the needle can be inserted and the insertion point are determined. The distance between the insertion point and the midline of the acantha, as well as the angle and depth of insertion, is measured. After the insertion point is confirmed with a pointer of CT, the insertion point is marked. The block needle is slowly advanced under the X-ray fluoroscopic guidance. When the needle is advanced to approximately 1/2 of the planned depth by the lateral approach to vertebral body or inserted into the intervertebral disc by the trans-intervertebral disc approach, CT is performed again to reconfirm the direction of the needle and the position of its tip. The needle is slowly advanced under the X-ray fluoroscopy-guided method by the loss-of-resistance method using physiologic saline. When resistance is lost, 5 mL of a contrast medium is injected, and CT is repeated. After spread of the contrast medium is confirmed, a local anesthetic is injected in the same manner.

When neurolytic agents are used with the techniques described above, the presence or absence of complications or analgesic effect is confirmed 20 min after injection of 10–20 mL of a local anesthetic. Then, a neurolytic agent at the same dose as that of the injected local anesthetic is slowly injected, while blood pressure and numbness in the areas from the groin to the lower limbs are monitored. When neurolytic agents are used, after 0.5 mL of physiologic saline is injected, the needle is retrieved with continuous slight suction by a syringe, and the procedure is completed. Especially after the application of block, attention should be paid to hypotension for 2 h, and patients should be on bed rest for 24 h. At the time of initial walking, attention should be paid to orthostatic hypotension.

We consider that IVRCT is superior and safer to use for grasping anatomical locations of the needle tip and drug solution.

40.6 Complications [1–3, 7]

40.6.1 Hypotension and Orthostatic Hypotension

Hypotension after the application of block usually resolves within 24 h. It should be taken into consideration that hypotension is caused by not only sympathetic nerve block but also bleeding. Although orthostatic hypotension may also occur, it usually resolves within 1 week. For the application of block using neurolytic agents, caution is needed because hypotension and orthostatic hypotension may persist for a long period of time.

40.6.2 Abdominal Symptoms

Because the parasympathetic nerve becomes dominant, diarrhea, abdominal pain, bloating, and other symptoms caused by increased bowel peristalsis may persist for several days. Diarrhea is considered to occur in 50% of cases.

40.6.3 Acute Alcohol Intoxication-Like Symptoms

Acute alcohol intoxication-like symptoms occur when a blood alcohol level increases after ethanol is used. Although they do not persist until the following day, what symptom appears after drinking alcohol should be identified before the application of block.

40.6.4 Infection

Adequate disinfection and clean procedure should be kept in mind. Especially when the trans-intervertebral disc approach is used, great caution should be given to avoiding diskitis. Prophylactic administration of antibiotics is preferable.

40.6.5 Drug Allergy

Because allergy due to contrast media is rare but may occur, caution is required.

40.6.6 Vascular Puncture and Injury

In case of the lateral approach to vertebral body from the left side, caution should be given to avoiding abdominal aortic injury. It is considered that, when 22-G to 23-G block needles are used, puncture of the abdominal aorta does not become a big problem. However, because block is frequently applied to patients with poor systemic conditions, attention should be paid to blood pressure after the application of block. There are reports describing that abdominal aortic dissection occurred after neurolytic agents were used. In suspected cases, CT should be performed.

40.6.7 Organ Puncture

The diaphragm, kidneys, ureters, liver, and lungs (pneumothorax) can be punctured. When the diaphragm is punctured, the shadow is strongly influenced by respiratory fluctuation after injection of a contrast medium, and severe radiating pain occurs in the shoulders, chest, and other parts after injection of a neurolytic agent. When the kidney is punctured, the needle moves in synchrony with respiration.

40.6.8 Neuropathy

Abdominal sympathetic nerve block and sensory nerve block of the lower limbs may occur. After injection of local anesthetics, sensory function should be sufficiently tested.

40.6.9 Others

Paraplegia and anterior spinal artery syndrome are rare but may occur. It is considered that the lateral approach to vertebral body from the right side is likely to cause puncture of the thoracic duct or azygous vein, while chylothorax reportedly occurs a few days after the use of the technique. Dysuria, psychosexual dysfunction, acute gastrectasis, and other complications have also been reported.

References

1. Shiotani M. Celiac plexus block. In: Wakasugi B, editor. Pain clinic nerve block. 2nd ed. Tokyo: Igakusyoin; 2002. p. 170–84. (in Japanese).
2. Ito T, et al. Celiac plexus block. In: Miyazaki T, editor. Nerve block—Rearranging of associated diseases and procedure. Tokyo: Sinkoukoueki; 2000. p. 310–5. (in Japanese).
3. Kato J, et al. Splanchnic nerve block. In: Miyazaki T, editor. Nerve block—Organization of associated disease and procedure. Tokyo: Shinkoukoueki; 2000. p. 31–327. (in Japanese).
4. Patt RB, et al. Technique for neurolytic neural blockade. In: Cousins MJ, et al., editors. Neural blockade. Philadelphia: Lippincott-Raven; 1998. p. 1035–47.
5. Waldman S. Celiac plexus block. Atlas of interventional pain management. Philadelphia: Saunders; 2004. p. 265–93.
6. Ina H, et al. New technique for the neurolytic celiac plexus block: the transintervertebral disc approach. Anesthesiology. 1996;85:212–7. (in Japanese)
7. Ronald K, et al. Aortic dissection as a complication of celiac plexus block. Anesthesiology. 1995;83:632–5.

Superior Hypogastric Plexus Block (X-Ray Fluoroscopy-Guided, CT-Guided)

41

Yutaka Tanabe

41.1 Introduction

41.1.1 What Is Superior Hypogastric Plexus Block? [1–6]

Superior hypogastric plexus block (SHPB) essentially consists of injecting a local anesthetic or a neurolytic to superior hypogastric plexus, which lies anterior to the fifth lumbar (L5) vertebra and the first sacral (S1) vertebra, to obtain a sympathetic nerve blocking effect.

41.2 Indications

SHPB is indicated for the relief of pain originating from the pelvic viscera (e.g., bladder, uterus, ovaries, testes, prostate, some of the colon, and rectum), and it is also used to relieve cancer pain and benign intractable pain (e.g., perineal pain or endometriosis).

41.3 Anatomy (Fig. 41.1) [1–6]

The superior hypogastric plexus is formed between the inferior extremity of the origin of the inferior mesenteric artery and the bifurcation of the main artery to the left and right common iliac arteries, by addition of the aortic plexus to the second to fourth lumbar splanchnic nerves, and it lies anterior to the fifth lumbar (L5) vertebra and the first sacral (S1) vertebra. It thereafter diverges to the left and right hypogastric nerves, which then converge to the inferior hypogastric plexus, which distributes out to the pelvic viscera and the external genitalia.

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41.4 Instruments and Drug Solutions

Needles:	22-G 12–15-cm block needles; 25-G injection needles (for local anesthesia); two 18-G injection needles (for drug preparation)
Injectors:	5-mL syringe and 10-mL syringe; 5-mL glass syringe (for loss-of-resistance method)
Drugs:	Local anesthetic drug (2% mepivacaine or 2% lidocaine) 20 mL; non-ionic aqueous contrast medium; 99.5% ethanol necessary in the case of neurolytic treatment
	Sterilization set
Additional instrument:	Metal measure

41.5 Procedures and Techniques [1–3, 5]

Either the paravertebral technique or the transdiscal technique may be used, depending on the path of block needle insertion. The transdiscal technique is widely used, but in some cases the injection can be anatomically difficult. Before performing the procedure, it is therefore necessary to use plain X-ray imaging to ascertain the space distance between the L5 vertebra and the sacral intervertebral disc, the shape of the L5 vertebral transverse process, and the degree of its opening relative to the iliac crest, and other aspects.

41.5.1 X-Ray Fluoroscopy-Guided Method

41.5.1.1 Transdiscal Technique

Body Position and Imaging Technique (Fig. 41.2)
The patient lies in the prone position, with a body pillow used beneath the lower abdomen to obtain the maximum possible opening between the L5 vertebra and the sacrum.

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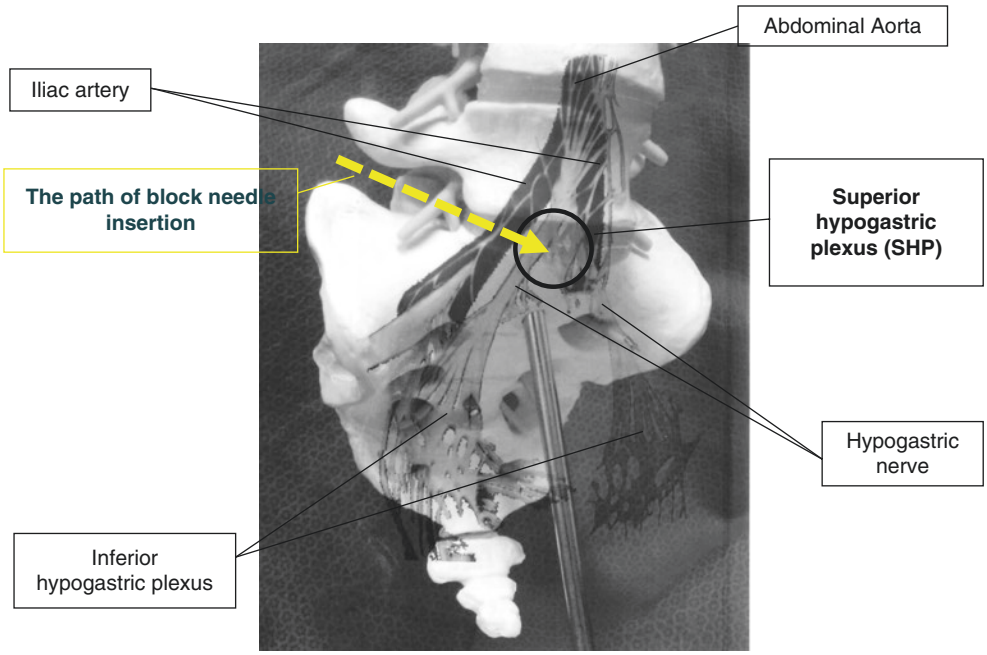

Fig. 41.1 SHPB lies anterior to the L5 and S1 vertebra (modified from the ref. 3)

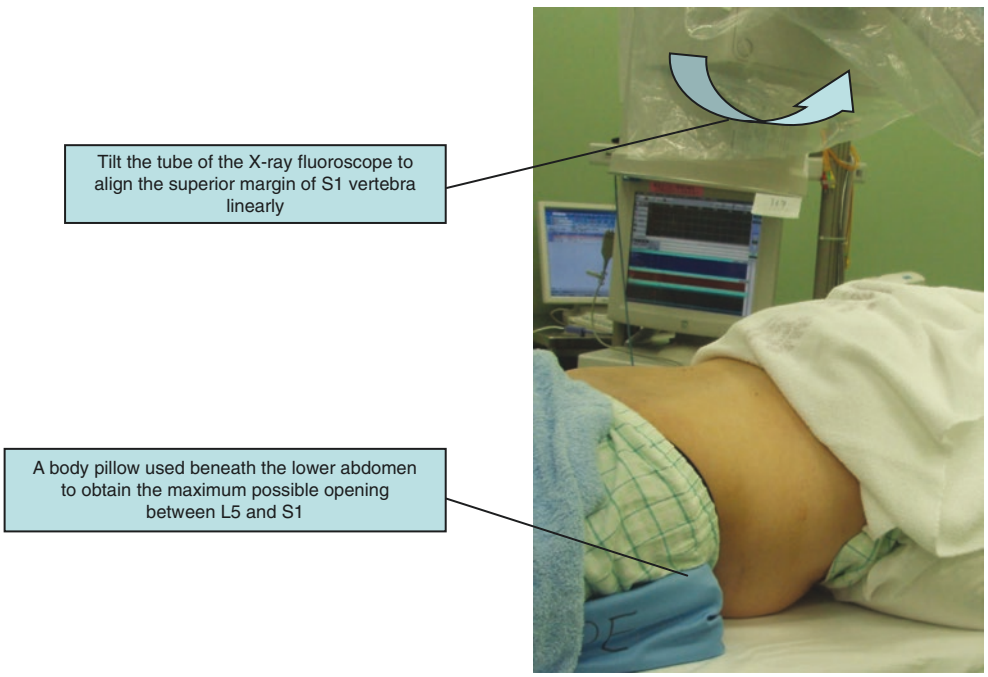

Fig. 41.2 Body position and imaging technique of X-ray fluoroscopy

Position the X-ray fluoroscope perpendicular to the patient's body axis. Observe the frontal view of the L5 vertebra and the sacrum, and tilt the tube of the X-ray fluoroscope to align the superior margin of the first sacral (S1) vertebra linearly. Check the lateral view as well.

Puncture Technique

Set the point of insertion at a distance 5–6 cm outside the L5 spinous process (center) between the L5 transverse process and the iliac crest, somewhat toward the inferior margin of the transverse process. Image the insertion direction, using the metal measure and the block needle. After local anesthesia has been achieved, slowly advance the block needle at an insertion angle of about 45–55° toward the L5 vertebra and the sacral intervertebral disc. Particular care is necessary just before entry to the intervertebral disc, as the needle may touch the L5 nerve root in some cases (Fig. 41.3). Note that when the block needle enters the intervertebral disc, the insertion resistance becomes somewhat stronger. When the block needle reaches about 1/4 of the intervertebral disc

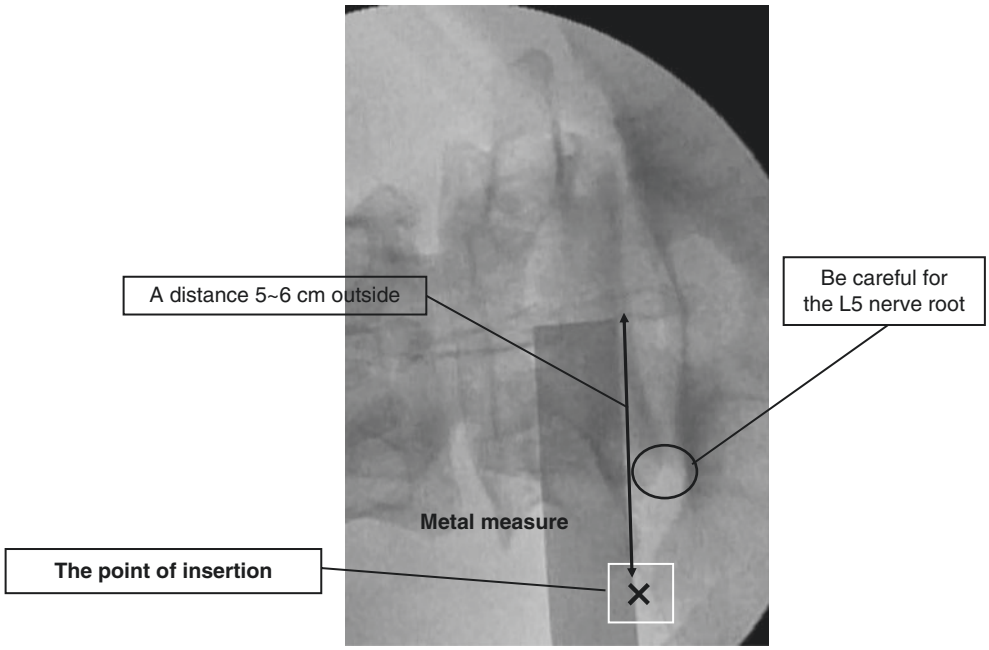

Fig. 41.3 The point of insertion

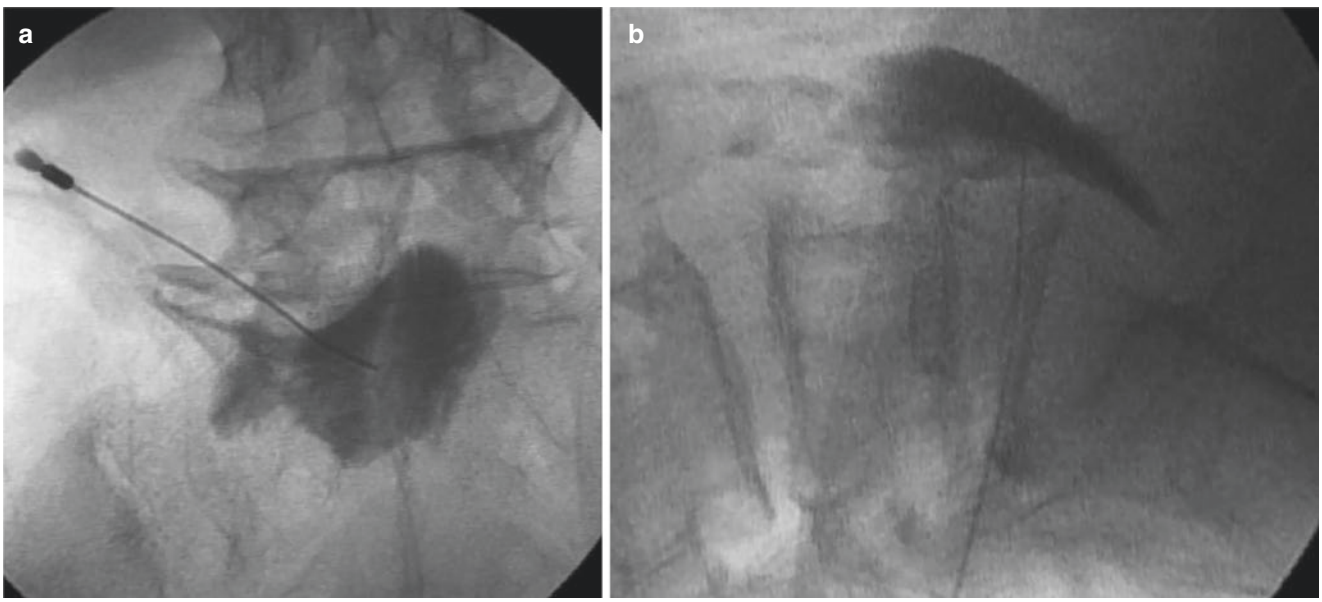

Fig. 41.4 Imaging findings. (**a**) The contrast medium spread on both sides in the frontal view. (**b**) The contrast medium spread in the shape of a mountain along the anterior margins of the L5 vertebra and the sacrum in the lateral view

left-right width in the frontal view, check the position of the needle tip in the lateral view. At this time, a needle point penetration to between 1/2 and 3/4 of the front-back width from the rear is ideal. Next, advance the block needle slightly, remove the inner tube, and attach the glass injector filled with physiological saline, and while applying pressure, slowly continue the advance. When the block needle tip completely penetrates through the intervertebral disc, the resistance to the applied pressure ends (whence comes the term "loss-of-resistance technique").

Confirm that the needle point is now near the center in the frontal image and forward of the intervertebral disc in the lateral image and that there is no reverse flow of blood, and then inject 5 mL of contrast medium while observing the image to confirm its spread on both sides in the frontal view, and in the lateral view its spread in the shape of a mountain along the anterior margins of the L5 vertebra and the sacrum (Fig. 41.4). After careful aspiration for blood, slowly inject 6–10 mL of local anesthetic (2% mepivacaine or 2% lidocaine). In the case of neurolytic use

(99.5% ethanol), confirm freedom from any perceptual disorder or motor paralysis in the lower extremities 20 min after injecting the local anesthetic, and then slowly inject the neurolytic in the same amount as the local anesthetic. In neurolytic cases, next inject 0.5 mL of air to empty the block needle and then withdraw the block needle while lightly aspirating the injector. Following implementation of the block, have the patient rest for 2 h in the prone or supine position.

41.5.1.2 Paravertebral Technique

Body Position and Imaging Technique

This technique may be performed in essentially the same manner as the transdiscal technique. First, confirm successful imaging of the L5 vertebra and forward of the sacrum in an oblique view at approximately 40–50°.

Puncture Technique

Set the point of insertion at a distance 6 cm outside the center at the level of the L4–L5 vertebrae. After achieving local anesthesia under oblique view, advance the block needle toward the region between the L5 vertebra and the sacrum. On reaching the inferior frontal region of the L5 vertebra, use the loss-of-resistance technique to advance further until the resistance ends approximately 1 cm before reaching the vertebral body. Confirm that the needle tip is positioned inside the vertebra in the frontal view, and then inject 5 mL of the contrast medium while observing the image. In the frontal view, confirm the formation of a long, narrow oval shape as though the L5 vertebra and the sacrum expand outward at the base (Fig. 41.5), and in the lateral view, confirm that the region from the lower part of the L5 vertebra to the anterior surface of the sacrum falls into shadow. Perform the same technique in the other side. After careful aspiration for blood, slowly inject 6–10 mL of local anesthetic (2% mepivacaine or 2% lidocaine) on each side. If a neurolytic is to be used, the procedure is the same as in the transdiscal technique.

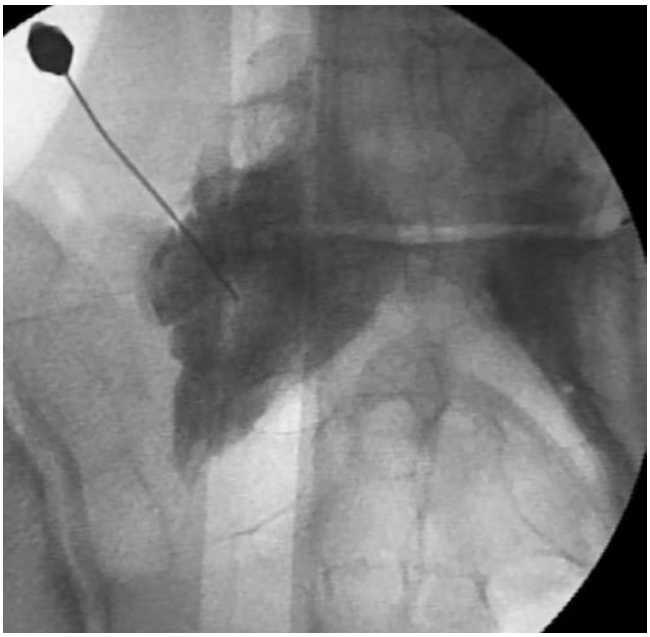

Fig. 41.5 Imaging finding of the paravertebral technique

41.5.2 CT-Guided Method [4]

Here we will describe the transdiscal technique.

41.5.2.1 Body Position and Preparation

The body position may be the same as in X-ray fluoroscopy-guided. With that body position, first perform CT imaging of the region from the L5 vertebra at the sacral level to obtain slices clearly showing the bifurcation of the abdominal aorta into the left and right common iliac arteries and the intervertebral disc between the L5 vertebra and the sacrum. Using slices under which the block needle can advance past the inner side of the iliac crest and the outer side of the superior articular process of the sacrum in a straight line toward the center (the target point) of the anterior side of the intervertebral disc, measure the distances and angles from the point of insertion to the midline and from the point of insertion to the target point, and draw the corresponding diagram.

41.5.2.2 Puncture Technique

Gauge the point of insertion, and slowly advance the block needle at the pre-measured angle of insertion angle (about 60°). After confirming by CT that the needle point has advanced toward the target point, continue to advance the block needle on to the intervertebral disc. When the block needle enters the intervertebral disc, the resistance to block needle insertion will become somewhat stronger. Under CT observation, advance the needle until just before its arrival at the anterior surface of the intervertebral disc. Confirm the position of the needle tip when resistance ends as found by the loss-of-resistance technique. Next, inject 5 mL of contrast medium while observing the images to confirm its spread to the anterior surface of the intervertebral disc, and then slowly inject 6–10 mL of the local anesthetic (2% mepivacaine or 2%lidocaine). If using a neurolytic, follow the same procedure as that used under X-ray fluoroscopy.

41.6 Complications

Infection, hemorrhage, and contrast medium allergy: Exercise due care in regard to discitis. Include sufficient sterilization and clean and hygienic operation, and consider antibiotic administration.

L5 nerve damage: Perform insertion slowly and carefully.

Lower extremity sensation and motor paralysis: May occur if any drug reaches an L5 or S1 nerve.

Bladder, rectal, or ejaculation disorder: Particular care is necessary in the case of cancer patients, as latent disorders may exist prior to implementation.

References

1. Masako I, Toyo M. Superior hypogastric plexus block. In: Mayumi T, editor. Clinical practice of anesthesia. Tokyo: Bunkodo; 2003. p. 222–5. (in Japanese).
2. Masako I. Superior hypogastric plexus block. Nerve blocks: full understanding of techniques. Pain Clinic (Supplement). 2006;27:S571–7. in Japanese
3. Yutaka T, Masako I, Toyo M. Superior hypogastric plexus block. In: Kiyoshige O, editor. Nerve blocks in X-ray fluoroscopy. Tokyo: Igakushoinn; 2009. p. 111–3. (in Japanese).
4. Hiroaki I. Superior hypogastric plexus block. CT guidance. Nerve blocks rearrangement and techniques of the allied disease. Tokyo: Shinko Trading Company Ltd; 2000. p. 343–6. (in Japanese)
5. Loeser JD, editor. Bonica's management of pain. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2001.
6. Waldman SD, editor. Hypogastric plexus block. Atlas of interventional pain management. 2nd ed. Philadelphia: Saunders; 2001. p. 411–8.

Ilioinguinal Nerve Block

42

Tatsuo Nakamoto

42.1 Introduction

42.1.1 What is the Ilioinguinal/Iliohypogastric Nerve Block?

The ilioinguinal/iliohypogastric nerve (II/IH) is one of the lumbar plexus branches from Th12, L1. It runs through the psoas major muscle on the outside into the fascia between oblique and transversus abdominis muscle and then travels medially and downward. This block provides analgesia of perception of the lower abdomen and groin skin.

This section discusses the ultrasound-guided identification of II/IH and measurement and blocking techniques.

42.2 Indication

Entrapment syndrome of II/IH, postoperative analgesia for inguinal hernia repair [1], pain on iliac bone harvesting, etc.

42.3 Anatomy (Fig. 42.1)

The ilioinguinal nerve and internal iliohypogastric nerve are branches of the lumbar plexus from Th12, L1, emerging from outside of the psoas muscle and passing through the abdominal side of quadratus lumborum muscle. They then pass forward and downward through the interfascia between the internal oblique muscle and transversus abdominis muscle to the inside of the iliac crest. The ilioinguinal nerve passes in the oblique muscles and comes into the inguinal canal from the superficial inguinal ring. The iliohypogastric nerve travels parallel to the ilioinguinal nerve between the fascia of the internal oblique and transversus abdominis muscles, branching to a lateral cutaneous branch and anterior cutaneous branch above the iliac crest.

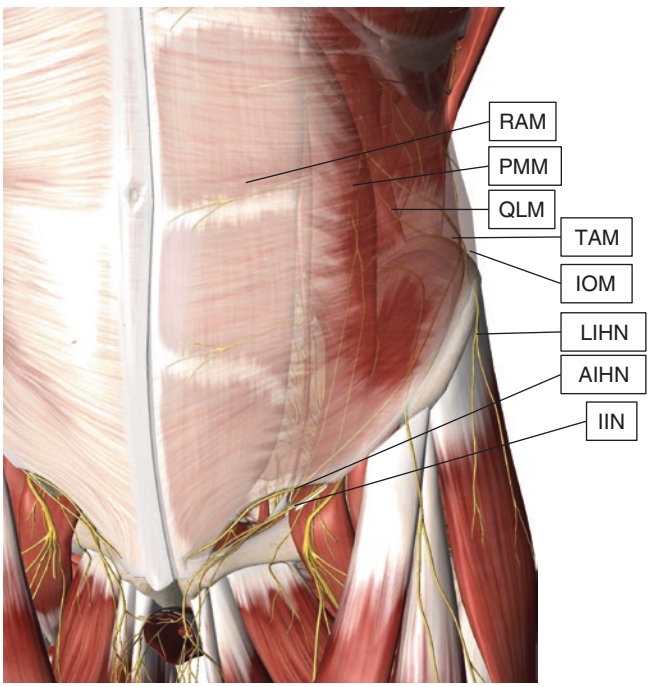

Fig. 42.1 Anatomy of ilioinguinal/iliohypogastric nerve. *AIHN* anterior cutaneous branch of iliohypogastric nerve, *IIN* ilioinguinal nerve, *IOM* internal oblique muscle, *LIHN* lateral cutaneous branch of iliohypogastric nerve, *PMM* psoas major muscle, *QLM* quadratus lumborum muscle, *RAM* rectus abdominis muscle, *TAM* transversus abdominis muscle. Image is from 3D4Medical's Essential Anatomy 5 application

42.4 Instruments and Drug Solutions

42.4.1 Material Preparation (Fig. 42.2)

High-resolution linear array probe (>10 MHz), sterilized probe cover or film dressings, 20–22G 50–80 mm Tuohy needle, alcohol-containing chlorhexidine, local anesthetics (LA), steroid products

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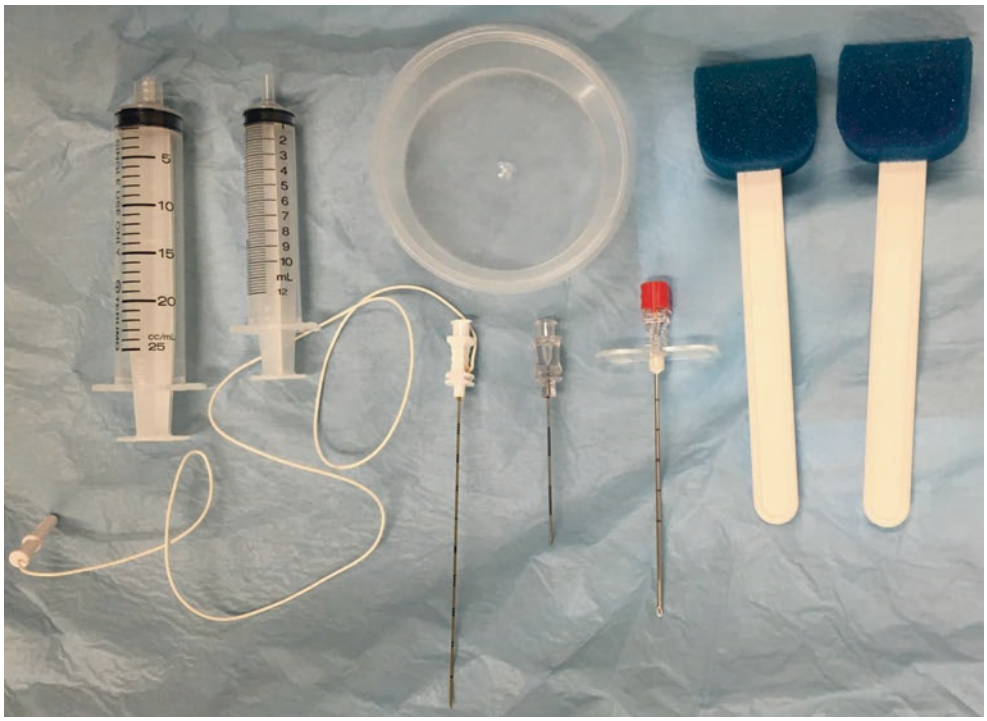

Fig. 42.2 Material and drugs for ilioinguinal/iliohypogastric nerve block

42.4.2 Drugs and Dosage

5–10 mL 0.5–1% mepivacaine or lidocaine.
5–10 mL 0.1% levobupivacaine or 0.15% ropivacaine.

42.5 Procedures and Techniques

Position: supine.

42.5.1 Landmarks Method

Anterior superior iliac spine, umbilicus.

42.5.2 Scanning (Fig. 42.3)

Place the linear probe on the lateral aspect of the line between the anterior superior iliac spine and the navel [2].

Confirm three-layer structure consisting of external and internal oblique muscles and transversus abdominis muscle.

The ilioinguinal nerve is identified as a hypoechoic round structure with hyperechoic surface between the fascias of the internal oblique and transversus abdominis muscles close to the iliac bone (Fig. 42.4).

Sliding proximally along the course of the II/IH nerve, determine the probe position where you can confirm the nerve well.

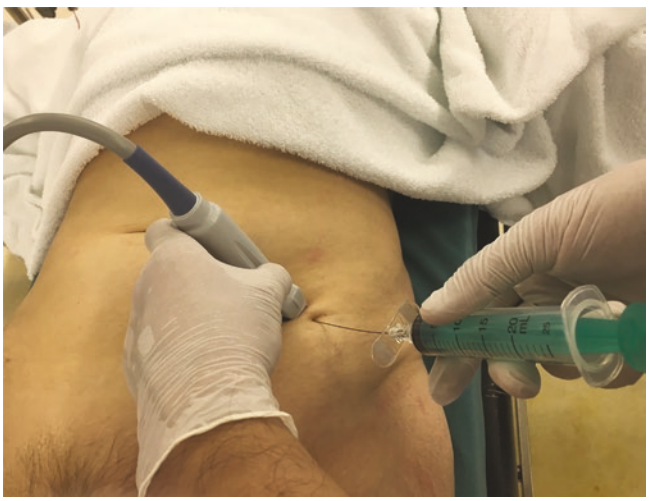

Fig. 42.3 Patient position and probe setting

42.5.3 Needle Insertion Technique [3]

1. Prepare the probe with sterilized probe cover or film dressing, and swab the block sites with antiseptic.
2. Place the probe in a position to adequately visualize sonoanatomy including the iliac crest, external oblique muscle, internal oblique muscle, transversus abdominis muscle, and ilioinguinal/iliohypogastric nerves, then insert the needle using an in-plane approach from the medial border of the probe to the interfascia between IOM and TAM medial to the nerve.

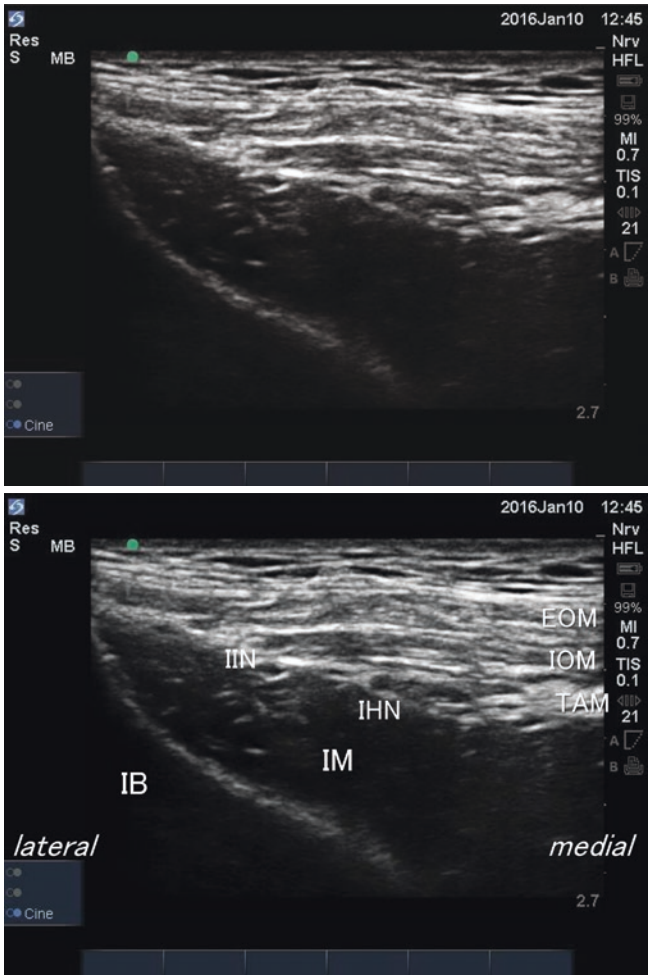

Fig. 42.4 Typical sonographic images for ilioinguinal/ iliohypogastric nerve block

3. Confirm that needle tip penetrates through dorsal fascia of IOM. Injection of LA provides the spread around the II/IH nerve with water dissection of the interfacial space.
4. Injecting the residual dose while adjusting the needle tip to completely surround the spread of LA around each nerve.
5. If each nerve is not visualized well, additional injection of LA into the interfascial space between EOM and IOM provides much better analgesia.

42.6 Complications

42.6.1 Bleeding, LA Toxicity

In this region, the nerves are located alongside blood vessels. Therefore, it is essential for safety to confirm the vessels by color Doppler and to make the split injection.

42.6.2 Femoral and/or Lateral Femoral Cutaneous Nerve Blocks [4]

LA spread to inside of the iliac muscle may cause femoral and/or lateral femoral cutaneous nerve block.

References

1. Baerentzen F, Maschmann C, Jensen K, et al. Ultrasound-guided nerve block for inguinal hernia repair: a randomized, controlled, double-blind study. Reg Anesth Pain Med. 2012;37:502–7.
2. Gofeld M, Christakis M. Sonographically guided ilioinguinal nerve block. J Ultrasound Med. 2006;25:1571–5.
3. Eichenberger U, Greher M, Kirchmair L, et al. Ultrasound-guided blocks of the ilioinguinal and iliohypogastric nerve: accuracy of a selective new technique confirmed by anatomical dissection. Br J Anaesth. 2006;97(2):238–43.
4. Buist RJ, Mansour NY. Femoral nerve block as a complication of Ilio-inguinal nerve block. Anaesthesia. 1988;43:805.

Comment

43

Kiyoshige Ohseto

43.1 Editor's Comment

43.1.1 Abdomen and Back Comment

The nerve block for abdominal visceral pain, which is a compartment block, can be more safely performed using the guidance of IVR-CT and other CT modalities that permit observation of the anatomical association with the position of the needle tip and spread of contrast media than using the previously used fluoroscopy-guided method.

43.2 Tanabe's Comment

1. The transdiscal technique is considered to have important advantages over the paravertebral technique: (1) it can be completed in a single procedure of block needle insertion and withdrawal, whereas the procedure must be performed once on the left and again on the right in the paravertebral technique; and (2) the amount of drug injected is smaller.
2. Performance of the procedure under fluoroscopy is more convenient than under CT guidance, and real-time observation of the lateral, vertical, and anteroposterior spread of the contrast medium and any entry into blood vessels can be readily performed. For the CT-guided procedure, the use of an IVR-CT as the CT system is preferable, if available.

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Part IX

Lumbosacral Region

Ultrasound-Guided Lumbar Plexus Block

44

Tatsuo Nakamoto

44.1 Introduction

44.1.1 What Is the Lumbar Plexus Block (LPB)?

The lumbar plexus (LP), generally consisting of L1–L4 roots, is divided to each terminal branch through the psoas major muscle. LPB is essentially defined as a "three-in-one block" because it offers complete block of femoral, lateral femoral cutaneous, and obturator nerves by injection into the compartment covered by the psoas fascia.

In this section, we explain the procedure of LPB detected by two techniques: nerve stimulation with a surface landmark method and ultrasound-guided method.

44.2 Indications

Anesthesia and postoperative analgesia for lower limb (hip, femur, knee), combined with sciatic nerve block as necessary.

Pain medicine: lumbago and/or lower limb pain, postoperative neuralgia of the thigh, cancer pain, etc.

44.3 Anatomy (Fig. 44.1)

LP consists of the anterior rami of L1–L4, each nerve running through the dorsal medial part of the psoas major muscle (posterior segment).

Terminal branches of LP include the ilioinguinal nerve (L1), iliohypogastric nerve (L1), genitofemoral nerve (L1–L2), femoral nerve (L2–L4), obturator nerve (L2–L4), and lateral femoral cutaneous nerve (L2, 3).

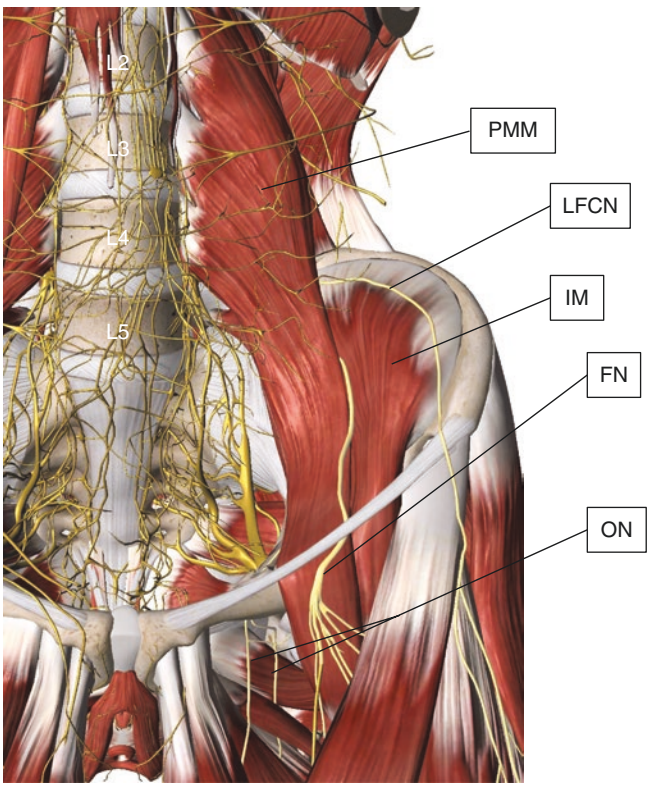

Fig. 44.1 Anatomy of lumbar plexus and psoas compartment. *FN* femoral nerve, *IM* iliac muscle, *LFCN* lateral femoral cutaneous nerve, *ON* obturator nerve, *PMM* psoas major muscle. Image is from 3D4Medical's Essential Anatomy 5 application

44.4 Instruments and Drug Solutions

44.4.1 Prepared Materials (Fig. 44.2)

2–5 MHz curved array probe, sterilized probe cover or film dressing, 20–22G 100–120 mm (stimulating) block needle, antiseptics, local anesthetics, and steroids.

Drugs and Dosage

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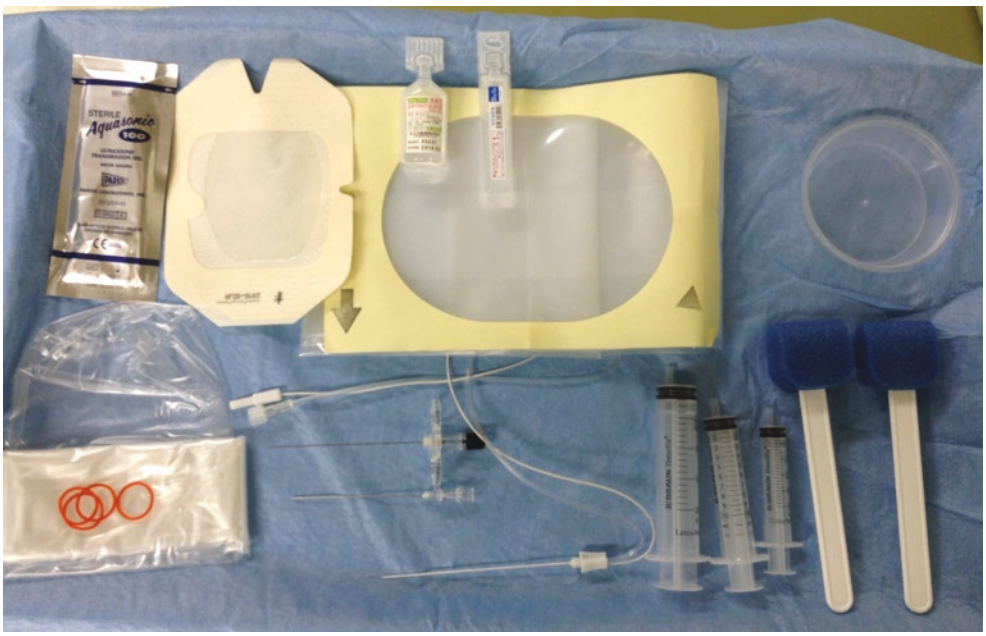

Fig. 44.2 Material and drugs for lumbar plexus block

Local anesthetics:
20–30 mL 0.3–0.75% ropivacaine or 0.25–0.5% levobupivacaine (for anesthesia).
10–15 mL of 0.5% lidocaine, 0.1% ropivacaine, or 0.0625% levobupivacaine (plus steroids as needed) (for pain medicine).

44.5 Procedures and Techniques

Position: Prone or lateral with affected side up and a pillow beneath the waist.

44.5.1 Landmarks Method

Position of US probe placement.

#Short-axis view (SAX): Place the probe perpendicular to the spine beside the L3 or L4 spinal process (Fig. 44.3a) [1].

Place the probe beside the spinal process and scan to lateral.

To obtain the Shamrock view, scan to the midaxillary line (Fig. 44.3c) [2].

#Long-axis view (LAX): Place the probe parallel to the spine and 4 cm lateral from the spinal process on L4 [3].

Adjusting the probe tilt, confirm the transverse process of L2–L4 with acoustic shadow (trident sign) (Figs. 44.3b and 44.4c).

44.5.2 Ultrasound-Guided Method

Scanning technique:

The patient is placed in the prone position or (affected side up) lateral position (Sims' position).

1. Place the curved array probe parallel to the spine.
2. Confirm the L3 and L4 level using lumbosacral imaging (horsehead sign) by parasagittal oblique scan.
3. Rotate the probe 90° at L3–L4 level, and scan to lateral while confirming lumbar structures (laminar, facet, transverse process, psoas major muscle, quadratus lumborum muscle, and erector spinae muscle) on intertransverse process (Fig. 44.4a) [4].
4. In Shamrock view, place the probe on the midaxillary line. All structures described above are clearly confirmed, because no acoustic shadow of the transverse process interrupts the image around it (Fig. 44.4b).
5. The lumbar plexus is located on the posteromedial aspect of the psoas muscle, just lateral to the vertebral body, and is delineated as a hyperechoic structure.

Needle insertion technique:

1. Prepare the probe with sterilized probe cover or film dressing, and swab the block sites with antiseptic.
2. Place the probe in the position to visualize adequate sonoanatomy by Shamrock view, and then insert the needle using an in-plane approach from 4 cm lateral to

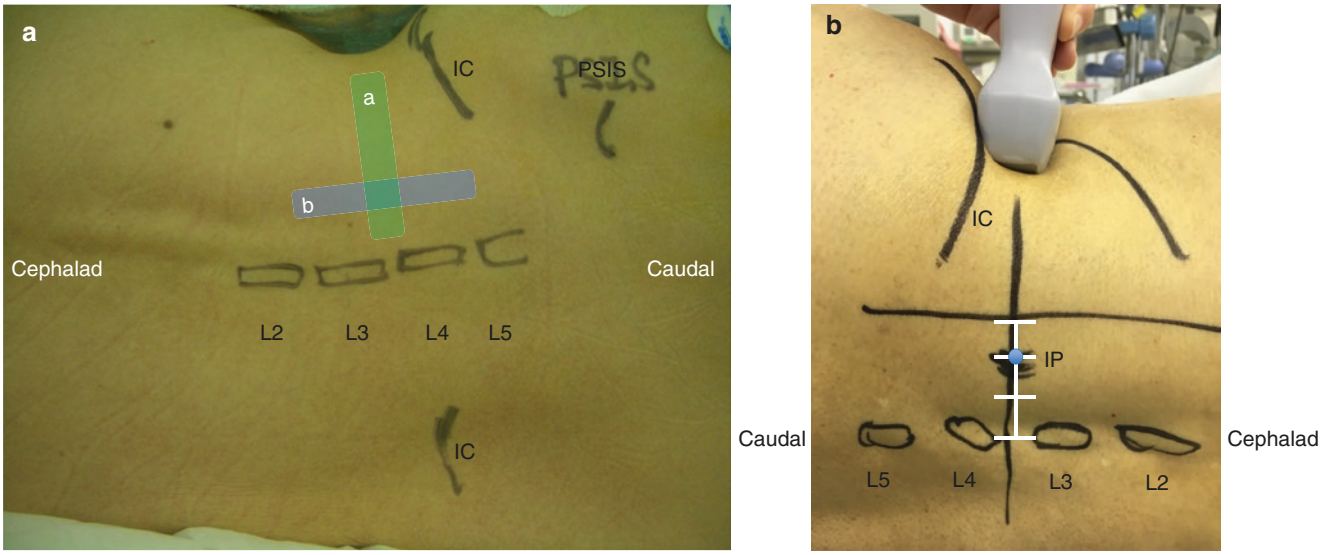

Fig. 44.3 Patient position and probe setting making patient lateral or Sims' position with block side up. Placing curved array probe for (**a**) short axial view and (**b**) longitudinal view

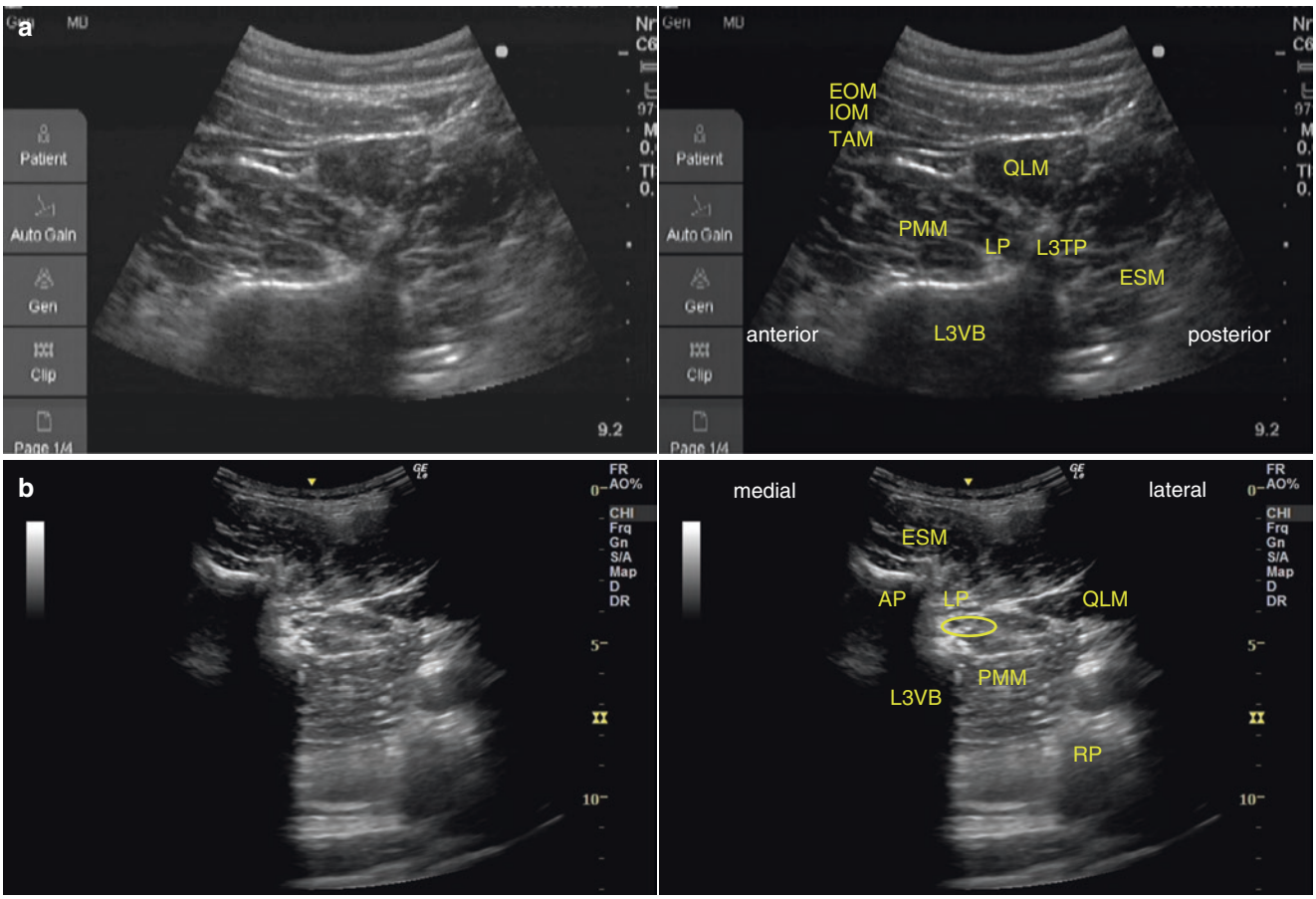

Fig. 44.4 Typical sonographic images for lumbar plexus block (**a**) Shamrock view, (**b**) short-axis view, and (**c**) long-axis view

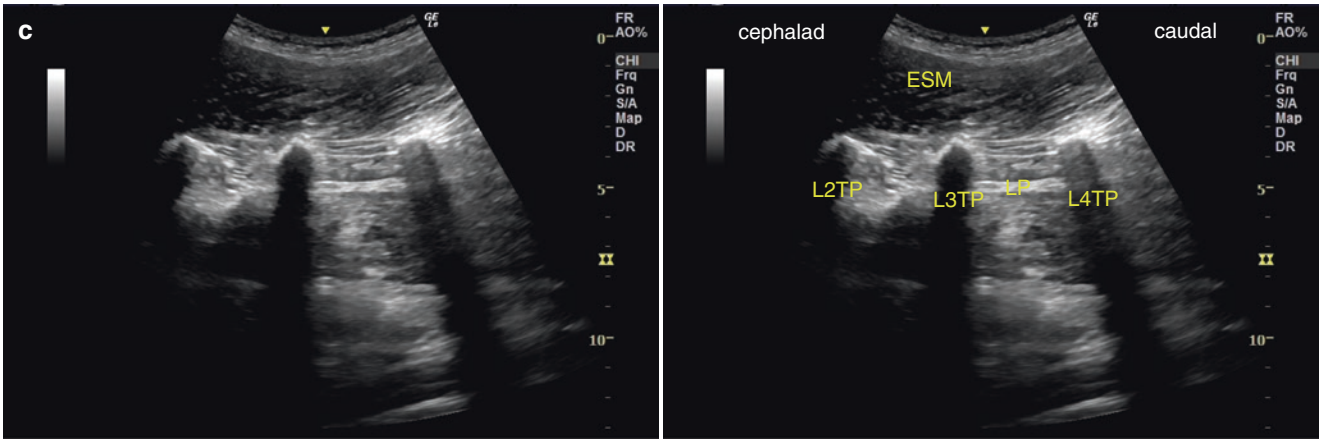

Fig. 44.4 (continued)

the midline on L4 to the posteromedial quadrant of psoas [5].
3. Combination of nerve stimulation and ultrasound guidance is recommended.
4. Confirming that needle tip penetrates through the ventral fascia of PM, injection of LA provides spread into the posteromedial aspect of the psoas muscle. In some cases, the lumbar plexus is confirmed by the spread of LA around the plexus.
5. Using Shamrock view, insert the needle parallel to the surface of the transducer after measuring the depth to LP.

44.6 Complications

#Intrapsoas hematoma.
#Epidural injection.
#Lumbar root injury.

References

1. Kirchmair L, Entner T, Wissel J, Moriggl B, Kapral S, Mitterschiffthaler G. A study of the paravertebral anatomy for ultrasound-guided posterior lumbar plexus block. Anesth Analg. 2001;93(2):477–81.
2. Lin JA, Lu HT, Chen TL. Ultrasound standard for lumbar plexus block. Br J Anaesth. 2014;113:188–9.
3. Karmakar M, Ho A, Li X, Kwok W, Tsang K, Kee W. Ultrasound-guided lumbar plexus block through the acoustic window of the lumbar ultrasound trident. Br J Anaesth. 2008;100(4):533–7.
4. Karmakar MK, Li JW, Kwok WH, Hadzic A. Ultrasound-guided lumbar plexus block using a transverse scan through the lumbar intertransverse space: a prospective case series. Reg Anesth Pain Med. 2015;40(1):75–81.
5. Capdevila X, Macaire P, Dadure C, Choquet O, Biboulet P, Ryckwaert Y, et al. Continuous psoas compartment block for postoperative analgesia after total hip arthroplasty: new landmarks, technical guidelines, and clinical evaluation. Anesth Analg. 2002;94(6):1606–13.

Lumbar Sympathetic Nerve Block

45

Tetsuya Sakai

45.1 Introduction

45.1.1 What Is a Lumbar Sympathetic Nerve Block (LSNB)?

An LSNB is a procedure performed to block the sympathetic nerve at the L2–L4 level [1]. Well-known approaches to lumbar sympathetic nerve include paravertebral [2–4] and transdiscal methods [5] under fluoroscopy-guided method. Recently, computed tomography (CT)-guided method approach has been added to the list of potential techniques [6]. The LSNB has been shown to offer significant diagnostic and therapeutic benefits for using local anesthetics. If its efficacy is temporary, a radiofrequency thermocoagulation technique [2] and injection of a neurolytic agent solution are considered for long-term effect [7].

45.2 Indications

The LSNB is effective for peripheral vascular disease, including arteriosclerosis obliterans and Buerger's disease, and sympathetically maintained pain in the lower extremity [8].

45.3 Anatomy

The lumbar sympathetic trunk consists of several ganglia between L1 and L5 vertebral bodies. On the right side, it runs posterior to the inferior vena cava, and on the left side, it runs lateral to and slightly behind the abdominal aorta [2, 3]. The trunk is located in the retroperitoneal compartment surrounded by the anterior surface of the psoas muscle and anterolateral to the lumbar vertebral bodies. The nerves running in the psoas muscle, kidney, urinary tract, and blood vessels are present in the insertion course from the lateral side of the spinous process to the target point. It is necessary to note the anatomical positions in order to avoid complications (Fig. 45.1).

45.4 Instruments and Drug Solutions

Needles:	25-guage 25-mm needle; 23-G 6-mm needle (for local anesthesia); three 21-guage 12–15-cm block needles; three 21-guage 144-mm radiofrequency electrode needle (non-insulated tip; 5–10 mm; for radiofrequency thermocoagulation)
Injectors:	5-mL and 10-mL syringe; 5-mL glass syringe
Drugs:	Local anesthetics (lidocaine, 0.5–1%), 10 mL; contrast medium, 6 mL; neurolytic agent, 50–100% alcohol 9 mL.
	Forceps
	Sterilization set
	Thermocoagulation set

45.5 Procedures and Techniques

45.5.1 Fluoroscopy-Guided Method

45.5.1.1 Paravertebral Approach [2–4]

The patient is placed in a lateral position with the affected side uppermost and with the knee bent slightly. A marking line is made on the skin 6–8 cm lateral to the spinous process sequence of L2–L4. Under lateral fluoroscopy, the C-arm used to locate a selected vertebral body is rotated so that the end plates of the vertebral body show straight. The insertion line of the needle, which links the center of the vertebral body to the inferior of the transverse process, is confirmed using a forceps in the lateral fluoroscopic view (Fig. 45.2).

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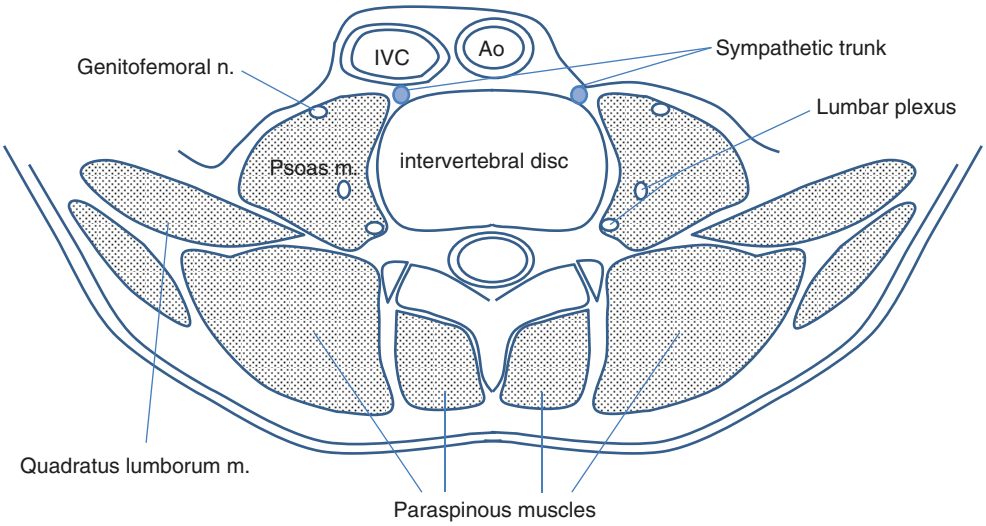

Fig. 45.1 Lumbar sympathetic trunk: cross-sectional anatomy

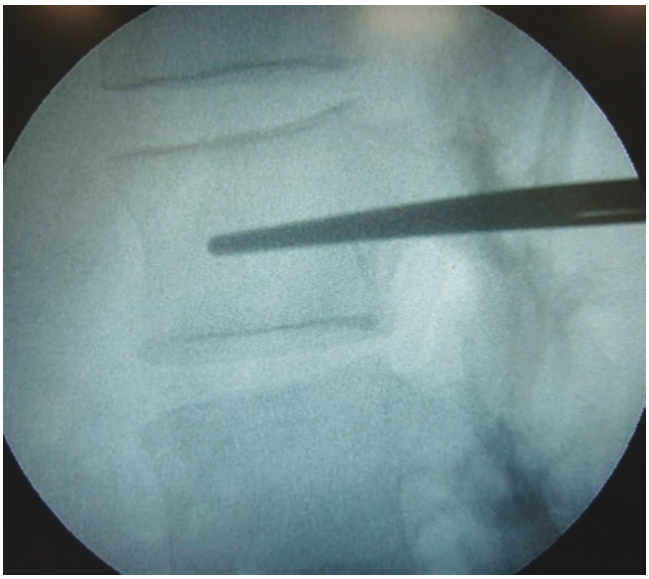

Fig. 45.2 The insertion line of the needle, which links the center of the selected vertebral body to the inferior of the transverse process, is confirmed using a forceps in the lateral fluoroscopic view

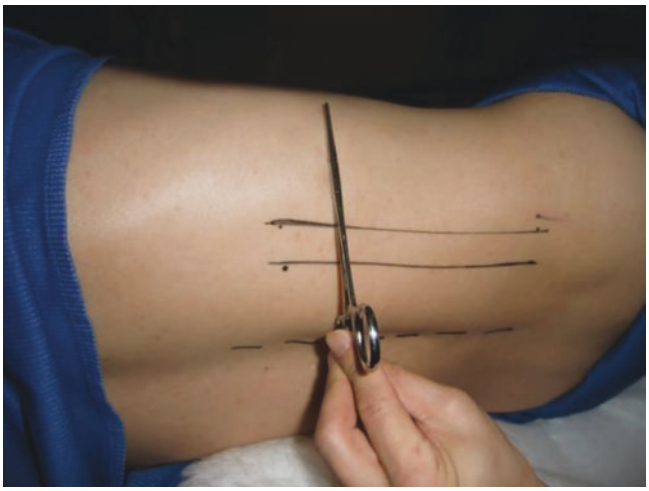

Fig. 45.3 The puncture site is the point where the forceps intersects the marking line

Then, the puncture site is decided as the point where the forceps intersects the marking line (Fig. 45.3).

After sterilization and subcutaneous anesthesia, a 23-guage 6-cm needle is inserted near the transverse process, and the local anesthetic is injected while the needle is withdrawn to the dermis. Then, a 21-guage 15-cm needle is advanced slowly, guided by the lateral fluoroscopic view, until it reaches the vertebral body. The needle is withdrawn to the dermis if it does not contact the vertebral body over its center. Then, the needle is redirected at a slightly steeper angle and "walked off" the anterolateral margin of the vertebral body (Fig. 45.4). The final needle position is confirmed in the anteroposterior and lateral fluoroscopic views.

A fixed volume (2 mL) of a contrast medium is injected through the needle at each level. The contrast medium is confirmed to spread along the anterior margin of the vertebral bodies in the lateral view and of the anterolateral vertebral bodies in the anteroposterior view (Fig. 45.5). The injected contrast medium appears striated and spreads in a diagonal pattern if the needle tip is present in the psoas muscle. The contrast medium disappears immediately if the needle tip is present in the vessel. In such cases, the needle tip is repositioned, and the contrast medium is injected again.

After confirming the proper positioning of the needle tip, 3–6 mL of lidocaine (1%) is injected at each level. A neurolytic agent is used for long-term pain relief if the local anesthetic block provides good but transient results. Prior to

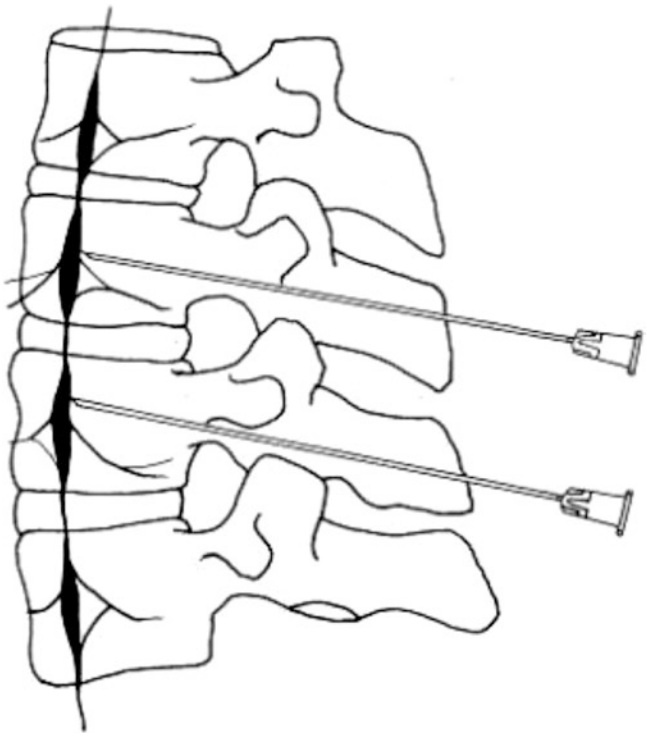

Fig. 45.4 The needle is advanced at a slightly steeper angle and then "walked off" the anterolateral margin of the vertebral body

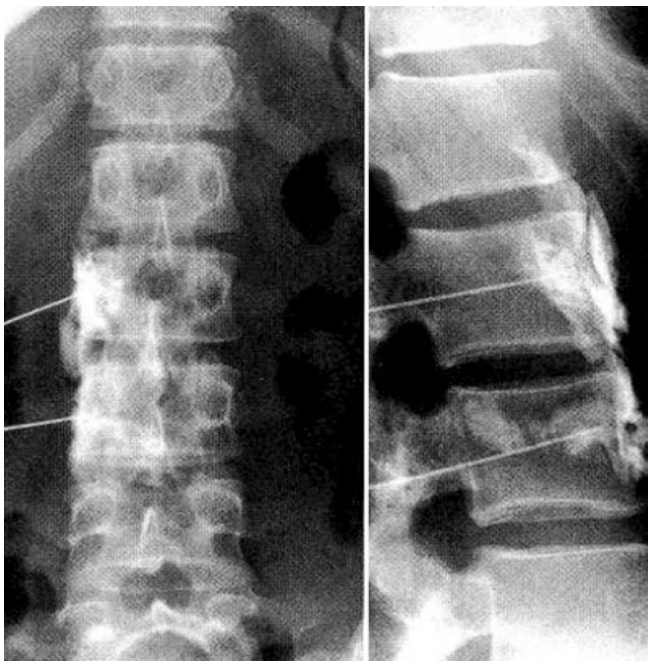

Fig. 45.5 Appropriate spread of the contrast medium is along the anterior margin of the vertebral bodies in the lateral view and anterolateral vertebral bodies in the anteroposterior view

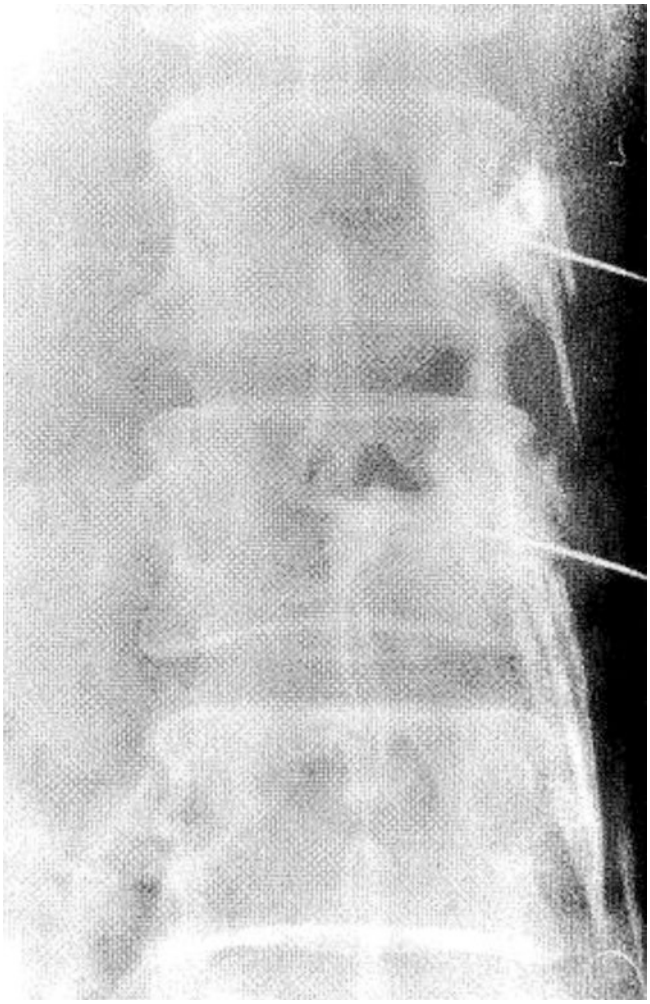

Fig. 45.6 Leakage of the contrast medium to the psoas muscle

injecting a neurolytic agent, the local anesthetic block should be performed. Then, 3 mL of the neurolytic agent is slowly injected at each level while monitoring the reaction of the patient. The neurolytic agent must not be injected at the level where the contrast medium leaks to the psoas muscle (Fig. 45.6). The injection of the neurolytic agent is discontinued immediately if the patient complains of pain at the injection site. After neurolytic agent injection, the patient is kept in the same lateral position for 2 h to prevent the spread of the neurolytic agent toward the genitofemoral nerve or posteriorly through the aponeurotic arcades in the origin of the psoas muscle.

45.5.1.2 Transdiscal Approach [5]

In the traditional paravertebral method of the LSNB, the needle must always contact the vertebral body when it advances. Therefore, it is sometimes difficult to conduct the procedure if the vertebral body is strongly transformed. In such cases, the transdiscal method should be used.

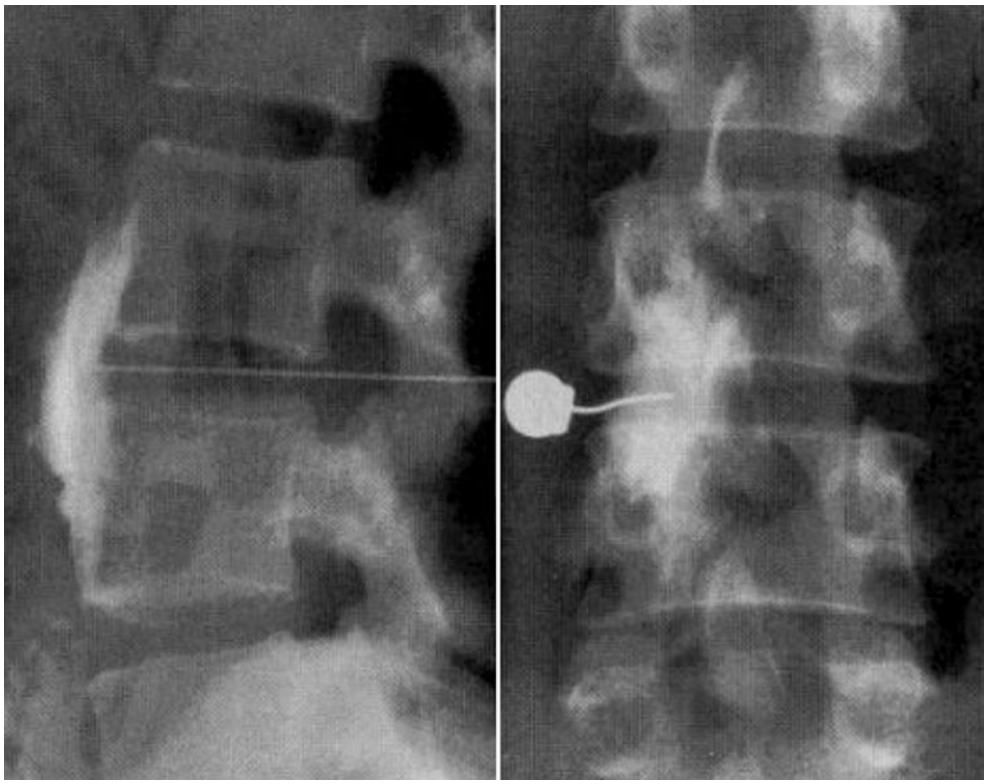

Fig. 45.7 Appropriate spread of the contrast medium in the retroperitoneal compartment surrounded by the anterior surface of the psoas muscle and the anterolateral to lumbar vertebral bodies

The patient is placed on the table in a prone position with a cushion under the abdomen. C-arm fluoroscope is adjusted to make the end plates of the vertebral body straight at the L2–L3 level in the anteroposterior view. The transdiscal insertion is attempted at the L2–L3 interspace. The insertion point is slightly lateral to the superior articular process of L3. After sterilization and local anesthesia with a 25-guage 25-mm needle on the dermis, a 23-guage 60-mm needle is advanced before the superior articular process with infiltrating local anesthesia. A 21-guage 15-cm needle is directed tangentially to the superior articular process and pierces the disc. Subsequently, the patient's position is changed from prone to lateral with the affected side uppermost, and the needle with a 5-mL glass syringe filled with saline is advanced with constant pressure. After the penetration of the disc is confirmed by the loss of the resistance method, the needle tip is checked in the anteroposterior view. The preferable positioning of the needle tip is inside the pedicle (Fig. 45.7).

The injection methods and the required concentrations of contrast medium, local anesthetic, and the neurolytic agent are similar to those in the paravertebral approach. Because the needle in the transdiscal approach does not pierce the tendinous arch of the psoas muscle, the incidence of genitofemoral neuritis induced by the neurolytic agent is lower compared with that in the paravertebral approach. In contrast, the preventive administration of antibiotics is recommended because the transdiscal approach is associated with a risk of infection.

45.5.1.3 Radiofrequency Thermocoagulation [2]

Radiofrequency thermocoagulation is not associated with a number of serious complications compared with neurolytic agent block. It is performed when the contrast medium leaks to the psoas muscle in the anteroposterior view and the neurolytic agent cannot be injected. A 21-guage 144-mm radiofrequency electrode needle (non-insulated tip; 5–10 mm) is used. Once the needle is properly placed, electrocoagulation of the area is performed at 80–90° for 120–180 s. The needle is then withdrawn 5 mm and the second lesion is performed.

45.5.2 CT-Guided Method [6]

The patient is placed on the CT table in the prone position. A marking device made of radiopaque wires is attached to the patient's lower back. After obtaining CT images at the L2 level, a figure of the shortest safe course to the target point (between the anterior angle of the psoas muscle and the anterolateral plane of the vertebral body) is drawn on a CT image. The insertion point is marked on the patient with the marking device.

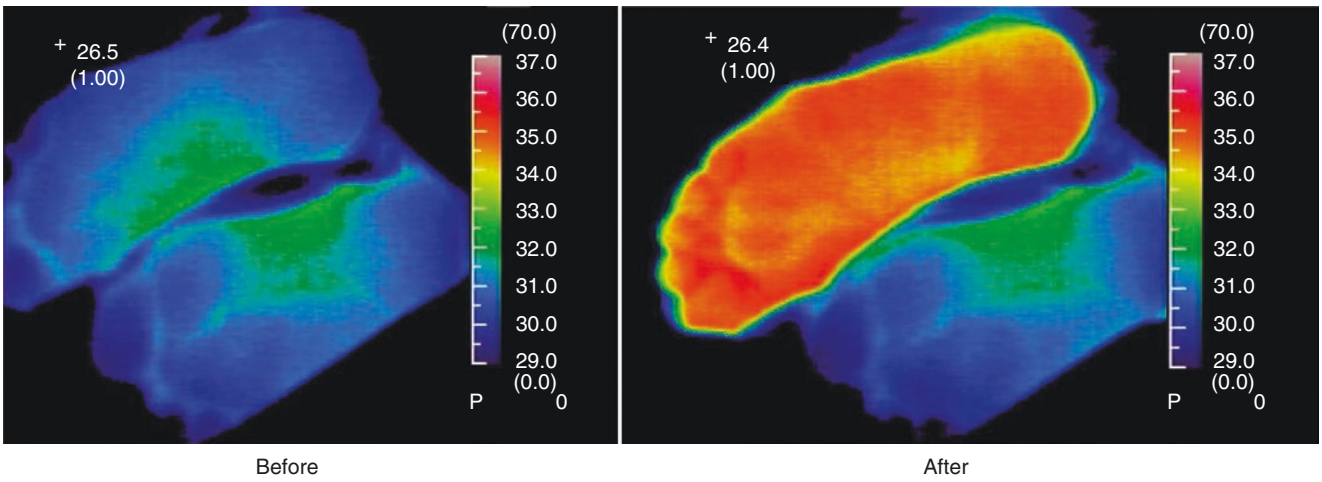

Fig. 45.8 Thermography before and after the left LSNB. The temperature of the left sole increases after LSNB

After sterilization and local anesthesia with a 25-guage 25-mm needle, a 21-guage 15-cm needle is inserted at the marked point. The insertion angle of the needle is adjusted using a red-colored guiding laser conforming to the scanning slice in the CT gantry. The needle is advanced following a drawn figure of the shortest safe course to the target point using real-time IVRCT fluoroscopy. Caution must be taken to avoid injury to the kidney, inferior vena cava, and ureter. When the needle tip reaches the target point, 0.5–1 mL of the contrast medium is injected. After confirming that the contrast medium remains at the appropriate site, 3–6 mL of lidocaine (1%) is injected. The injection of the neurolytic agent is allowed only when the contrast medium spreads into the retroperitoneal compartment surrounded by the anterior angle of the psoas muscle and the anterolateral vertebral body.

45.6 Evaluation of LSNB

The effect of LSNB can be evaluated visually by thermographic images of the lower extremities, especially the soles (Fig. 45.8).

45.7 Complications

45.7.1 Neurolytic Genitofemoral Neuritis

Neurolytic genitofemoral neuritis is the most common complication of LSNB. The genitofemoral nerve running the psoas muscle may be injured. In such case, sensory loss and pain often persist for several months [4, 7].

45.7.2 Ejaculation Disorder

Ejaculation disorder occurs in an LSNB for bilateral L1. Neurolytic agent injection even in L2 may spread through the level of L1 [9].

45.7.3 Kidney and Ureteric Injury

There is the inferior pole of the kidney at the level of L2, and the renal puncture is possible when the distance from the spinous process to a needle insertion point is more than 7 cm [6]. There also has been a report of a ureteric injury [10].

45.7.4 Other Complications

Hemorrhage induced by vascular injury may occur. However, these complications are rare if the LSNB is performed carefully by an experienced pain clinician.

References

1. Umeda S, Arai T, Hatano Y, Mori K, Hoshino K. Cadaver anatomic analysis of the best site for chemical sympathectomy. Anesth Analg. 1987;66:643–6.
2. Rocco AG, Palombi D, Raeke D. Anatomy of the lumbar sympathetic chain. Reg Anesth. 1995;20:13–9.
3. Sayson SC, Ramamurthy S. Sympathetic blocks. In: Warfield CA, Bajwa ZH, editors. Principle & practice of pain medicine. 2nd ed. New York: McGraw-Hill; 2004. p. 696–709.
4. Hong JH, Kim AR, Lee MY, Kim YC, Oh MJ. A prospective evaluation of psoas muscle and intravascular injection in lumbar sympathetic ganglion block. Anesth Analg. 2010;111:802–7.

5. Ohno K, Oshita S. Transdiscal lumbar sympathetic block: a new technique for a chemical sympathectomy. Anesth Analg. 1997;85:1312–6.
6. Koizuka S, Saito S, Obata H, Tobe M, Koyama Y, Takahashi A. Anatomic analysis of computed tomography images obtained during fluoroscopic computed tomography-guided percutaneous lumbar sympathectomy. J Anesth. 2008;22:373–7.
7. Bonica JJ. Neurolytic agent lumbar sympathetic block. In: Bonica JJ, editor. The management of pain. Philadelphia: Lea & Febiger; 1990. p. 2020–5.
8. Day M. Sympathetic blocks: the evidence. Pain Pract. 2008;8:98–109.
9. Terrone C, Castelli E, Aveta P, Cugudda A, Rocca Rossetti S. Iatrogenic ejaculation disorders and their prevention. Minerva Urol Nefrol. 2001;53:19–28.
10. Dirim A, Kumsar S. Iatrogenic ureteral injury due to lumbar sympathetic block. Scand J Urol Nephrol. 2008;42:492–3.

Part X

Pelvis

Sacroiliac Joint Block (Ultrasound-Guided, X-Ray Fluoroscopy-Guided)

46

Hisashi Date

46.1 Introduction

46.1.1 What Is a Sacroiliac Joint Block?

A sacroiliac joint block is a method of nerve block that is useful for the diagnosis and treatment of "sacroiliac arthropathy." The diagnosis of sacroiliac joint pain is characterized by the following three features: (1) the patients themselves can point a finger at the site of pain (one-finger test), and the site involves the posterior superior iliac spine and its surrounding area; (2) sacroiliac stress tests (Newton test, Gaenslen test, Patrick test, and FADIR test) are positive; and (3) an epidural block is ineffective, whereas a sacroiliac joint block achieves a remission rate of more than 70%.

Successful injections into the joint cavity require skill because of anatomical reasons. Infiltration into the ligament and not being restricting to the joint cavity alone may be more effective because the cause of the pain sometimes lies in the ligament rather than in the joint cavity itself.

46.2 Indications

Diagnosis and treatment of sacroiliac joint pain.

46.3 Anatomy (Fig. 46.1)

The sacroiliac joint is a joint that connects the sacral bone and the iliac bone and links the trunk and the lower limbs. Because it bears a great load, this joint is anchored by a group of well-developed ligaments and myofascias. The ligaments surrounding the sacroiliac joint include the anterior sacroiliac ligament on the ventral side and the posterior sacroiliac ligament in the surface layer and the interosseous sacroiliac ligament in the deep layer on the backside, and these all support the joint. Myofascias are present in a more superficial layer than the ligaments and fixed with the tendon of the biceps femoris muscle, the erector spinae muscle, the latissimus dorsi muscle, the iliopsoas muscle, and the lumbar quadrate muscle. The sacroiliac joint surface is not parallel

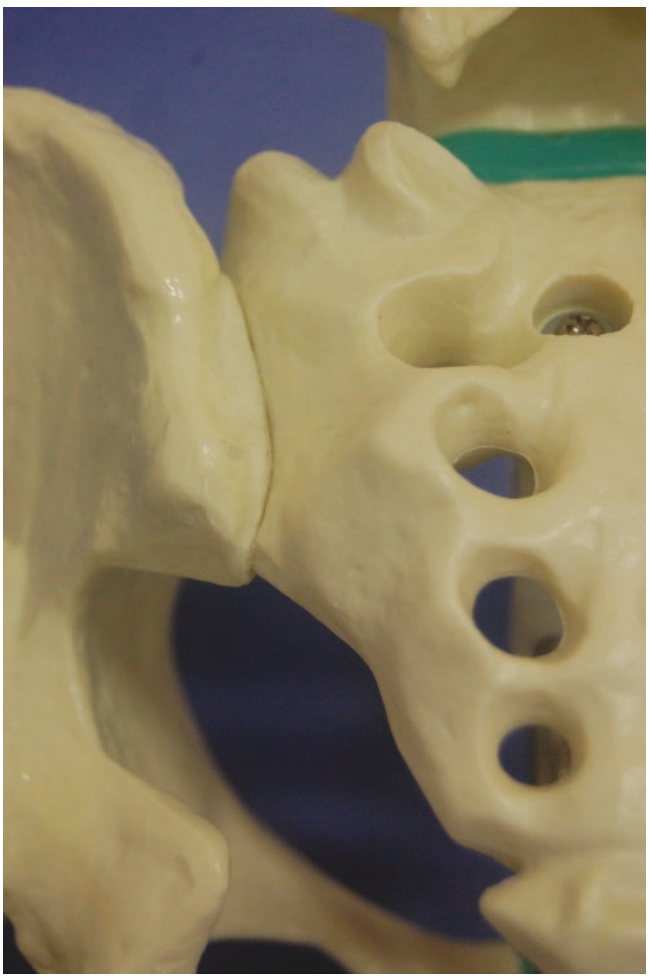

Fig. 46.1 Anatomy of the sacroiliac joint. The joint surface is not parallel to the spinal column

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to, but at a certain angle with, the spinal column. Therefore, a slit on the X-ray image may not represent the joint cavity, and it is common that only the posterior sacroiliac ligament or interosseous sacroiliac ligament is visualized.

46.4 Instruments and Drug Solutions

1. Puncture needle: 23G 6-cm block needle.
2. Three 5 mL syringes (for local anesthesia, contrast agent injection, and drug solution injection).
3. Drug solution: 1% lidocaine, water-soluble steroids.

46.5 Procedures and Techniques

The approach of the sacroiliac joint block is X-ray fluoroscopy-guided or ultrasound-guided. For an X-ray fluoroscopy-guided block, the drug solution is injected into the joint cavity, whereas for an ultrasound-guided block, it is injected into the ligament posterior to the joint [1].

46.5.1 X-Ray Fluoroscopy-Guided Sacroiliac Joint Block (Fig. 46.2)

The patient should be placed in a mild oblique, prone position with the unaffected side up. The bulb is swung toward the cranial side to make the cartilage end plates at L5/S1 align. The site that gives a clear visual of the slit of the sacroiliac joint should be searched for by swinging the bulb in an oblique direction. The block is usually performed on the caudal side. A puncture at a site slightly caudal to the caudal end of the slit (where the slit is no longer visible) is likely to achieve the injection into the joint cavity. After confirming with contrast agent that the needle is in the joint cavity or in the ligament, 5–10 mL of local anesthetic and steroid should be injected [2, 3]. When the injection resistance is high, it is common that the needle tip is contacting the bone surface, thus requiring adjustment of the position of the needle tip [4].

46.5.2 Ultrasound-Guided Sacroiliac Joint Block (Fig. 46.3)

The patient should be placed in the supine position. A convex-type probe is used. First, the lumbar spinous processes should be observed while placing the probe parallel to the spinal column. The spinous process at S1 should be identified with the probe moved toward the caudal side. When the probe is moved parallel to the spinal column, the posterior superior iliac spine comes into sight (easily identifiable because of acoustic shadow). At this point, the probe should be rotated 90° in order to make it vertical to the spinal column. The dorsal sacroiliac ligament and interosseous sacroiliac ligament are found in an area of slightly high density near the corner that is made by the posterior superior iliac spine located at the apex. The needle tip should be inserted into the intended site by the parallel method in order to inject the drug solution.

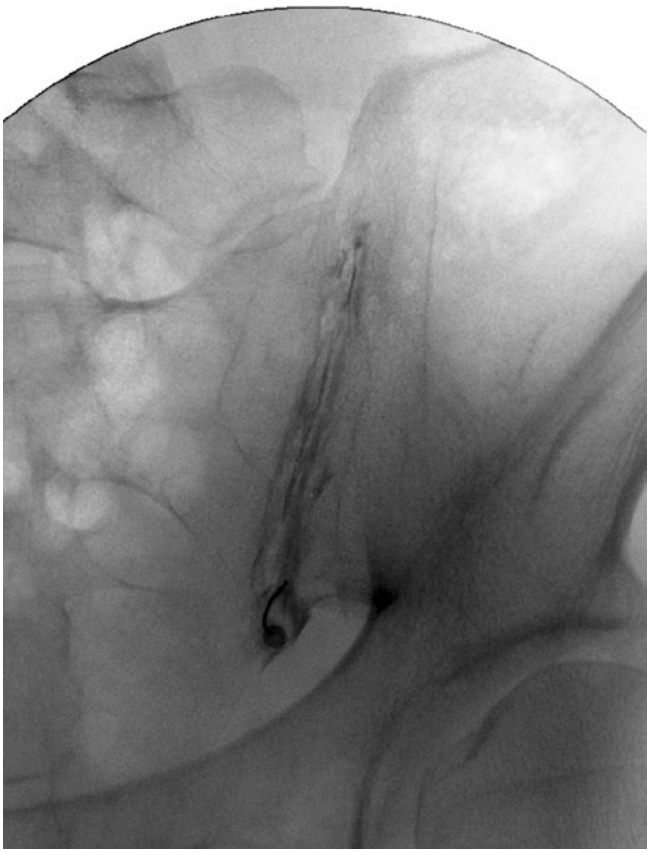

Fig. 46.2 X-ray-guided block. The joint surface is visualized

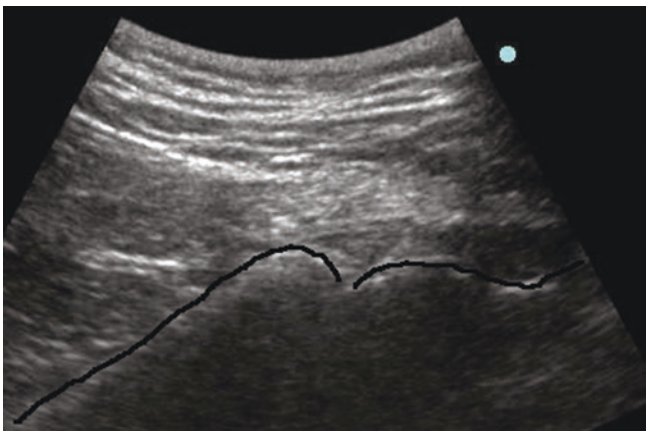

Fig. 46.3 Ultrasound-guided block. The posterior superior iliac spine should be used as a guide

46.5.3 Rest Time After the Block

A rest of approximately 1 h is necessary. An injection of a large volume of the drug solution may cause sciatic nerve block, leading to leg weakness. It is necessary to confirm the absence of leg weakness at the end of the rest time.

46.6 Complications

1. Infection: Infection can be prevented with adequate skin disinfection. It is important not to move the needle tip around after insertion.
2. Bleeding: Bleeding is likely to occur when the puncture is repeated. It should be noted that an injection into the ligament is as good as an injection into the joint cavity when X-ray-guided block is conducted.

References

1. Kim WM, Lee HG, Jeong CW, et al. A randomized controlled trial of intra–articular prolotherapy versus steroid injection for sacroiliac joint pain. J Altern Complement Med. 2010;16:1285–90.
2. Luukkainen RK, Wennerstrand PV, Kautiainen HH, et al. Efficacy of periarticular corticosteroid treatment of the sacroiliac joint in non–spondyloarthropathic patients with chronic low back pain in the region of the sacroiliac joint. Clin Exp Rheumatol. 2002;20:52–4.
3. Liliang PC, Lu K, Weng HC, et al. The therapeutic efficacy of sacroiliac joint blocks with triamcinolone acetonide in the treatment of sacroiliac joint dysfunction without spondyloarthropathy. Spine (Phila Pa 1976). 2009;34:896–900.
4. Hansen H, Manchikanti L, Simopoulos TT, et al. A systematic evaluation of the therapeutic effective ness of sacroiliac joint interventions. Pain Physician. 2012;15:E247–78.

47 Radio-frequency Thermocoagulation of Sacroiliac Articular Branches (X-Ray Guided): High-Frequency Thermocoagulation of the Sacroiliac Joints

Toshio Itabashi, Takayasu Kakinuma, and Hiroyuki Uchino

47.1 Introduction

What is high-frequency thermocoagulation of the sacroiliac joints [1–3]

The sacroiliac joints disperse and transmit load from the trunk to the lower limbs. Because load is horizontally applied on the articular surfaces, the joints are likely to be stressed, and arthropathy is caused by an unnatural posture and other conditions due to injury, pregnancy, delivery, lumbar spine disease, and coxarthropathy. Moreover, laxity of the ligaments around the joints causes an unstable pelvic ring.

Sacroiliac osteoarthropathy is frequently associated with pain of the lumbogluteal region that is enhanced by standing up and walking. However, because referred pain to the lower limbs, including the femoral, inguinal, sural, and foot regions, is common, sacroiliac osteoarthropathy needs to be differentiated from ischialgia and coxarthropathy. X-ray film shows narrowing and ossification of the sacroiliac joint spaces, while CT shows deformity and irregularity of the joints. Provocation tests include Newton test, Gaenslen test, zazen test, and pendulum test, and nerve block is effective for diagnosis and treatment. Thermocoagulation is a therapy to achieve long-term effects in cases in which the effect of sacroiliac joint block is temporary.

47.2 Indications

The indications include sacroiliac osteoarthropathy, ankylosing spondylitis, and other conditions causing pain or tenderness in the sacral region.

47.2.1 Anatomy

The sacroiliac joints are richly innervated by the ventral rami of the L5 and S1 vertebral bodies distributed on the anterior surfaces of the joints, the superior gluteal nerve and external branches of the dorsal rami of the S1–S2 vertebral bodies distributed on the lower surfaces, and the external branches of the dorsal rami of the L5 and S1 vertebral bodies distributed on the posterior surfaces (Fig. 47.1). Thermocoagulation of the external branches of the dorsal rami of L5 to S2 vertebral bodies is often effective.

47.3 Instruments and Drug Solutions

Needle:	25G 25mm needle, 22G 97mm guiding needle
Syringe:	5 mL disposable syringe
Medicine:	Local anesthetics, non-ionic contrast media
	High-frequency thermocoagulation set

47.4 Procedures and Techniques [4, 5]

A patient is placed in the prone position with a pillow under the abdomen so that the direction of radio-frequency energy from the tube becomes parallel with the end plate between the L5 and S1 vertebral bodies. The level to which the therapy is to be applied is selected from the L5 and S1 to S4 vertebral bodies on the basis of the tenderness point on the body surface. The position of the sacral hiatus is identified by fluoroscopy-guided method, and a local anesthetic is administered to the area slightly below the sacral hiatus. Because each branch extending from the dorsal rami of the S1 to S4 vertebral bodies to the sacroiliac joints externally spreads from the sacral hiatus in a radial fashion, radiating pain can be induced by gradually moving the needle attached to the external and superior border of the sacral hiatus downward along the border. When stimulation of 50-Hz

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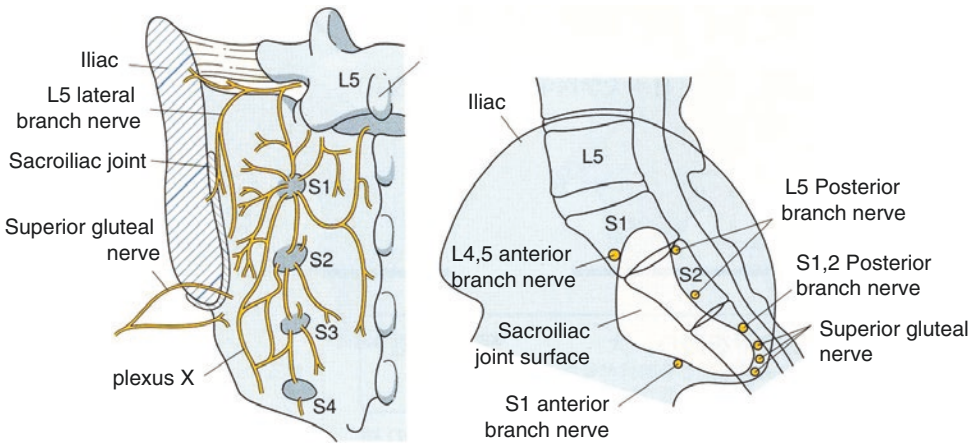

Fig. 47.1 Anatomy of the sacroiliac joint nerve

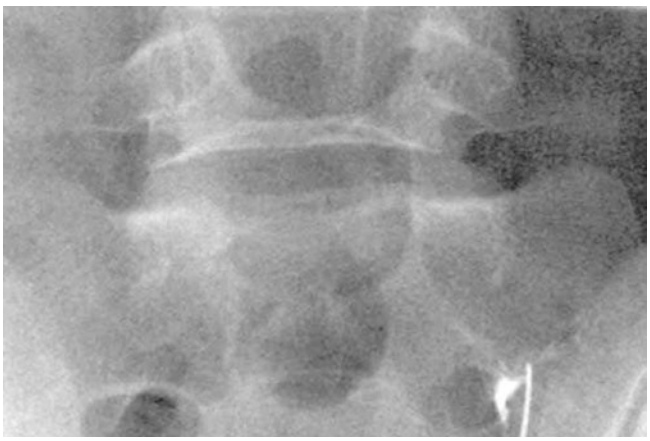

Fig. 47.2 High-frequency thermocoagulation of the right S1 dorsal ramus

frequency induces radiating pain at the site, a small amount of a contrast medium is injected to confirm that the needle is not inserted into any nerve root or blood vessel (Fig. 47.2). After injection of 0.5 mL of 2% mepivacaine, thermocoagulation is performed at 70–90 °C for 90 s. High-frequency thermocoagulation of the dorsal ramus of the L5 vertebral body is performed in the same manner as that of the medial branches of the dorsal rami in the lumbar region.

47.5 Complications

Complications include nerve root thermocoagulation, diminished sensation, and enhanced pain.

References

1. Murakami E, et al. The basics of sacroiliac joint related waist buttocks pain. Spine & Spinal Cord. 2000;13:439–44. (in Japanese)
2. Hajiri Y, et al. Sacroiliac joint block. In: Shiotani M, editor. An illustrated guide to pain clinic. Tokyo: Shinkoukoueki; 2000. p. 239–44. (in Japanese).
3. Yamagami H. Sacroiliac joint pain. In: Ogawa S, editor. Pain clinic for the orthopedics disease. Tokyo: Shinkoukoueki; 2003. p. 260–3. (in Japanese).
4. Nakanisi S, et al. High-frequency thermocoagulation of the sacroiliac joints. In: Nerve block under fluoroscopy. Tokyo: Igakusyoin; 2009. p. 141–2. (in Japanese).
5. Cohen SP, Strassels SA, Kurihara C, et al. Outcome predictors for sacroiliac joint (lateral branch) radiofrequency denervation. Reg Anesth Pain Med. 2009;34:206–14.

Sacrococcygeal Joint Block (Fluoroscopy-Guided, Ultrasound-Guided)

48

Kenji Shida

48.1 Introduction

48.1.1 Sacrococcygeal Joint Block

A sacrococcygeal joint block is a procedure used in the management coccydynia associated pain [1]. On physical examination the patient exhibits point tenderness over the coccyx. The pain is provoked by direct pressure, such as sitting.

48.2 Indication

Coccydynia is a common painful condition that is localized in the region of the coccyx (tail bone) and is evoked by pressure stimulation. The idiopathic cases have to be excluded, such as infections, tumor, fracture (lateral radiographs and/or MRI), psychogenic chronic pain, and referred pain, from the lower pelvic visceral disorders without evoked pain.

48.3 Anatomy

The sacrococcygeal joint is a fibrocartilaginous joint between sacrum and coccyx [2]. The anterior and posterior sacrococcygeal ligaments support the sacrococcygeal joint. The triangular coccyx usually consists of four rudimental bony segments that are typically fused without the first coccygeal segment (Co1). Co1 is the widest and largest in caudal vertebrae. Between Co1 and Co2 segments, a vestigial intervertebral disc may be present and can form a potential localization point for post-traumatic hypermobility.

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48.4 Instruments and Drug Solutions

Needles:	23G 2.5 cm disposable needle
Syringes:	5 mL syringes
Drug solutions:	0.5–1% lidocaine or mepivacaine, dexamethasone 2–4 mg
X-ray-guided:	Contrast medium (non-ionic water-soluble) 2–3 mL
	Ultrasound-guided kit
	Skin preparation kit

48.5 Procedures and Techniques

48.5.1 Landmark Method

Usually a 1 and 1/2-inch needle is employed. The use of longer needles increases the incidence of complications, such as intravascular injection, caudal epidural injection, and the anterior sacrococcygeal ligament penetration. Fluoroscopy-guided method or ultrasound-guided method for needle placement may be more beneficial and safe [3, 4].

48.5.2 Fluoroscopy-Guided Method

The patient is placed in the prone position with a pillow under the pelvis. The legs are abducted to prevent tightening of the gluteal muscles. In anteroposterior (AP) view, the angle of the X-ray tube is adjusted to be able to see accurately the sacrococcygeal joint surface. In lateral view (Fig. 48.1), the distance between the skin and the sacrococcygeal joint is measured.

Preparation of a large area of skin with antiseptic solution is carried out, so that the sacrococcygeal joint at the base of sacrum can be palpated aseptically. Superficial tissues are anesthetized with local anesthetic. In AP view, a needle is inserted through the skin at about 45 degree angle into the region of the sacrococcygeal joint. If contact with the bony

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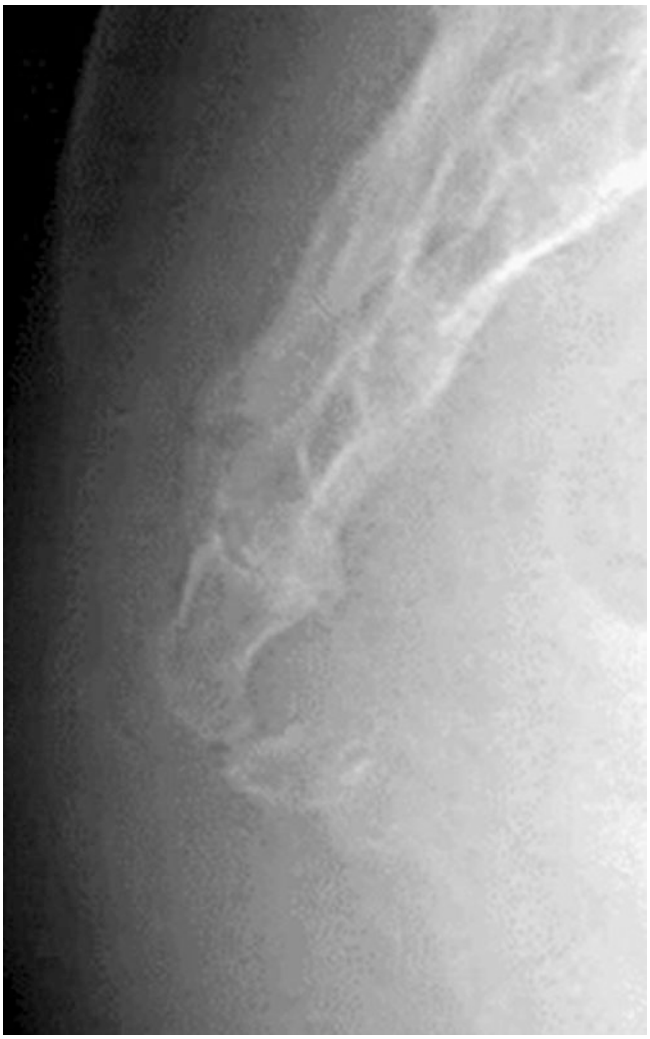

Fig. 48.1 Lateral view, demonstrating a dislocated coccyx

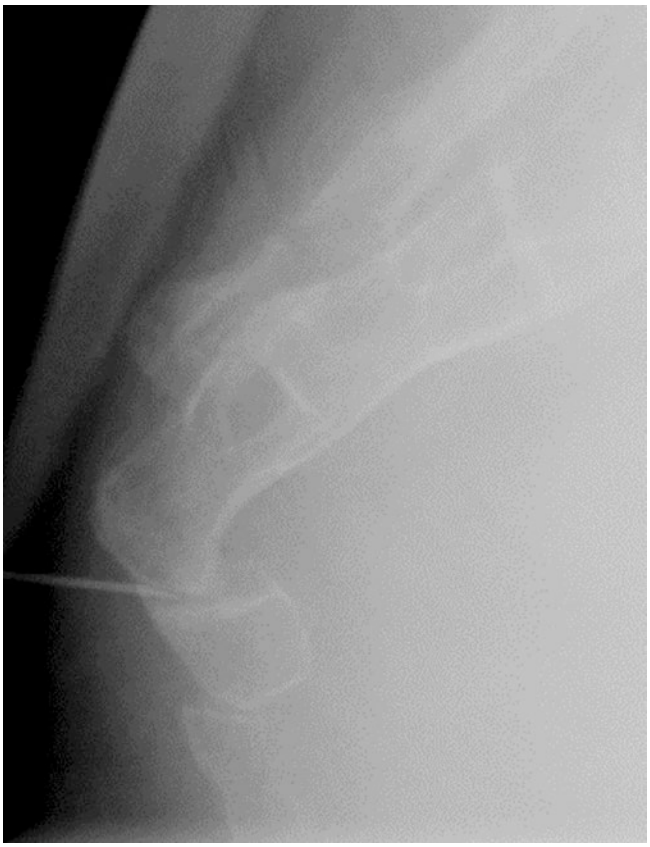

Fig. 48.2 Lateral view, fluoroscopy-guided sacrococcygeal joint block, with the needle tip in the dislocated joint

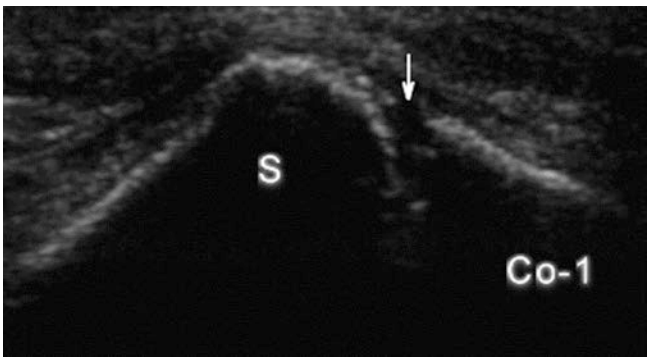

Fig. 48.3 Composite image of the sacrum and coccyx in long-axis, the sacrum (S) is proximal to Co-1, divided by the sacrococcygeal joint (arrow)

wall occurs or the needle reaches a length which has been measured at the beginning, the position of the needle tip has to be confirmed in lateral view. When the needle is satisfactorily positioned (Fig. 48.2), a contrast medium is injected and then a local anesthetic with/without steroid is injected.

48.5.3 Ultrasound-Guided Method

The transducer is placed in long axis over the coccyx, which usually involves the sacrococcygeal joint (cleft) between the base of sacrum and coccyx. A needle is inserted into the sacrococcygeal joint through a caudal-to-cephalad approach in-plane of the ultrasound image, and then the drug solution is injected to the ligament. A linear or microconvex probe is usually used, but in obese patients, such as the depth over 4 cm (1.5 inch), convex probe is useful. In longitudinal view, an ultrasound pre-scanning is conducted over the area to identify the sacral hiatus, sacrococcygeal ligament, sacrococcygeal junction, and coccyx in order from cephalad (Fig. 48.3).

48.6 Complications

The major complication of this injection technique is infection caused by proximity to the rectum. Care must be taken to avoid placing the needle too deeply.

References

1. Waldman SD. Sacrococcygeal joint injection. In: Atlas of pain management injection techniques. 3rd ed. Philadelphia: Elsevier; 2013.
2. Woon JT, Stringer MD. Clinical anatomy of the coccyx: a systematic review. Clin Anat. 2012;25:158–67.
3. Mitra R, Cheung L, Perry P. Efficacy of fluoroscopically guided steroid injections in the management of coccydynia. Pain Physician. 2007;10:775–8.
4. Lirette LS, Chaiban G, Tolba R, Eissa H. Coccydynia: an overview of the anatomy, etiology, and treatment of coccyx pain. Ochsner J. 2014;14:84–7.

Ganglion Impar Block

49

Yoichiro Abe

49.1 Introduction

The ganglion impar is thought to be a mixed nerve composed of the sympathetic nerve and the coccygeal (somatic) nerve. For intractable perianal pain, Plancarte et al. and Ito et al. reported the efficacy of a ganglion impar block, and Yuda and Tateyama reported the efficacy of a coccygeal nerve block [1–3].

The current ganglion impar block approaches include insertion of a curved needle from the anal side of the coccyx (the original approach) and vertical insertion of a needle from the sacrococcygeal region (the vertical approach). However, the ganglion impar may be hard to reach depending on the shape of the coccyx. We have been successfully using the approach from the right side of the ganglion under fluoroscopy-guided method along with high-frequency thermocoagulation.

49.2 Anatomy

See Chap. 48 Sacrococcygeal Joint Block (X-Ray Fluoroscopy-Guided, Ultrasound-Guided).

49.3 Instruments and Drug Solutions

1. X-ray fluoroscopy equipment (X-ray equipment to provide frontal and lateral fluoroscopic views), fluoroscopy table, TV monitor, and medical table.
2. Injection needles (disposable).
   - 23 G, 6 cm; 21 G, 3.8 cm; 18 G, 3.8 cm
3. Injection syringes (disposable).
   - Three 5 mL injection syringes (2 for local anesthesia and 1 for contrast dye).
4. A Sluyter-Mehta Kit (97 mm needle with a 10 mm non-isolation part for a thoracic sympathetic nerve block or a 144 mm needle for a lumbar sympathetic nerve block).
5. High-frequency apparatus.
6. Local anesthetic: 1–2% mepivacaine (carbocaine).
7. Contrast dye: iohexol (Omnipaque) or iotrolan (Isovist).

49.4 Procedures and Techniques

Perform pelvic magnetic resonance imaging (MRI) in advance to morphologically check for any contradictions to a nerve block.

1. Lay the patient in the left lateral position to align the end plate of the sacrococcygeal joint in the lateral fluoroscopic view (Fig. 49.1).
2. Determine the needle insertion site by pressing the buttocks with fingers or Pean forceps to find the spot where the laterally inserted needle will reach around the sacrococcygeal joint. Select a needle according to the distance

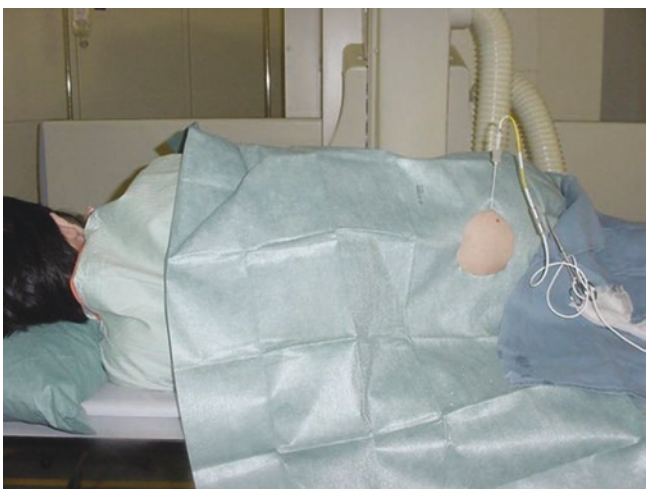

Fig. 49.1 Position. Lay the patient in the left lateral position to align the end plate of the sacrococcygeal joint in the lateral fluoroscopic view

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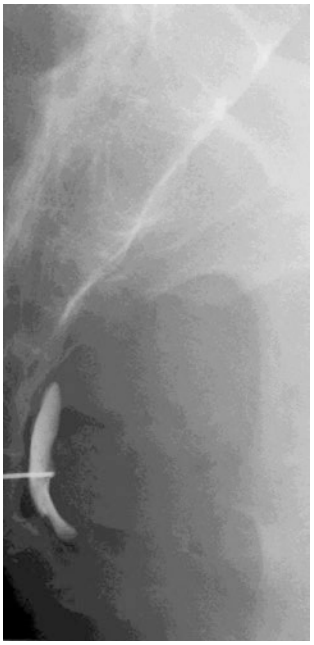

Fig. 49.2 Lateral view. Contrast medium spread in front of the sacrococcygeal area in the lateral view

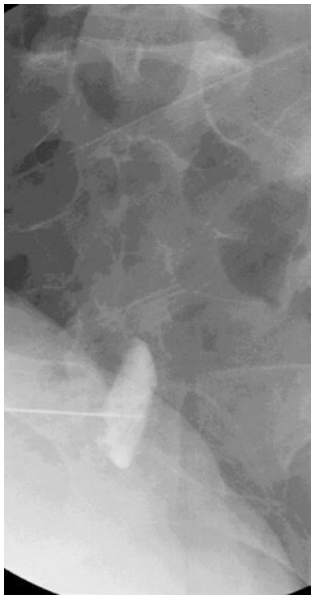

Fig. 49.3 Anteroposterior view. Mostly symmetrically at the midline in the frontal view

between the insertion site and the middle of the sacrum. Since we generally insert the needle about 70 to 100 mm right lateral to the sacral hiatus, we use 144 mm high-frequency thermocoagulation guiding needles with a 10 mm non-isolated part for a lumbar sympathetic nerve block. Place the needle adjacent to the anterior surface of the sacrum.

3. Walk the needle to the anterior surface of the sacrum. Switch the fluoroscopy to the frontal view, and move the needle further to the center of the sacrum Fig. 49.1 (Fluoroscopy 1).
4. Switch the inner cylinder of the needle to the electrode needle. Stimulate at 50 Hz/0.5 V on the STIM mode and check for provoked pain at the site of the original pain and the absence of abnormal pain or sensations in the lower limbs or the abdomen. Inject Omnipaque 3 mL and ensure no leakage to the vessels and that the dye has been spread in front of the sacrococcygeal area in the lateral view and mostly symmetrically at the midline in the frontal view (Figs. 49.2 and 49.3). Inject 2% carbocaine 3 mL and check for pain relief and no complications before performing the high-frequency thermocoagulation.
5. Have the patient rest in the dorsal position for about 1 hour.

49.5 Complications

No serious complications should occur other than local hematoma and infections. The risk of sciatic nerve injury is very low because the needle is moved toward the sacrum.

References

1. Plancarte R, Amesua C, Patt RB. Presacral blockade of the ganglion of walther (Ganglion impar). Anesthesiology. 1990;73(3A)
2. Prithvi Raj P. Current review of pain (Alon P Winnie). Curr Med. 1994:72–3.
3. Patt RB, Cousins MJ. Techniques for neurolytic neural blockade. In: Cousius MJ, Bridenbaugh PO, editors. Neural blockade. New York: Lippincott-Raven; 1998. p. 1007–61.

Intra-articular Injection of the Hip Joint

50

Kunihiko Murai and Kiyoshige Ohseto

50.1 Introduction

Intra-articular injection of the hip joint may be useful for the treatment of hip joint associated pain, for the differentiation of coxarthrosis from lower extremity neuropathy, and also helpful for making a definitive diagnosis before surgical procedures [1]. Intra-articular injection allowed correct identification of the source of the pain with a sensitivity of 87%, a specificity of 100%, and an efficiency of 88% [2].

Antecedent physiological examinations are recommended before application of intra-articular injection. The true positive rates of the examination of tenderness of the femoral triangle (of Scarpa), Patrick test, FADIR test, and the tenderness of the posterior site of the hip joint are estimated to be 100%, 100%, 80.6%, and 70.9%, respectively [3]. Therapeutic intraarticular hip injection is useful for the treatment of hip joint pain, and diagnostic injection is helpful in the differential diagnosis of coxarthrosis from lower extremity neuropathy when considering surgical treatment [1]. In diagnostic purpose, intraarticular injection allows identification of the source of the pain with a sensitivity of 87%, a specificity of 100%, and an efficiency of 88% [2]. Physical examinations should be performed before application of intraarticular injection. The true positive rates of tenderness of the femoral triangle (of Scarpa), Patrick test, FADIR test, and the tenderness of the posterior site of the hip joint are estimated to be 100%, 100%, 80.6%, and 70.9%, respectively [3].

50.2 Indications

Hip joint associated pain: coxarthrosis.

Longer-term chondroprotective effect is not expected.

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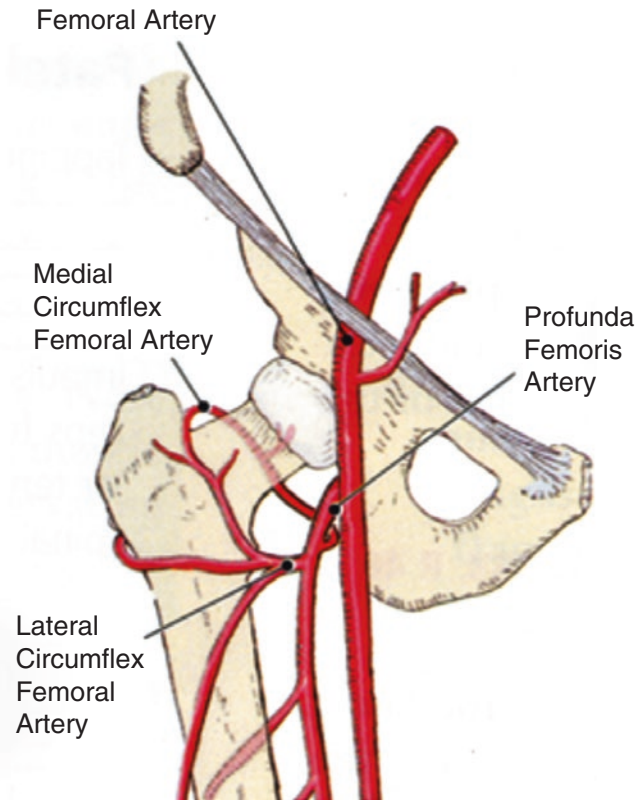

Fig. 50.1 Anterior view of femoral arteries a round hip joint. Medial and lateral femoral circumflex artery arises laterally from the profunda femoris artery that derives from femoral artery passing medial to the hip joint

50.3 Anatomy

The hip joint is located in a mediocaudal direction from the ASIS (black plot) that is a bony projection of the iliac bone and a landmark of surface anatomy (Fig. 50.1). The ligaments of the hip reinforce the articular capsule in which the needle tip is to be introduced through the ligament (Fig. 50.2). The innervation of the hip joint region consists of the femoral nerve, obturator nerve, and sciatic nerve. Lower extremity

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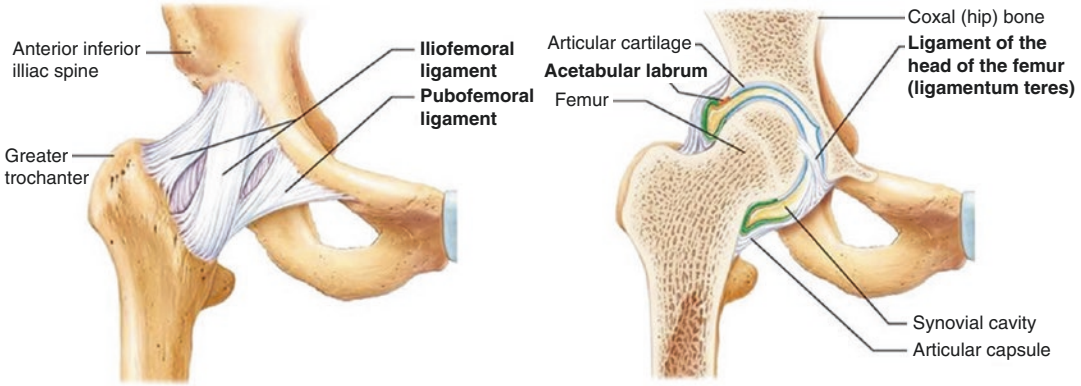

Fig. 50.2 The hip joint ligaments. Anterior view of the articular capsule of the hip, displaying the capsular ligaments as distinct bands reinforcing the capsule. Drugs should be injected into the capsule. (Practical Orthopaedic Sports Medicine & Arthroscopy first Edition, 2007 Lippincott Williams & Wilkins)

pain originating in the hip joint is explained as resulting from these innervations [4] (Figs. 50.1 and 50.2).

The primary blood supply to the femoral head and neck originates from the medial femoral circumflex artery, which is a branch of the deep femoral artery (arteria profunda femoris). The medial femoral circumflex artery wraps around the iliopsoas tendon passing between the iliopsoas and pectineus muscles, then to the medial and posterior aspect of the femoral neck. In the adult, the lateral epiphyseal artery from the medial femoral circumflex artery plays an important role in the femoral head blood supply.

50.4 Instruments and Drug Solutions

1. Sterilized echo probe cover or plastic bag (US guidance).
2. Sterilized rubber band (US guidance).
3. Sterilized ultrasound gel (US guidance).
4. 10 mL syringe (1% lidocaine 10 mL + triamcinolone acetonide 40 mg)
5. 5 mL syringe (Isovist® 240/300) (radiographic guidance)
6. Block needle or 6 cm disposable needle.
7. Extension tube.
8. Chlorhexidine in alcohol and swab.

50.5 Procedures and Techniques

An anterior, anterolateral, or lateral approach is taken to the hip joint. Accurate methods for hip injections without the use of imaging have been suggested [5]*; however, the anterior landmark method has an insufficient success rate of 60%, and the lateral approach has a rate of 80%, with a slight risk of femoral nerve puncture* [6]*. Therefore, we recommend using* fluoroscopy-guided method *or ultrasound*-guided method.

50.5.1 X-Ray Fluoroscopy-Guided Method

The entrance site is approximately 2.5 cm distal to the anterior-superior iliac spine (ASIS). After local anesthesia, a 22-gauge block needle is introduced into the skin and directed toward the superolateral corner of the femoral head on the AP radiograph. Once the needle tip reaches the femoral head, 3 mL of contrast dye is injected, and a fluoroscopic radiograph is taken to confirm intra-articular placement of the needle tip (Fig. 50.3). Then 3–4 mL of 1% lidocaine and, for treatment purposes, 1 mL of a solution containing 40 mg triamcinolone acetonide is injected.

50.5.2 Ultrasound-Guided Method

A patient is placed in the supine position, with the hip in neutral to slight internal rotation. The ASIS is palpated, and the transducer is oriented in a sagittal plane medial to the ASIS. The transducer is moved medially to the femoral head. The transducer is then rotated into the transverse plane and moved medially to identify the femoral nerve and vessels. Then the transducer is moved back to the anterior hip joint in the oblique sagittal plane visualizing the femoral head-neck view or rotated approximately 30–40° visualizing the long-axis femoral head-neck view. Then a block needle is inserted to the junction of the femoral head-neck following local anesthesia, and 3–4 mL of 1% lidocaine and, for treatment purposes, 1 mL of a solution containing 40 mg triamcinolone acetonide is injected, while visualizing the capsular distention (Fig. 50.4).

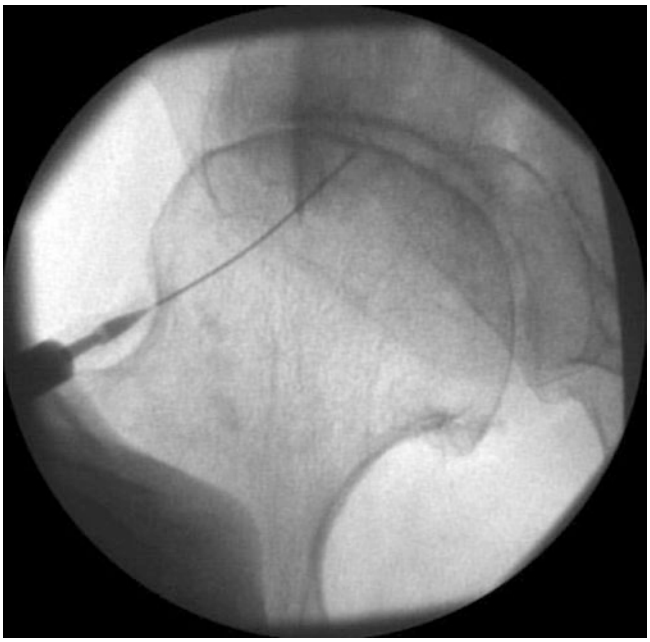

Fig. 50.3 X-ray arthrography of the hip joint after injection of contrast dye. The needle tip is inserted into the hip joint posteromedially

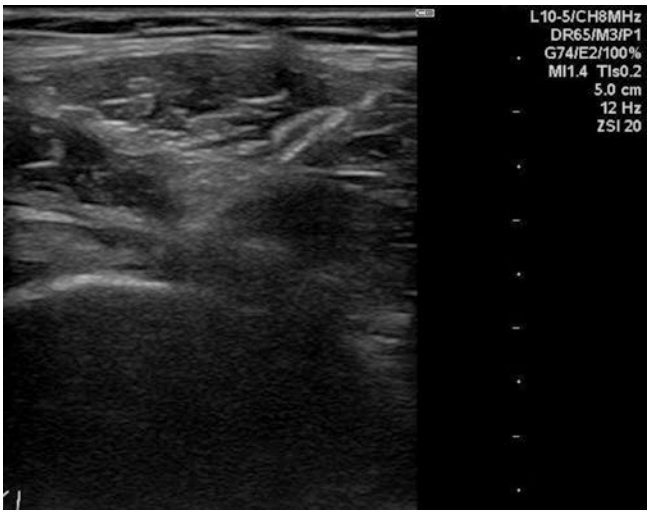

Fig. 50.4 Ultrasound image of the femoral head-neck view. The needle is inserted mediocranially along the lines of femoral neck to the femoral head. The capsular distention is observed as low echoic area

50.6 Complications

Potential complications include infection, damage to femoral nerves, raising blood sugar levels in diabetic patients, intravascular injection of local anesthetics, and improper placement of medication.

References

1. Yamauchi Y, Jinno T, Koga D, Morita S, Muneta T, Shinomiya K. Usefulness of intraarticular injection in the diagnosis of the hip joint diseases. J East Jpn Orthop Traumatol. 2010;22:46–51. (in Japanese)
2. Kleiner JB, Thorne RP, Curd JG. The value of the bupivacaine hip injection in the differentiation of coxarthrosis from lower extremity neuropathy. J Rheumatol. 1991;18(3):422–7.
3. Kobayashi Y, Koyano G, Kitahama J, Iwase K, Hirakawa M, Tomioka H, Suzuki M. Is low back pain really originated from lumbar spine? - Evaluation of the pain derived from hip joint among the patients with a chief complaint of low back pain. J East Jpn Orthop Traumatol. 2014;26(1):21–5. in Japanese
4. Birnbaum K, Prescher A, Hessler S, Heller KD. The sensory innervation of the hip joint. Surg Radiol Anat. 1997;19(6):371–5.
5. Leopold SS, Battista V, Oliverio JA. Safety and efficacy of intraarticular hip injection using anatomic landmarks. Clin Orthop Relat Res. 2001;391:192–7.
6. Ziv YB, Kardosh R, Debi R, Backstein D, Safir O, Kosashvili Y. An inexpensive and accurate method for hip injections without the use of imaging. J Clin Rheumatol. 2009;15(3):103–5.

Radiofrequency Thermocoagulation of Hip Articular Branches (X-ray Fluoroscopy-Guided)

51

Hisashi Date

51.1 Introduction

51.1.1 What is the Radiofrequency Thermocoagulation of the Hip Articular Branches?

Radiofrequency thermocoagulation of the hip articular branches is a method of thermocoagulation using radiofrequency waves to treat hip joint-derived pain by identifying the route of the sensory nerve distributed over the hip joint.

51.2 Indications

Intractable hip pain (hip pain due to avascular necrosis of the femoral head, hip osteoarthritis, rheumatoid arthritis, after femoral head replacement, etc.)

51.3 Anatomy (Fig. 51.1)

The sensation of the hip joint is supplied by the articular branches of the obturator, femoral, superior gluteal, and sciatic nerves. The articular branch of the obturator nerve runs beneath the so-called teardrop seen on the X-ray image. It is distributed over the pubofemoral ligament and the femoral head, which is involved in pain in the medial thigh skin. The articular branch of the femoral nerve bifurcates from the middle of the muscular branch and is distributed over the iliofemoral ligament. It transmits pain from the anterior surface of the thigh. The articular branches of the obturator and femoral nerves are involved in the main causes of pain. The articular branch of the superior gluteal nerve runs from the gluteal muscle to the anterior inferior iliac spine, and it is distributed over the iliofemoral ligament, which is involved in pain around the outside of the thigh. The articular branch of the sciatic nerve runs behind the acetabulum and bifurcates from the concurrently running quadrate femoral muscle branch. It is distributed over the iliofemoral ligament, which is involved in pain occurring around the center caudal side of the buttocks.

51.4 Instruments and Drug Solutions

1. Puncture needle: 22G Sluijter needle (92–99 mm; 4 mm in the non-insulated part)
2. Electrode: Sluijter-Mehta Kit
3. 10-cc syringe (local anesthesia, contrast agent)
4. 5-cc syringe (contrast agent)
5. 2-cc syringe (anesthesia for coagulation)
6. High-frequency generator
7. Drug solution: 1% lidocaine

51.5 Procedures and Techniques (X-ray Fluoroscopy-Guided Method)

Because the obturator nerve is often involved in hip pain, this procedure is first conducted on the articular branch of the obturator nerve and then on the articular branch of the femoral nerve. If pain persists, the articular branch of either the superior gluteal or the sciatic nerve is subsequently targeted. If this technique is used for the articular branch of the sciatic nerve, a change in body position is required.

51.5.1 Techniques for the Puncture of the Articular Branch of the Obturator Nerve

The body position used is the supine position with the affected side front (Fig. 51.2). Generally, no pillow is used. The patient's body position should be adjusted in order to

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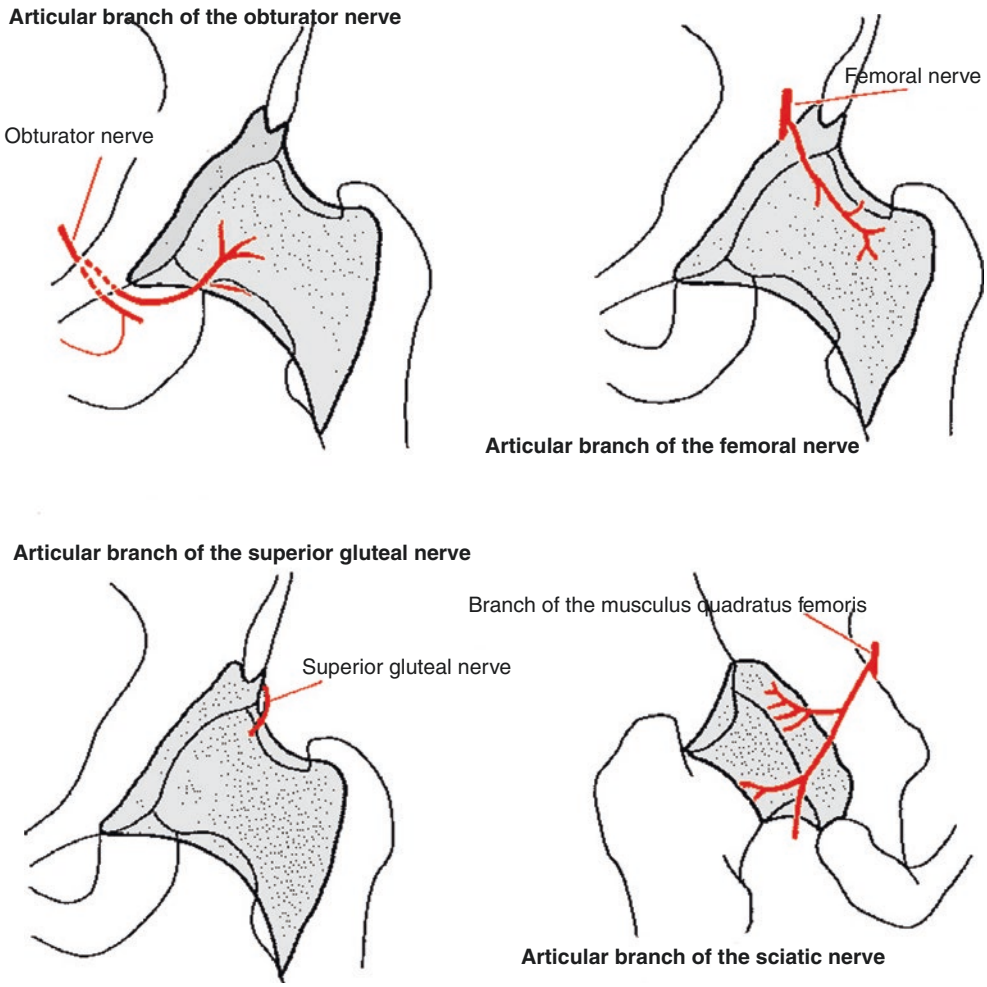

Fig. 51.1 Sensory nerve branches supplying the hip joint. The articular branches of the obturator, femoral, superior gluteal, and sciatic nerves are distributed over the hip joint (Ref. 1)

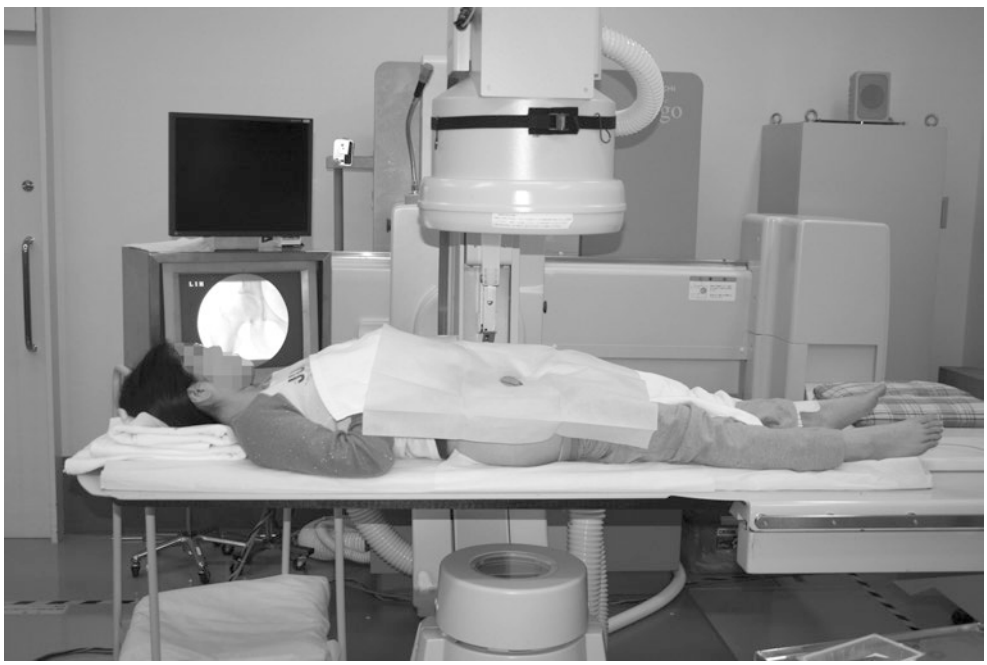

Fig. 51.2 Body position. The patient is placed in a supine position with the affected side to the front

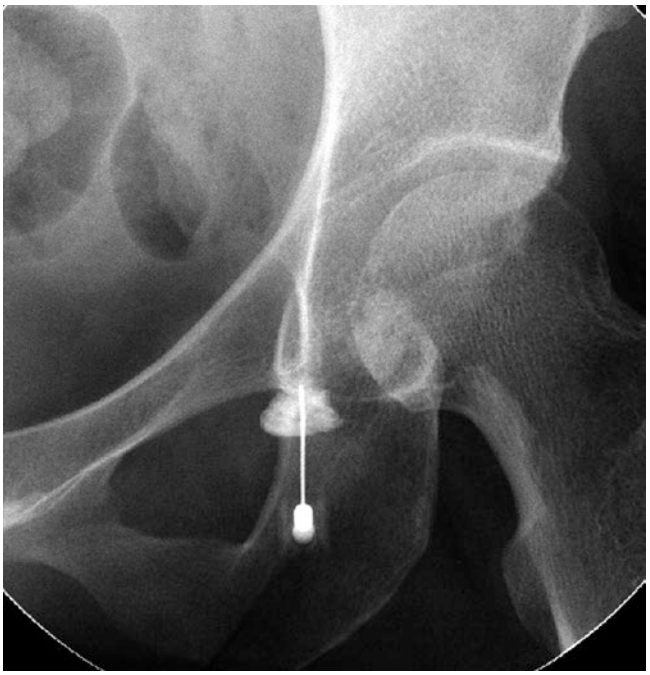

Fig. 51.3 Block of the articular branch of the obturator nerve. The marginal area of the hip joint acetabulum of the iliac bone is the target

obtain a proper frontal view with the C-arm vertical and not twist the pelvis. The femoral plexus sheath should be identified by palpation and then marked with a skin pen in advance. During the puncturing, caution is necessary so as not to cause overlap of the femoral artery and the vein/nerve with the puncture route by using the femoral artery as a guide mark. Local anesthesia is applied to the skin around the caudal side of the teardrop in the lower part of the inner side of the hip joint on the inner side of the femoral plexus sheath. In this case, the anesthetic procedure is considered adequate if a wheal is produced on the skin at the puncture site because nerve stimulation is difficult to obtain if deep-seated anesthesia is applied. A Sluijter needle should be used for the puncture, and it should be aimed at the ischial bone just beneath the teardrop under X-ray guidance. When the needle contacts the bone wall, the cannula should be removed, and an electrode (Sluijter-Mehta Kit) should be inserted in order to provide radiofrequency stimulation (50–100 Hz). Radiating pain usually sets in at ~0.5 V. Reproducibility should be confirmed with on or off stimulation. If no radiating pain is experienced by the subject at 0.5 V, the output power should be increased to 1 V. If there is still no radiating pain, the site with the greatest pain should be identified by wandering on the bone wall in the vicinity. Low-frequency stimulation (2–5 Hz) should be given to the site where the most prominent radiating pain is experienced, and the absence of twitch should be confirmed. At this point, a contrast study should be conducted to confirm that there is no involvement of plexuses or nerves on the X-ray images (Fig. 51.3). Because the contrast study is aimed at confirming the absence of intravascular injection or contact with the femoral or sciatic nerve, no typical contrast images are obtained. The radiography should cover a large field to clarify the positional relationship with the overall hip joint. If the images obtained have no problematic findings, 1 mL of lidocaine should be injected, and radiofrequency coagulation should be conducted at 90 °C for 120 s. The patient should rest in bed for 90 min after the block, and the absence of leg weakness should be confirmed at the end of the rest time.

51.5.2 Technique for the Puncture of the Articular Branch of the Femoral Nerve (Fig. 51.4)

The needle should be inserted toward the marginal area of the acetabulum near the anterior inferior iliac spine outside the femoral plexus sheath. The subsequent procedures are the same as above.

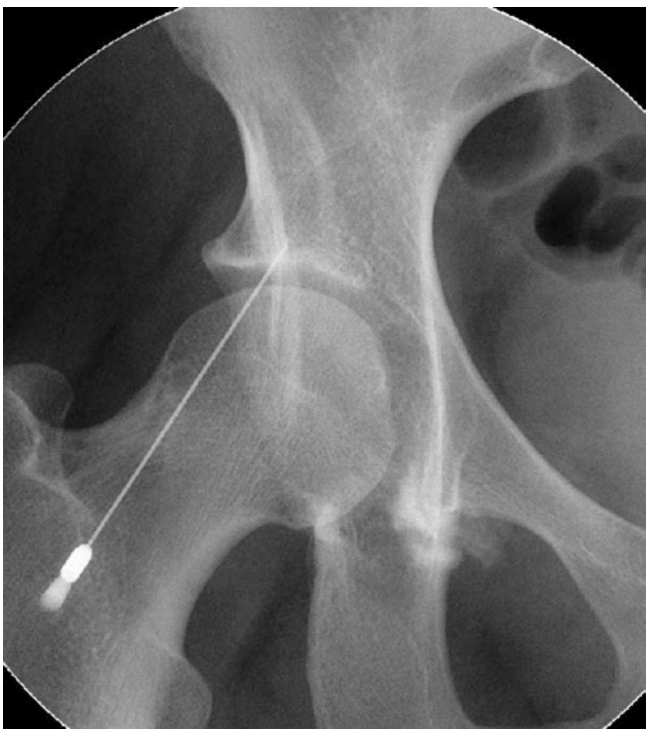

Fig. 51.4 Block of the articular branch of the femoral nerve. The marginal area of the acetabulum near the anterior inferior iliac spine outside the femoral plexus sheath

51.6 Complications

51.6.1 Infection

Although this technique is not associated with insertion of the needle into the joint, arthritis may occur if the needle enters the joint.

51.6.2 Nerve Injury

If the needle sticks into the muscle branches of the femoral nerve or the sciatic nerve by mistake, weakness may occur. The position of the needle tip should be confirmed before the radiofrequency thermocoagulation, and implementation of the procedure should be discontinued if the propriety of the needle-tip position is in question.

51.6.3 Bleeding

Bleeding may occur when the femoral artery or vein is pricked by mistake. The femoral artery should be palpated in advance, and the site of puncture should be chosen to avoid the femoral artery.

51.6.4 Charcot's Joint

Charcot's joint is a joint deformation that is caused by excessive load imposed on the joint in a painless state. This technique alone does not eliminate pain completely, and, therefore, it is unlikely to result in this complication.

Reference

1. Okada K. New approach to the pain of the hip joint. Pain Res. 1993;8:125–35. (in Japanese).

Comment

52

Yoichiro Abe

52.1 Comment to Chap. 49: Ganglion Impar Block

The advantages of the lateral approach include the following: (1) the procedure is not affected by the shape of the sacrococcygeal area; (2) the needle is inserted laterally to the sacrum to allow the needle tip to reach the midline easily; and (3) high-frequency thermocoagulation is not associated with complications such as neuritis and can be safely used in patients with nonneoplastic pain. Needle insertion from the right side is safer because it protects the sigmoid colon unless the patient has had total pelvic exenteration. We perform mandatory pelvic MRI before each nerve block to further ensure the patient's safety.

Although further evaluation is necessary, none of our patients have had complications after thermocoagulation at 90°C.

We described the ganglion impar block (high-frequency thermocoagulation) using a right lateral approach.

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Part XI

Lower Extremity

Lateral Femoral Cutaneous Nerve Block

53

Natsuko Oji

53.1 Introduction

An LFCN block is used into the patients with lateral femoral pain. This block is used both for diagnosis and for treatment. An LFCN block is carried out using the landmark method or an ultrasound-guided approach.

53.2 Indications

We use an LFCN block for inguinal and femoral pain used by meralgia paresthetica. Meralgia paresthetica is one of the entrapment neuropathies. Its occurrence has some correlation with the use of corsets, obesity, diabetes, iatrogenic damage, and pregnancy. However the cause is unknown in many cases. It can be diagnosed with an LFCN block.

53.3 Anatomy

The LFCN arises from the anterior branches of L2–3. After emerging from the lateral border of the psoas major muscle, it divides into an anterior and posterior branch (Fig. 53.1). The anterior branch courses inferiorly and laterally toward the anterior superior iliac spine (ASIS). It then passes underneath the inguinal ligament and over the sartorius muscle into the thigh. The LFCN provides sensory innervation to the lateral thigh (Fig. 53.2). Anatomic variants of the LFCN may be present in 25% of patients [1].

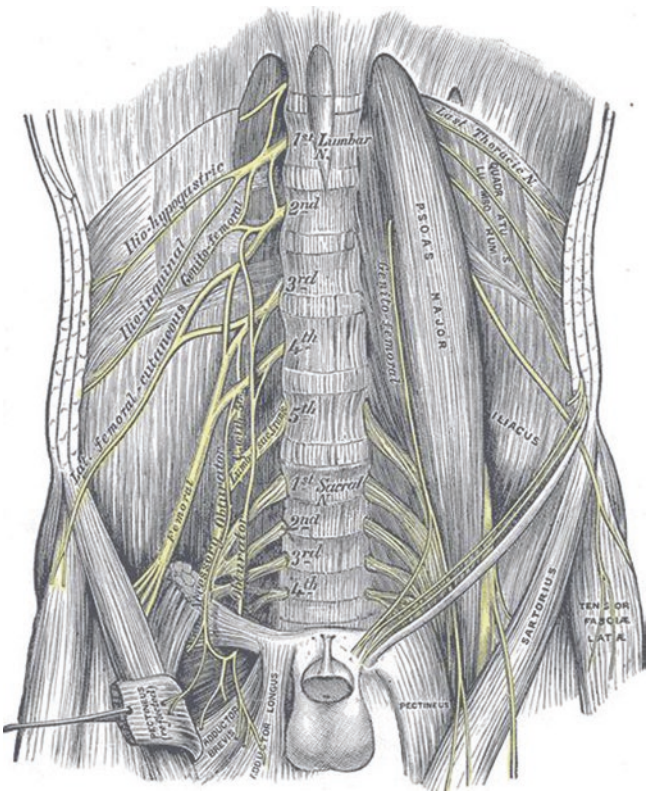

Fig. 53.1 Muscles and nerves of posterior abdominal wall. The LFCN arises from the anterior branches of L2-3 [2]

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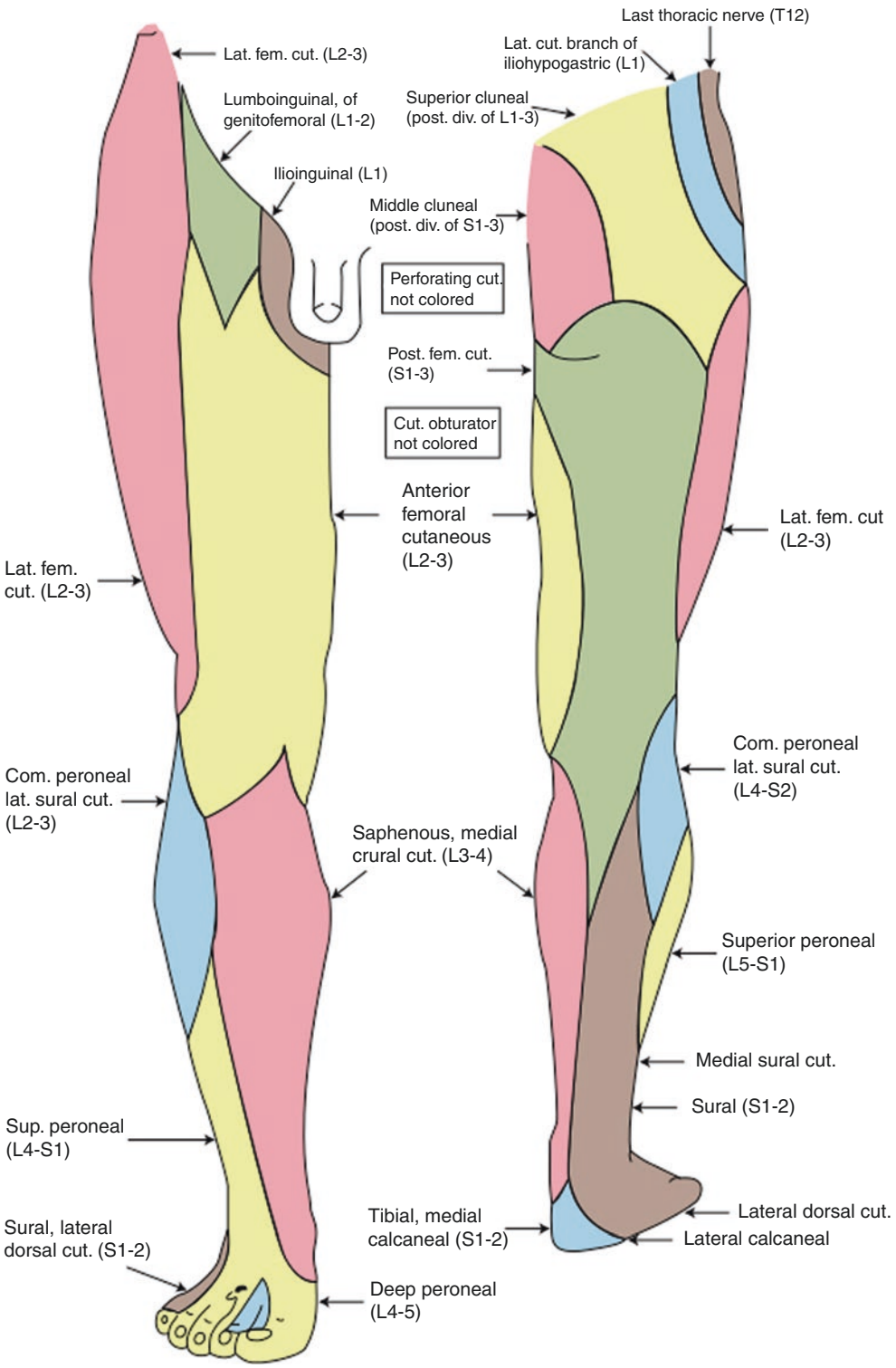

Fig. 53.2 Cutaneous nerves of the right thigh

53.4 Instruments and Drug Solutions

Refer to other sections.

53.5 Procedures and Techniques

53.5.1 Landmark Method

An LFCN block is carried out with the patient in a supine position. Vertically insert a 25G needle at the point of 2.5 cm inside and 2.5 cm caudally from the ASIS. Move the needle into the resistance of the femoral fascia. Inject 1–2 mL of the local anesthetic when the needle penetrates the fascia, and inject 1–2 mL of additional local anesthetic just above the fascia when removing the needle.

53.5.2 Ultrasound-Guided Method

An ultrasound-guided LFCN block is carried out with the patient in a supine position to check the locations of the ASIS and inguinal ligament. A linear probe is selected. The sartorius muscle and tensor fasciae latae muscle start from the ASIS. The LFCN is located between the sartorius and tensor fasciae latae muscle one-third down the proximal thigh from the hip; LFCN is found near the ASIS under ultrasound guidance. 5 mL of local anesthesia is injected into the fascia.

53.6 Complications

An LFCN block is a safe nerve block.

Complications such as bleeding, infection, and nerve damage are rare.

References

1. Patijn J, Mekhail N, Hayek S, Lataster A, van Kleef M, Van Zundert J. Meralgia paresthetica. Pain Pract. 2011;11(3):302–8.
2. Gray H. Anatomy of the human body. Philadelphia: Lea & Febiger; 1918.

Femoral Nerve Block

54

Tatsuo Nakamoto

54.1 Introduction

The femoral nerve, one of the principle branches in the lumbar plexus, consists of ventral rami of L2-4 and innervates the anterior of the thigh, anteromedial leg, and joints of hip and knee. In the subinguinal region, femoral nerve lies in the compartment surrounded by the fascia iliaca (FI), iliopsoas muscle (IPM), and lateral border of femoral artery.

The femoral nerve block, using nerve stimulation-guided (NSG) or ultrasound-guided (USG) methods, is easier to identify the location of the nerve than other blocks because of obvious anatomical landmark and ultrasound image [1, 2]. The femoral nerve block provides good anesthesia and analgesia combined with the sciatic nerve block for various lower extremity surgeries.

54.2 Indications

Thigh pain, pain on femoral neck fracture, gonalgia, coxalgia, and postoperative analgesia of the lower extremity [3]

54.3 Anatomy (Fig. 54.1)

The femoral nerve is the main branch of the lumbar plexus, consisting of L2–L4 anterior rami, with innervating sensory branches to the anterior thigh and medial leg, motor branches to the femoral quadriceps muscle and sartorius muscle, and articular branches to the hip and knee joints. It passes through the muscular lacuna, covered with FI, and locates on medial border of IPM beneath the inguinal crease and lateral of the femoral artery.

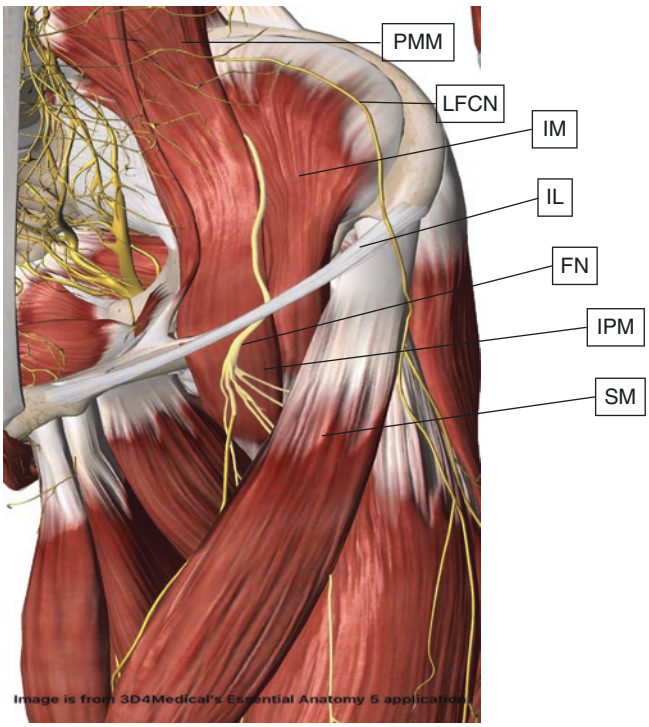

Fig. 54.1 Anatomy of femoral nerve and subinguinal region. *FN* femoral nerve, *IL* inguinal ligament, *IM* iliac muscle, *IPM* iliopsoas muscle, *LFCN* lateral femoral cutaneous nerve, *PMM* psoas major muscle, *SM* sartorius muscle. Image is from 3D4Medical's Essential Anatomy 5 application

54.4 Instruments and Drug Solutions

54.4.1 Preparation (Fig. 54.2)

High-frequency linear array probe, sterilized probe cover and/or film dressing, 22G 70–100 mm block needle (for USG), 50 mm insulated block needle (for NSG), ethanol with chlorhexidine, and local anesthetics (LA)

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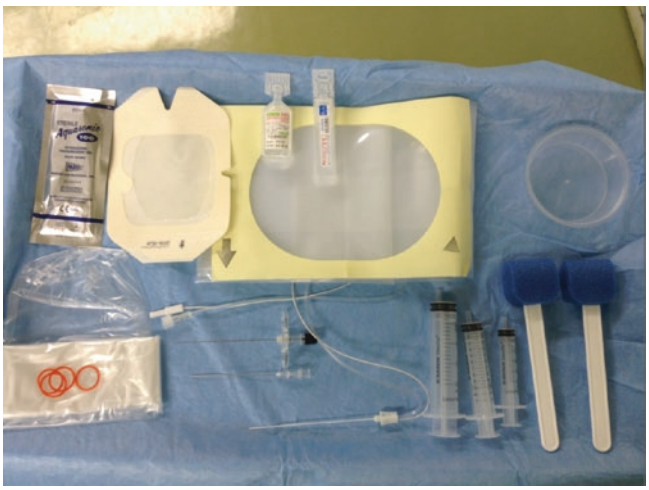

Fig. 54.2 Material and drugs for femoral nerve block

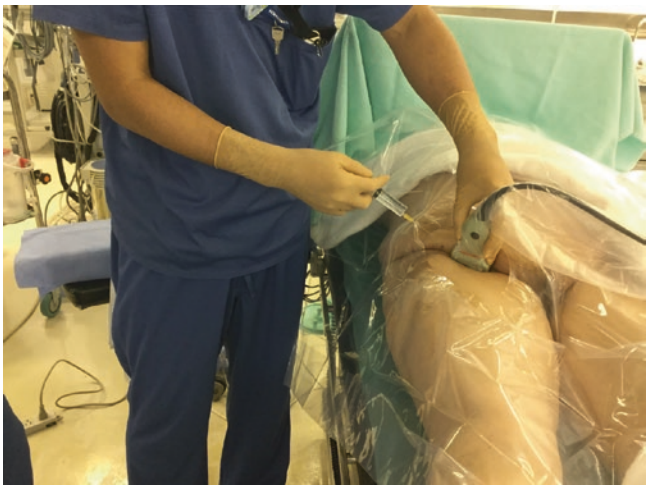

Fig. 54.3 Patient position and anatomical landmarks for nerve stimulation-guided femoral nerve block. *ASIS* anterior superior iliac spine, *FA* femoral artery, *IC* inguinal crease, *IL* inguinal ligament, *IP* insertion point

54.4.2 Drugs and Dosage

5–10 mL LA for pain control described below
0.5–1% Mepivacaine or lidocaine
0.1% Levobupivacaine or 0.15% ropivacaine

54.5 Procedures and Techniques

54.5.1 Femoral Nerve Block Using NSG

Technique (Fig. 54.3)

Patient position	Supine with slight external rotation of the hip joint
Landmarks	Inguinal ligament, anterior superior iliac supine (ASIS), pubic tuberculosis, and femoral artery
Insertion point	Cross-point 2 cm caudal from inguinal ligament and 1–2 cm lateral from femoral artery

54.5.2 Needle Insertion and Nerve Detection Using NSG

After disinfecting the field, insert the insulated needle connected to the nerve stimulator at the point described above, with 30–40° angle to the skin cephalad.

Nerve stimulation starts at 1 mA, 0.1 ms wide, and 2 Hz.

"2-Pop" with piercing of the fascia lata and FI is important. Quadriceps muscle contraction (movement of the patella) is also observed. Then decrease the stimulus current, and advance the needle carefully while looking for places with further muscle contraction.

1. After confirming quadriceps muscle contraction (movement of the patella), decrease the level of stimulation to under 0.5 mA while confirming muscle twitch by adjustment of the needle tip.
2. If the needle tip is beside the nerve, a small amount of local anesthetic will eliminate the motor twitch.
3. Inject the residual dose taking care not to make intravascular injection.

54.5.3 Femoral Nerve Block Using USG [3]

Procedure

- Patient position (Fig. 54.4): supine position with slight external rotation of the hip joint
- Landmarks: FI, IPM, femoral artery, fascia lata, and sartorius muscle (SM)
- Scanning technique: Place the linear array probe on the inguinal crease, and verify the sartorius muscle, IPM, and femoral artery. The ventral fascia of SM is fascia lata, and the dorsal one is FI, which is clearly visible when tilting the probe slightly to cephalad [4].
- Tracing FI medially, the femoral nerve is observed as a hyperechoic oval structure medial to the femoral artery and between FI and IPM (Fig. 54.5).

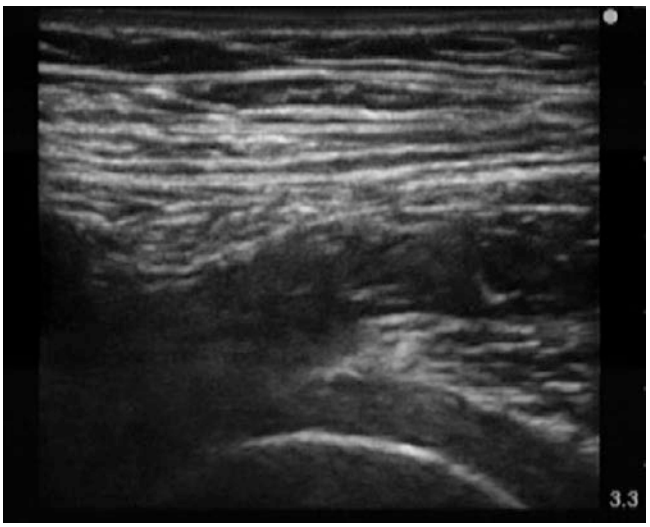

Fig. 54.4 Patient position and probe placement for US-guided femoral nerve block

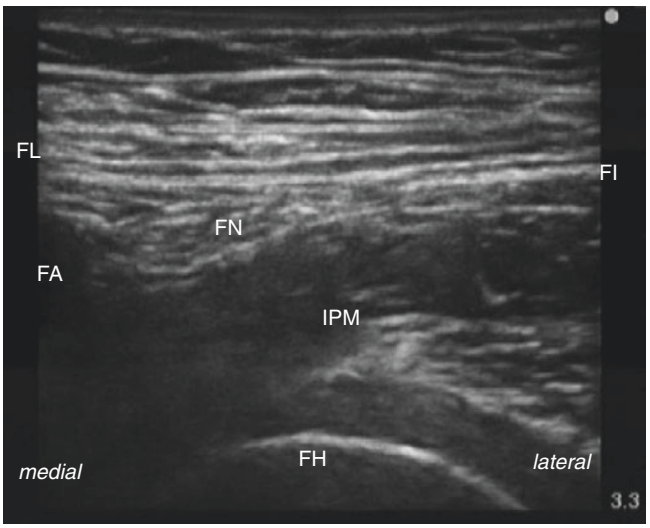

Fig. 54.5 Typical sonographic images (**a**) and those interplitations (**b**) for US-guided femoral nerve block. *FA* femoral artery, *FI* fascia iliaca, *FL* fascia lata, *FN* femoral nerve, *IPM* iliopsoas muscle

Needle insertion technique:

1. Prepare the probe with a sterilized probe or film dressing, and swab the block sites with antiseptic.
2. Place the probe in the position to visualize adequate sono-anatomy including FI and femoral nerve, and then insert the needle using an in-plane approach from the lateral border of the probe to the lateral edge of FI and IPM adjacent to the femoral nerve.
3. Confirming that the needle tip penetrates through FI, injection of LA provides a spread around the femoral nerve away from surrounding tissue (Fig. 54.6).
4. Inject the residual dose while adjusting the needle tip to complete surrounding spread of LA around the femoral nerve.

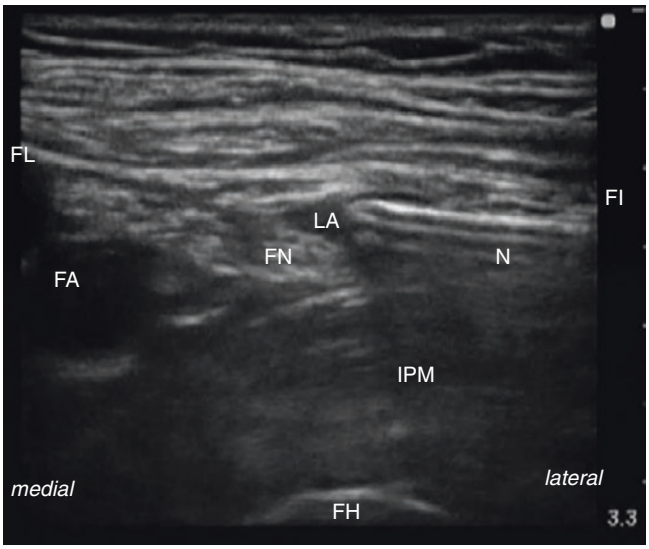

Fig. 54.6 Spread of local anesthetics around the femoral nerve by injection via the needle. *FA* femoral artery, *FI* fascia iliaca, *FL* fascia lata, *FN* femoral nerve, *IPM* iliopsoas muscle, *LA* local anesthetics, *N* needle

54.6 Complications

1. Nerve damage: 0.5 mA or more required to determine muscle contraction for patients with peripheral neuropathy with nerve stimulation.
   - If muscle contraction is absent, the patient may complain of radiating pain.
2. Intravascular injection/topical anesthetic drug poisoning: caution required in divided doses to basic chemical injection; sometimes associated with the regurgitation of blood or local anesthetic toxicity symptoms.

References

1. Marhofer P, Schrogendorfer K, Koinig H, Kapral S, Weinstabl C, Mayer N. Ultrasonographic guidance improves sensory block and onset time of three-in-one blocks. Anesth Analg. 1997;85(4):854–7.
2. Marhofer P, Schrogendorfer K, Wallner T, Koinig H, Mayer N, Kapral S. Ultrasonographic guidance reduces the amount of local anesthetic for 3-in-1 blocks. Reg Anesth Pain Med. 1998;23(6):584–8.
3. Sites B, Beach M, Gallagher J, Jarrett R, Sparks M, Lundberg C. A single injection ultrasound-assisted femoral nerve block provides side effect-sparing analgesia when compared with intrathecal morphine in patients undergoing total knee arthroplasty. Anesth Analg. 2004;99(5):1539–43.
4. Soong J, Schafhalter-Zoppoth I, Gray AT. The importance of transducer angle to ultrasound visibility of the femoral nerve. Reg Anesth Pain Med. 2005;30(5):505.

Sciatic Nerve Block

55

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55.1 Introduction

The sciatic nerve is the longest peripheral nerve in the human body. It relate to many types of pain including not only radicular pain by lumbar disease, but also various types of impingement pain and neuropathic pain caused by diabetes mellitus, arteriosclerotic obstruction, ischemic desease, and nerve damage.

The sciatic nerve is visible at multiple points from the parasacral region to terminal branches using ultrasound. Ultrasound-guided procedure to the sciatic nerve is useful not only for anesthesia and analgesia of surgery, but also for pain management using pulsed radiofrequency on the lower extremity.

In this section, we describe the parasacral and popliteal approach, which is used widely in clinical practice, by landmark with nerve stimulation-guided (NSG) and by ultrasound-guided (USG) methods in sciatic nerve blocks.

55.2 Indications

Sciatica, piriformis syndrome, painful ischemic toe, postoperative pain below knee, etc.

55.3 Anatomy (Fig. 55.1)

The sciatic nerve is the principal nerve of the sacral plexus, consisting of L4, 5, S1-3 spinal roots joined together on the outer border of the sacral bone. The sciatic nerve runs through the infrapiriform foramen, the lower part of the greater sciatic foramen (GSF) separated by the piriform muscle (PM), to the outside of the pelvis with the posterior femoral cutaneous nerve and inferior gluteal artery. Well-known individual variations of the relationship between sciatic nerve and PM, almost 10–20% in peroneal component, are involved in piriformis syndrome (Fig. 55.2).

In the thigh region, it runs down through the greater trochanter (GT) and ischial tuberosity (IT), parallel to the biceps femoris muscle (BFM), and bifurcates into the tibial nerve (TN) and common peroneal nerve (CPN) in the popliteal region.

55.4 Instruments and Drug Solutions

Preparation

Curved array probe, linear array probe, sterilized probe cover or film dressing, 22G 70–100 mm sonogenic needle for USG, 21G 100 mm insulated needle (NSG), antiseptics, local anesthetics (LA), and steroids

Drugs and dosage

5–10 mL of LA as described below

0.5–1% Mepivacaine or lidocaine, 0.1% levobupivacaine, and 0.15% ropivacaine

55.5 Procedures and Techniques

55.5.1 Parasacral Sciatic Nerve Block

This approach, at the level of PM, provides a proximal sciatic nerve block including articular branches.

55.5.1.1 Landmark Method with Nerve Stimulation

Technique

Patient position:

Prone position or Sims' position with affected side up (Fig. 55.2)

Landmarks:

Posterior superior iliac spine (PSIS), sacroiliac joint (SIJ), and IT

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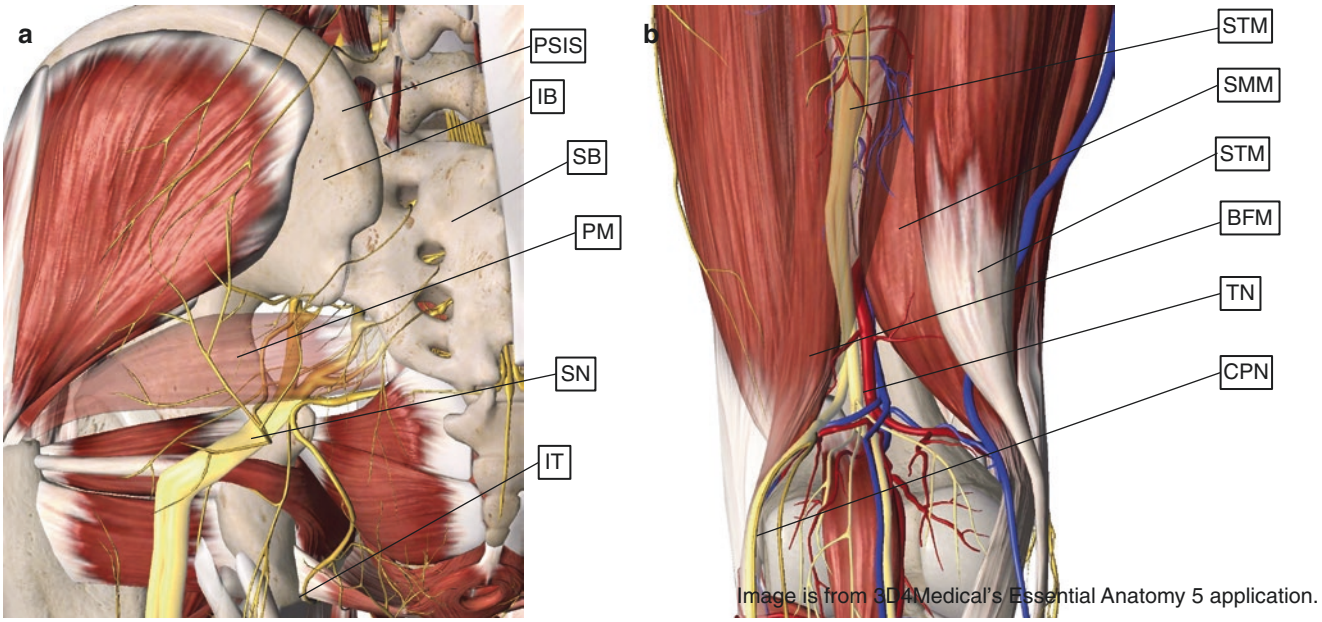

Fig. 55.1 Anatomy of the sciatic nerve. (**a**) Proximal region, (**b**) distal region. *BFM* biceps femoral muscle, *CPN* common peroneal nerve, *IB* iliac bone, *IT* ischial tuberosity, *PM* piriform muscle, *PSIS* posterior superior iliac spine, *SB* sacral bone, *SMM* semimembranosus muscle, *SN* sciatic nerve, *STM* semi-tendinous muscle, *TN* tibial nerve. Image is from 3D4Medical's Essential Anatomy 5 application

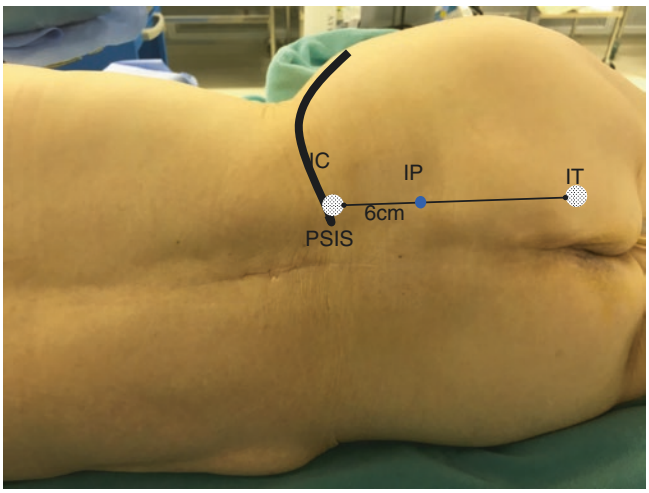

Fig. 55.2 Patient position and probe setting for sciatic nerve block. (**a**) Parasacral approach, (**b**) popliteal approach

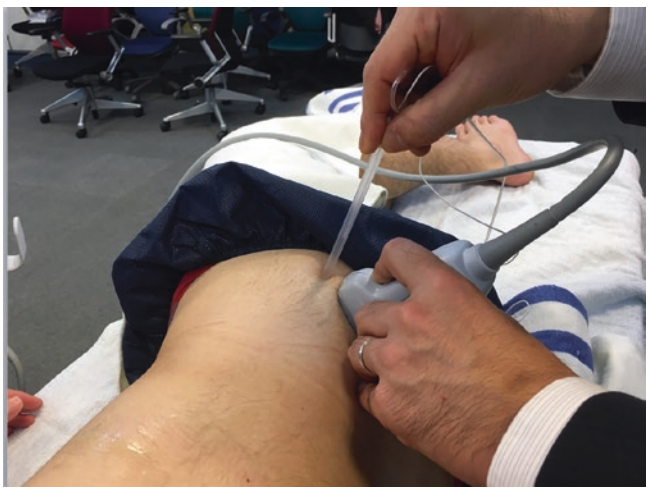

Fig. 55.3 Typical sonographic images for sciatic nerve block (pre-scanning). (**a**) Parasacral approach, (**b**) popliteal approach

Insertion point:
6 cm caudal from PSIS on the line connected to IT
Needle insertion technique [1]:

1. Insert the insulated needle perpendicular to the skin at the point described above after swabbing with antiseptic.
2. Start nerve stimulation with settings of 2 Hz, 1.5 mA, and 0.1 ms.
3. Adjust the needle direction about 10–20° caudally and laterally, when the needle tip contacts the iliac wing.
4. Upon confirming dorsi flexion or plantar flexion, decrease the level of stimulation to under 0.5 mA while confirming muscle twitch by adjustment of needle tip.
5. If the needle tip is placed beside the nerve, a small amount of local anesthetic will eliminate the motor twitch.
6. Inject the residual dose while taking care not to make intravascular injection.

55.5.1.2 Ultrasound-Guided Method

Scanning technique (Fig. 55.3) [2]:

1. Palpating SIJ, place the probe perpendicular to the body axis. The gluteal muscles and surface of the iliac bone, imaged as a hyperechoic slope, are observed in this position.

2. Sliding the probe caudally along with SIJ, the intrapelvic structure appears by US when the probe reaches GSF.
3. PM in the back of the gluteus maximus muscle (GMM) appears as a slightly hypoechoic structure, and it is easy to confirm the sliding of PM by hip rotation while modifying the probe position longitudinally with PM (line between lateral border of sacral to GT).
4. The sciatic nerve is identified as hyperechoic structure behind the ventral fascia of PM, medial to the ischial bone, configured outside of GSF.
5. Simultaneously confirm the superior gluteal artery and inferior gluteal artery medial or ventral to sciatic nerve by using color Doppler.

Needle insertion technique:

1. Prepare the probe with a sterilized probe or film dressing, and swab the block sites with antiseptic.
2. Place the probe in a position to adequately visualize the sonoanatomy, and insert the needle using an in-plane approach from the lateral border of the probe to the sciatic nerve adjacent to the medial border of the ischium.
3. Confirming that needle tip penetrates through the ventral fascia of PM, injection of LA provides a spread around the sciatic nerve away from surrounding tissue.

Complications:

1. Hemorrhage:
   - It is very important to confirm no aspiration of blood (NSG) or vessel flow by color Doppler (USG), because the superior and inferior gluteal arteries are located on the medial or ventral sides of the sciatic nerve.
2. Nerve injury:
   - Incorrect settings of stimulating current in NSG and misplacement of the needle tip in USG may cause puncture of the nerve.
3. Pelvic organ puncture:
   - Needling too deeply beyond the level of the sciatic nerve carries a higher risk of puncture of the pelvic organs.

55.5.2 Popliteal Sciatic Nerve Block

This approach, at the level of the popliteal region, provides a distal sciatic nerve block including the knee joint. In the ultrasound technique using a high-resolution linear array probe, it is convenient to perform catheterization and a selective branch block because of the high-quality image and needle visualization.

55.5.2.1 Landmark Method with Nerve Stimulation

Technique

Patient position:

Prone position or lateral position with affected side up

Landmarks:

Popliteal crease (PC), BFM, and semi-tendinous muscle/semimembranosus muscle (STM/SMM)

Insertion point:

1–1.5 cm lateral and 7 cm caudal from the top of the triangle with PC as the base and BFM and STM/SMM as the sides.

Needle insertion technique:

1. Insert the insulated needle perpendicular to the skin at the point described above after swabbing with antiseptic.
2. Start nerve stimulation with settings of 2 Hz, 1.0 mA, and 0.1 ms.
3. After confirming dorsiflexion (CPN stimulation) or plantar flexion (TN stimulation), decrease the level of stimulation to under 0.5 mA while confirming muscle twitch by adjustment of needle tip. In general, plantar flexion is more suitable for good anesthesia.
4. If the needle tip is placed beside the nerve, a small amount of local anesthetic will eliminate the motor twitch.
5. Inject the residual dose while taking care not to make intravascular injection.

55.5.2.2 Ultrasound-Guided Method (Just Below Bifurcation)

Patient position:

Prone position or supine position with knee flexion and hip adduction

Landmarks of sonographic image:

Popliteal artery (PA), popliteal vein (PV), BFM, and STM/SMM

Scanning technique:

1. Place the probe on PC, and confirm BFM on lateral and STM/SMM on medial sides, respectively.
2. Sliding the probe with a slight tilt cephalad, TN is confirmed as a hyperechoic round structure in front of PA and a hypoechoic round structure with pulsation located between BFM and STM/SMM.
3. Tracing TN back to sciatic nerve, the confluence with CPN, almost half sized and located in lateral to TN. It's so important to identify the bifurcation of sciatic nerve to TN and CPN.
4. The sciatic nerve in this region is composed of endoneurium, perineurium, and epineurium. However, recently, the paraneural sheath (PS) has been mentioned as the outermost layer of the sciatic nerve [3, 4]. Injection of LA

into the PS provides more rapid onset of analgesia and longer efficacy [5].
5. It is very important to identify the bifurcation of the sciatic nerve and PS.

Needle insertion technique:

1. Prepare the probe with a sterilized probe or film dressing, and swab the block sites with antiseptic.
2. Place the probe in a position to adequately visualize the sonoanatomy (bifurcation, PS), and then insert the needle parallel to the probe from the lateral thigh while adjusting the ultrasound plane toward the sciatic nerve.
3. Confirming that needle tip penetrates through the common PS between TN and CPN, injection of LA provides a spread around both nerves.
4. Inject the residual dose while adjusting the needle tip to complete the surrounding spread of LA.

55.6 Complications

1. Hemorrhage, unintentional intravascular injection: It is very important to confirm no aspiration of blood (NSG) or vessel flow by color Doppler (USG), because PA and PV are located on the ventral side of the sciatic nerve.
2. Nerve injury: Incorrect settings of the stimulating current in NSG and misplacement of the needle tip in USG may cause direct puncture of the nerve.

References

1. Cuvillon P, Ripart J, Jeannes P, Mahamat A, Boisson C, L'Hermite J, et al. Comparison of the parasacral approach and the posterior approach, with single- and double-injection techniques, to block the sciatic nerve. Anesthesiology. 2003;98(6):1436–41.
2. Ben-Ari AY, Joshi R, Uskova A, Chelly JE. Ultrasound localization of the sacral plexus using a parasacral approach. Anesth Analg. 2009;108(6):1977–80.
3. Andersen HL, Andersen SL, Tranum-Jensen J. Injection inside the paraneural sheath of the sciatic nerve: direct comparison among ultrasound imaging, macroscopic anatomy, and histologic analysis. Reg Anesth Pain Med. 2012;37(4):410–4.
4. Karmakar MK, Shariat AN, Pangthipampai P, Chen J. High-definition ultrasound imaging defines the paraneural sheath and the fascial compartments surrounding the sciatic nerve at the popliteal fossa. Reg Anesth Pain Med. 2013;38(5):447–51.
5. Perlas A, Wong P, Abdallah F, Hazrati LN, Tse C, Chan V. Ultrasound-guided popliteal block through a common paraneural sheath versus conventional injection: a prospective, randomized, double-blind study. Reg Anesth Pain Med. 2013;38(3):218–25.

Saphenous Nerve Block (Landmark, Ultrasound-Guided Method)

56

Masayuki Fukazawa

56.1 Introduction

The saphenous nerve branches out from the femoral nerve. It governs cutaneous sensations of the inner leg from the knee joint to the medial malleolus in the foot.

It branches from a femoral nerve posterior branch, and a lower line costs adductor jurisdiction along the sartorius back and it goes through deep fascia of the thigh at the height of the knee joint from the interval of a sartorius and the gracilis muscle and appears to the outer layer and branches it to infrapatellar branch and leg cutaneous branch. Furthermore, a lower line costs the immediate rear of the great saphenous vein in subcutaneous tissue along the tibia medial margin. The saphenous nerve branches it in a cutaneous branch network to influence a medial malleolus ahead widely at the height of the ankle.

56.2 Indications

Pain inside thighs, adductor canal syndrome.

56.3 Instruments and Drug Solutions

Landmark method; 25–27G needle or 22–23G nerve block needle, 5–10 mL syringes, local anesthetic.

Ultrasound-guided method; 23G catheran needle or 22–23G nerve block needle, 5–10 mL syringes, (extension tube), linear probe (5–15 MHz), jelly for ultrasound, sterilization cover, and local anesthetic.

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56.4 Procedures and Techniques

56.4.1 Physique

The practiced stands on the block side. The patient extends a knee joint in face-up position, makes the outside fall down, and slightly rotates echo probe externally.

56.4.2 Block

56.4.2.1 Landmark Method

Approach through the Sartorius muscle: I perform the procedure by applying the resistance disappearance law. After skin sterilization, I insert a needle from the part of the 4 cm cranial 7 cm rear from the inside superior border of the kneecap and slightly push forward a stitch for caudalis. After passing the deep fascia of the thigh and sartorius muscular fasciae and after confirming that there is no countercurrent of the blood in the part that felt pop feeling and resistance disappearance when it goes through muscular fasciae, I give a local anesthetic in doses of around 10 mL divided into small quantities.

parasaphenous approach: I let a local anesthetic infiltrate it around the great saphenous vein at the height of the tibial tuberosity. After inserting the part needle which great saphenous vein can identify after skin sterilization and having confirmed that there is not a countercurrent of blood, I give a local anesthetic in divided total dosage is 5–10 mL in small quantities around the outside in the blood vessel of the saphena. There is a method to perform while performing nerve stimulation using a nerve stimulator then but does not have to look for a radiation ache forcibly.

56.4.2.2 Ultrasound-Guided Method

Approach [1] through the sartorius (Fig. 56.1): After skin sterilization, expose the linear probe that hits supersonic wave jelly, cover with sterilization cover at the inner distal

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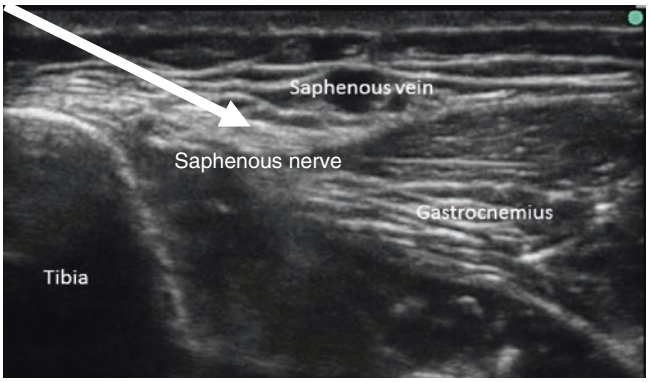

Fig. 56.1 Saphenous nerve block. Ultrasound guidance for nerve block. Approach through sartorius muscle

thigh for the major axis of lower limbs perpendicularly, and confirm femoral artery doing heartbeat. The saphena runs a certain adductor jurisdiction between a sartorius and vastus medialis muscles with a thigh status pulse and is recognizable as a structure of high echo characteristics between both lines. I insert a needle in flat way of ascetic practices for a probe from the inside and push forward a stitch below the saphenous nerve. After having confirmed that there is not a countercurrent of blood when the stitch arrives at it, the appropriate site is administered a local anesthetic in divided doses around 5–10 mL in small quantities. I perform it so that a local anesthetic is given to all nerve laps while pulling back the stitch and then changing direction.

Parasaphenous approach (Fig. 56.2): It is slightly more distal than the tibia medial condyle and exposes the linear probe that hits the supersonic wave jelly and is covered with a sterilization cover for the major axis of the lower limbs perpendicularly and, after skin sterilization, confirms a saphena. The saphenous nerve may be recognizable as a small structure of high echo characteristics around a saphena but is often not recognizable. I insert a needle in flat way of ascetic practices as a probe on the inside and push forward a stitch in the saphenous nerve or the proximal part of the saphena. After having confirmed that there is not a countercurrent of blood when the stitch arrives at the nerve, the appropriate site is administered a local anesthetic in divided

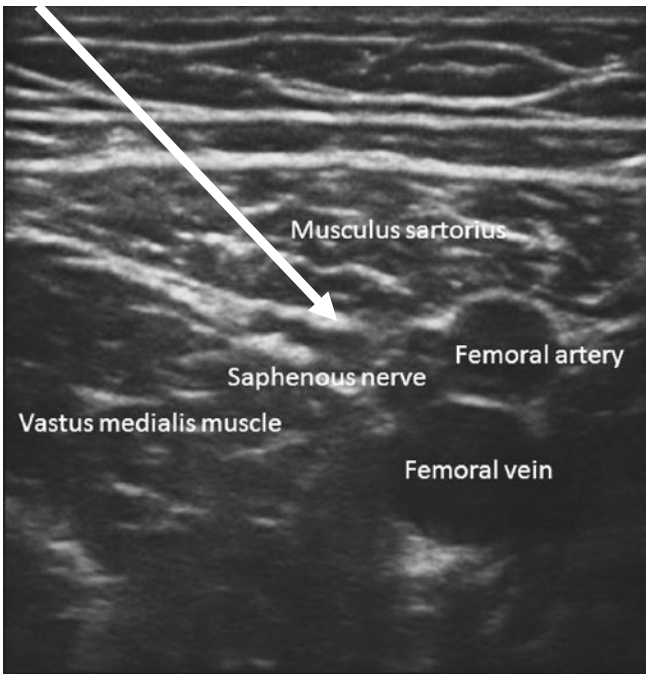

Fig. 56.2 Parasaphenous approach

doses around 5–10 mL in small quantities. I do it in such a way that a local anesthetic is given to all nerve laps (or the saphena neighborhood) while pulling back the stitch and then change direction.

56.5 Complications

Serious complications with the saphenous nerve block are rare. Complications may include blood vessel puncture, infection in blood vessel, infusion, and nerve damage.

Reference

1. Shougo T. Saphenous nerve block. A well-understood neural block method. Tokyo: Chugsi-Igakusha; 2011. p. 148–53.

Tibial Nerve Block

57

Saki Kamata

57.1 Introduction

57.1.1 What is the Posterior Tibial Nerve Block?

The tibial nerve is the nerve that is present inside the two large branches of the sciatic nerve. When exiting the popliteal fossa, the tibial nerve is still located in deep layers of the muscle [1]. Therefore, the occurrence of neuropathies is rare in this region.

57.2 Indications

Indications for the posterior tibial nerve block include anesthesia for surgery, pain caused by peripheral arterial disease, reflex sympathetic dystrophy, entrapment neuropathy (such as Morton's neuroma and tarsal tunnel syndrome), and knee joint pain caused by osteoarthritis of the knee joint.

57.3 Anatomy

The tibial nerve is a branch of the sciatic nerve, originating from the lumbar nerve roots of L4 to L5 and the sacral nerve roots of S1–S3. It splits from the common peroneal nerve at the distal 1/3 of the femur before traveling down. The tibial nerve is about two times larger in diameter than the common peroneal nerve. It descends with the posterior tibial artery along the posterior part of the knee joint through the deep layers and intersects with the popliteus muscle before existing between the two heads of the gastrocnemius muscle below the soleus muscle. The nerve then travels down underneath these muscles, along the medial border of the Achilles tendon, before reaching the flexor retinaculum where it splits into the medial and lateral plantar nerves. The articular branches of the tibial nerve are distributed to the knee joint and talocrural joint. The muscular branches are distributed mainly to the gastrocnemius muscle, soleus muscle, plantar muscle, popliteal muscle, posterior tibial muscle, flexor digitorum longus muscle, and flexor hallucis longus muscle. The cutaneous branches of the tibial nerve include medial sural cutaneous nerve, medial calcaneal branches, medial plantar nerve, and lateral plantar nerve and provide sensory innervation to the skin below the lower leg.

57.4 Instruments and Drug Solutions

- High-frequency linear ultrasound probe
- A 27 G × 1.9 cm or 25 G × 2.5 cm disposable needle
- A 5 mL syringe (Carbocaine 0.5–1%)
- A water-soluble steroid

57.5 Procedures and Techniques (Fig. 57.1)

57.5.1 Approach from the Popliteal Fossa

The patient is placed in the prone position. A high-frequency linear ultrasound probe is usually used to obtain high-resolution images; however, since the target nerve is located slightly deeper than the superficial layers, a lower-frequency probe may be desired depending on the patient's physical size. The probe is placed perpendicular to the longitudinal axis of the knee joint. First, the popliteal artery and vein are identified on ultrasound images of the transverse creases of the popliteal fossa. If the images are unclear, the use of color Doppler is recommended. The tibial nerve can generally be identified at this location, in the superficial layers immediately lateral to the popliteal artery and vein. The tibial nerve is located about 1-cm deep to the surface and about 0.5–1.5 cm distal to the popliteal artery, which serves as a landmark. At this level, the shape of the tibial nerve appears to be

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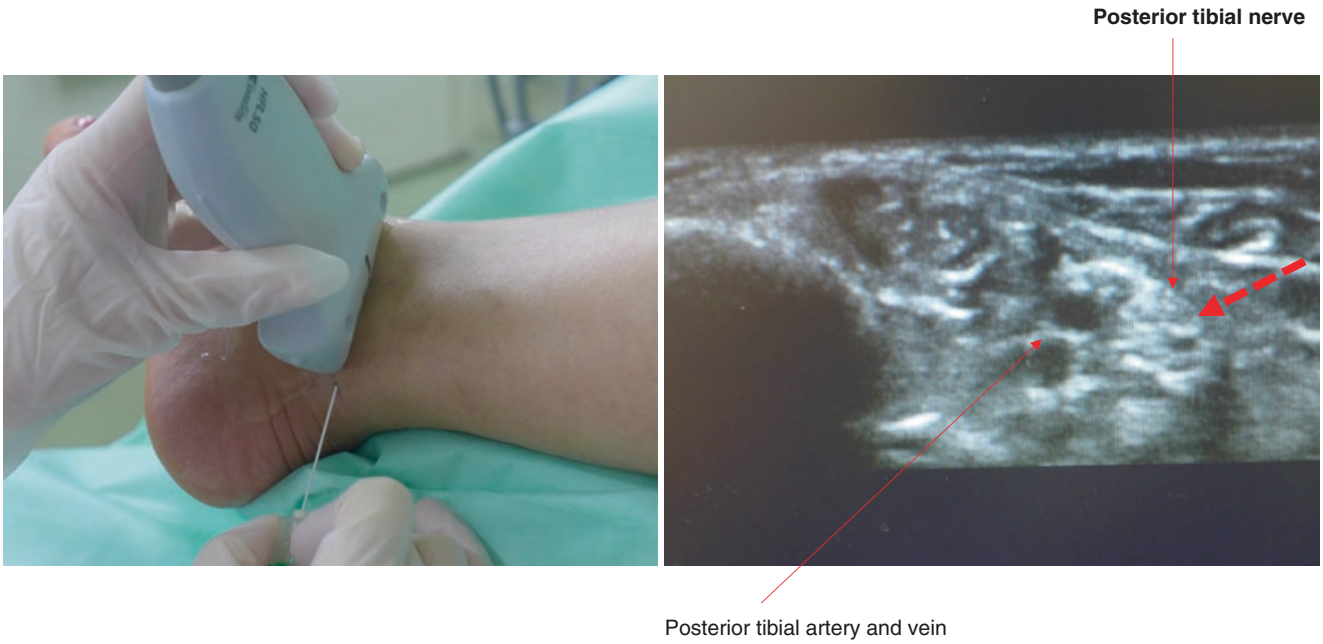

Fig. 57.1 Posterior tibial nerve block

circular or elliptical measuring 4–10 mm in diameter. On the lateral side of the tibial nerve, the common peroneal nerve may also be seen with similar shading. Local anesthesia is administered intradermally or subcutaneously as needed, and the needle is inserted from the mid-lateral side of the probe, in parallel to the probe. The needle tip is advanced as close to the target nerve as possible. The needle is then held in place, and 2–5 mL of a local anesthetic agent is injected while ensuring that there is no backflow of blood.

57.5.2 Approach from the Medial Malleolus

The patient is placed in the supine position. If necessary, a pillow or bolster is placed underneath the lower leg on the affected side to elevate the ankle to improve the ease of the procedure. Since the tibial nerve is located relatively superficial at the level of the medial malleolus, a high-frequency linear ultrasound probe is used to obtain high-resolution images. In an average-sized adult patient, the ultrasound image depth should be set at approximately 2 cm. The probe is placed dorsal to the medial malleolus and perpendicular to the longitudinal axis of the tibial bone. The pulsatile posterior tibial artery is identified near the tibial bone, which appears as a hyperechoic area with acoustic shadowing. The tibial nerve is often located immediately posterolateral to the posterior tibial artery and seen as a circular or oval honeycomb structure. Local anesthesia is administered intradermally or subcutaneously as needed, and the needle is inserted from the anterior side of the probe, in parallel to the probe. The needle tip is advanced as close to the target nerve as possible. The needle is then held in place, and 2–5 mL of a local anesthetic agent is injected while ensuring there is no backflow of blood [2].

57.6 Complications

Infection, nerve damage, bleeding or hematoma formation resulting from vessel puncture, and paralysis of the muscles supplied by the nerve.

References

1. Tsui BCH. Ankle blocks. In: BCH T, editor. Atlas of ultrasound and nerve stimulation-guided regional anesthesia. New York: Springer-Verlag; 2007. p. 205–13. (in Japanese).
2. Saito Y, et al. Posterior tibial nerve block, Ultrasound-guided nerve block. Tokyo: Igakushoin; 2009. p. 312–3. (in Japanese).

IRS

58

Hitoaki Sato

58.1 Introduction

Intravenous regional sympathetic block (IRSB), a technique first described in 1974 by Hannington-Kiff, is intravenous regional neural blockade. Local intravenous administration of guanethidine in patients with Sudeck's atrophy and ischemic ulcer of the lower leg showed pain-relieving effects [1]. In this method, a sympathetic blocking agent with local anesthetic is injected from a peripheral vein of affected limb whose proximal portion is tightened by tourniquet for CRPS; the effectiveness of steroids instead of guanethidine has also been reported [2].

58.2 Indications

Those painful diseases of peripheral limb which are expected to relieve symptoms) by improving blood flow are indicated, such as intractable ulcer, post-herpetic neuralgia and CRPS.

58.3 Instruments and Drug Solutions [3]

Upper limb: reserpine (1 mg/mL) 1 mL and 0.5% mepivacaine (or lidocaine) mixture, total amount of 20–25 mL

Lower limb: reserpine (1 mg/mL) 1.5–2 mL and 0.5% mepivacaine (or lidocaine) mixture, total amount of 30–50 mL

(Guanethidine has not been available commercially in Japan, so we use reserpine instead.)

58.4 Procedures and Techniques [3]

1. Wrap a double-cuff pneumatic tourniquet around the affected limb (or wrap two single-cuff tourniquets in parallel).
2. Place a cannula into a peripheral vein on the dorsum of the affected hand (foot) of the patient in the supine position. Attach a three-way stopcock in the venous line for the purpose of administration of the drug and prevention of the venous return. After placement, the line is filled with heparinized saline to prevent blood clots.
3. Raise the limb vertically for 5 min to exsanguinate venous blood and then wind an Esmarch bandage proximally up the arm to empty the blood from the region to be anesthetized (Fig. 58.1).
4. Inflate the proximal cuff of the tourniquet. Required cuff pressure is at least 1.5-times higher than blood pressure (the rough standard of the cuff pressure is 250 mmHg for the upper limb and 300–450 mmHg for the lower limb).
5. Return the limb to the horizontal position, and inject the drug solution. Then fill the venous line with heparinized saline (Fig. 58.2).
6. After 5 min since the injection of the drug, inflate the distal cuff up to the same pressure of the proximal cuff, and then deflate the proximal cuff.
7. Keep the tourniquet inflated for 15 min and then gradually deflate it.

58.4.1 Important Points of Technique

1. It is important to wind up the Esmarch bandage from the peripheral side to the central. Previous peripheral nerve block of the affected limb may alleviate pain associated with winding Esmarch in patients with severe allodynia.

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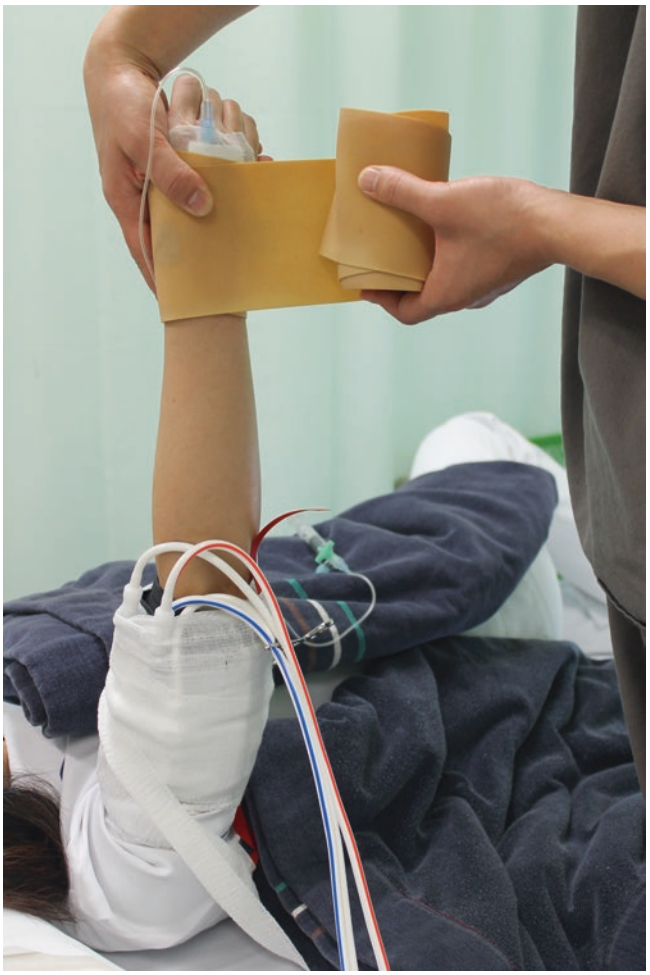

Fig. 58.1 Winding up with Esmarch bandage

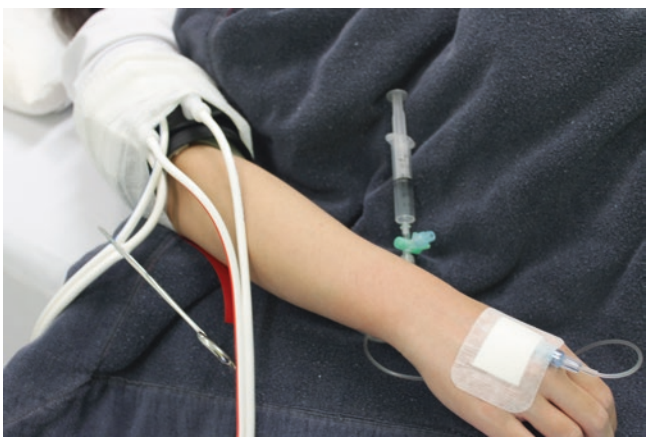

Fig. 58.2 Injection of drug solution

2. In order to establish a good ischemic state before injecting the drug solution and to avoid systemic circulation of the drug after injection, it is necessary to prevent loosening of the tourniquet after inflation. As further safeguards, wrap a bandage around the tourniquet to prevent its loosening or slipping, and clamp two air hoses with forceps to prevent air leakage. In addition, check whether the tourniquet is loose or not by touching with your hand before injecting the drugs.
3. Sometimes discomfort, hypotension, or bradycardia may occur due to systemic effects of the chemical solution after cuff deflation. So you must pay special attention at the cuff deflation. The bed rest with medical observation for more than 30 min after deflation is recommended.

58.5 Complications

1. *Hypotension, headache, and flush*: These are systemic effects of reserpine after cuff deflation.
2. *Local anesthetic intoxication*: Increased blood level of local anesthetics after cuff deflation is the cause of this.
3. *Exacerbation of pain and peripheral neuropathy*: With only 15 min ischemic state, those symptoms may occur especially in patients with peripheral vascular occlusive disease.

References

1. Hannington-Kiff JG. Intravenous regional sympathetic block with guanethidine. Lancet. 1974;25:1019–20.
2. Varitimidis SE, et al. Complex regional pain syndrome type 1 as a consequence of trauma or surgery to upper extremity: management with intravenous regional anaesthesia, using lidocaine and methylprednisolone. J Hand Surg Eur Vol. 2011;36(9):771–7.
3. Iseki M. Intravenous regional sympathetic nerve block. Pain Clinic. 2011;32:S205–10.

Part XII

Epidural Block

Thoracic Epidural Block (Landmark, X-Ray-Guided, and Ultrasound-Guided Methods)

59

Keiko Mamiya

59.1 Introduction

59.1.1 Thoracic Epidural Block

The thoracic epidural block affects the somatic nerves and autonomic nervous system (e.g., disturbance of peripheral blood circulation) of the upper limbs or the trunk by injecting some agent (mostly a local anesthetic) into the epidural space at Th1–Th12. When the purpose is for relief of pain, there is no need to obtain complete analgesia or muscle relaxation, as in the operating room. Sufficient analgesia can be obtained with a lower dose of local anesthetic.

This chapter describes the landmark method, X-ray-guided block, and ultrasound-guided block.

59.2 Indications

This procedure is indicated in cases of herpes zoster-related pain, postherpetic neuralgia, intercostal neuralgia, spondylosis deformans in the thorax, disc herniation in the thorax, CRPS, post-spinal cord injury pain, phantom pain, traumatic brachial plexus injury, myofascial pain syndrome, post-thoracotomy pain syndrome, postoperative pain, postoperative cicatrix pain syndrome, cancer pain, and hematogenous disorder in the upper limbs [1, 2].

59.3 Anatomy

There are 12 thoracic vertebrae, which begin at the lower level of the seventh cervical vertebra and end at the upper level of the first lumbar vertebra. The spinous processes are more sharply angled in the mid-thoracic region, especially Th4–Th10 (Fig. 59.1). The distances between the yellow ligament and dura are 1.5–2 mm in the cervix, 3–5 mm in the thorax, and 5–6 mm in the lumbar region. As part of the epidural space of the thorax is very narrow, special attention is required to avoid puncturing the dura [3–5].

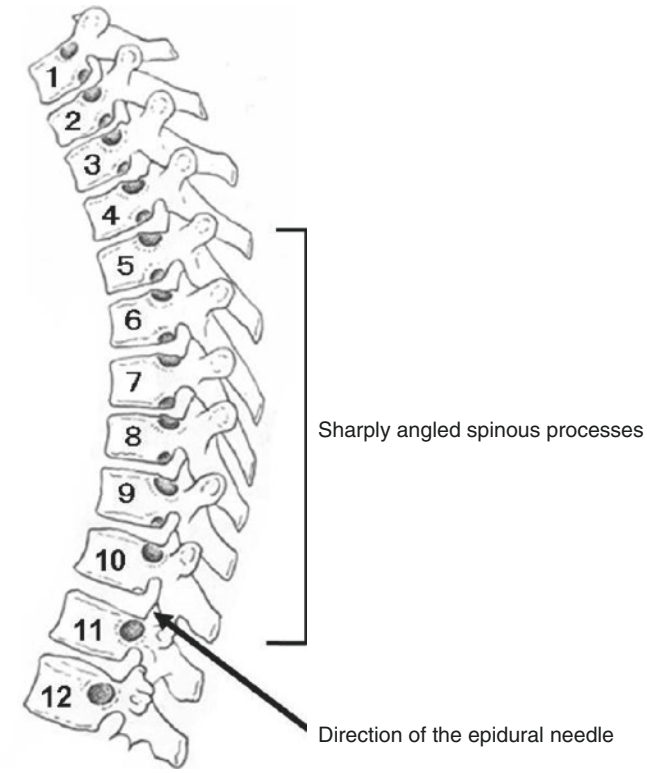

Fig. 59.1 Anatomy for thoracic epidural block

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59.4 Instruments and Drug Solutions

Needle:	20–22G, 6–8 cm Block needle or 20G–22G Tuohy needle
In continuous :	17–18G Tuohy needle for intubation of administration the epidural catheter
Syringe:	10 mL and 5 mL glass syringes
Liquid agent:	0.5%–1% mepivacaine 5–8 mL, dexamethasone 2–4 mg, and saline 20 mL
X-ray-guidance:	Nonionic water-soluble contrast medium (iohexol) 2–3 mL
Continuous injection pump:	0.5%–1% mepivacaine 100 mL or 0.125%–0.2% ropivacaine 100 mL 2–6 mL/h
Sterilization kit:	Cotton ball, chlorhexidine-alcohol
Instruments:	For ultrasound guidance: sterilized plastic bag, sterilized rubber band, extension tube, and sterilized jelly. For X-ray guidance: Pean forceps (long) and fluoroscopic C-arm. For nerve stimulation: nerve stimulator and needles for stimulator

59.5 Procedures and Techniques

59.5.1 Landmark Method

The landmark method for epidural block has been used for a long time and has been applied via the median approach or paramedian approach (Fig. 59.2). The median approach involves selecting a puncture point at the interspinous process area at the median line of the back. Therefore, the needle proceeds in order through the skin, subcutaneous fat tissue, supraspinous ligament, interspinous ligament, and yellow ligament and then reaches the epidural space. In the paramedian approach, the needle passes through a point 1–2 cm lateral from the midline in order to detour the spinous process. Therefore, the needle proceeds in order through the skin, subcutaneous fat tissue, and yellow ligament and then reaches the epidural space.

In the lateral position, after sterilization of the puncture site, local anesthesia is applied at the interspinous process from the skin with 1% mepivacaine. Then, the epidural needle proceeds 2–3 cm. To identify the epidural space, the loss-of-resistance method and hanging-drop method can be used. As a fine Tuohy needle (20–22G) is used in pain clinics, the loss-of-resistance method is applied at the outpatient office. In the loss-of-resistance method, after pulling out the stylet of the needle, a glass syringe filled with saline is connected to the needle. For a right-handed operator, the needle is held with the left thumb and index finger, while the glass syringe is held with the right index finger and the middle finger. The needle is advanced in a step-by-step manner with application of pressure onto the plunger with right thumb. When the needle has penetrated the yellow ligament, the feeling of resistance will disappear. At this point, the agent should be injected.

When attempting intubation into the epidural space, an 18G epidural needle should be used. Therefore, the hanging-drop method can also be applied. In the hanging-drop method, after passing the epidural needle 2–3 cm under the skin, the stylet is pulled out, and a drop of saline is placed on the needle. The epidural needle is held with both thumbs and index fingers, and the needle is advanced carefully. When the tip of the needle penetrates the yellow ligament, the saline drop will be sucked up. At this point, a tube can be inserted or some agent should be injected [3].

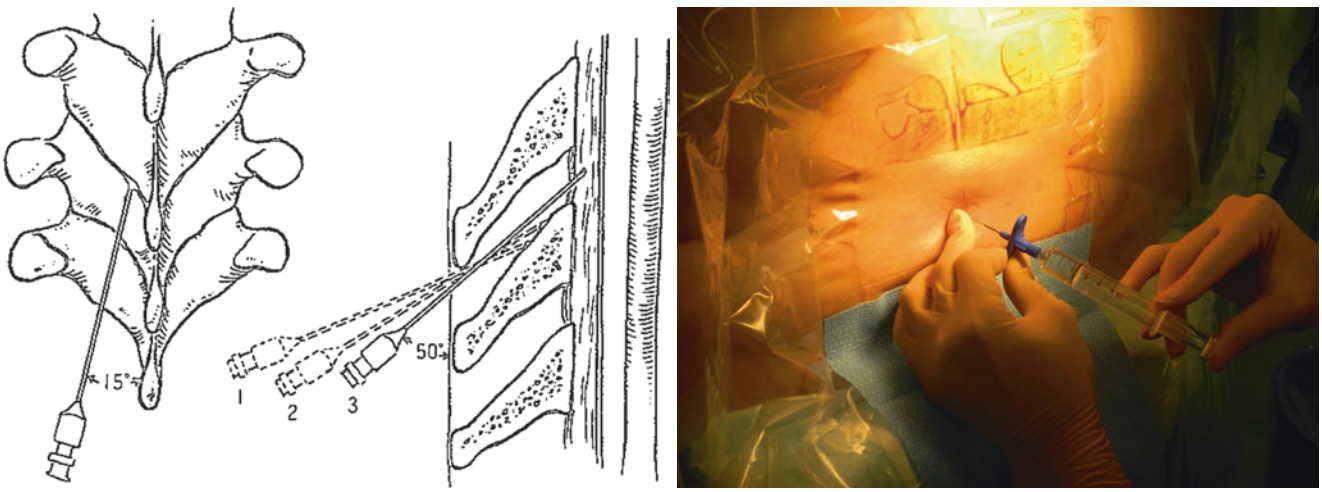

Fig. 59.2 The paramedian approach. Bromage PR: Paramedian approach, identification of the epidural space. Chapter 6, Epidural Analgesia. Philadelphia. WB Saunders, 1978, 197

59.5.2 X-Ray Fluoroscopy-Guided Method

59.5.2.1 Position and Imaging

Positioning and imaging the targeted region (Fig. 59.3).

In the prone position, a pillow or spacer is applied to open the intervertebral space.

When targeting the upper thoracic vertebrae region, the patient must be relaxed and a stable position is obtained by opening the scapulae.

For fluoroscopy, use a C-arm fluoroscopy instrument with a variable incidence angle. Tilt 0°–30°.

For radiography, when contrast medium is applied, the anterior view and lateral view, if needed, should be taken to cover the whole contrasted area.

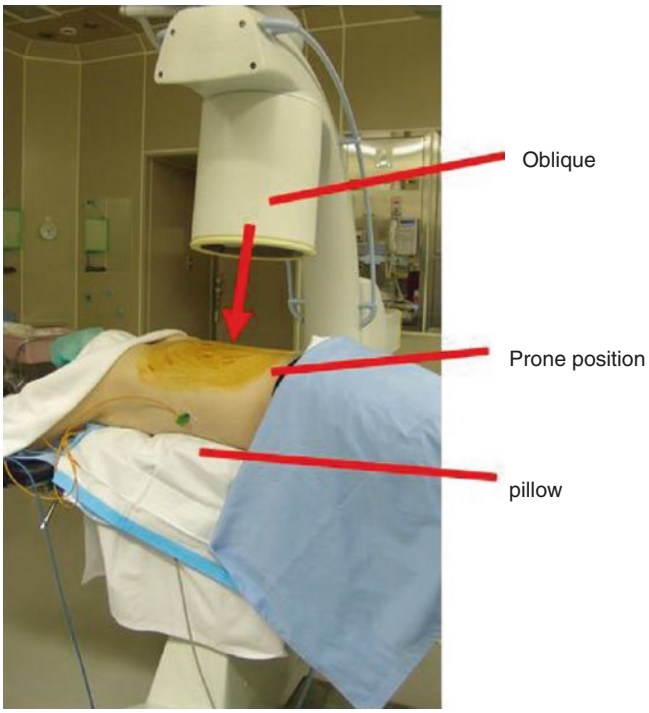

Fig. 59.3 Position and imaging

59.5.2.2 Puncture and Agent Administration

The patient is positioned on the fluoroscopic monitor with the spinous process of the targeted vertebra set at the center of the bilateral pedicle of the vertebral arch (Fig. 59.4). Then, the C-arm is tilted to the caudal side to obtain a wide view of the gap between arches (Fig. 59.5). The puncture target is selected in the middle and lower point of the gap. A Pean forceps is used to mark the puncture site.

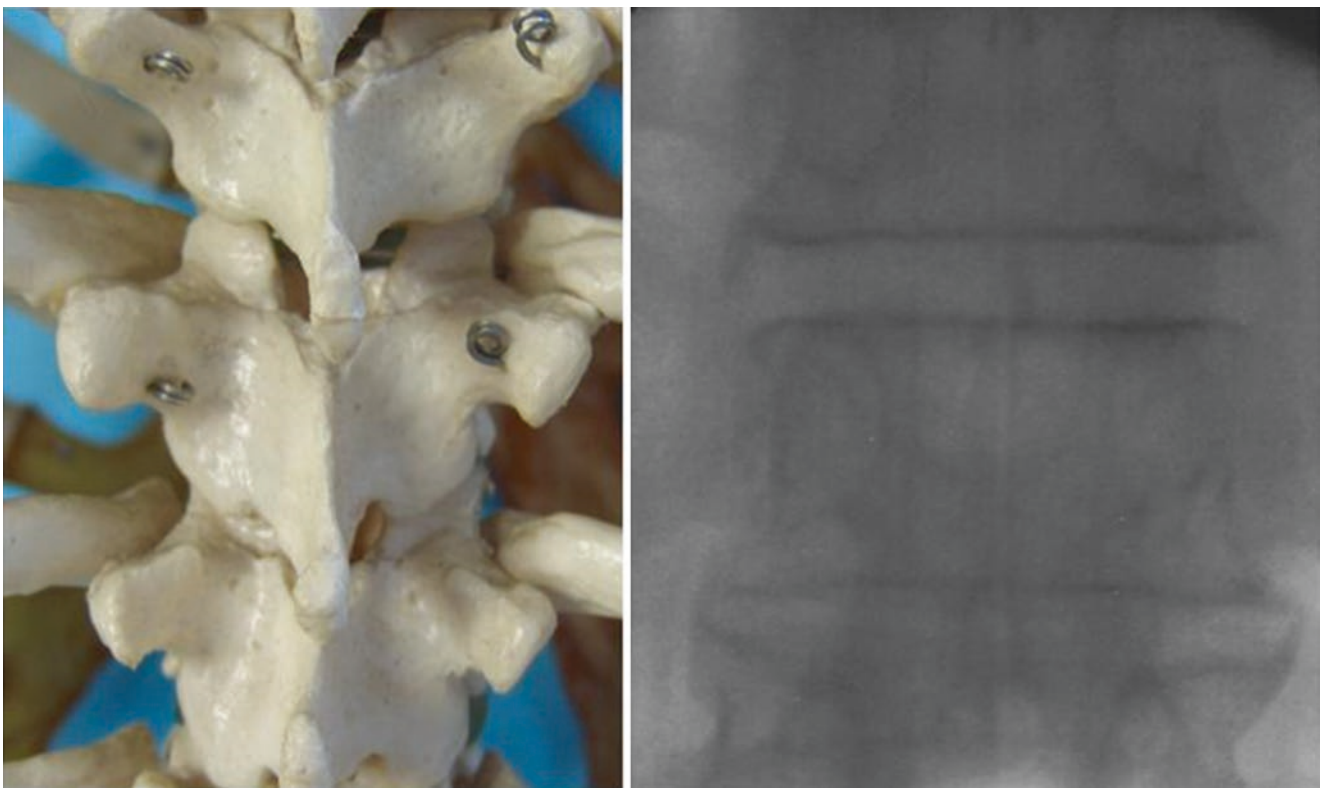

Fig. 59.4 Setting the bilateral pedicle of the vertebral arch at the center

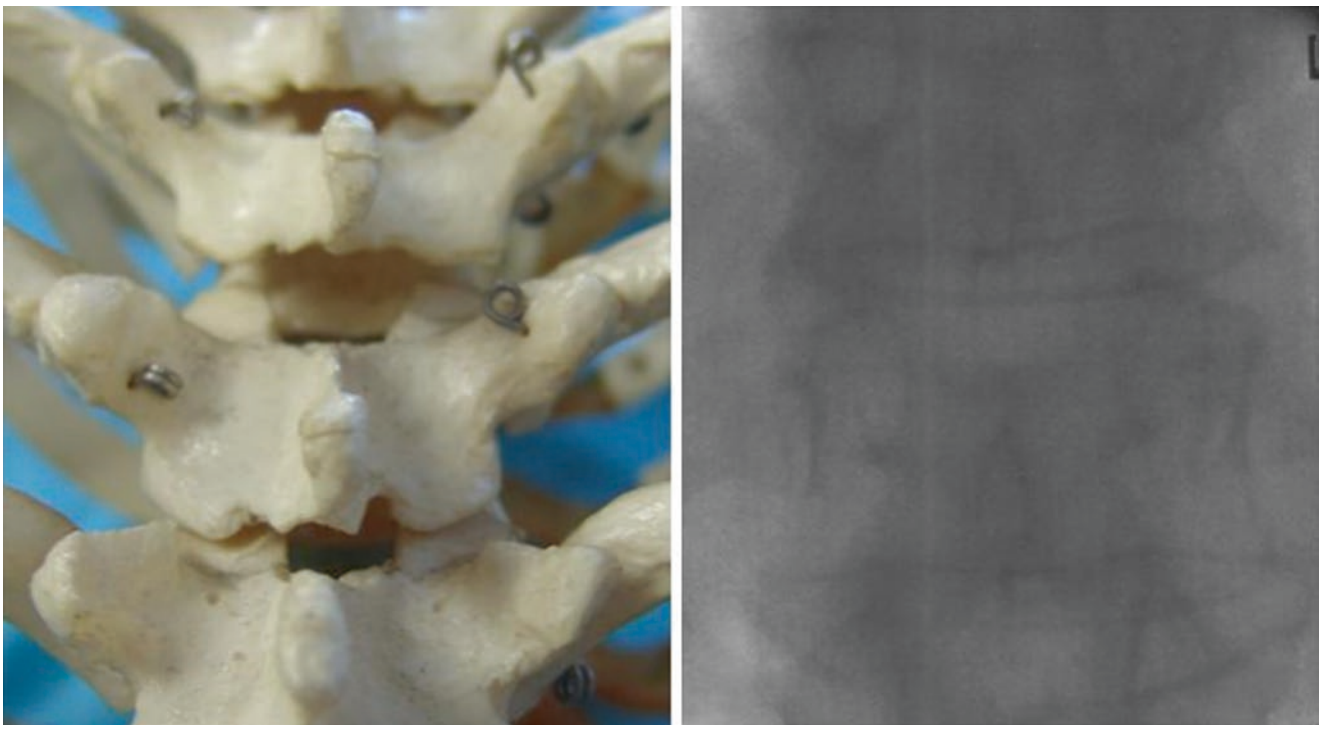

Fig. 59.5 Tilting the C-arm to the caudal side

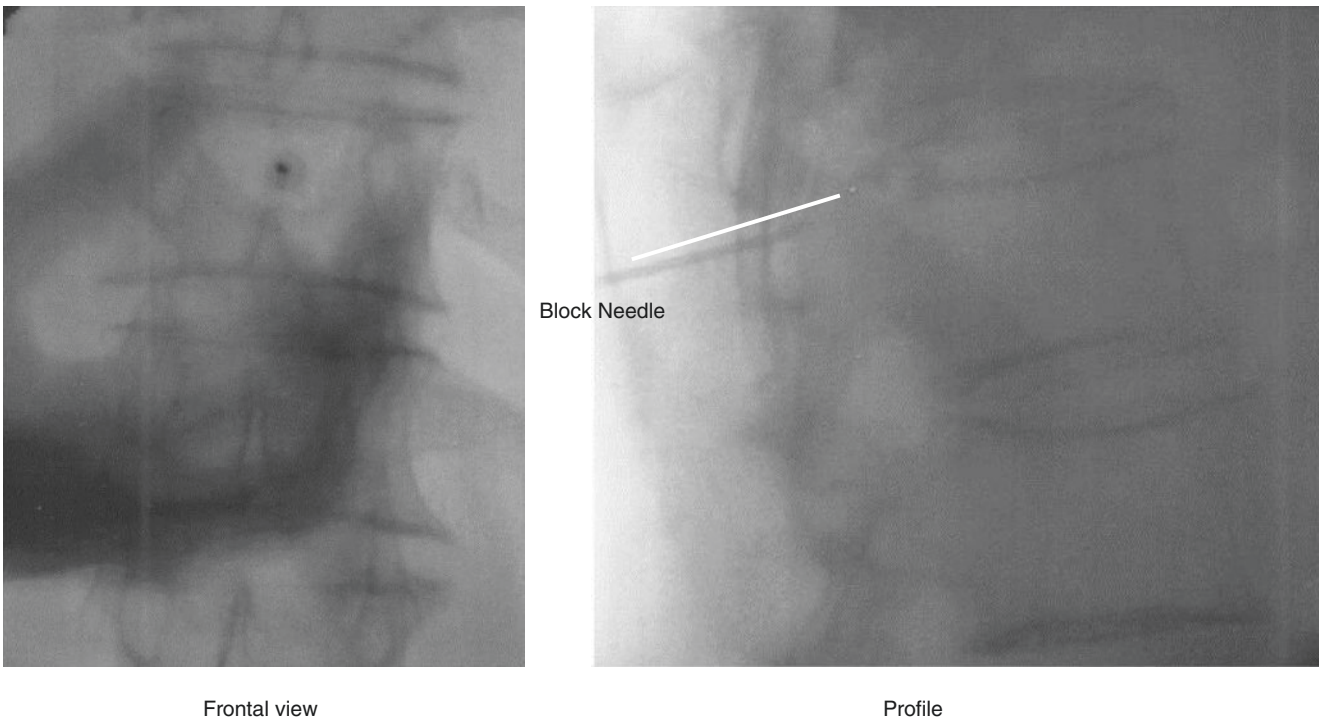

Fig. 59.6 Position and direction of the Tuohy needle

Local anesthesia is applied using 0.5–1% mepivacaine. The skin is fixed by finger placement, and the block needle carefully punctures the middle of the gap. The needle should be seen as a dot on the monitor image (Fig. 59.6). At this step, the tip of the needle is slightly aimed toward the cranial side (Fig. 59.7). When the needle proceeds into the supraspinous ligament and then the interspinous ligament, fixing of the needle can be felt. After pulling out the stylet of the block

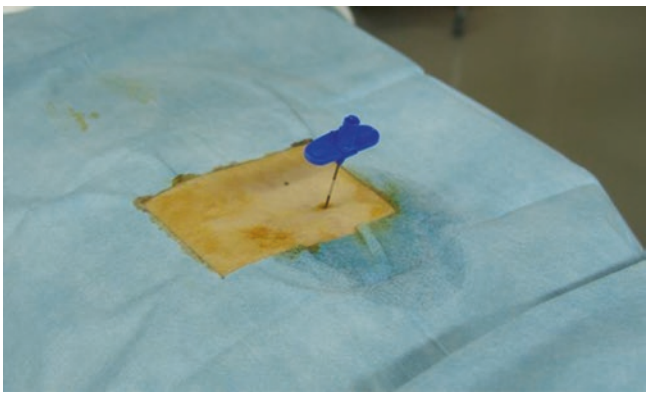

Fig. 59.7 Puncture point of the Tuohy needle

needle, it is necessary to confirm that the tip has reached the epidural space by the loss-of-resistance method using a saline-filled glass syringe. If it is not clear that the tip is in the epidural space or in the loose tissue, the depth of the needle can be checked in the lateral view (Fig. 59.6). It is necessary to ensure that blood or cerebrospinal fluid is not aspirated. With a single administration procedure, the agent is injected slowly. For the continuous administration method, the catheter is intubated. The position of the catheter tip and the effective space should be checked by injection of contrast medium. For epidurography, contrast medium must be used. Following administration of 2–10 mL of iohexol (contrast medium), the radiograph should be taken immediately. After taking roentgenographs, saline should be administered to wash out the contrast medium. In the continuous injection method, the continuous injection pump with local anesthetic is connected [6].

59.5.3 Ultrasound-Guided Method

In pediatric cases [7, 8] or obese patients, ultrasound-guided block is applied mainly to select the puncture point or to measure the distance from the skin to the epidural space by pre-scanning prior to the procedure. Strictly, therefore, ultrasound-guided epidural puncture is not performed as thoracic epidural block [9].

59.5.3.1 Position

The echo probe should be applied to the position of the actual procedure, in the prone or lateral position, to achieve somewhat real situation.

59.5.3.2 Ultrasound Imaging

When targeting the upper thoracic vertebra region, the seventh cervical vertebra can be used as a guide, while the sacrum can be used as a guide for the lower thoracic vertebrae region to determine the targeted area.

A convex probe (approximately 5 MHz) is used to visualize the short axis image in the midline to identify the spinous process. The probe is tilted slightly laterally from the median, where there is no disturbance of the spinous process, to take the axial image.

The ribs, transverse processes, apophyseal joints, and vertebral arches should be confirmed, and the distance to the epidural space from the skin should be measured as a guide for epidural puncture (Fig. 59.8).

In the upper or lower thoracic vertebra region, the dura can be observed from the paramedian area.

However, as the spinous process is long in the caudal direction, the epidural space can be barely seen in middle region below Th3.

59.5.3.3 Puncture Method

For puncture with real-time imaging, the assistant should hold the probe. In the paramedian approach, image observation can be performed until reaching the vertebral arch. Thereafter, it is necessary to check the epidural space by the loss-of-resistance method.

59.6 Complications [2]

Hypotension: Hypotension can occur due to sympathetic nerve block. This can be obviated by raising the lower limbs, maintaining the venous infusion line, transfusion, and hypertensor administration.

Respiratory depression: Epidural block of the upper thoracic region may result in respiratory depression. Therefore, oxygen saturation monitoring is advisable. In cases of respiratory depression, oxygenation and respiratory management should be considered.

Spinal cord injury and nerve injury: In cases of spinal cord injury or nerve injury, severe fulgurant pain can occur in the area supplied by the nerve. The needle and catheter should be removed immediately, and symptomatic treatment should be administered until alleviation.

Epidural hematoma: When unknown sensory and/or motor nerve disturbance occur, further investigation should be done immediately by contrast MRI. The decision to perform surgical or conservative treatment should be made based on the neurological symptoms and imaging findings.

Epidural abscess: In cases of pain with abnormal sensation, pain at the puncture point, or pyrexia, the possibility of epidural abscess should be considered, and immediate

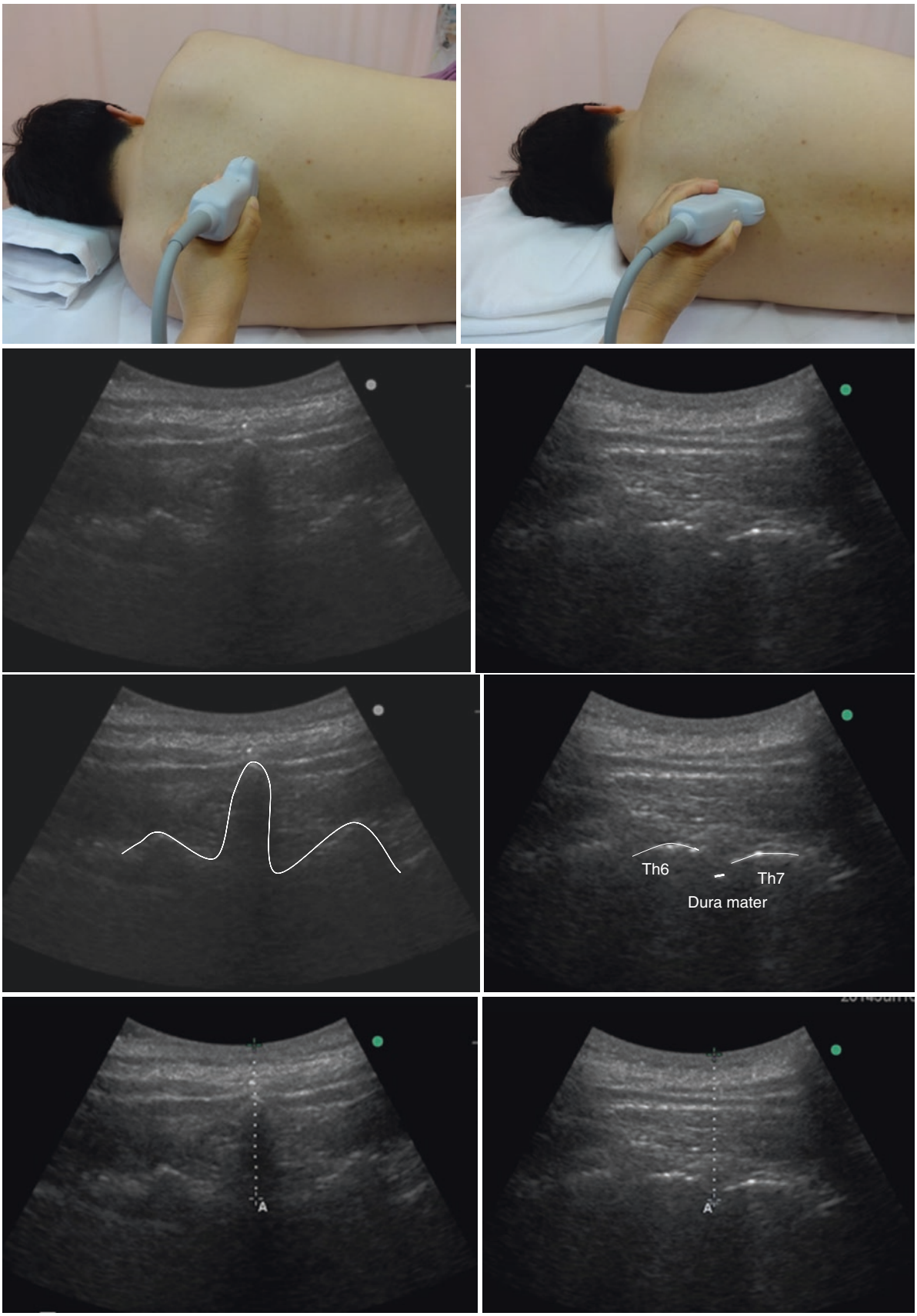

Fig. 59.8 Ultrasound-guided approach (Th6/7)

investigation by contrast MRI should be performed. When an epidural catheter is used, it should be removed immediately, and bacterial culture examination should be performed. The decision to perform surgical rescue or conservative antibiotic therapy should be made based on the symptoms and imaging findings.

Post-dural puncture headache (PDPH): In cases in which the dura is punctured by accident, ambulation should be delayed and drip infusion therapy should be given. An epidural blood patch should be considered in cases in which the symptoms persist.

Spinal block: As higher thoracic epidural block may induce total spinal anesthesia, a great deal of care is required. There is little respiratory depression and marked decrease of blood pressure by the lower thoracic epidural block. Therefore, early diagnosis, appropriate breathing, and circulatory control are necessary.

Local anesthetic toxicity: Misinjection of the local anesthetic into a vein in the epidural space may result in local anesthetic toxicity. If convulsions occur, anticonvulsant administration and oxygenation and respiratory care should be conducted.

References

1. Hamaguchi S, Kitajima T. Thoracic epidural block. Pain Clinic. 2006;27(10):S351–9.
2. Sasaki J, Kikuchi H. Thoracic epidural block, nerve block. Kobe: Sinko Koeki; 2000. p. 215–8.
3. Naganuma Y. Epidural block, pain clinic. 2nd ed. Tokyo: Igakushoin. p. 50–5.
4. Mizobuchi S. Epidural Spinal Block, Atlas of Anatomy for Regional Nerve Blocks multi-view point and multi-layer 3D color photographs MEDSi. p 113–120.
5. Deschner B, Allen M, de Leon O. Epidural blockade, textbook of reginal anesthesia. New York: Mc Graw Hill. p. 229–67.
6. Hashimoto K. X-ray-guided epidural block, pitfalls & knack for pain clinicians. Tokyo: Nakayama Shoten; 2007. p. 122–4.
7. Willschke H, Marhofer P, Bösenberg A, et al. Epidural catheter placement in children: comparing a novel approach using ultrasound guidance and a standard loss-of-resistance technique. Br J Anaesth. 2006;97(2):200–7.
8. Kil HK, Cho JE, Kim WO, et al. Prepuncture ultrasound-measured distance: an accurate reflection of epidural depth in infants and small children. Reg Anesth Pain Med. 2007;32(2):102–6.
9. Menacé C, Choquet O, Abbal B, et al. Real-time ultrasound-guided epidural anaesthesia technique can be improved by new echogenic Tuohy needles: a pilot study in cadavers. Br J Anaesth. 2014;113(2):299–301.

Lumbar Epidural Block

60

Kenji Shida

60.1 Introduction

60.1.1 Lumbar Epidural Block

Lumbar epidural blocks are a common treatment option for many forms of low back pain and sciatica. The goal of the injection is pain relief whereby a local anesthetic with or without corticosteroids is injected into the epidural space. The anti-inflammatory effect of the corticosteroid is responsible for providing pain relief when inflamed nerve roots exist. Blind techniques using anatomical landmarks can be performed, but elective spinal injections should be performed with imaging guidance, such as fluoroscopy or ultrasound.

60.2 Indications

Lumbar epidural blocks are used for pain control in patients with spinal canal stenosis, intradiscal degeneration, herniated nucleus pulposus, sciatica, or radiculopathy. The block is used also in the treatment of zoster-related pain.

The technique is applied during the subacute phase of a painful condition and during the chronic phase of some diseases when the pain does not subside with conservative treatments [1, 2]. Sometimes in the acute phase of a highly painful condition, the block is used in combination with a pharmacologic treatment.

When low concentrations of local anesthetics are injected into the epidural space, the technique can provide more selective blockade of the sympathetic nervous system. Therefore it is useful in the initial evaluation of whether to provide lumbar sympathetic blocks and in treating lower extremity peripheral vascular diseases. The duration of neural blockade is prolonged when epidural catheters are used.

60.3 Anatomy

The iliac crest is a commonly used anatomical landmark, as this level roughly corresponds with the body of L4. Radiography ensures the correct localization of the lumbar vertebrae.

In adults, the spinal cord terminates around the level of the disc between L1 and L2, below which lies a bundle of nerves known as the cauda equina. The lumbar spinous processes are shorter, broader, and more horizontal than those of the thoracic vertebrae. The lumbar epidural space is wider than the cervical or thoracic epidural space.

60.4 Instruments and Drug Solutions

Needles:	25G 2.5 cm needle and epidural needle
Syringe:	Loss-of-resistance syringe—glass or plastic—and 5 mL syringes
Drug solutions:	0.5–1% lidocaine or mepivacaine, dexamethasone 2–4 mg, and normal saline
X-ray-guided:	Contrast medium (nonionic water-soluble)
	Ultrasound-guided kit
	Skin preparation kit

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60.5 Procedures and Techniques

60.5.1 Landmark Method (Fig. 60.1)

The patient is lying in the lateral decubitus position with the back parallel to the bed. The interlaminar approach using the loss-of-resistance technique is a common way of performing a blind epidural injection. The needle is placed into the ligamentum flavum using a median or paramedian approach, and the stylet is removed. A glass syringe containing 2–3 mL of normal saline is attached to the needle. Steady pressure is applied to the plunger, and then the needle is advanced slowly and steadily until loss of resistance is noted. The choice of the agent is determined depending on the purpose. A combination of local anesthetic and anti-inflammatory steroids is selected for the treatment of radiculopathy. Indwelling epidural catheters are helpful in long-term pain relief.

60.5.2 Fluoroscopy-Guided Method

Fluoroscopy-guided procedures are used to locate the target site and to guide the needle to it. A test dose of contrast medium is injected in order to ensure proper localization within the epidural space. There are two different techniques for applying this method, namely, translaminar [1] and transforaminal injection. Transforaminal injection is beneficial for the treatment of radiculopathy.

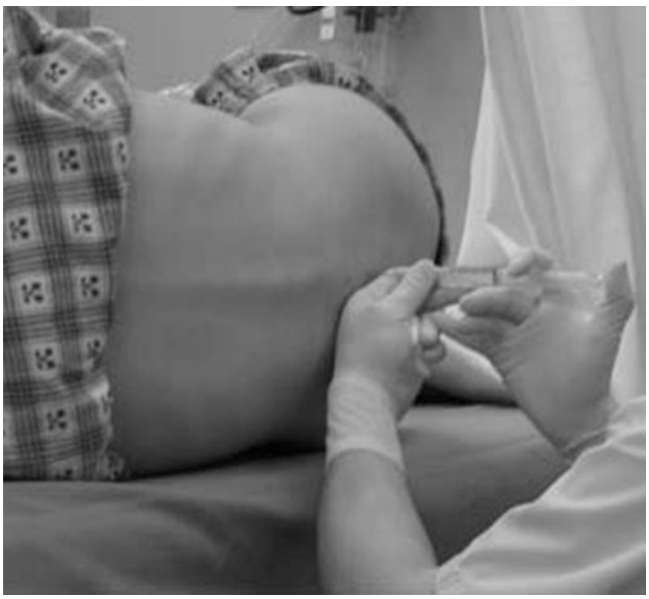

Fig. 60.1 Lumbar epidural block, blind landmark technique

60.5.2.1 Translaminar Approach (Fig. 60.2)

The patient is placed in the prone position with a pillow placed under the abdomen.

An anteroposterior (AP) view is used to identify the appropriate interlaminar space; the distance between the designated spinous process and its respective two pedicles should be equidistant. It is performed by placing a needle in the midline or paramedian line (on the side of the pathology) and just traversing the ligamentum flavum with the loss-of-resistance technique. Contrast medium is injected under fluoroscopic visualization to confirm epidural localization and exclude inadvertent placement in the blood vessels, musculature, subdural space, or intrathecal space.

60.5.2.2 Transforaminal Approach

(See Part 16 on nerve root block.)

60.5.3 Ultrasound-Guided Method (Fig. 60.3)

Ultrasound scanning is a useful tool to help perform epidural block in case of a presumed difficult puncture, such as in patients with high BMI [2]. Pre-puncture ultrasound examination is commonly performed for estimating the depth to the epidural space and determining the optimal insertion point. The longitudinal paramedian approach is able to confirm information about the epidural space between lamina of two different vertebrae with excellent imaging quality more easily than the median approach.

60.6 Complications

Epidural block is a relatively safe technique with a very low rate of complications. Complications that have been reported include epidural hematoma, abscess, nerve injury, anaphylactoid reaction, hypotension, local anesthetic intoxication, and headache in cases where there is injury to the dura mater and loss of cerebrospinal fluid (CSF).

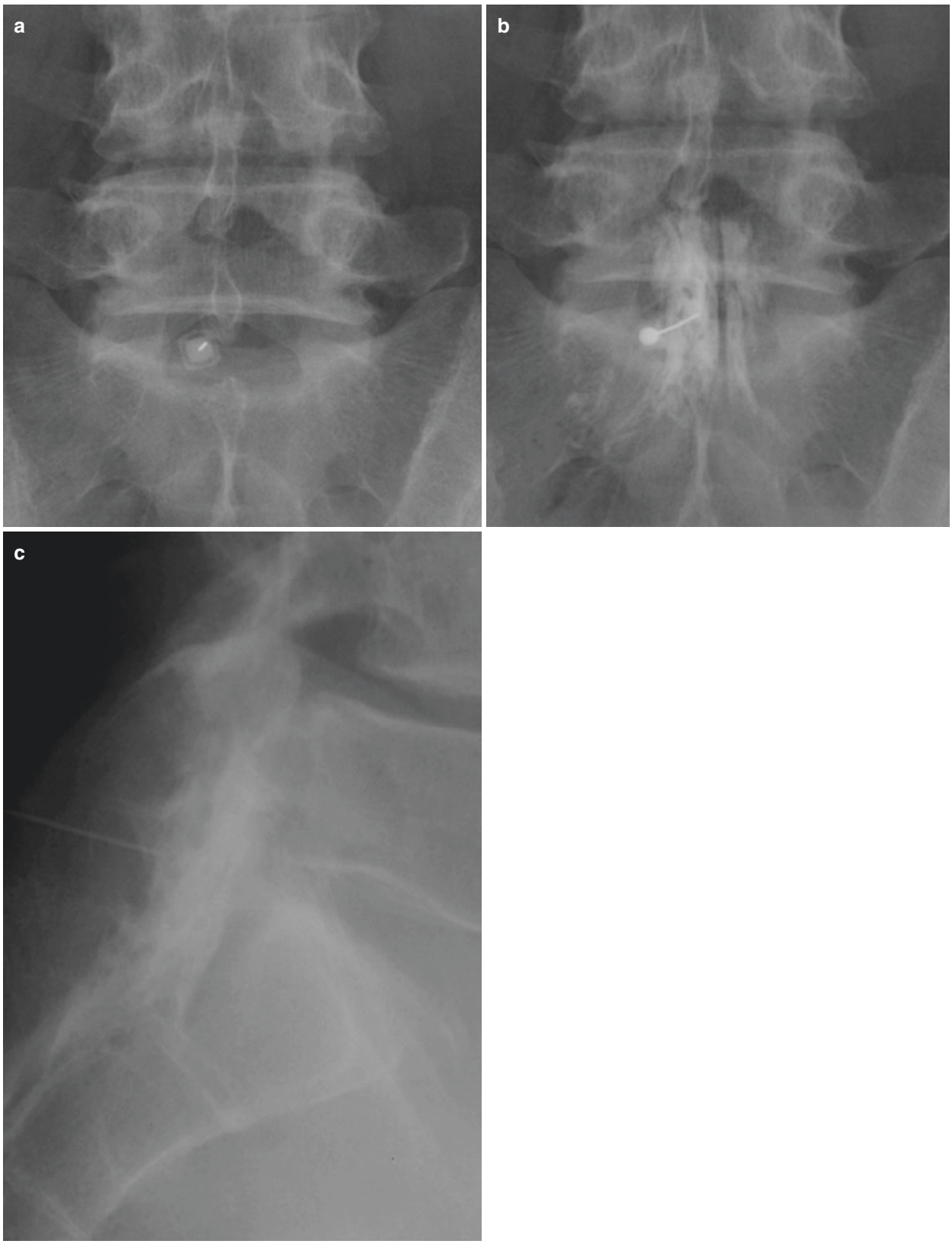

Fig. 60.2 Images of stages of a fluoroscopy-guided, lumbar translaminar block. (**a**) AP view of the needle placed to the left of the midline, through the L5-S1 interlaminar space. (**b**) AP view after injection of contrast medium. Contrast demonstrates the epidural flow. (**c**) Lateral view after injection of contrast medium

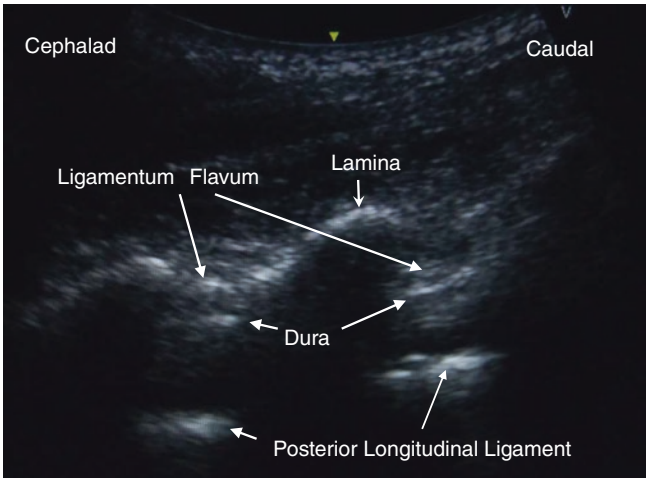

Fig. 60.3 Composite image of a paramedian oblique sonogram of the lumbar spine in the long axis

Epidural injection should not be applied when the patient has any blood coagulation disorder or receives anticoagulants.

References

1. Rthmell JP. Interlaminar Epidural Injection. Atlas of Image-guided Intervention. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2012. p. 34–63.
2. Grau T, et al. The lumbar epidural space in pregnancy: visualization by ultra-sonography. Br J Anaesth. 2001;86:798–804.

Sacral Epidural Block

61

Tadashi Tanoue

61.1 Introduction

61.1.1 Sacral Epidural Block

The sacral epidural block is performed with the patient in the prone position or the lateral position. It is important to detect the sacral hiatus to perform this block (Fig. 61.1).

Although the sacral epidural space is a mildly negative-pressure area, sacral epidural block is easy to perform when we can define the sacral hiatus, the important landmark. If it is difficult to detect the sacral hiatus because of obesity or some other reason, the ultrasound echo is useful to detect both the location of the sacral hiatus and the depth of the sacral epidural space. It is always necessary to confirm the anatomical sacral hiatus exactly. In cases where the sacral bones are not yet fused (infants and children), ultrasound echo guidance is very useful and highly recommended because we can confirm the placement of the needle tip [1].

61.2 Indications [2]

Sacral epidural block with local anesthetics is used for pain management of the lumbar and sacral areas, lower extremities, and pelvic organs. It is also used for postsurgical pain and palliative care to manage cancer-related pain and herpes zoster-related pain. Additionally, it is useful for ischemic diseases such as vasospastic and vaso-occlusive disease, chronic benign pain syndrome including low back pain, lumbar radiculopathy, lumbar disc herniation, canal stenosis, post-laminectomy syndrome, vertebral compression fracture, diabetic polyneuropathy, postherpetic neuralgia, complex regional pain syndrome, phantom limb pain, and pelvic pain syndrome.

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61.3 Anatomy

The sacrum, consisting of the five fused sacral vertebrae, is sandwiched between the iliac bones. The upper side is in contact with the fifth lumbar vertebra, and the lower side is in contact with the coccyx (Fig. 61.1a, b). First, we locate the tip of the coccyx by the second finger, move it upward along the midline continuing to the median sacral crest, and we can notice the sacral hiatus surrounded on both sides by the sacral horn (cornu). The lines which link the sacral hiatus and the right and left posterior superior iliac processes make an equilateral triangle [3] (Fig. 61.2). The line between the right and left posterior superior iliac processes is at the second sacral vertebral process level. The dural sac filled with cauda equina nerves and cerebrospinal fluid in the sacral canal reaches to the upper one-third of second sacral vertebral level in adults [4], below which is the caudal epidural space. In infants, the dural sac extends to the second sacral level [5].

61.4 Instruments and Drug Solutions

Needle:	A 25–23 G, 25–38 mm length of needle for adults or a 23 G and 16–19 mm needle length with wings for infants and small children.
Syringe:	20 mL, 10 mL, and 5 mL syringe. Resistance during medicinal solution infusion is strong with 20 mL syringes.
Liquid medication:	0.5–1.0% lidocaine or mepivacaine.
Sterilization kit:	Cotton ball, chlorhexidine-alcohol, and gauze to prevent disinfectant from getting into the anus and the rectal mucous membrane.

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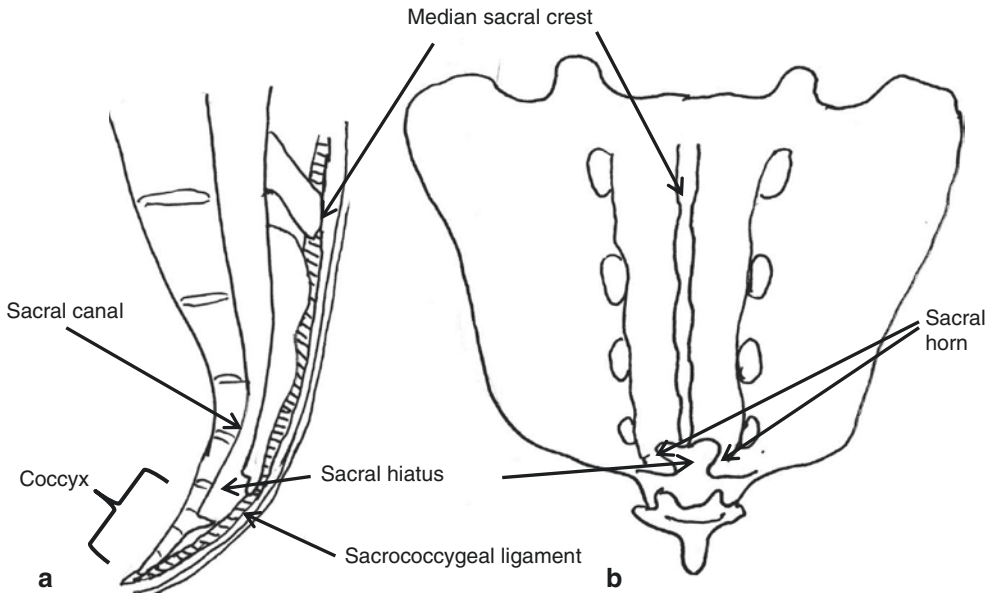

Fig. 61.1 Anatomy of sacral region for sacral epidural block. (**a**) Median sagittal tomographic image. (**b**) Posterior view

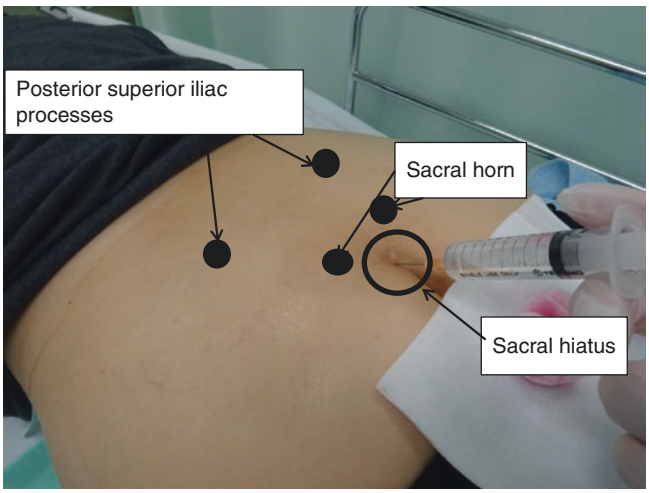

Fig. 61.2 Landmarks for sacral epidural block

For ultrasound guidance:	Sterilized plastic bag, sterilized rubber band, sterilized jelly, and extension tube.
For X-ray guidance:	C-arm-type X-ray fluoroscopic imaging equipment and non-ionic water-soluble contrast media (e.g., iohexol, 2–3 mL).

61.5 Procedures and Techniques

61.5.1 Landmark Method (Fig. 61.2)

Although we often perform the caudal block with the patient in the prone position, the patient can also take the lateral position, holding hip and knee joints in their arms for surgical anesthesia. The lines which link the sacral hiatus to both posterior superior iliac processes make an equilateral triangle, as shown in Fig. 61.2 [3]. After locating the sacral hiatus, the needle is inserted from the sacral hiatus into the sacrococcygeal ligament at an angle of 45 degrees. When the tip of the needle penetrates the sacrococcygeal ligament, the resistance disappears. The needle is made shallow and moderately pushed forward several millimeters. If there is no reflux of blood or cerebrospinal fluid, the local anesthetic is injected into the caudal epidural space.

61.5.2 Ultrasound-Guided Method (Fig. 61.3)

A linear probe at a frequency of 10–15 MHz is placed on the dorsal surface of the sacral midline and moved along to find the sacral hiatus and sacral horns. We can also locate both the sacrococcygeal ligament and caudal epidural space. We follow the landmark method afterward, and we can see the needle going through the sacrococcygeal ligament and can confirm that a medicinal solution was injected into the sacral epidural space.

61.5.3 X-ray Fluoroscopy-Guided Method

When the sacral epidural block is carried out under fluoroscopy, we use the C-arm. The procedure is the same as mentioned above. However, the needle tip sometimes glides toward the superior border of the sacrum and may not enter the sacral hiatus. In this case we can confirm it by lateral view through the C-arm. We can confirm whether the needle

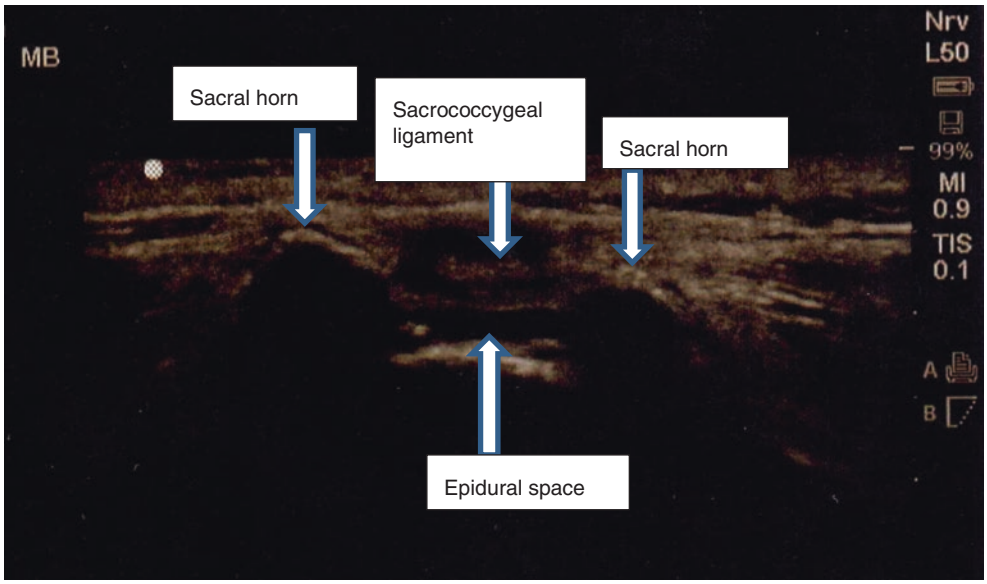

Fig. 61.3 Cross-sectional image at sacral horn

tip is in the caudal epidural space or not in the subarachnoid space by contrast media infusion.

61.6 Complications [2]

There are few complications during the sacral epidural block. We should be careful about bleeding, subarachnoid block, and local anesthetic toxicity. When the needle tip goes outside the sacrum, local anesthetic is injected hypodermically. Also, when the needle tip is located in the periosteum or sacrococcygeal ligament, the resistance at the infusion site becomes strong and produces pain. When the needle is in the marrow of the sacral vertebrae, blood local anesthetic level increases slightly. The ultrasound guidance method prevents these complications associated with the position of the needle tip.

References

1. Hotta K. Caudal epidural block. In: Komatsu T, Sato Y, Seo N, Hirota K, editors. Ultrasound echo guided regional block. Tokyo: Kokuseido; 2008. p. 181–6. (in Japanese).
2. Waldman SD. Caudal epidural nerve block: Prone position. In: Waldman SD, editor. Atlas of interventional pain management. 2nd ed. Philadelphia: Saunders; 2004. p. 380–92.
3. Senoglu N, Senoglu M, Oksuz H, et al. Landmarks of the sacral hiatus for caudal epidural block: an anatomical study. BJA. 2005;95:692–5.
4. Senoglu N, Senoglu M, Ozkan F, et al. The level of termination of the dural sac by MRI and its clinical relevance in caudal epidural block in adults. Surg Radiol Anat. 2013;35:579–84.
5. Skin SK, Hong JY, Kim WO, et al. Ultrasound evaluation of the sacral area and comparison of sacral interspinous and hiatal approach for caudal block in children. Anesthesiology. 2009;111:1135–40.

Comment

62

Keiko Mamiya

62.1 Comment to Chapter 60: Thoracic Epidural Block (Landmark, X-ray-Guided, and Ultrasound Method)

Among the procedures for thoracic epidural block, the landmark method has a longer history than the others and is well established. Thoracic epidural block is sometimes difficult to perform because the spinous processes are long in the mid-thoracic region compared to epidural block in other regions. In patients with spinal deformity or severe obesity in which it is difficult to perform the landmark method, the X-ray-guided method should be adopted. The X-ray-guided method can confirm the expanse of drug solution and intravascular infusion in real time. However, this technique involves exposure of the patient to X-rays.

Ultrasound-guided thoracic epidural block requires an assistant to hold the probe. It can be adopted prior to the procedure, to measure the distance from the epidural space and skin surface, and determine the site of puncture in pediatric patients and obese individuals. Ultrasound-guided block is easy and can be performed at the bedside without concerns regarding X-ray exposure. We expect that future improvements in ultrasound instruments will result in epidural block under ultrasound guidance becoming easier to perform.

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Part XIII

Epidural Intervention Therapy

Spinal Cord Stimulation

63

Takahisa Nishiyama

63.1 Introductions

Spinal cord stimulation (SCS) is a neuromodulation technique used to alleviate refractory chronic pain. SCS can improve activities of daily living and quality of life in patients suffering from refractory chronic pain.

With this technique, pain is relieved by electrical stimulation of the dorsal column of the spinal cord.

The stimulation electrode is placed in the dorsal epidural space at the spinal level that is thought to be causing the pain. The electrical stimulation of the dorsal column of the spinal cord provides pain relief (Fig. 63.1).

63.2 Introductions

The most common indications of SCS include the following: failed back surgery syndrome (FBSS) [1], complex regional pain syndrome (CRPS), peripheral vascular disease (PVD) [2], and angina pectoris [3].

The other indications are as follows: refractory chronic pain in postherpetic neuralgia, multiple sclerosis, spinal canal stenosis, spinal cord injury, Parkinson disease, and motor disorders such as spasticity and spasmodic torticollis.

Patients most likely to benefit from SCS are those who (1) have neuropathic pain, (2) feel stimulation in the area of the

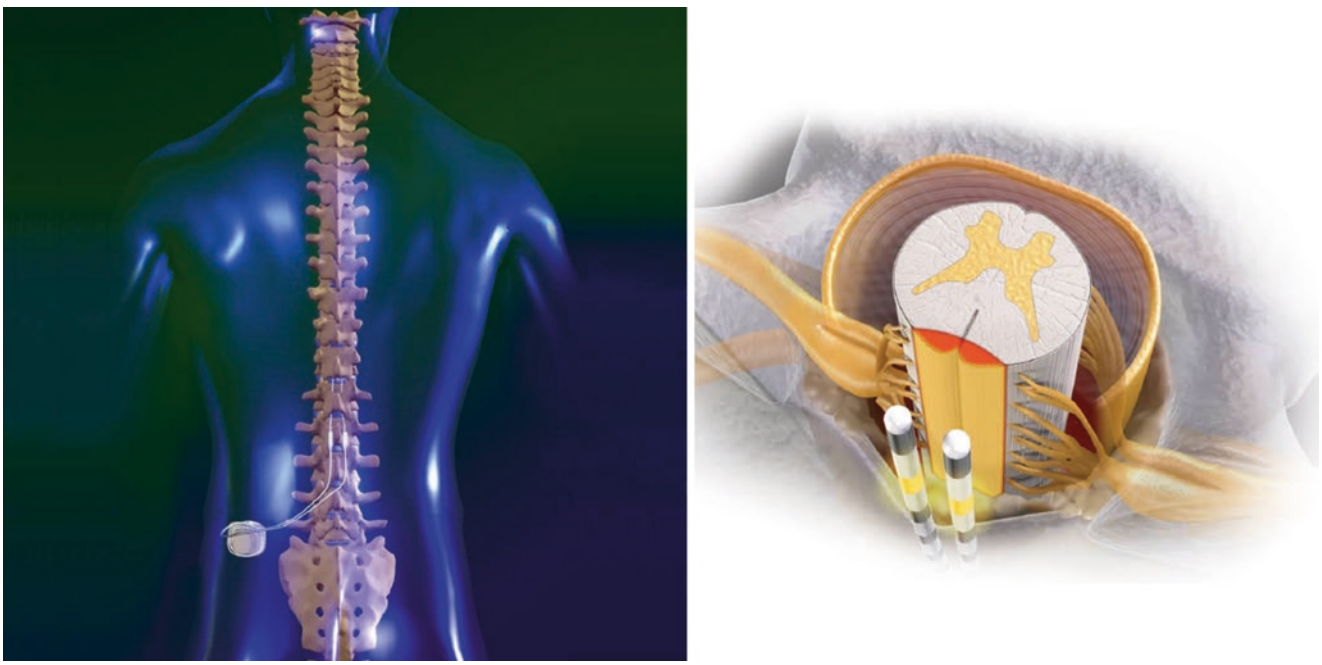

Fig. 63.1 Spinal cord stimulation. The electrode is inserted into the epidural space, and stimulation is performed

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pain, and (3) have experienced successful nerve block, at least temporarily. It is reported that SCS is more effective for limb pain than for trunk pain. SCS is also highly effective for pain and circulatory disorders in patients with peripheral vascular disease.

SCS is not indicated for patients with severely immunocompromised status, diabetic mellitus, bleeding tendency, and those in whom cessation of antiplatelet or anticoagulant drugs is difficult.

63.3 Anatomy

63.3.1 Mechanisms of Action

The potential mechanisms of action are as follows:

1. The gate control theory (the role of the dorsal horn in pain modulation): the electrical stimulation induces activation of inhibitory interneurons, leading to pain relief.
2. Suppression of pain transmission: the electrical stimulation suppresses the abnormal responsiveness of a wide dynamic range of neurons in the dorsal horn of the spinal cord.
3. Stimulation and activation of descending inhibitory pathways.
4. Activation of the inhibitory pathways mediated by γ-aminobutyric acid (GABA).
5. Sympathoinhibitory action.

Please see the section of epidural block regarding the anatomy of the epidural space.

63.4 Instruments and Drug Solutions

In Japan, SCS equipment is manufactured by the Medtronic Co., Ltd., St. Jude Medical Co., Ltd., and Boston Scientific Co., Ltd.

An implanted pulse generator (IPG) is connected to the electrode when implantation is performed. The IPG, having a small memory and processor, can provide a variety of programmed stimulation. There are two different types of battery: a built-in battery and a rechargeable battery (charging type). The frequencies of pulse are usually between 2 Hz and 1000 Hz, although there are devices that allow a higher frequency of up to 10 kHz or more in other countries. Some equipment automatically changes the program according to the body position. There is also equipment that is compatible with MRI use. Suitable equipment should be selected for each patient.

Currently, many types of electrodes are available. Regarding the shape, the catheter-type and puddle-type are available among others. Electrodes are placed percutaneously or surgically. There are also electrodes that are compatible with MRI use.

It is expected that, with the development of new IPGs and electrodes, the potential benefits of SCS will continue to expand.

63.5 Procedures and Techniques (Fig. 63.2)

The SCS procedure is usually performed in two stages. First, **trial stimulation** is performed to evaluate the pain relief effect. If the trial stimulation provides satisfactory pain relief, implantation of the pulse generator is performed. This two-stage procedure has the advantage of determining if the treatment is effective or not before implantation. However, patients with a higher risk of infection or bleeding or those who are thought to be good candidates for this treatment often undergo a **single-stage procedure**.

There are two types of trial stimulation: **puncture trial** and **surgical trial.** In **puncture trial,** the electrode is removed irrespective of the test results. If the treatment is ineffective, the procedure is finished after removing the electrode. If the treatment is effective, insertion of a new electrode and implantation of the IPG are required. **Surgical trial** is performed when implantation of the IPG is highly expected; therefore, the electrode is inserted through a skin incision. If the treatment is effective, implantation of the IPG is performed. If the treatment is ineffective, the electrode is removed and the skin is sutured.

A single-stage procedure without a trial period is occasionally performed when there are risks such as skin infection and when the effectiveness of the treatment is evident.

63.5.1 Placement of Electrodes

The electrode is inserted using X-ray fluoroscopy-guided method under local anesthesia. Patients are operated in the prone position. If this is difficult, they are operated in the lateral position. The puncture site is several vertebrae below the target site, as the electrode is moved cranially. In surgical trial, through a small incision and abrasion, the electrode is placed in the epidural space using a puncture needle. In puncture trial, the electrode is placed in the epidural place using a puncture needle under local anesthesia without performing skin incision.

The optimal spinal and vertebral levels for electrode placement vary depending on the site of pain (Fig. 63.3). The

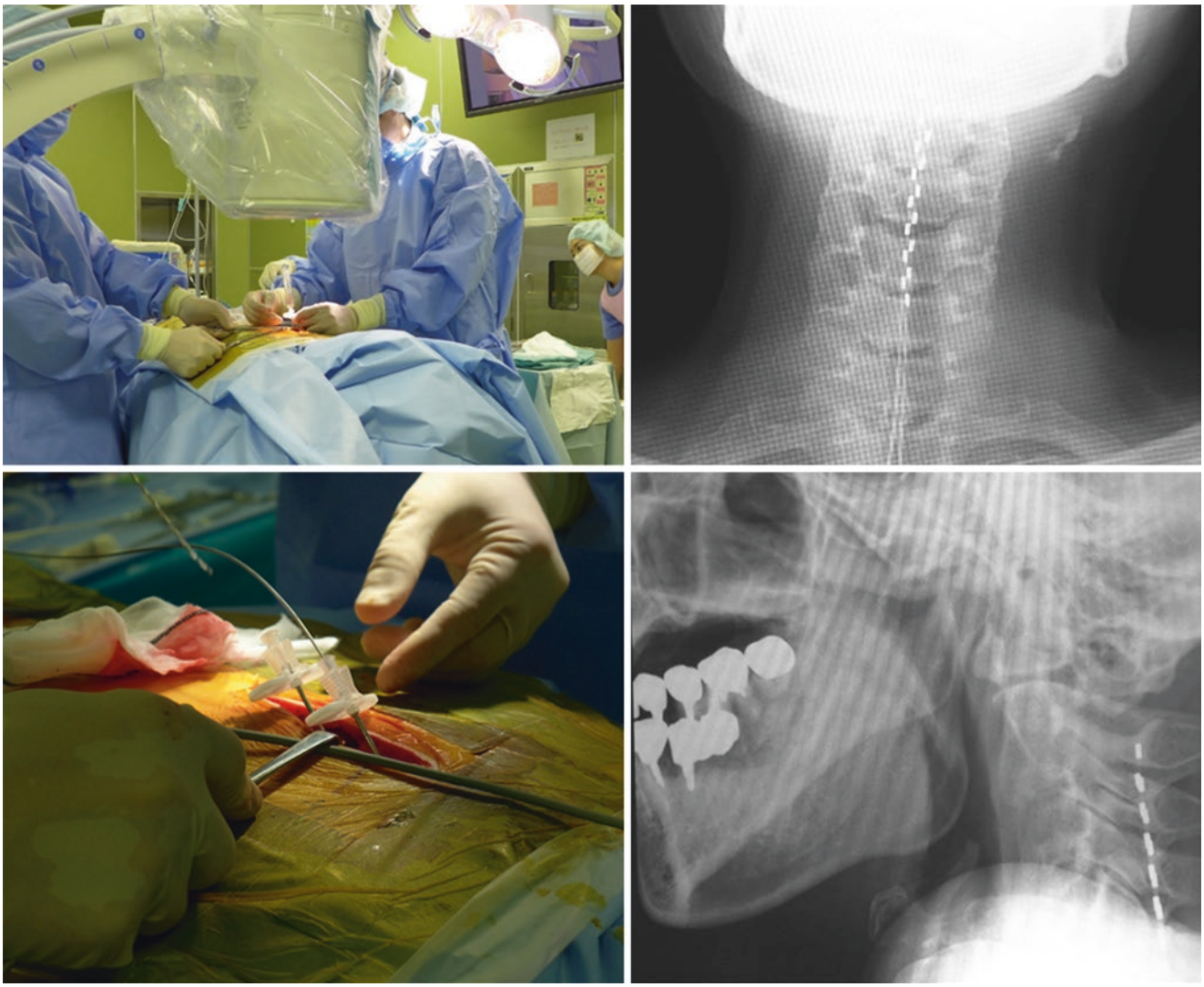

Fig. 63.2 Dermatomal levels of spinal cord stimulation. The optimal spinal level for stimulation is estimated based on the dermatome. The position of the SCS lead is determined with reference to the vertebral levels using fluoroscopy. Clinicians should be aware of the discrepancy in vertebral column levels and spinal cord levels

electrode is placed on the dorsal midline, shifting slightly toward the affected side, in the subdural space. Intraoperative testing stimulation is performed, and the position of the electrode is adjusted so that the patient feels stimulation in the area of the pain with the minimum stimulation. In surgical trial, after determining the position, the electrode is fixed to the fascia using an anchor and buried in the subcutaneous tunnel for maintaining hygiene. In puncture trial, the electrode is directly fixed to the skin.

We can also implant two or three electrodes to enhance treatment effect. This dual-lead stimulation provides more programming options and is thus useful for patients with severe pain or those who have pain over a wide area of the body. There is also an attempt to place the electrode in a caudal direction close to the nerve root to treat pain in the sacral region.

63.5.2 Trial Period

The trial period is typically several days to 1 week. The polarity of the electrode, stimulation output, frequency, and pulse width can be changed during the trial period. The decision whether or not to perform implantation is made on the basis of the results in the trial period. The puncture trial period can be extended for treatment purposes.

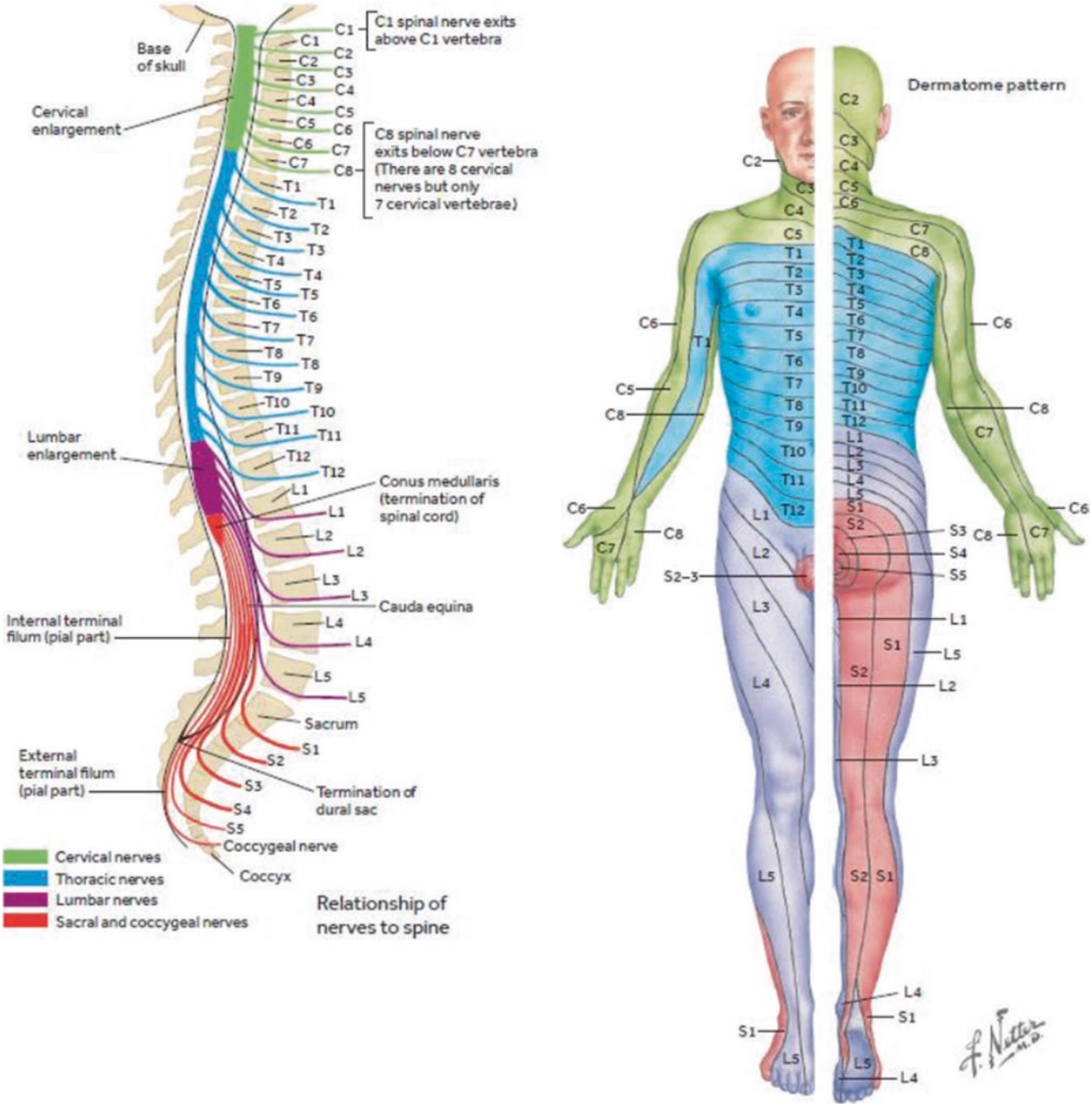

Fig. 63.3 DERMATOME. UC201000393c EN © 2016 Medtronic, Inc. Medical Illustration. Copyright © Elsevier—publisher and copyright holder of the Netter Collection of Medical Illustrations. All rights reserved

63.5.3 IPG Implant

If a beneficial effect of the test stimulation on pain relief is demonstrated and the patient is satisfied with the treatment, we proceed to permanent implantation after obtaining informed consent. The IPG is implanted subcutaneously under local or general anesthesia.

For some patients with electrodes placed in the cervical vertebra or upper thoracic vertebra, the IPG is implanted into the anterior chest. For patients with electrodes placed in the lower thoracic vertebra or lumbar vertebra, the IPG is implanted into the hypochondriac region, lower abdominal region, or lateral buttock. The IPG is fixed by suturing to the subcutaneous tissue or fascia in order to prevent migration

and rotation. The electrode is connected to the IPG through a subcutaneous tunnel.

IPG replacement surgery is needed at some time in the future. For the built-in battery type, replacement surgery is required when the battery is depleted. The battery life of the IPG varies with usage. For the charging type, the battery can be recharged transcutaneously, although replacement at intervals of 9 or 10 years is recommended.

63.6 Complications

Potential complications at the time of electrode insertion are similar to those of epidural catheter insertion. The long-term complications after implantation include migration and breakage of the electrodes (disconnection, etc.), change or loss of stimulus sensation, infection and hematoma in the region of the pulse generator and electrode, and pain in the region of the pulse generator.

The use of a cautery knife, diathermy, and a cardiac pacemaker must be avoided. The potential risks of MRI include heat and migration of the pulse generator, and damage to the program, although there are some equipment and electrodes that are compatible with MRI use.

References

1. Frey ME, Manchikanti L, Benyamin RM, et al. Spinal cord stimulation for patients with failed back surgery syndrome: a systematic review. Pain Physician. 2009;12:379–97.
2. Ubbink DT. et al: Spinal cord stimulation for critical leg ischemia: a review of effectiveness and optimal patient selection. J Pain Symptom Manag. 2006;31(Suppl):S30–5.
3. Börjesson M, Andréll P, Mannheimer C. Spinal cord stimulation for long–term treatment of severe angina pectoris: what does the evidence say? Futur Cardiol. 2011;7:825–33.

Epidural Lavage and Nerve Block (X-Ray-Guided)

64

Kumiko Hida and Maya Hayashi

64.1 Introductions

64.1.1 Epidural Lavage and Nerve Block [1]

Epidural lavage is a minimally invasive technique for treating lumbar radiculopathy when conventional epidural steroid injections have failed.

The proposed mechanisms of added volume include not only washout of inflammatory cytokines but also lavage of the epidural space, suppression of ectopic discharge from injured nerves, and enhanced blood flow to ischemic nerve roots.

64.2 Indications

Spinal stenosis, failed back surgery syndrome, and lumbar intervertebral disk herniation

64.3 Anatomy

An epidural scar tissue was the result of a surgical procedure or a nonsurgical phenomenon. The relationship between the presence of the scar tissue and pain is still being debated.

64.4 Instruments and Drug Solutions

64.4.1 Needles

A 25G needle and 17G Tuohy epidural needle

64.4.2 Solutions

10 mL of 1% lidocaine, 40 mL of normal saline, 10 mL of radiopaque contrast agent, and 2 mL of dexamethasone sodium phosphate

64.4.3 Other Equipment

5, 10, and 20 mL syringes and epidural catheter

64.5 Procedures and Techniques [2, 3]

The procedures were performed under X-ray fluoroscopy-guided method in an outpatient setting with the patient in the prone position.

The sacral hiatus was identified and marked by using lateral fluoroscopy.

A sterile prep and drape were used.

After infiltrating the subcutaneous tissue with 1% lidocaine, a 17G Tuohy epidural needle was used to enter the caudal epidural space through the sacral hiatus.

The stylet was removed, and using a standard technique, the epidural catheter was advanced to the position adjacent to the nerve roots believed to be responsible for the patient's symptoms on the basis of history, physical examination, and imaging studies. Correct positioning within the caudal epidural space and mapping the location of the filling defects were accomplished by injecting radiopaque contrast agent for use in the lateral and anteroposterior views. Whenever possible, the catheter was guided into the lateral recess/ventral epidural space.

After negative aspiration for blood and cerebrospinal fluid, the following solutions were sequentially injected: normal saline (5–40 mL) and 1% lidocaine (5 mL) with dexamethasone sodium phosphate (1–2 mL).

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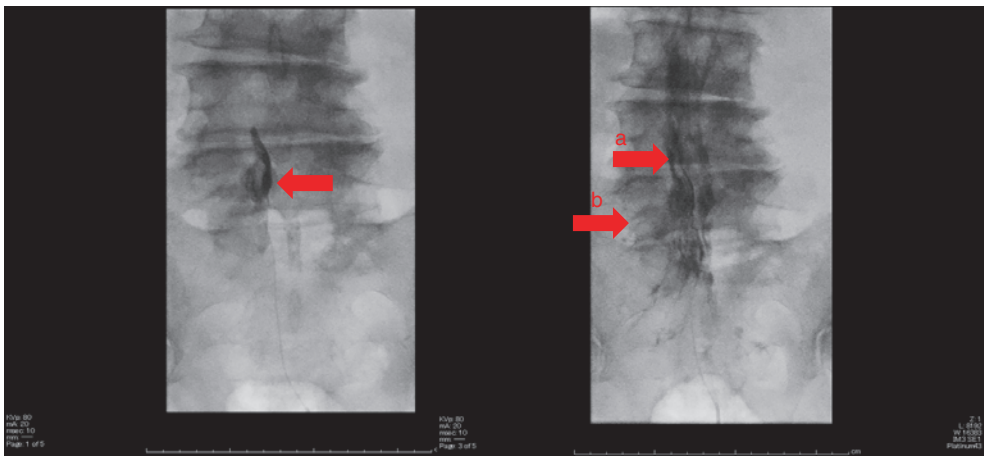

Fig. 64.1 Sequential anteroposterior fluoroscopic images demonstrating successful epidural lavage. (Left) Arrow shows the radiopaque navigable catheter inserted to the level of left L5 root at lumbar spine. (Right) Contrast reinjection after epidural lavage demonstrating improved spread cephalad (**a**) and to the left (**b**)

At the end of the procedure, 4–6 mL of the radiopaque contrast agent was reinjected to ascertain improved spread (Fig. 64.1).

64.6 Complications

Bleeding, infection, and nerve damage

Intravascular injection, transient nerve irritation, and dural puncture

Catheter remnant, epidural abscess, and meningitis

Cerebrospinal fluid leakage and post-dural puncture headache

Neurological sequelae resulting from a hematoma or compression from administration of large volume of the injectate

References

1. Lee F, Jamison DE, Hurley RW, Cohen SP. Epidural lysis of adhesions. Korean J Pain. 2014;27:3–15.
2. Scuderi GJ, Brusovanik GV, Anderson DG, Dunham CJ, Vaccaro AR, Demeo RF, Hallab N. Cytokine assay of the epidural space lavage in patients with lumbar intervertebral disk herniation and radiculopathy. J Spinal Disord Tech. 2006;19:266–9.
3. Hsu E, Atanelov L, Plunkett AR, Chai N, Chen Y, Cohen SP. Epidural lysis of adhesions for failed back surgery and spinal stenosis: factors associated with treatment outcome. Anesth Analg. 2014;118:215–24. https://doi.org/10.1213/ANE.0000000000000042.

Epiduroscopy

65

Takashi Igarashi and Hisashi Date

65.1 Introduction

65.1.1 Epiduroscopy

Epiduroscopy is a diagnostic/treatment method to perform perineural perfusion, lavage, adhesiolysis, and drug administration under direct vision while observing the epidural space using an endoscope in patients with intractable low back/lower limb pain. It is emphasized as a noninvasive treatment for patients with lumbar disc herniation, lumbar spinal canal stenosis, or syndromes after lumbar vertebral surgery. This method may facilitate accurate drug administration to the lesion site and extensive epidural block following this procedure. In Japan, it has been designated as advanced medical treatment by the Ministry of Health, Labour and Welfare.

65.2 Indications

Indications include intractable low back pain and sciatica that do not respond to conservative treatment. Epiduroscopy is effective for intervertebral disc hernia, lumbar spinal canal stenosis, and syndromes after lumbar vertebral surgery.

65.3 Anatomy

Refer to the sections "Epidural block" and "Sacral block".

65.4 Instruments and Drug Solutions

Drugs

- Epidural administration: physiological saline (500 mL), topical anesthetics, steroids, and contrast medium.
- Systemic administration: sedative hypnotics (propofol, dexmedetomidine), narcotics (fentanyl), and antibiotics (cefazolin).

Instruments

- Endoscope: flexible endoscope measuring 0.9 mm in diameter.
- Guided catheter™ (outer diameter, 2.6 mm): This catheter is attached to an endoscope, can undergo flexion at the endoscope tip, and infuse drug solution.

Access kit™: Disposable instruments such as a Tuohy needle, guidewire, and introducer are included.

65.5 Procedures and Techniques [1–3]

An electrocardiogram, the blood pressure, and percutaneous oxygen saturation should be taken. After securing vascular access, the patient should be placed in a prone position. During epiduroscopy, conscious sedation with propofol must be performed.

Endoscopic operations should be aseptically conducted under X-ray fluoroscopy-guided method. (1) The skin involving the sacral hiatus is disinfected, and a clean surgical field is prepared using perforated cover cloth. (2) A topical anesthetic is infused so that it infiltrates the skin, subcutaneous tissue, and sacrococcygeal ligament. In our hospital, 1% lidocaine containing epinephrine is used. (3) A Tuohy needle is inserted into the epidural space through the sacral hiatus (Fig. 65.1). (4) Contrast medium is infused through the Tuohy needle to confirm that the needle end is present in the epidural space. (5) A guidewire is inserted into the epidural space through the Tuohy needle (Fig. 65.2).

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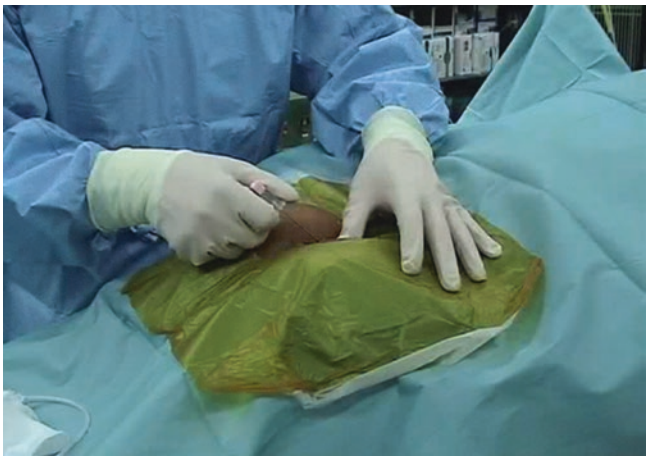

Fig. 65.1 The sacral hiatus is punctured using a Tuohy needle

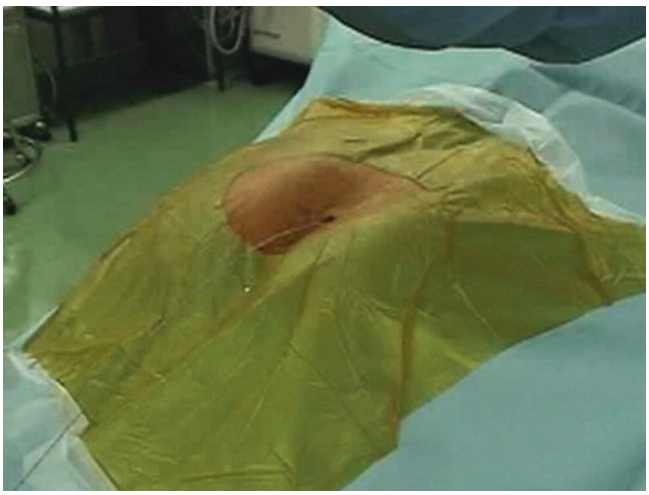

Fig. 65.3 The Tuohy needle is removed

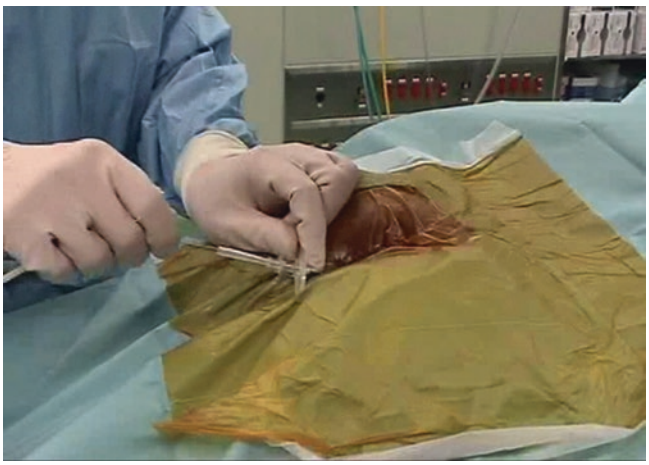

Fig. 65.2 A guidewire is inserted through a Tuohy needle

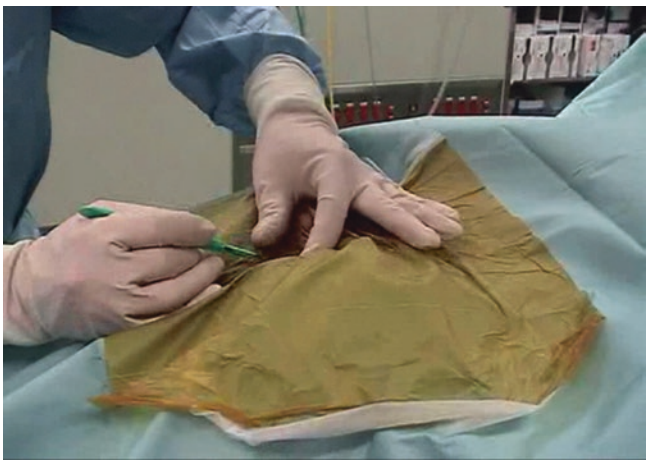

Fig. 65.4 The skin and ligament are incised

(6) The guidewire is left in position, and the Tuohy needle is removed (Fig. 65.3). The skin and sacrococcygeal ligament are incised (Fig. 65.4). (7) The subcutaneous tissue is extended using a diathermic sheath (Fig. 65.5), and an introducer is inserted. (8) The introducer is left in position, and the guidewire and diathermic sheath are removed (Fig. 65.6). (9) A Guided catheter™-attached thin endoscope is inserted into the epidural space through the introducer (Fig. 65.7). (10) While infusing physiological saline through the Guided catheter™, examination of the epidural space, exfoliation of adhesion, and drug infusion are performed using an endoscope. If necessary, fluoroscopy or contrast medium is concomitantly used, and the endoscope's position is confirmed. (11) The skin is then sutured, and epiduroscopy is completed.

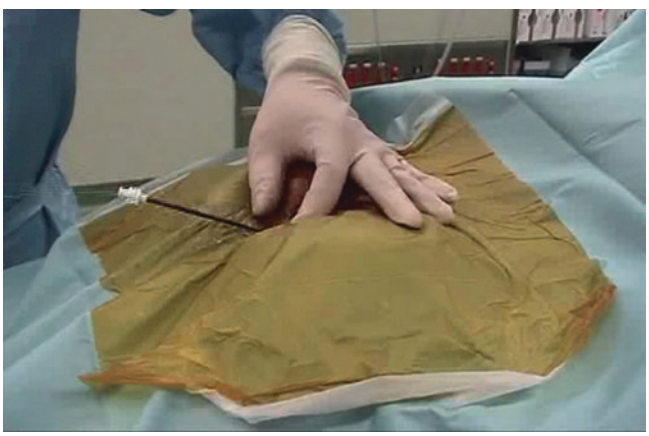

Fig. 65.5 The puncture site is magnified using a diathermic sheath

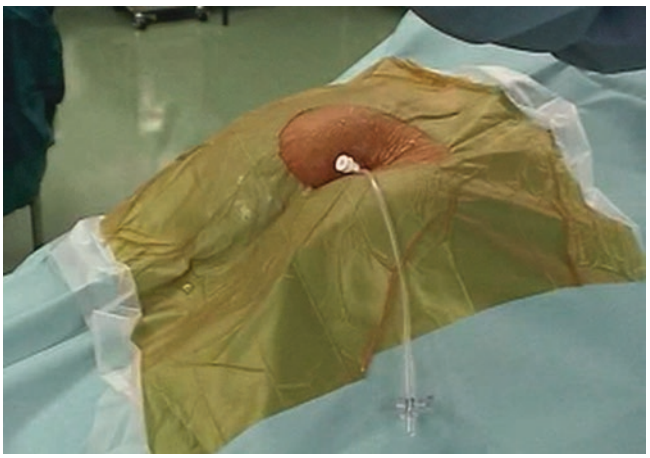

Fig. 65.6 An introducer is inserted into the epidural space of the sacrum

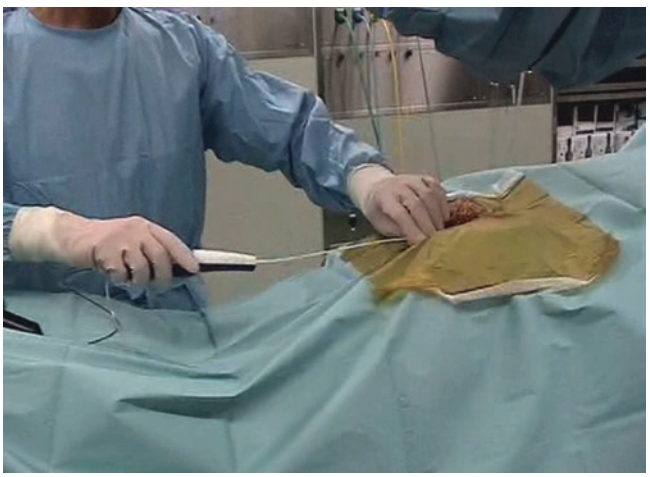

Fig. 65.7 An endoscope is inserted through the introducer

65.6 Endoscopic Findings

As normal findings, the pachymeninx, adipose tissue, connective tissue, blood vessels, and nerve root can be observed in the epidural space of the lumbar region. As abnormal findings, perineural congestion, flare, ischemia, proliferation of connective tissue, and adhesion are observed. In patients with lumbar disc herniation, a hernial mass is present, and findings regarding the grade of stenosis are obtained in those with lumbar spinal canal stenosis. In those with syndromes after lumbar vertebral surgery, marked perineural adhesion, cicatricial tissue, and irregularly proliferating connective tissue are observed.

65.7 Complications

The most frequent complication during epiduroscopy is headache. The dose of drug solution and rate of administration must be considered. Protracted complications after epiduroscopy include wound infection, infectious diseases of the central nervous system, intracranial hemorrhage, epidural hematoma of the spinal cord, spinal infarction, nerve injury, and dural puncture (2).

Epiduroscopy is contraindicated for patients with coagulation disorder, severe hepatopathy, nephropathy, allergy to topical anesthetics, increased intracranial pressure, or lesions occupying the central nervous system and pregnant women. Patients with malignant diseases, visceral organ diseases, or mental factor-related low back pain are sometimes encountered, but, as a rule, treatment for the primary disease should be mainly performed in these patients. In the presence of marked/progressive paralysis related to spinal disease or bladder and rectal disturbance, surgery should be primarily selected rather than epiduroscopy.

Infection control strategies are important. When infection occurs, serious, intractable sequelae may persist. It is necessary to handle endoscopic instruments carefully and complete epiduroscopy in a short period. To prevent wound infection in the sacral region after surgery, patients are instructed to wipe the anus only in the direction from the back to front area following defecation until the wound has healed.

References

1. Igarashi T, Hanaoka K. Epiduroscopy. Tokyo: Kokuseido Shuppan; 2002. (in Japanese)
2. Manchikanti L, Singh V, Derby R, et al. A randomized, controlled trial of spinal endoscopic adhesiolysis in chronic refractory low back and lower extremity pain. BMC Anesthesiol. 2005;5:10.
3. Igarashi T, Hirabayashi Y, Seo N, et al. Lysis of adhesions and epidural injection of steroid/local anaesthetic during epiduroscopy potentially alleviate low back and leg pain in elderly patients with lumbar spinal stenosis. Br J Anaesth. 2004;93:181–7.

Racz Catheter Percutaneous Epidural Neuroplasty (The Racz Procedure)

66

Koichi Mizuno and Ryosuke Naiki

66.1 Introductions

66.1.1 Epidural Neuroplasty

The Racz procedure typically involves accessing the epidural space by using a blunt-tip needle and inserting a catheter. The tip of the catheter is designed as round, deflective, atraumatic, and kink/collapse resistant. The catheter is then advanced to the adhesion site, where epidurography was used to map out the adhesions [1]. The analgesic effect is mediated by chemical adhesiolysis via the administration of local anesthetics, steroids, 10% hypertonic saline, and hyaluronidase, rather than by mechanical ablation [2]. Consent is required to use hyaluronidase, a noninsurance-applicable drug.

The Racz procedure, a minimally invasive and effective technique, represents an important part of the interventional repertoire for the treatment of axial spinal or radicular pain.

66.2 Indications

Failed back surgery syndrome, axial pain of the neck/back, and radiculopathy secondary to epidural fibrosis after surgery are good indications for the use of the Racz procedure.

Some cases of spinal stenosis or disk herniation are adapted for the Racz procedure, including cases of contrast injection (epidurography) that demonstrate filling defects corresponding to patients' radicular complaints.

66.3 Anatomy

See sections of epidural block, discography, selective nerve root injection, and epiduroscopy.

Understanding the three-dimensional positional relationship between the epidural space, nerve root, facet joint, and foramen is important.

66.4 Instruments and Drug Solutions (Fig. 66.1)

RX epidural needle®, spring guide epidural catheter (Racz catheter, Epimed International), and C-arm fluoroscopy unit.

66.5 Procedures and Techniques [1]

A procedure is selected based on the caudal, transforaminal, or interlaminar placement of catheters. Epidural fibrosis should be diagnosed by performing epidurography and neurological examinations in advance. A catheter is inserted in

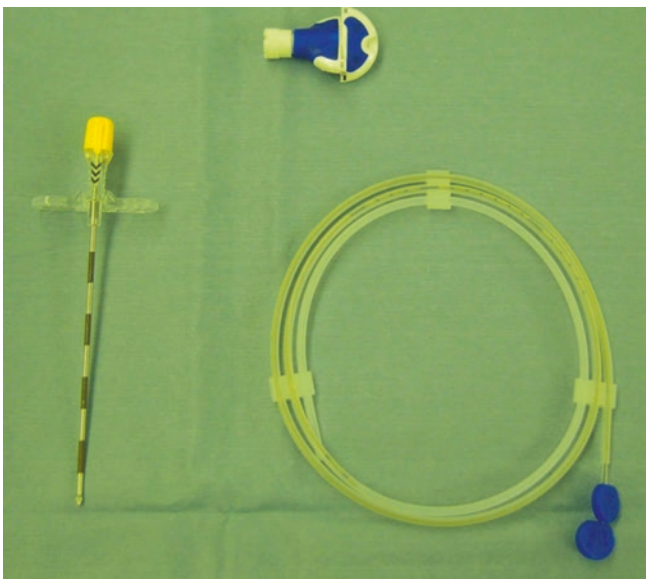

Fig. 66.1 Racz catheter kit (RX epidural needle®, spring guide epidural catheter, and Stingray® Connector)

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the desired symptomatic site in the ventral lateral epidural space. Interlaminal catheters are placed in the case of cervical and thoracic adhesiolysis. The caudal and transforaminal placement of catheters will be described in detail, frequently performed in lumbar and caudal adhesiolysis.

66.5.1 Caudal (Trance Hiatus) Approach

The patient is positioned on the table in the prone position. The sacral hiatus is identified via palpation or with X-ray fluoroscopy-guided method. The needle entry point is 1–3 cm lateral and 3–5 cm caudal to the sacral hiatus on the side opposite the documented radiculopathy (Figs. 66.2 and 66.3). The needle is inserted in the sacral canal through the sacral hiatus. The needle tip should cross the midline of the sacrum toward the side of the radiculopathy and should be below the level of the S3 foramen. After confirmation of the proper placement of the needle on anteroposterior (AP) and lateral fluoroscopic images, a Racz catheter with a bend in the distal tip is inserted through the needle. The bend should be 2.5 cm from the tip of the catheter, at a 30° angle. The bend will enable steering of the catheter to the target level. The direction of the catheter is just near the midline to advance the catheter to the dorsal epidural space. Then, the curve is directed to the ventral lateral target epidural site.

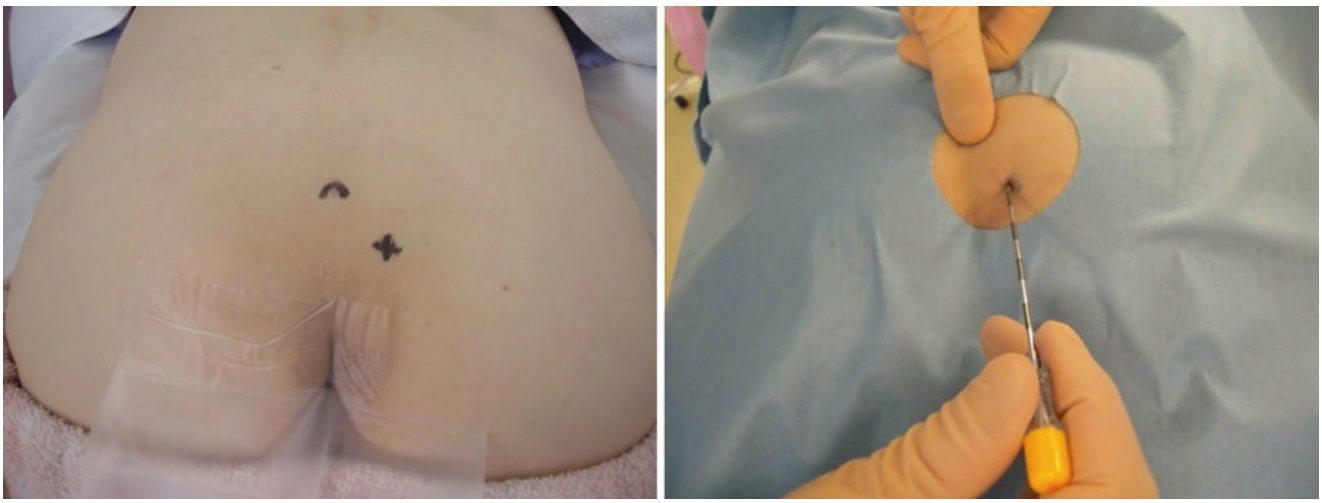

Fig. 66.2 Needle entry of caudal approach

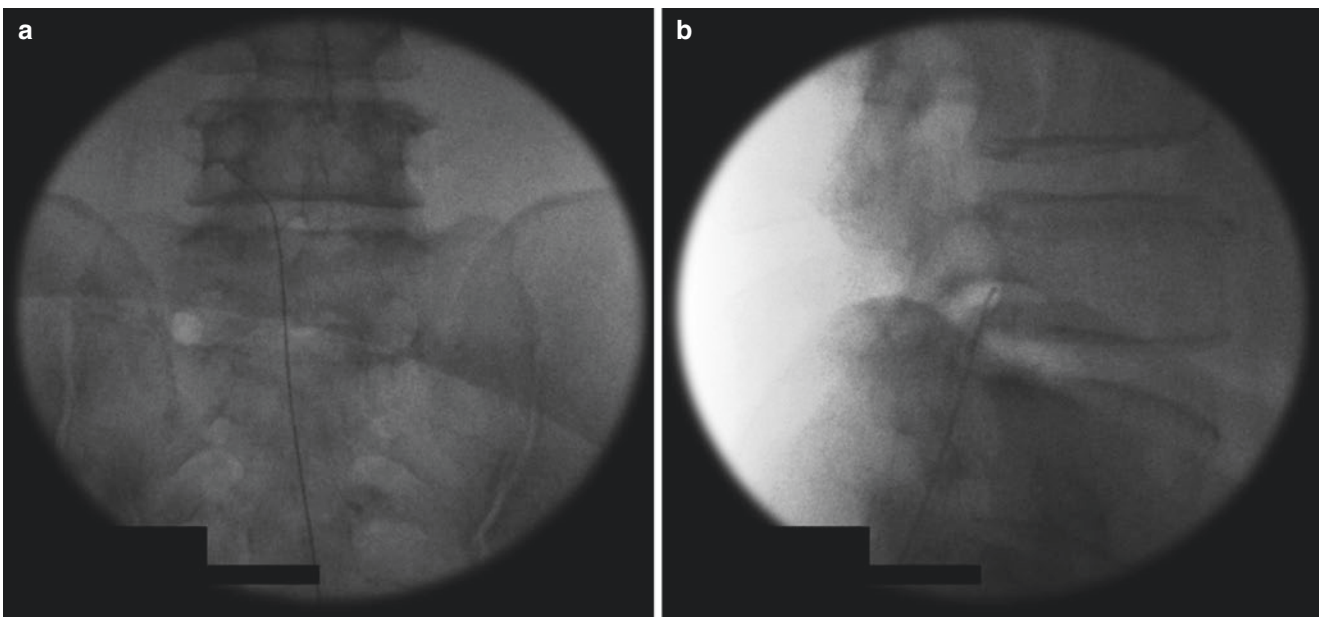

Fig. 66.3 (**a**) AP epidurogram of caudal approach. (**b**) Lateral epidurogram of caudal approach

Needle rotation and catheter navigation may need to be used to reach the target. Check the AP and lateral fluoroscopic images to confirm that the catheter tip is in the ventral lateral epidural space.

66.5.2 Lumbar Transforaminal Approach (Figs. 66.4 and 66.5)

The patient is positioned on the table in the prone position. The C-arm is tilted toward the side until the adjacent vertebral end plates are aligned and angled laterally in the oblique view and until the upper tip of the subject's superior articular process (SAP) is pointing medial to the midpoint above the vertebral body. The needle entry point is a fluoroscopic landmark of SAP, which is usually 6–10 cm laterally from a median line. The needle with a curved tip directed medially is inserted and advanced under fluoroscopy-guided method until contact is made at the upper portion of the SAP, closer to its lateral edge. The needle is turned until the curved tip is directed laterally and then advanced about 1–2 mm away from the SAP. Anterior to the SAP, the needle is rotated until the curved tip is redirected medially. Then, the needle is advanced through the intertransverse ligament until a "pop" is felt. The "loss of resistance" technique is safer than feeling for a "pop" to confirm that the needle tip is placed in the neural foramen. Once the intertransverse ligament is perforated, the catheter is steered to the ventral lateral epidural space or, anatomically, in the foramen above or below the exiting nerve root [3]. Placement of the catheter in the anterior epidural space is then confirmed on a lateral image.

66.5.3 Standard Protocol of Adhesiolysis (1–2 Days of Hospitalization)

1. Iohexol 240 is injected through the catheter to outline the filling defect.
2. Dexamethasone 4–8 mg (+ hyaluronidase 1500 units diluted in 10 mL of preservative-free saline) is injected.
3. An injection of a local anesthetic (5–10 mL of 0.2–0.3% ropivacaine or levobupivacaine) is provided. The volumes of the injectates vary with the target site.

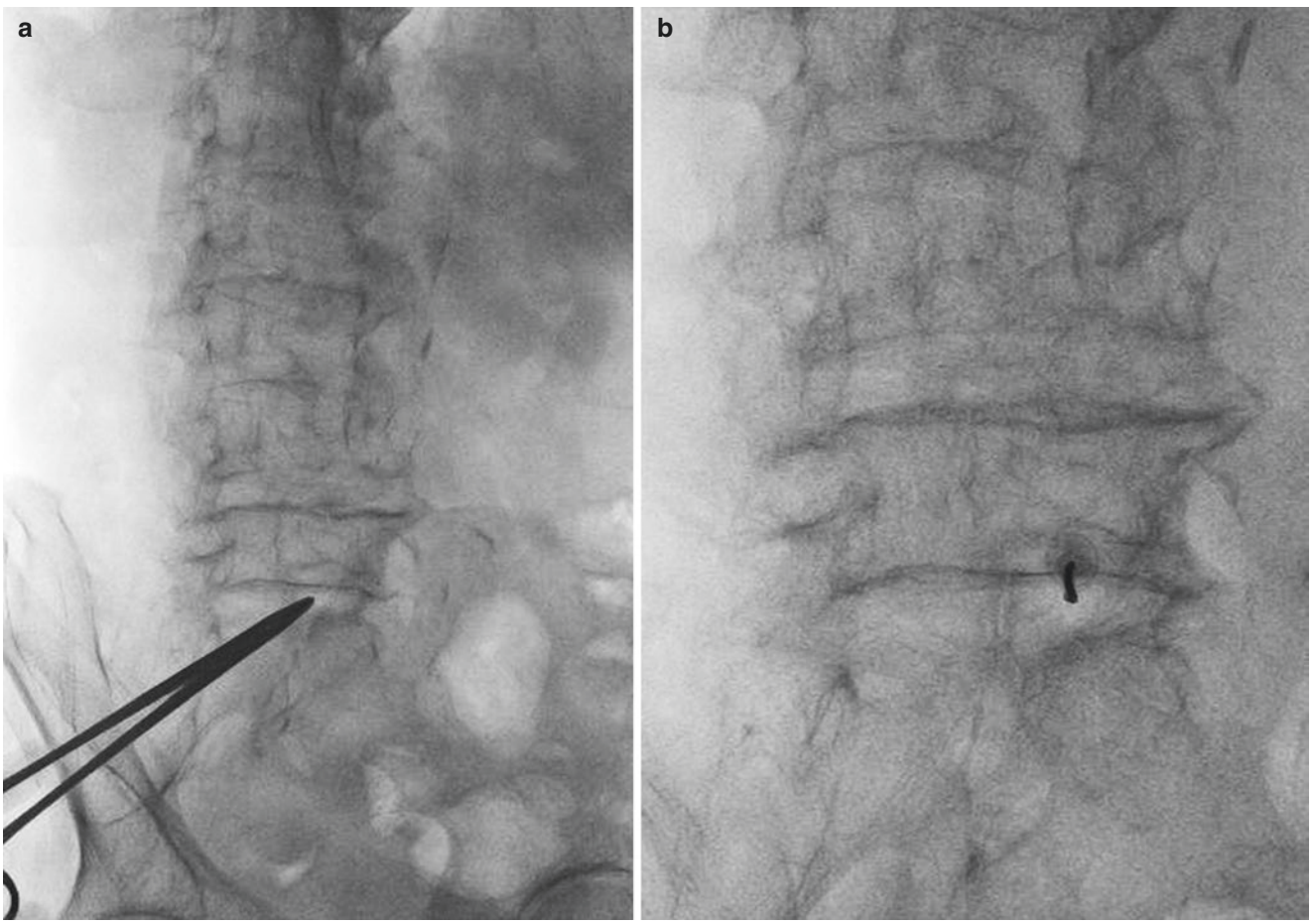

Fig. 66.4 (**a**) Oblique view of transforaminal approach. (**b**) Needle advancing into neural foramen

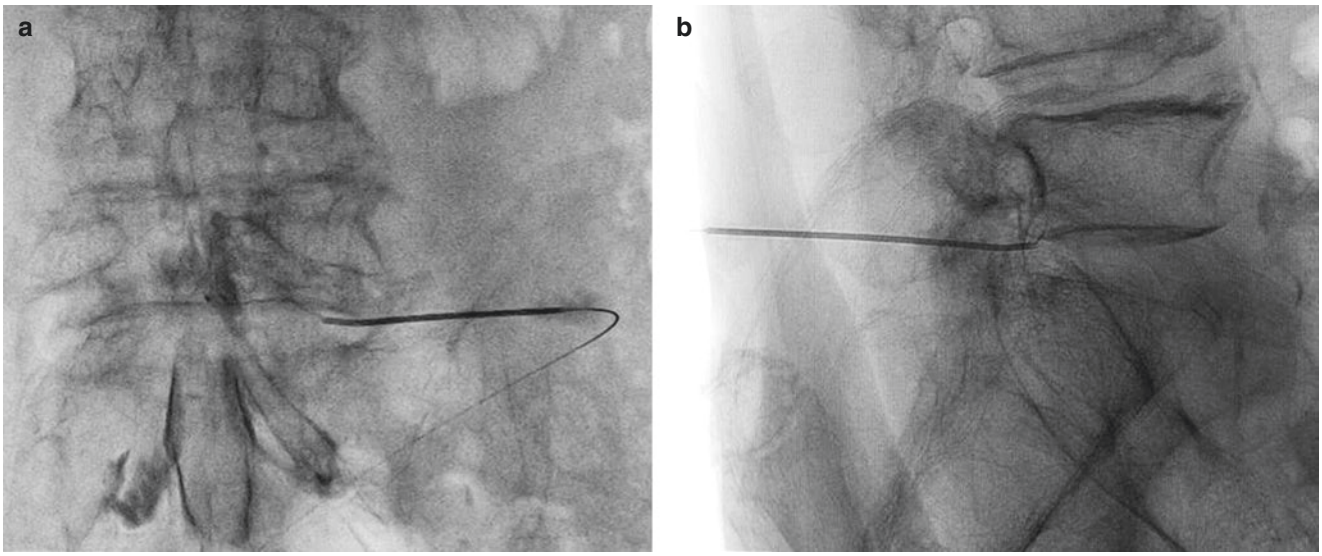

Fig. 66.5 (**a**) AP epidurogram of transforaminal approach. (**b**) Lateral epidurogram of transforaminal approach

4. The patient's motor function is evaluated 20–30 min after local anesthetic injection, and 8–10 mL of 10% hypertonic saline is injected over 30 min.
5. Steps 3 and 4 are repeated on the second day.
6. The catheter is removed at the time of discharge.

66.6 Complications

As for any epidural intervention, intravascular injection, transient nerve irritation, dura puncture, epidural abscess, and torn catheter during withdrawal are some of the general complications associated with the Racz procedure. Strict evaluation of contrast radiographs is required to prevent subarachnoid injection of local anesthetic or hypertonic saline.

References

1. Racz GB, et al. Epidural lysis of adhesions and percutaneous neuroplasty. London: INTECH Open Access Publisher; 2012.
2. Lee F, et al. Epidural lysis of adhesions. Korean J Pain. 2014;27(1):3–15.
3. Zhu J, et al. Alternative approach for lumbar transforaminal epidural steroid injections. Pain Physician. 2011;14(4):331–41.

Comment

67

Takashi Igarashi and Youichiro Abe

Spinal cord stimulation (SCS), epidural lavage, epiduroscopy, and Racz catheter therapy are noninvasive treatment procedures for intractable low back/lower limb pain.

With respect to indications, SCS can be indicated for various conditions, because it may be more effective for neuropathy-related pain than the other treatments. However, during SCS, a foreign body is inserted into the body; therefore, the patient's daily life may be restricted after treatment. On the other hand, there are no daily restrictions related to epidural lavage, epiduroscopy, or Racz catheter therapy.

Epiduroscopy has a merit: macroscopic perineural findings are obtained. However, capital investment for an endoscopic system is necessary. On the other hand, neither epidural lavage nor Racz catheter therapy requires an endoscopic system; therefore, initial capital investment by hospitals is not necessary.

With respect to instrumental operations, epiduroscopy facilitates operations at the endoscope tip. Therefore, it is useful for treating patients with marked perineural adhesion or various conditions. For epidural lavage or Racz catheter therapy, marked adhesion sometimes makes operations at the target site difficult, whereas lumbosacral and cervical/thoracic vertebral approaches are possible, which is a major merit.

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Part XIV

Subarachnoid Block

Thoracic Subarachnoid Phenol Block (Landmark Technique, X-ray-Guided)

68

Masako Iseki

68.1 Introductions

68.1.1 What Is Thoracic Subarachnoid Block?

Thoracic subarachnoid block alleviates pain in areas innervated by the thoracic spinal cord by injecting a topical anesthetic or neurolytic agent into the subarachnoid space. Although the use of thoracic subarachnoid blocks with topical anesthetics alleviates pain by blocking the input from the spinal cord, this technique is not generally used in pain clinics due to its adverse effects on the patient's respirations and/or circulation.

The application of thoracic subarachnoid blocks with phenol glycerin alleviates pain by selectively denaturalizing or destroying dorsal nerve roots, thus blocking afferent noxious input, and is used to ameliorate cancer pain.

68.2 Indications

Chest and/or back pain in cancer patients localized to one side of the patient's body.

68.3 Anatomy

The spinal cord is wrapped in leptomeninges and contained within the subarachnoid space, which is filled with cerebrospinal fluid (CSF). The lower end of the spinal cord in adults corresponds to the first lumbar vertebra. Two-thirds of the blood supply to the spine is provided via the anterior spinal artery, with one-third provided via the posterior spinal artery. The ventral side of the spinal cord contains anterior horns through which motor nerves and efferent autonomic nerve fibers run, while the dorsal side contains posterior horns comprising sensory nerves and afferent autonomic nerve fibers. As the spine and spinal cords are divided into two to three segments staggered within the thoracic region, care must be taken to place the patient in the appropriate position so that the neurolytic agent spreads to the posterior horns. In addition, the point of needle insertion must be determined taking into consideration the degree of misalignment between the segments.

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68.4 Instruments and Drug Solutions

68.4.1 Equipment and Drugs Required for Thoracic Subarachnoid Phenol Block (Fig. 68.1)

Needle:	22-G 8-cm nerve block needle
Injector:	1 mL syringe
Drugs:	1% mepivacaine or lidocaine (for skin anesthetization) 10% phenol glycerin 2–3-mL of nonionic water-soluble contrast medium for myelography if performed under X-ray guidance
Antiseptic kit:	Cotton balls, chlorhexidine-containing ethanol, etc.
For X-ray guidance:	C-arm X-ray unit

68.5 Procedures and Techniques

68.5.1 Procedure (Landmark Method)

Stabilize the patient in the lateral position, taking care to not obscure the point of needle insertion (Fig. 68.2).

Bend the bed so that the area containing the insertion point and target spinal cord segment is at the lowest level (Fig. 68.3), and then tilt the bed toward the patient's back by 45° [1] (Fig. 68.4).

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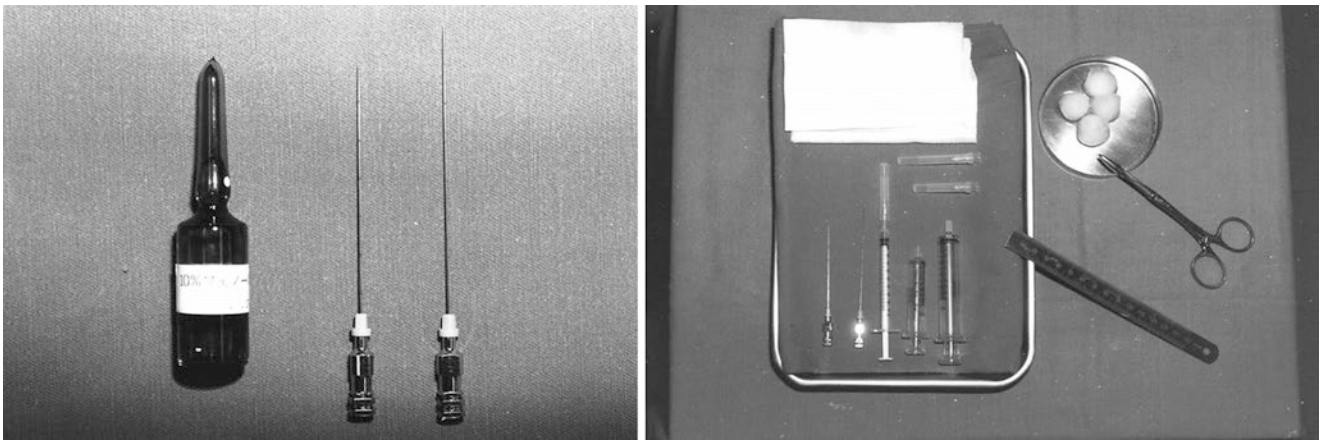

Fig. 68.1 Equipment and drugs. 10% phenol glycerin and metal block needles (7 or 8 cm). Cotton balls impregnated with chlorhexidine in 70% ethanol. 1 mL syringe for subarachnoid phenol block

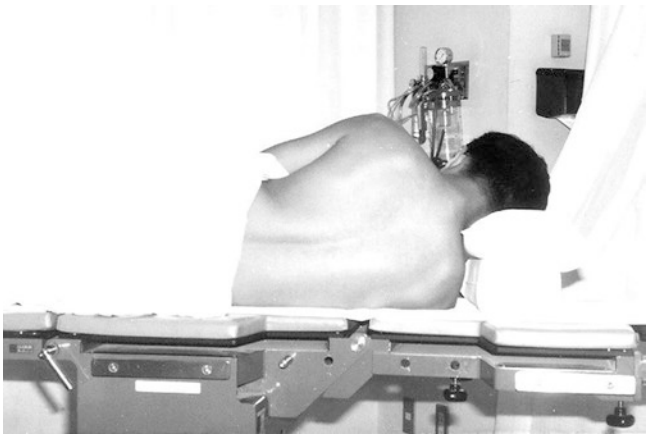

Fig. 68.2 Patient position #1 for thoracic phenol block. Lateral position with the painful side down

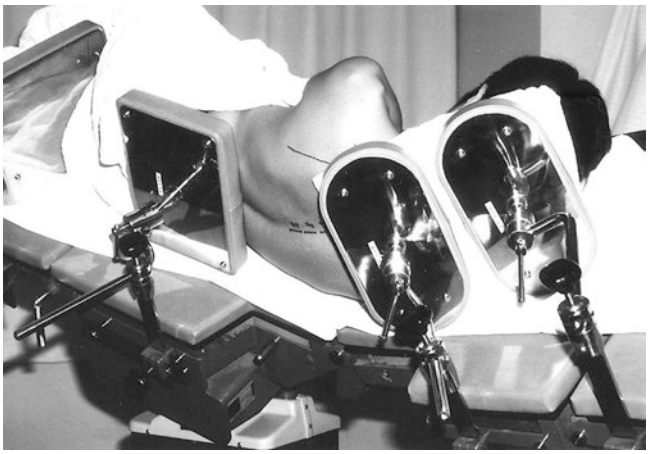

Fig. 68.4 Patient position #3 for thoracic phenol block. Tilt the bed by 45° toward the patient's backside so that the back faces downward

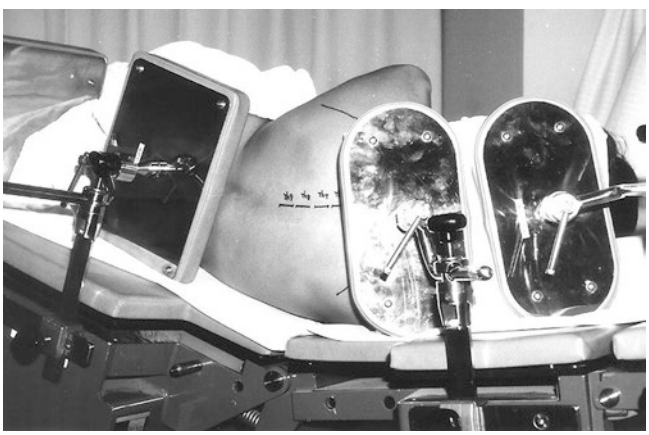

Fig. 68.3 Patient position #2 for thoracic phenol block. Stabilize the patient's occipital region, back, and buttocks using stabilizer pads. Bend the bed so that the subarachnoid space in the painful spinal cord segment is at the lowest level

Sterilize the insertion point and surrounding area, anesthetize the skin, and insert the needle. Carefully advance the needle, adjusting the angle so that the tip remains on the affected side of the median line of the body. The operator should be able to feel the resistance when the tip enters the yellow ligament, after which the resistance is lost when the tip penetrates the subarachnoid membrane and enters the epidural space (Fig. 68.5).

Once CSF leakage is noted, turn the needle several times by 90° increments to confirm that the CSF is clear at all angles. Inject 0.2 mL of 10% phenol very slowly. Once the injection is complete, remove the syringe from the needle in order to confirm that the CSF leakage continues to be clear, and then remove the needle. Have the patient rest while maintaining their current position for 30 minutes, then tilt the bed back to its original position, and allow the patient to rest for an additional 30 minutes. Use cold or pinprick stimulation to check for the position and area at which anesthesia is obtained.

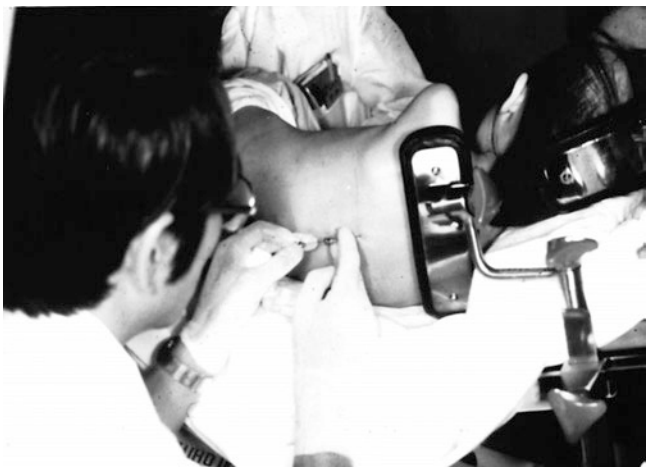

Fig. 68.5 The thoracic phenol block needle being inserted and advanced. Advance the needle until the tip penetrates the dura mater

68.5.2 Procedure Performed Under X-ray Fluoroscopy-Guided Method [2]

Have the patient lie in the lateral position with their affected side down, and assume a knee-chest position, taking care that the X-ray machine does not touch the patient. The point of insertion should be selected within the intervertebral area closest to the intervertebral foramen that controls the center of the region of pain. Insert the needle from a point higher than the median line, use X-ray imaging to guide the needle tip so that the tip is located within the affected side of the median line as it enters the subarachnoid space (Fig. 68.6), and check for CSF leakage. For spinal cord imaging, inject 0.1–0.2 m of nonionic water-soluble contrast medium using an extension tube, and subsequently confirm based on the image obtained with contrast medium that only the lower edge of the subarachnoid space is visible, while the contrast medium is contained within the target subarachnoid space and spreads in the cranial and caudal directions (Fig. 68.7). After confirming the disappearance of the contrast medium under X-ray guidance, inject 0.2 mL of 10% phenol very slowly.

68.6 Complications

1. Changes in the patient's circulatory dynamics and/or respiratory status, including a reduction in blood pressure, cardiac slowing, and/or respiratory depression.
2. Headache, nausea, and dizziness after puncturing the arachnoid membrane.
3. Infections, including meningitis.
4. Movement disorders of the upper or lower limbs (if the drug leaks into the area innervated by the cervical or lumbar nerves).

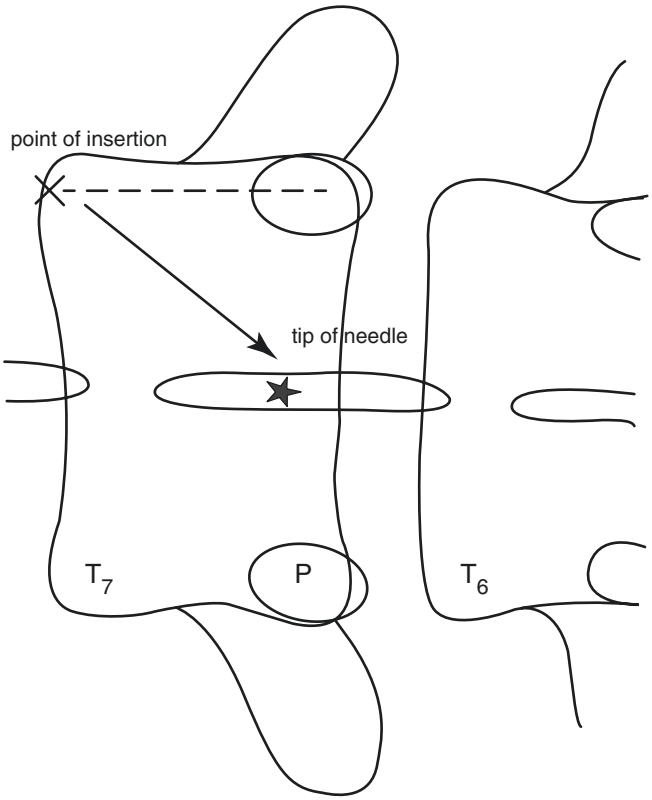

Fig. 68.6 X-ray fluoroscopy-guided subarachnoid block. Confirm the insertion point for the needle and the direction it should be advanced

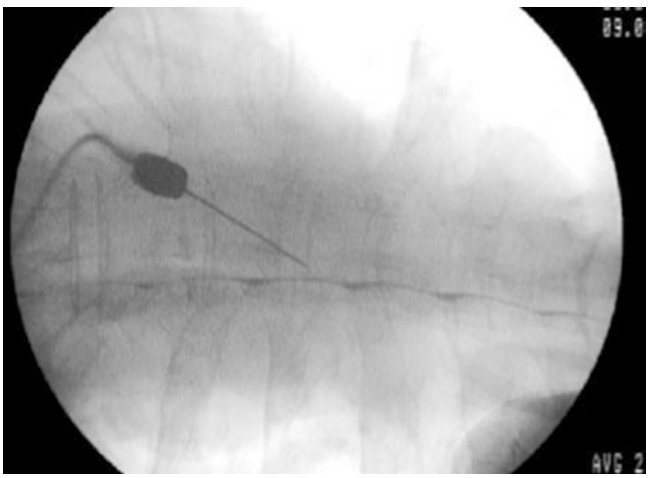

Fig. 68.7 X-ray fluoroscopy-guided subarachnoid block 2. Using X-ray subarachnoid imaging with contrast medium, check for the spread of the medium

5. Spinal cord injury. (This may occur if the operator fails to notice the needle tip entering the subarachnoid space and further advances the needle.)
6. Nerve root injury. (This may occur if the needle tip deviates from the median line, advancing into the nerve root.)

7. Damage to nutrient vessels. The spinal cord in the Th1-4 and K1 region is prone to ischemia. Damage to the anterior spinal artery may cause impairment of mobility.

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References

1. Tanabe Y. Subarachnoid phenol block. Pain Clinic. 2011;32: S291–8.
2. Fujii T, Nobuhiro H, Tubota S, Nagaro T. The role of interventional treatment in cancer pain. Pain Clinic. 2007;28:643–50.

Saddle Phenol Block (Landmark Technique)

69

Masako Iseki

69.1 Introductions

69.1.1 What Is Saddle Phenol Block?

Saddle phenol block refers to a nerve block technique for alleviating pain in the lower sacral nerves in which phenol glycerin is injected into the subarachnoid space from between the fifth lumbar and sacral vertebrae while the patient is in the sitting position. Due to its poor selectivity for dorsal root ganglia, bladder and rectal disturbances may be associated with the block method.

69.2 Indications

Cancer pain in the anal and perineal areas [1].

69.3 Anatomy

The lower spine includes five pairs of sacral nerves and a pair of coccygeal nerves.

69.4 Instruments and Drug Solutions

Needle:	22-G 8-cm nerve block needle
Injector:	1-mL syringe
Drugs:	1% mepivacaine or lidocaine (for skin anesthetization)
	10% phenol glycerin
Antiseptic kit:	Cotton balls, chlorhexidine-containing ethanol, etc.

69.5 Procedures and Techniques (Landmark Method)

Prepare the bed so that the patient can maintain a sitting position while leaning on to the affected side. After providing sterilization and skin anesthesia to the area between the fifth lumbar and sacral vertebrae, the needle is advanced following the standard technique for lumbar punctures. The operator should feel resistance when the needle penetrates the yellow ligament and the subsequent disappearance of resistance when the needle tip penetrates the arachnoid membrane to enter the epidural space.

After leakage of the cerebrospinal fluid (CSF) is observed, turn the needle several times by 90° increments to confirm that the CSF is clear at all angles. Inject 0.2–0.3 mL of 10% phenol very slowly (Fig. 69.1). Once the injection is

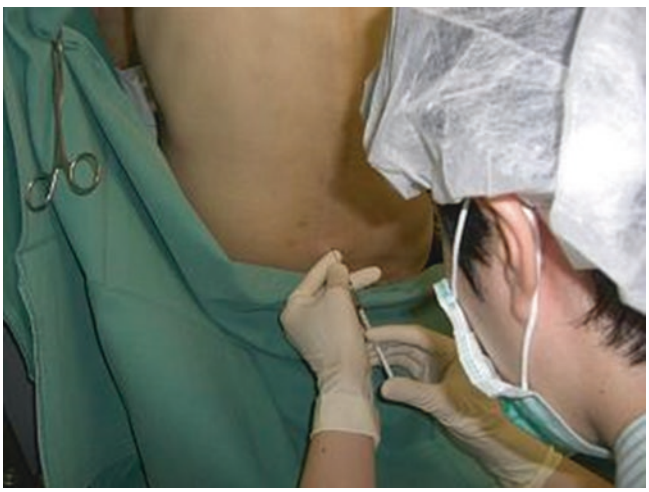

Fig. 69.1 Saddle phenol block. The patient maintains a sitting position during the operation. Advance the needle slowly until the tip penetrates the dura mater

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complete, remove the syringe from the needle to once again confirm clear CSF leakage, and then remove the needle. Ask the patient to rest while maintaining the sitting position for 30 minutes. Use cold or pinprick stimulation to check for the position and region at which anesthesia is obtained.

69.6 Complications

1. Bladder and rectal disturbances
2. Loss of muscle strength in the lower limbs
3. Meningitis
4. Damage to the cauda equina nerves
5. Headache and/or nausea

Reference

1. Fitzgibbon DR, Loeser JD. Cancer pain assessment, diagnosis, and management. Philadelphia: Lippincott Williams & Wilkins; 2010. p. 256–7.

Lumbar Subarachnoid Block

70

Rie Hasegawa and Masako Iseki

70.1 Introductions

70.1.1 What Is Lumbar Subarachnoid Block?

Lumbar subarachnoid block alleviates pain below the umbilical region by anesthetizing the anterior and posterior roots of the spinal cord with the injection of topical anesthetics into the subarachnoid space from an intervertebral point below the third lumbar vertebra, which subsequently affects the anterior and posterior roots of the spinal cord. Strong alleviation of cancer pain may be obtained with lower doses of opioids (mostly morphine) compared to topical anesthetics. Before applying lumbar subarachnoid block in patients with cancer pain, a single test block is often used to confirm the effectiveness of the block treatment for the patient.

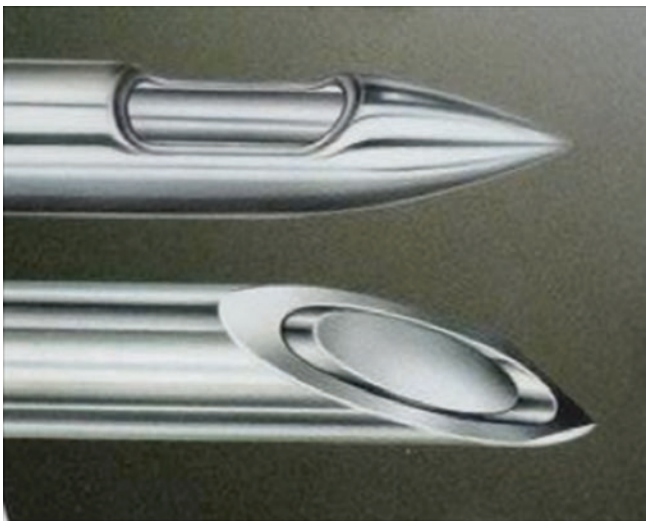
70.2 Indications

- Surgery in the lower back or limbs and/or lower abdominal region.
- Strong pain in the lower body.
- As a test before administering opioids into the subarachnoid space to treat cancer pain.

70.3 Anatomy (Fig. 70.1)

As the medullary cone usually reaches to a height between the first and second lumbar vertebrae, the needle is inserted below this level to avoid spinal cord injury.

The spine is naturally curved, forming an "S" shape with the cervical vertebrae inflecting forward, the thoracic vertebrae inflecting backward, and the lumbar vertebrae inflecting forward. When a patient assumes the dorsal position, the fourth cervical and third lumbar vertebrae generally become highest, while the fifth thoracic and third sacral vertebrae are lowest. The direction of the flow of the drug is dictated by whether the needle is inserted into the cranial or caudal side of the third lumbar vertebra [1].



Above: Pencil type needle
Below: Quincke type needle

Fig. 70.1 Above: Pencil-type needle. Below: Quincke-type needle

70.4 Instruments and Drug Solutions

70.4.1 Equipment and Drugs Required for Lumbar Subarachnoid Block

Needle:	22–29-G 75–90-mm nerve block needle (*1)
Injector:	Glass syringe
Drugs:	1% mepivacaine or lidocaine (for skin anesthetization)

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	0.25–0.5% high-density or isodense bupivacaine (for injection into the subarachnoid space) (*2)
	Under X-ray: nonionic water-soluble contrast medium for myelography
Antiseptic kit:	Cotton balls, chlorhexidine-containing ethanol, etc.
Equipment:	For ultrasonic guidance: a convex or linear probe
For X-ray guidance:	A C-arm X-ray unit

(*1) Needle selection: One potential complication of lumbar subarachnoid block is a headache after piercing the dura mater. As the occurrence of this complication depends on the needle gauge (thicker needles are more likely to cause headaches than thinner needles) and shape (Quincke needles are more likely to cause headaches than pencil-point needles [2]), the needle used for the operation must be selected taking these parameters into consideration.

(*2) Topical anesthetics used for injection: The specific weight of the cerebrospinal fluid (CSF) is 1.005–1.009, whereas that of high-density bupivacaine is 1.025–1.031 and that of isodense bupivacaine is 1.002–1.007. Accordingly, the distribution of the drug differs depending on which topical anesthetic is used. Generally, high-density drugs are more desirable when only one side of the patient, a wider area, or an area above the umbilical region is targeted. On the other hand, isodense drugs are better if the patient is unable to lie with their affected side pointing down.

70.5 Procedures and Techniques

70.5.1 Landmark Method

The landmark technique is generally performed in the lateral position. Have the patient bend his/her hip and knee joints, and subsequently bend forward their neck and back. The point of needle insertion is determined using a line connecting the right and left upper posterior iliac crests (called Tuffier's line or Jacoby's line) that generally runs through the fourth lumbar spinous process (50%), the fourth/fifth lumbar intervertebral region (25%), or the fifth lumbar spinous process (25%). If lumbar X-ray images obtained prior the operation are available, the level of Jacoby's line should be confirmed.

Two approaches are used for the landmark technique: (1) the median approach, in which the needle is inserted between the two spinal processes that flank the target insertion point, and (2) the paramedian approach, in which the needle is inserted slightly off the median line. The latter approach is used in patients with deformed lumbar vertebrae or other factors causing the use of the median approach to be difficult.

Following the administration of subcutaneous infiltration anesthesia, insert the needle, and advance it carefully. After feeling some resistance when the needle tip reaches the yellow ligament, the resistance will disappear when the tip enters the epidural space, after which the arachnoid membrane can be felt as the needle pierces through it. In order to prevent trauma, however, it is recommended that the piston be removed frequently to check for leakage of cerebrospinal fluid (CSF).

Once CSF leakage is noted, turn the needle several times by 90-degree increments to confirm that the CSF is clear at all angles, then attach the syringe containing the drug, and inject the solution.

70.5.2 Ultrasound-Guided Method

This technique is performed with the patient in the lateral position. It is desirable to run a preliminary scan with the ultrasonic apparatus in order to generate a block map that will serve as a guide for locating the puncture point, direction, and depth required to insert the needle [3].

On a median sagittal tonogram (Fig. 70.2), move the probe cephalad from the caudal end along the sacral bone, fifth lumbar vertebra, and fourth lumbar vertebra so that the probe is positioned over the target intervertebral location. At this position, generate an image containing the supraspinous ligament, yellow ligament, and dura mater, which will be used to guide the location of the puncture point, direction, and depth for needle insertion.

With a transverse (short-axis) view in which the probe is turned 90 degrees from the sagittal view (Fig. 70.3), generate an image containing the dura mater and surrounding area. Adjust the axis of the probe so that the shading on the spinal processes disappears, the intervertebral joint appears symmetric on both sides of the processes, and the dura mater and epidural space appear as if they are connecting the bases of the processes. Subsequently insert the needle along the axis obtained above.

70.5.3 X-ray Fluoroscopy-Guided Method

For this technique, the patient lies in either the lateral or abdominal position. If the abdominal position is used, insert a pillow under the lumbar area in order to place the lower back and bed in parallel, making it easier to observe the intervertebral region. Adjust the axis of the X-ray tube so that the spinal processes run in the center and the end plates are aligned in a single line.

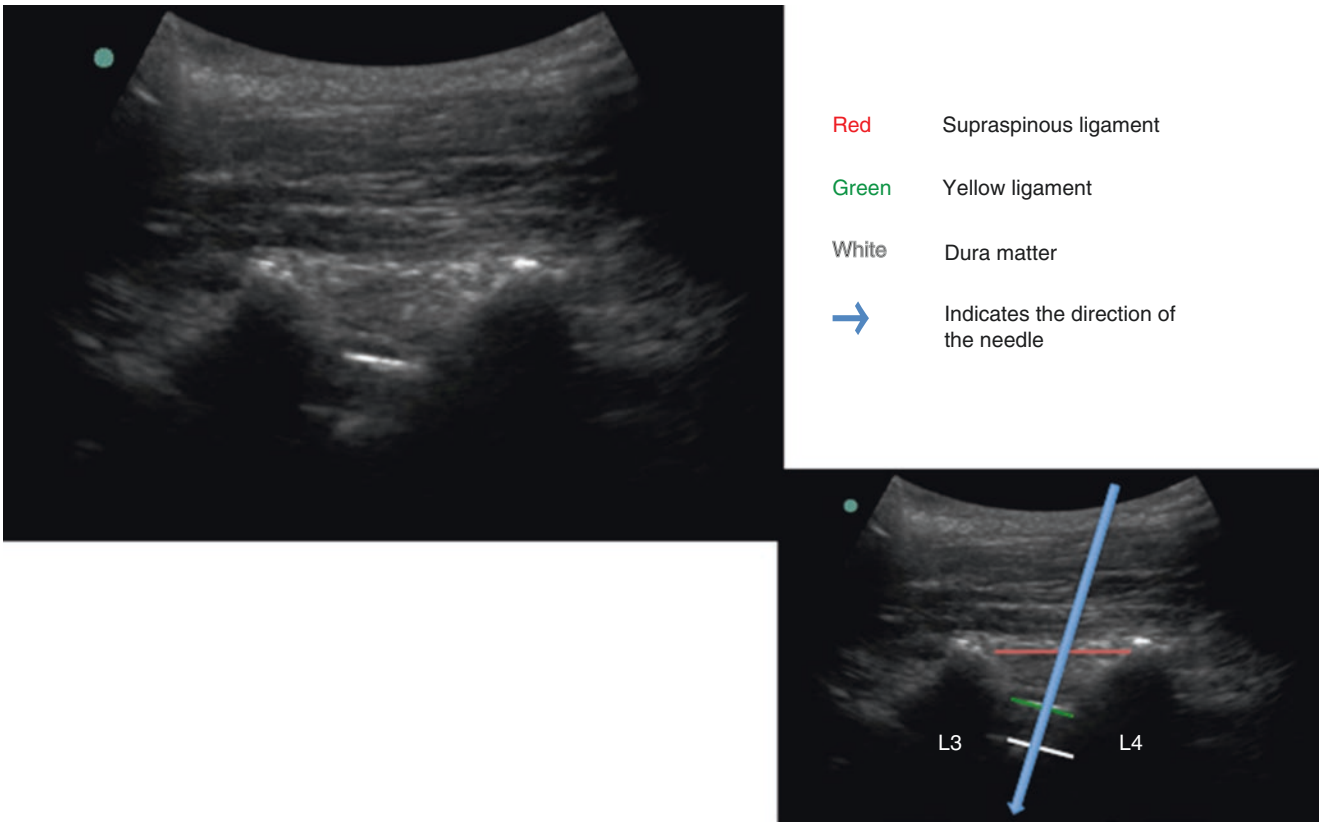

Fig. 70.2 Sagittal view

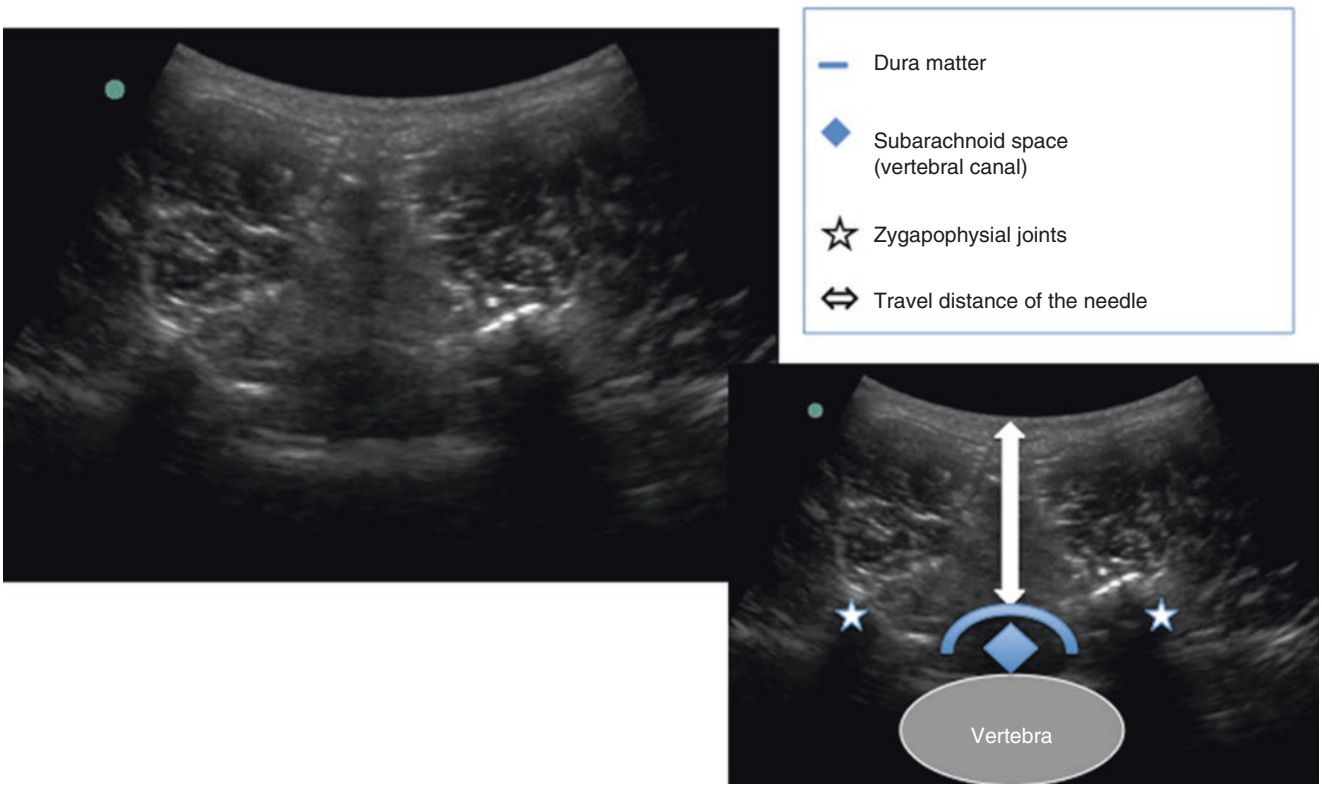

Fig. 70.3 Horizontal view

After confirming the space between the spinal processes, apply topical anesthetics to the target area, and advance the needle so that the needle is displayed as a single dot.

70.6 Complications

Headache after piercing the arachnoid membrane: In addition to the gauge and shape of the needle, age and gender influence the incidence of headache after this procedure, with headaches being more frequently observed among young and female patients, especially those who are pregnant.

Damage to the nerve: Care must be taken to choose an insertion point below the medullary cone and avoid causing any damage during catheter insertion.

Cauda equina syndrome: Very rarely, temporary abnormal sensations, mobility disturbances, and/or bladder or rectal dysfunction may be observed, most of which remit within approximately 2 months.

Respiratory depression: Respiratory depression may occur if the target area for anesthesia is positioned at a higher level, causing the anesthetic to spread to the phrenic nerve.

References

1. Junzou Takeda supervision. Ronald D. Miller Original. Miller's Anesthesia; 2007. p. 1287–310.
2. Aamodt A, Vedeler C. Complications after LP related to needle type: pencil-point versus Quincke. Acta Neurol Scand. 2001;103:396–8.
3. Balki M, Lee Y, Halpern S, Carvalho JC. Ultrasound imaging of the lumbar spine in the transverse plane: the correlation between estimated and actual depth to the epidural space in obese parturients. Anesth Analog. 2009;108:1876–81.

Pain Alleviation with Subarachnoid Opioid Injection

71

Masako Iseki

71.1 Introductions

71.1.1 What Is Subarachnoid Pain Alleviation Using Opioids?

Subarachnoid pain alleviation is a method in which opioids and topical anesthetics are injected into the cerebral fluid. In most cases, this technique is performed using continuous injection with a catheter placed in the subarachnoid space. Opioids used for this purpose include fentanyl and morphine. Of these agents, fentanyl exhibits high lipophilicity resulting in the administration of the same volume as that applied dermally, whereas morphine is water-soluble, and its effectiveness varies greatly depending on the route of administration. Compared to the subcutaneous or intravenous administration of morphine, subarachnoidal administration can be used to reduce the dose of the drug by a factor ranging from 1/50 to 1/150.

In order to maximize the alleviating effects of the applied topical anesthetic, it is ideal to place the catheter such that the drug spreads to the neuromeres corresponding to the region of pain. If the site of pain is located above the second lumbar vertebra, however, both arachnoid piercing and catheter placement should be performed carefully to avoid any damage to the spinal cord, as the subarachnoid space contains the spinal cord nerves. A technique is often practiced in which a single block is performed before placing the catheter for continuous subarachnoid opioid administration in order to confirm that the block is indeed effective.

71.2 Indications

Subarachnoid opioid administration is indicated for cancer pain in patients with a previous history of opioid switching or treatment with supplementary analgesics that was unable to effectively alleviate the pain and/or control breakthrough pain.

71.3 Anatomy

Refer to the "Anatomy" sections in Chaps. 68 and 70.

71.4 Instruments and Drug Solutions (Fig. 71.1)

Needle:	22-G Tuohy needle
Injector:	For the topical anesthetic and saline
Drugs:	1% mepivacaine or lidocaine (for skin anesthetization) Saline Nonionic water-soluble contrast medium
Antiseptic kit:	Cotton balls, chlorhexidine-containing ethanol, etc.
For X-ray guidance:	C-arm X-ray unit

Fig. 71.1 Subarachnoid catheter placement kit containing the needle for puncturing the dura mater, catheter, guide for the catheter, and subcutaneous implant port

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71.5 Procedures and Techniques

In order to avoid spinal nerve injuries, the needle is generally inserted below the second lumbar vertebra. The distance between the point of insertion and the target neuromere should be measured beforehand. While the patient lies on his/her side in the knee-chest position, the operator advances the tip of the Tuohy needle into the epidural space using the loss of resistance method. Monitoring the position of the needle tip on a lateral X-ray screen facilitates the operation. Once the needle tip reaches the epidural space, remove the piston of the syringe, and further advance the tip into the subarachnoid space while checking for leakage of cerebrospinal fluid (CSF). Once backflow of the CSF is observed, use contrast medium to obtain an image of the subarachnoid space in order to confirm that the tip has reached the subarachnoid space and that no constriction or obstruction is apparent. After this step, slowly insert the catheter cranially for the previously measured distance. Inject the contrast medium into the catheter in order to confirm under X-ray fluoroscopy-guided method that the catheter runs straight cranially on the patient's affected side. Then pass the catheter under the skin from the point of insertion in order to connect it to an access point embedded in either the abdomen or chest.

As to the initial dose of administration, inject 0.5 mL/h of 0.01% morphine hydrochloride and 0.05% bupivacaine using an injection pump equipped with the PCA function [1].

71.6 Complications

1. Meningitis
2. CSF leakage
3. Pain after spinal puncture
4. Accidental decannulation

Reference

1. Hattori S, Sano H, Tanaka K, Yokota M. Intrathecal morphine treatment in advanced cancer pain patients. Masui. 2009;58(11):1384–92.

Total Spinal Block (TSB)

72

Yutaka Masuda

72.1 Introduction

In Japan, total spinal block (TSB) [1, 2] was performed as a therapeutic procedure for whiplash injury between the 1960s and 1970s. Its indication was subsequently extended to intractable pain in the head, cervix, and upper limbs.

Various powerful nerve block techniques, including nerve root block, have been recently developed. As a result, TSB is now rarely performed.

72.2 Indications

TSB is currently performed when the conventional stellate ganglion block (SGB) or epidural block (EP) are not as effective. TSB is indicated for intractable pain. TSB is typically administered in cases of whiplash injury, cervical spondylosis deformans, post-therapeutic neuralgia, headache, and complex regional pain syndrome (CRPS).

72.3 Anatomy

The spinal column consists of many vertebrae, including seven cervical vertebrae, twelve thoracic vertebrae, five lumbar vertebrae, sacrum, and three to five caudal vertebrae.

A vertebra consists of a centrum on the anterior side, and a vertebral arch on the posterior side, with a vertebral foramen formed between them.

The connection of the vertebral foramen is through the spinal canal. The spinal canal begins at the cranial cavity, through the great foramen. The end of the canal is exposed at the sacral hiatus.

The spine is covered by a membrane consisting of three sheets of connective tissue within the spinal canal. These are, from the outermost tissue, the dura mater, arachnoid mater, and pia mater.

The circumference of the spine is filled with cerebrospinal fluid, and the arachnoid mater is attached to the inside of the dura mater; this constitutes the subarachnoid cavity.

The puncture is possible from a cisternal tap to L5-S1 spinous processes and a transsacral tap to S1-S3.

The tissues that the needle passes through, by median approach, are the skin, subcutaneous tissue, a supraspinous ligament, an interspinous ligament, a yellow ligament, dura mater, and subarachnoid space.

72.4 Instruments and Drug Solutions

Needles:	#22-gauge 6–7 cm block needle and #25-gauge 2.5 cm needle for local anesthesia
Syringe:	5 ml and 20 ml
Local anesthetic:	1% and 2% mepivacaine
Anesthesia apparatus:	Mask and bag for artificial respiration, tracheal intubation set, suction apparatus, and intravenous drip sets. Disinfectant: sterile square cloth, sterile absorbent gauze, and cotton ball
Drugs:	Atropine, sedatives (diazepam, midazolam), and vasopressors

72.5 Procedures and Techniques

TSB is not an outpatient medical treatment; therefore, the patient needs to be admitted to the hospital.

TSB can be performed provided that circulatory organs, respiratory organs, and kidneys function normally. In addition, anticlotting drugs must not be taken.

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72.5.1 Management Before Starting TSB

For an extremely nervous patient, a low dose of sedative may be used preoperatively. Eating and drinking must be stopped 6 h before the procedure. Before beginning the TSB, lactated Ringer's solution is infused in the treatment room.

Blood pressure and pulse rate are measured every 5 min, as well as the general anesthesia is monitored.

72.5.2 Position of Block and Sit of Puncture

The patient is placed in the lateral position. If the patient is in the right or left lateral recumbent position, the block is performed with the main symptom side facing upwards. Although the puncture is usually performed from a lower cervical vertebrae or upper thoracic vertebrae, whether the effect will reach the nerve field in agreement with the symptom is taken into consideration and determines the position. Usually, it is carried out between C5/6 and T1/2.

72.5.3 Concentration and Volume of Mepivacaine to be Used

In the case of Tsumura and colleagues [1, 2], 1.5% mepivacaine 20 ml was used. However, the concentration and volume of mepivacaine should be determined following careful consideration of age and general condition.

72.5.4 Spinal Tap, and Injection of Local Anesthetic

This is carried out similar to lumbar anesthesia. An operator stops the needle when the needle reaches the intrathecal space, fixes the needle firmly, and injects a local anesthetic for approximately 20 ml. After the local anesthetic injection, an operator draws out needle quickly, and sticks gauze and a plaster on the skin. The patient is then placed in the supine position.

72.5.5 Patient Care Under TSB

Diazepam or midazolam, 10 mg intravenously (i.v.), can be given to avoid any uncomfortable sensation at the beginning of TSB. Over 40% oxygen in air is given via face mask. After the patient becomes unconscious and paralyzed and dilation of pupils and loss of light reflex are observed, artificial ventilation starts using a mask, laryngeal mask, or endotracheal tube to maintain the end-tidal carbon dioxide tension between 35 and 40 mmHg.

The circulation dynamics in TSB are stable, and it can be controlled by adjusting the speed of infusion (Fig. 72.1 [3]).

Approximately 60 min later, spontaneous breathing recovers, the laryngeal mask or endotracheal tube is removed, and 40% oxygen in air is administered via a face mask. Spontaneous respiration returns 5–10 min after cervical assisted respiration muscle movement appears. An operator removes the tracheal tube or laryngeal mask at this time. The patient is kept on bed rest for 12 h after TSB.

When compared with the usual endotracheal anesthesia, there are very few secretions in the respiratory tract and the mouth.

In some cases, EEG is recorded in TSB. Although there were no abnormalities such as epilepsy in anamnesis, abnormal seizure patterns have been recorded [3]. In such patients, abnormal symptoms were not seen after TSB. However, abnormal EEG was not recorded when diazepam or midazolam is used at the time of local anesthetic injection.

Diazepam or midazolam can control abnormal EEG and avoid any uncomfortable sensation at the beginning of TSB. Therefore, these drugs are very important medicines for use with TSB.

72.6 A Curative Effect and Results

From the results of 66 cases (488 times) of TSB that we have performed, 28 cases had excellent outcomes, 26 cases were effective, and 12 cases were invalid (Table 72.1 [3]).

The study of Yokoyama and colleagues [4], who performed TSB for intractable pain, has reported that the curative effect is temporary and declines with time.

The curative effect of TSB is considered to be a block that extends to not only the peripheral nervous system, but also the central nervous system.

Therefore, in order to guarantee the therapeutic effect of TSB, it is necessary to clarify the cause of pain and timing of TSB. Therefore, further studies to assess this will be needed in the future.

72.7 Complications

Spinal headache, amnesia, spinal cord injury, vascular injury, bleeding, etc.

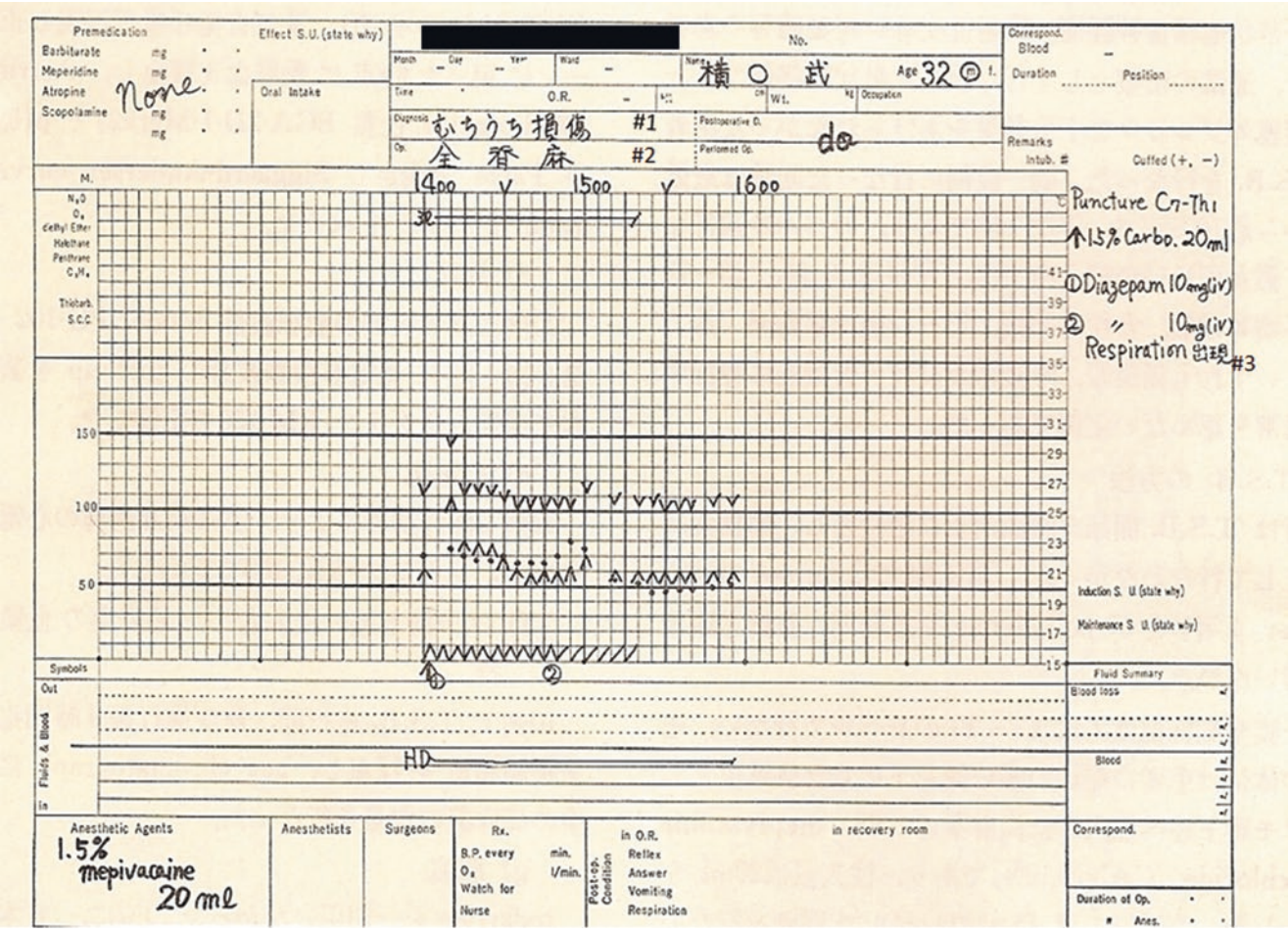

Fig. 72.1 The circulation record of TSB [3]. The circulation dynamics in TSB are stable. In this case, the respiratory arrest time was 50 min

Table 72.1 The treatment results of TSB

Diagnosis	Cases	No. of TSB (mean)	Effect		
			++	+	−
Cervico-omo-brachial syndrome	15	1–35 (11)	3	10	2
Whiplash injury	12	1–29 (10)	6	5	1
Headache	8	2–12 (5)	4	3	1
Herpes zoster postherpetic neuralgia	7	1–9 (5)	5	1	1
Reflex sympathetic dystrophy	6	4–15 (5)	3	1	2
Others	18	1–11 (4)	7	6	5
Total	66	488 (7)	28	26	12

++: excellent, +: effective, −: invalid

References

1. Tsumura Y, Hoshiga T. Subarachnoidal injection therapy in chronic case of the so-called whiplash injury syndrome. Acta Anaesthesiol Scand. 1971;15:61–4.
2. Tsumura Y, et al. Studies of total spinal block as a therapeutic procedure (part 1). Masui. 1972;21:352–60. (in Japanese).
3. Masuda Y. Clinical studies in total spinal block. J Showa Med Assoc. 1976;36:396–404. (in Japanese).
4. Yokoyama M, Itano Y, Kusume Y, et al. Total spinal anesthesia provides transient relief of intractable pain. Can J Anaesth. 2002;49:810–3.

Comment

73

Masako Iseki

73.1 Comment to Chap. 69: Subarachnoid Block

For both the Landmark and X-ray techniques, it is important to frequently remove the piston of the syringe while advancing the needle to check for leakage of the CSF in order to prevent trauma.

Use frozen-stored 10% phenol, which has higher viscosity. After confirming leakage of the CSF, quickly draw the phenol into a 1-mL syringe, and inject the solution at a slow rate of approximately 0.1 mL/min.

After injecting 10% phenol, periodically check for a decrease in sensation in each segment (5, 10, and 30 min) using pinprick and cold tests. The final evaluation should be performed several days after the operation.

73.2 Comment to Chap. 69: Saddle Phenol Block (Landmark Technique)

The operator must provide a sufficient explanation to the patient and obtain his/her consent from the patient in advance regarding the risk of bladder and rectal disturbances. Patients with concomitant neurogenic bladder dysfunction due to tumor infiltration of the tumor or pelvic operation surgery are of at particularly high risk. On the other hand, in contrast, those patients with both artificial anus and history of ileal conduit operation surgery are good candidates for the block technique, since the operator does not need to be concerned with the risk of bladder and rectal disturbances.

73.3 Comment to Chap. 70: Lumbar Subarachnoid Block

The use of lumbar subarachnoid block with neurolytic phenol for cancer pain is limited to very special cases due to the risk of motor paralysis of the lower limbs. This technique is also rarely used to treat non-cancer pain.

73.4 Comment to Chap. 71: Pain Alleviation with Subarachnoid Opioid Injection

The point of insertion must be selected after checking for spinal stenosis or other anatomical changes due to metastasis using X-ray and spinal MRI. If the operation must be performed above the level of the second lumbar vertebra, extra care must be taken to ensure safety, as the subarachnoid space contains the spinal nerves. For this reason, the principle of segmental anesthesia is often not adhered to, and the second–third or third–fourth intervertebral areas are instead chosen as the insertion point leaving approximately 10 cm of the catheter in the subarachnoid space.

73.5 Comment to Chap. 72: Total Spinal Block (TSB)

73.5.1 A Curative Effect and Results

From the results of 66 cases (488 times) of TSB that we have performed, 28 cases had excellent outcomes, 26 cases were effective, and 12 cases were invalid.

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The study of Yokoyama and colleagues, who performed TSB for intractable pain, has reported that the curative effect is temporary and declines with time.

The curative effect of TSB is considered to be a block that extends to not only the peripheral nervous system, but also the central nervous system.

Therefore, in order to guarantee the therapeutic effect of TSB, it is necessary to clarify the cause of pain and timing of TSB. Therefore, further studies to assess this will be needed in the future.

Part XV

Intervertebral Joint, Radiofrequency Thermocoagulation of Posterior Medial Branch

Cervical Facet Joint Block

74

Takahisa Nishiyama and Kiyoshige Ohseto

74.1 Introduction

74.1.1 What Is Facet Pain? [1]

Among forms of the pain affecting the occipital region, temporal/posterior neck, and scapula, pain involving the facet joint is referred to as facet joint pain. Pain can be due to acute sprain of the neck but can also arise from chronic joint capsule inflammation, long-term excessive loading, and other factors. For example, if an automobile standing still is hit by a truck from the rear, the automobile driver's neck vibrates forcefully in the anteroposterior direction, causing facet injury and the onset of pain.

74.2 Indications

74.2.1 Signs/Symptoms Plus Diagnosis and Treatment

Facet joint disease shows characteristic signs/symptoms. Pain arises in the occipital region, lateral/posterior neck, and scapula, and motion restriction due to pain is often seen during extension and rotation of neck. The presence of tender points in the facet is a simple and characteristic finding (Fig. 74.1). There are no characteristic findings on diagnostic imaging.

After other possible diseases have been ruled out by physical examination and diagnostic imaging, facet block is conducted. The affected joint level is definitively diagnosed by contrast-enhanced radiography of the facet and local anesthetic injection into the same site. If steroids are administered simultaneously with local anesthetic injection, prolonged symptom alleviation is achieved in some cases, but early relapse of symptoms also occurs in many cases. Thus, radiofrequency thermocoagulation (RFT) is applied to achieve long-term alleviation of symptoms (Fig. 74.2).

74.3 Anatomy

The facet (zygapophysial) joints are formed by the superior articular process of the inferior lumbar vertebra and the inferior process of the superior lumbar vertebra. Its structure is distinct in the cervical, thoracic, and lumbar regions. Each facet has dual innervations. For example, the L4/L5 facet is supplied by L4 and L5 medial branch of the dorsal ramus.

74.4 Instruments and Drug Solutions

Needles:	2.5 cm 25 G needle, 22 G needle for the nerve block (6 cm)
Syringes:	Three syringes for 5 mL
Drugs:	Local anesthetic (1% mepivacaine or lidocaine)
	Dexamethasone (4 mg and 8 mg)
	Non-ion water-soluble contrast medium

74.5 Procedures and Techniques

74.5.1 Cervical Facet Block (X-Ray Fluoroscopy-Guided Method)

Facet block employs an anterior oblique approach, as well as lateral and posterior oblique approaches.

74.5.1.1 Position

Anterior oblique approach: The patient assumes a supine position, with the affected site placed higher (a 20°

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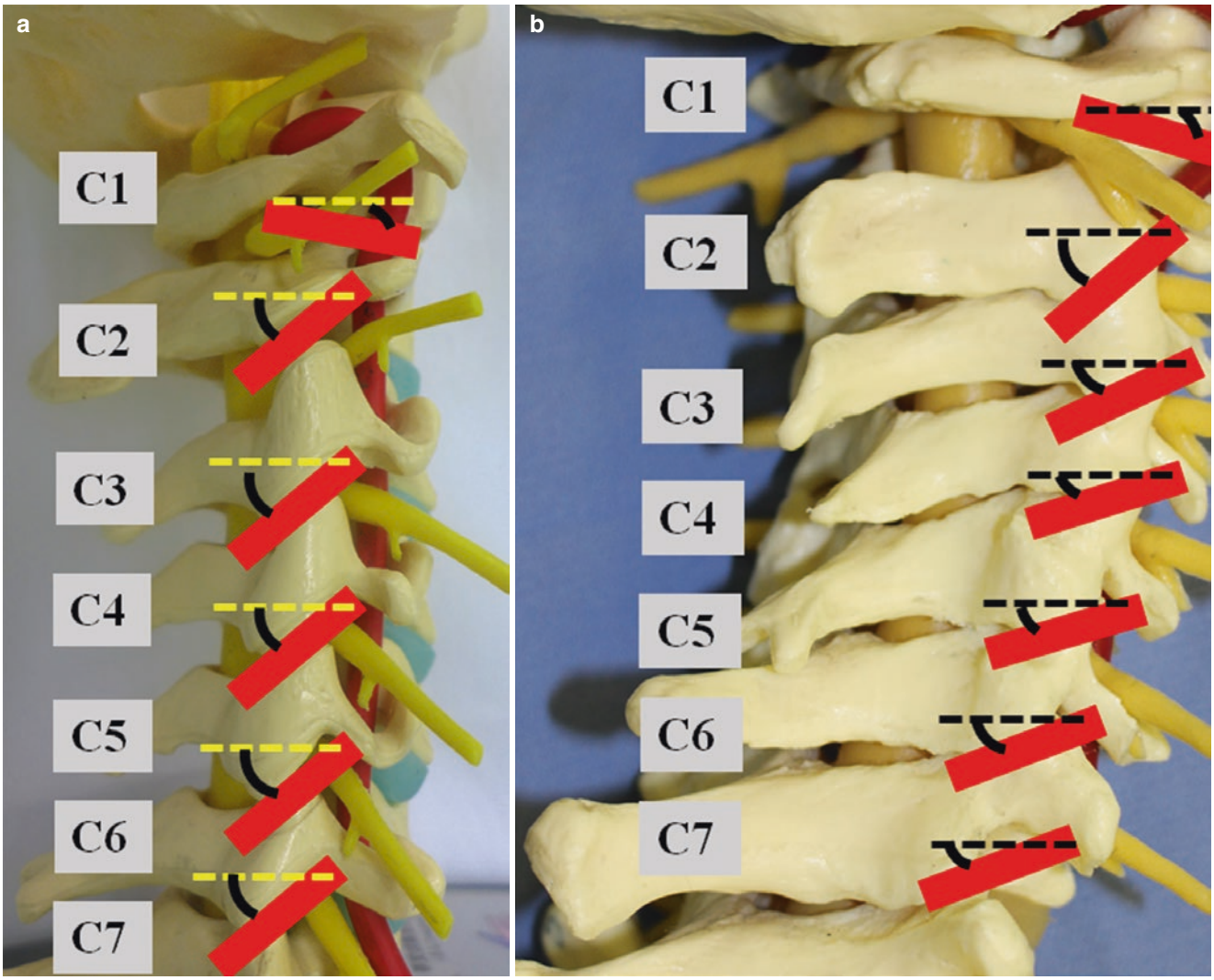


Fig. 74.1 Locations of facets and identifying tender points. Facets are located near the body surface, allowing simple exploration of tender points

oblique position with a pillow placed under the shoulder of the affected side). The face is directed toward the intact side, with the height of the pillow under the head being raised, such that the patient assumes a position of slight flexion. The tube position is shifted toward the head, in an arrangement which allows clear visualization of the articular plane (Fig. 74.3a).

Lateral/posterior oblique approach: The patient assumes a lateral decubitus or a prone position. In the case of assuming the prone position, a pillow is placed under the shoulder of the affected side (10° oblique position). The face is directed toward the intact side, with a pillow placed low under the head, to assure that the patient assumes a position of slight flexion. The tube position is shifted toward the feet, arranged so as to allow clear visualization of the articular plane (Fig. 74.3b). This procedure can be difficult, if the tube dislocation is large. An essential point in positioning is to determine the placement of the patient while checking the fluoroscopic image prior to disinfection, such that the facet can be clearly visualized while minimizing tube dislocation.

74.5.1.2 Needle Insertion

While touching the facet with the left index finger, the surgeon applies a 6 cm 23 G needle to the upper edge (or the lower edge) of the target joint and then punctures the joint by sliding the needle. When the needle enters the joint, a specific sensation may be perceived in the hand, and the patient may complain of induced pain. If contrast material (iohexol) is injected, the patient feels reproducible pain as the contrast within the joint is enhanced. The same steps are taken on a few joints above and under the target joint (Fig. 74.4a). Furthermore, 1% lidocaine (0.5–1 mL) combined with betamethasone (0.5–1 mg) is injected, and alle-

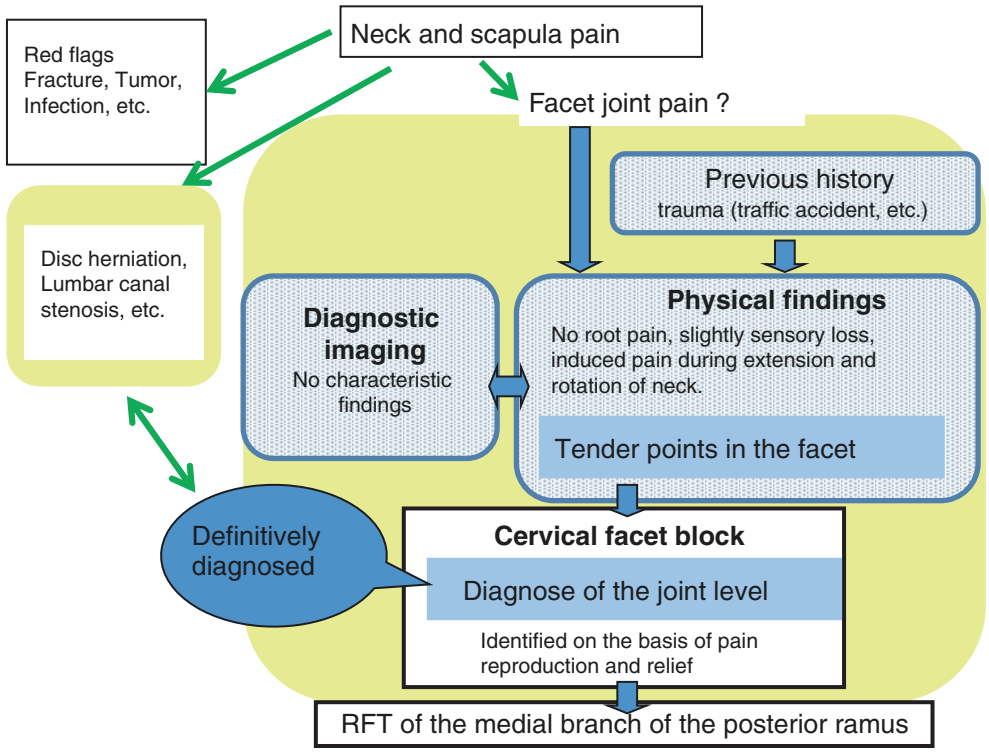


Fig. 74.2 Flow chart on management of facet joint pain

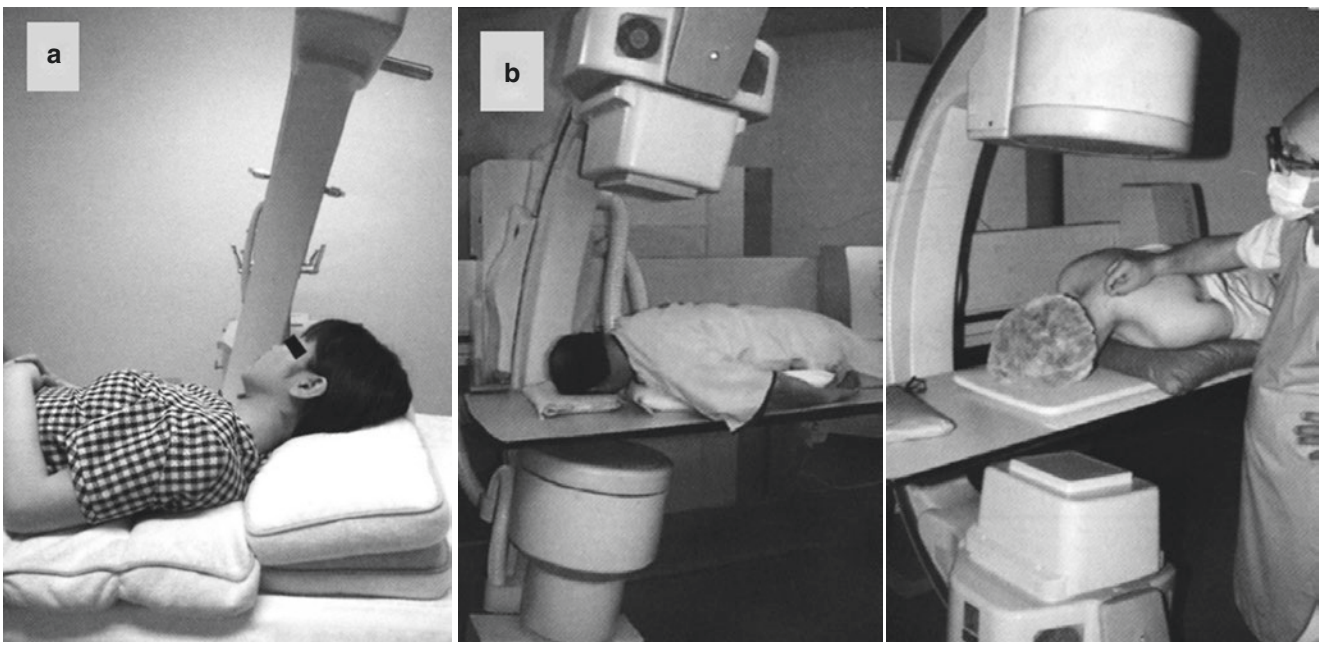
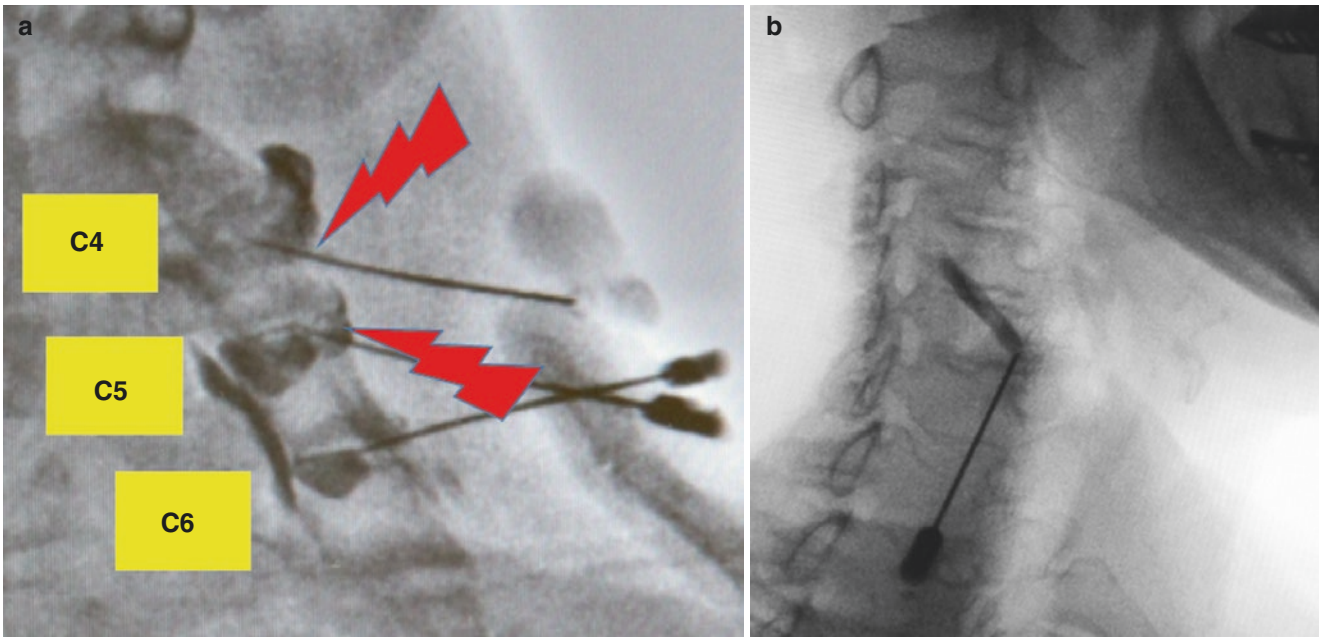


Fig. 74.3 Patient position for facet radiography under fluoroscopic guidance. (**a**) Anterior oblique approach. (**b**) Prone oblique approach

viation of the pain is then confirmed. Thus, the site affected by pain is identified on the basis of pain reproduction and relief. This is a rapid procedure, eliminating restriction of neck motion, but the pain relapses several days later in many cases. RFT is required to achieve long-lasting pain relief.



a. Facet radiography

b. Radiofrequency thermocoagulation

Fig. 74.4 (**a**) Facet radiography and (**b**) radiofrequency thermocoagulation (RFT) of the medial branch of the posterior ramus of the spinal cord. (**a**) Fluoroscopic left cervical facet radiography (C3/C4, C4/C5, C5/C6). Intense radiating pain at C5/C6 resulted from contrast enhancement and drug injection. (**b**) RFT of the medial branch of the posterior ramus at C4

74.5.2 Ultrasound-Guided Method [2]

The facet can be observed employing ultrasonography. Under ultrasound guidance, the facet can be punctured with a needle while the patient is in the lateral decubitus position (Fig. 74.5). The target joint level is easier to check if the number of joints from the C6 level is counted. This procedure is sometimes performed under fluoroscopic observation.

74.5.2.1 RFT of the Medial Branch of the Posterior Ramus of the Spinal Cord [3]

The facet is comprised of upper and lower articular processes, and the medial branch of the posterior ramus of the spinal cord is distributed within it. The facet is double-regulated by the medial branch of the posterior ramus of the spinal cord (e.g., the C5/C6 facet is regulated by the C5 and C6 medial branches of the posterior ramus).

The patient assumes a prone position with the face directed to the affected side. A pillow is placed under the shoulder of the affected site (an approximately 10° inclination of both shoulders). If the pillow is set higher, matching of the intervertebral disc endplate is easier. The body position is fine-tuned to assure that the pedicle on the affected site appears circular. The essential aspect of patient positioning is to guide the patient toward assuming a position which facilitates matching the intervertebral disc endplate and allows clear visualization of the pedicle. A specific Sluyter needle is applied to the adjacent bone under fluoroscopic guidance, and the surrounding area is punctured several times to identify the site that is the source of radiating pain. The inner sheath is removed at this site, and a stimulus electrode is inserted. Stimulation is applied in the stimulatory mode (50 Hz, 0–0.5 V) to confirm intensification of radiating pain. If radiating pain is absent, the surrounding area is explored by applying stimulation under fluoroscopic guidance to identify the site which is the source of radiating pain (Fig. 74.4b). Contrast enhancement is performed, and the absence of the needle within all blood vessels is confirmed before a local anesthetic is administered. Then, RFT is performed at a lesion mode of 80 °C for 90 s. During RFT, the arm needs must be continuously monitored to assure the absence of swelling and paralysis. Immediately after RFT, the pain-caused neck motion restriction often disappears.

Because the posterior ramus of the spinal cord regulates muscular motions of the posterior neck, RFT of multiple posterior rami can result in pain caused by muscular weakness. For this reason, when dealing with facet pain at several sites, RFT needs to be applied on several different occasions

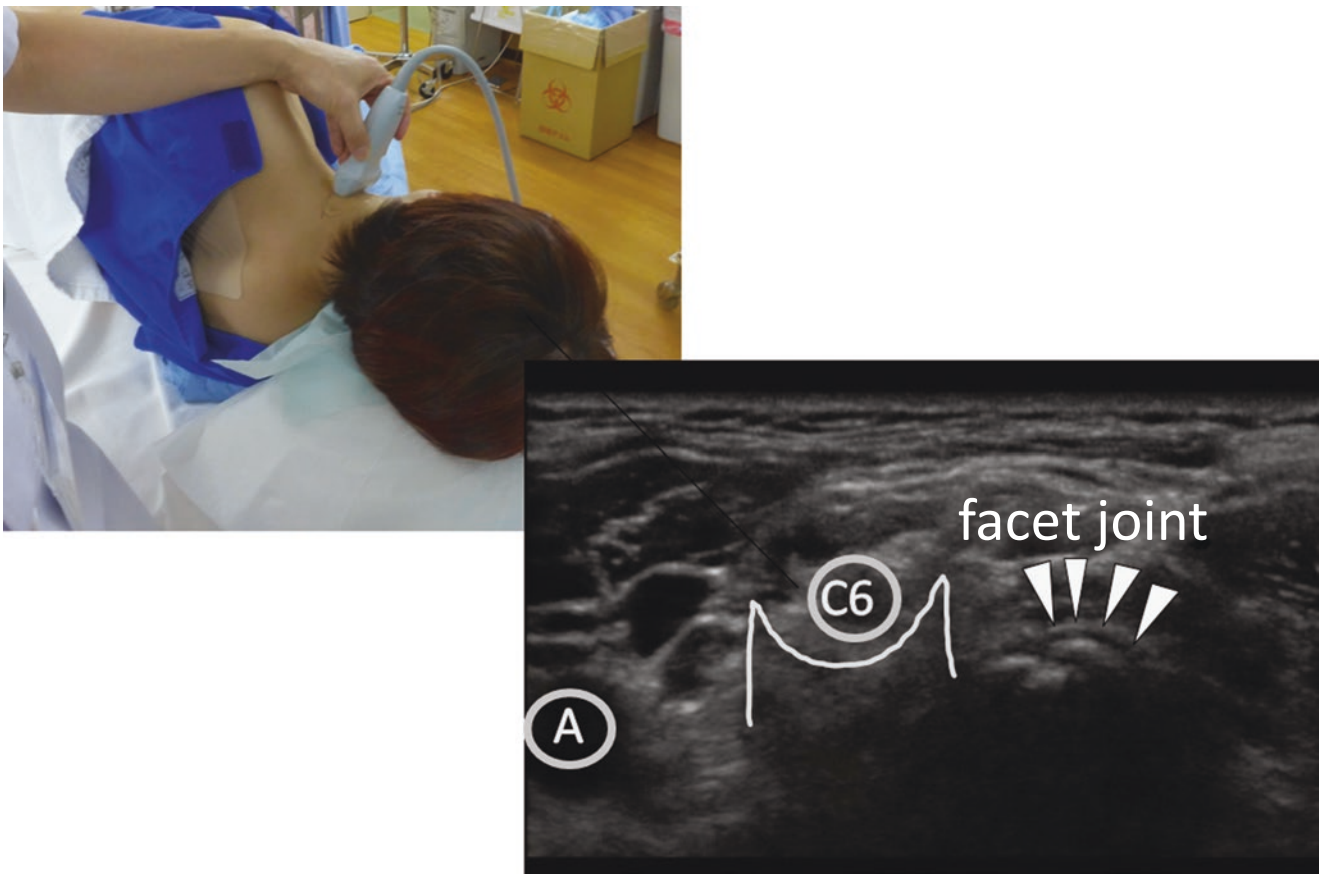


Fig. 74.5 Ultrasound-guided facet block. Body position and imaging. (A) common carotid artery. (C6) C6 nerve root. (▼) Facet

while changing the RFT-applied site from one treatment session to the next.

74.5.3 Conclusions

Facet joint disease is often overlooked because it is difficult to detect with diagnostic imaging. If the tender point of the facet can be identified, the treatment steps (from facet radiography to RFT of the medial branch of the posterior ramus of the spinal cord) can be smoothly undertaken in many cases [4]. It is important to consider the possibility of facet joint disease during routine clinical practice when dealing with patients complaining of neck pain [5].

References

1. Bogduk N. Clinical anatomy of the lumbar spine and sacrum, 4th ed.
2. Loizides A, et al. Ultrasound-guided injections in the lumbar spine. Med Ultrason. 2011;13:54–8.
3. Falco FJ, et al. Systematic review of therapeutic effectiveness of cervical facet joint interventions: An update. Pain Physician. 2012;15:E839–68.
4. Manchikanti L, et al. An update of evaluation of therapeutic thoracic facet joint interventions. Pain Physician. 2012;15:E463–81.
5. Datta S, et al. Systematic assessment of diagnostic accuracy and therapeutic utility of lumbar facet joint interventions. Pain Physician. 2009;12:437–60.

Radiofrequency Thermocoagulation of Posterior Medial Branch of Cervical Spinal Nerve

75

Makoto Fukusaki

75.1 Introductions

Cervical radiofrequency (RF) neurotomy means to be thermocoagulated by radiofrequency cervical medial branch for chronic neck-shoulder pain which derived from cervical facet joints, resulting in getting prolonged therapeutic effects for a long period.

75.2 Indications

Cervical RF neurotomy is applied to neck-shoulder pain and nape-back pain which derived from facet joints due to cervical spondylosis, cervical disc hernia, osteoporosis, compression fracture of cervical vertebral body, and cervical metastatic cancer. The therapeutic effectiveness for neck-shoulder pain should be showed by cervical medial branch blocks and/or cervical intra-articular injection with local anesthetic before cervical RF neurotomy [1]. Lord S et al. [2] reported the effectiveness of cervical RF neurotomy on the facet joint pain in RCT. Recently, Falco et al. [3] conclude that in systematic review of therapeutic effectiveness of cervical facet joint interventions in patients diagnosed with cervical facet pain due to cervical medial branch blocks with a comparison of placebo and local anesthetic, the indicated evidence for cervical RF neurotomy is level II-1 or II-2.

75.3 Anatomy

The posterior primary divisions leave the anterior division and pass posteriorly over the posterior portion of transverse process around the anterior column. All posterior primary divisions of cervical nerves divide into medial and lateral branches. The medial branches pass the dorsal portion around the hollow of joint column (here is the point of thermocoagulation) and become superficial and deep branches posteriorly to supply the skin and subcutaneous structures. The cranial and caudal branches of the deep medial branches appear from dorsal joint column and are distributed to a facet joint (Fig. 75.1 [4]). The cervical facet joint pain, occipital and postero-superior neck pain, posteromedial and postero-inferior neck pain, postero-inferior neck and superior scapular pain, and medial scapular pain are derived from C2/C3 facet joint, C3/C4 and C4/C5 facet joints, C5/C6 facet joint, and C6/C7 facet joint, respectively [5, 6].

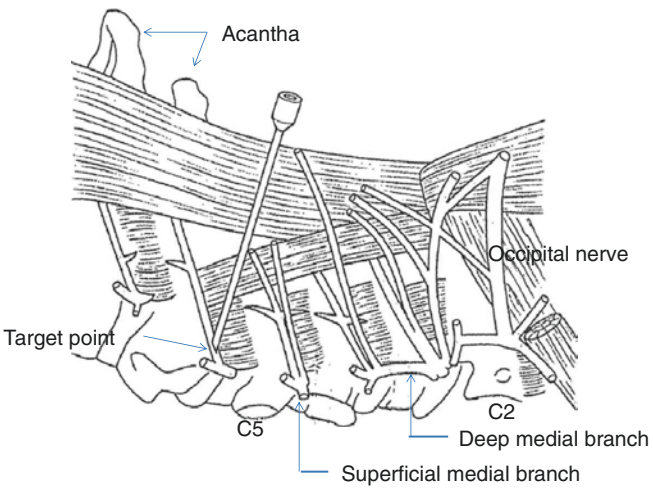


Fig. 75.1 Anatomy of cervical posterior medial branches (supine position)

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75.4 Instruments and Drug solutions

Insulation needle:	Teflon-coated needle of 97 mm with an exposure of 4 mm
Syringes:	Three syringes for 5 mL
Drugs:	Local anesthetic (1% and 2% mepivacaine or lidocaine), dexamethazone (4 and 8 mg), and non-ion water-soluble contrast medium
Sterilization set:	Some kinds of ethyl alcohol
Thermocoagulator (radiofrequency lesion generator unit) radiographic instrument:	Fluoroscopy (C-arm) and roentgenograph
Ultrasound instrument:	Sterilized vinyl pouch, rubber band, and jelly, extension tube

75.5 Procedures and Techniques

The patients lie in prone position with the head on radiolucent rest which affords full access to the neck. Gauci CA [7] recommends supine position for the upper cervical medial branch neurotomy and a prone position for the lower (C5/C6) medial branch neurotomy.

The patient is obtained a clear lateral view of cervical spine by the C-arm (X-ray) fluoroscopy-guided method, and then the C-arm should be rotated on an oblique view of the cervical spine. In this oblique view, intervertebral foramina and their associated facet joints are clearly obtained. The C-arm should control the position of the oblique view for seeing the pedicle of arch of cervical vertebra and posterior tubercle of cervical vertebra in symptom side. When a nerve block needle is contacted in the deep branches around the hollow of joint column, the radiating pain is obtained (Fig. 75.2). After the reproducibility pain, the contraction of paravertebral muscle at 5 Hz and the radiating pain at 50 Hz could be verified. The best position in thermocoagulation is the point which the radiating pain is gotten by electrical stimulation with pulse width of 1 ms and low voltage of less than 0.5 V. Then motor nerve stimulation is performed at 5 Hz and 0.5 mV at the same point. If intraradicular, intra-articular, and intravascular enhancements are not observed after radiograph with contrast medium, a 0.5 mL of 2% mepivacaine is injected. Without complication, once or twice thermocoagulation is performed at 60–90 °C for 90 s. After completion of thermocoagulation, the electrode needle is removed and bleeding stopped with oppression.

75.6 Complications

1. Skin hypoesthesia: no problem for narrow range and temporariness.
2. Depression of dorsal muscle power: slight depression may be caused by some points of thermocoagulation at the same time.

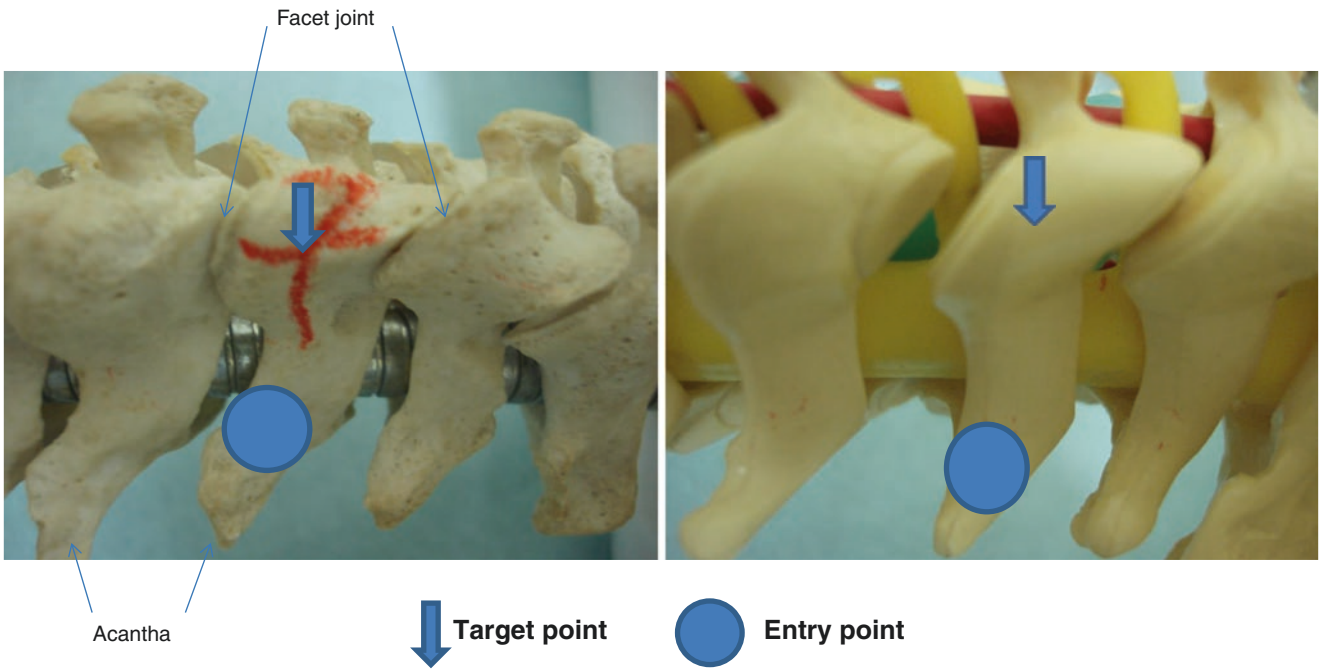

Fig. 75.2 Target and entry point in cervical RF neurotomy (prone position)

3. Pain enhancement: pain enhancement may be caused temporarily in the point thermocoagulated. The mixture of local anesthetic and steroid may be effective for the prophylaxis.
4. Residual pain: nonsteroidal anti-inflammatory drugs may be given for residual pain after thermocoagulation.

References

1. Manchikanti L, Singh V, Rivera J, Pampati V. Prevalence of cervical facet joint pain in chronic neck pain. Pain Physician. 2002;5:242–9.
2. Lord SM, Bamsley L, Wallis BJ, McDonald GJ, Bogduk N. Percutaneous radio-frequency neurotomy for chronic cervical zygapophyseal joint pain. N Engl J Med. 1996;335:1721–6.
3. Falco FJ, Manchikanti L, Datta S, Wargo BW, Geffert S, Bryce DA, Atluri S, Singh V, Benyamin RM, Sehgal N, Ward SP, Helm S 2nd, Gupta S, Boswell MV. Systematic review of the therapeutic effectiveness of cervical facet joint interventions: an update. Pain Physician. 2012;15(6):E839–68.
4. Ohseto K. 11 Keitsui sekizuishinnkei koushinaisokushi kousyuhanetsugyoukohou. In: Ohseto K, editor. Toushika shinnkeiburokkuhou. Tokyo: Igakushoin; 2009. p. 44–6. (in Japanese).
5. Dwyer A, Aprill C, Bogduk N. Cervical zygapophyseal joint pain patterns. I: a study in normal volunteers. Spine. 1990;15:453–7.
6. Fukui S, Ohseto K, Shiotani M, Yuda Y, Wakasugi B. Referred pain distribution of cervical zygapophyseal joints and cervical dorsal rami. Pain. 1996;68:79–83.
7. Gauci CA. Manual of RF techniques 2nd edition a practical manual of radiofrequency procedures in chronic pain management. Amsterdam: Flivo Press; 2008. Chapters 38–46.

Thoracic Facet Block

76

Hideki Toyokawa

76.1 Introductions

76.1.1 About Thoracic Facet Block

Thoracic facet block is performed to relieve pain originating in the intervertebral joint [1]. The procedure is performed under local anesthesia or steroids. It is also useful as a diagnostic nerve block [2]. Blocking the posterior/medial branches of the spinal nerve will have the same efficacy. This article describes the landmark method, the ultrasound-guided approach, and the X-ray fluoroscopic approach.

76.2 Indications

Spondylosis deformans, intervertebral joint pain associated with thoracic compression fracture

76.3 Anatomy

Similar to the lumbar vertebra, the thoracic vertebra is supported by the intervertebral discs in the front and by the intervertebral joints with their superior and inferior articular processes in the back. A pair of intervertebral joints about 1 cm in diameter is located on both sides of each thoracic vertebra. The intervertebral joints are dually innervated by the upper and lower posterior/medial branches of the spinal nerve (Fig. 76.1).

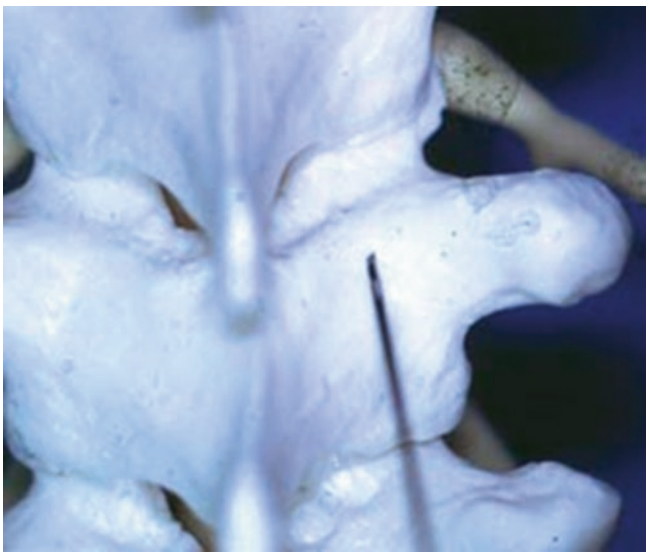

Fig. 76.1 Anatomical approach (X-ray fluoroscopy)

76.4 Instruments and Drug Solutions

Needles:	2.5 cm 25 G needle, 22 G needle for the nerve block (6–10 cm)
Injection syringes:	Three 5 mL syringes (for local anesthesia, steroid, and contrast dye)
Drugs:	0.5–1% lidocaine, 5 mL; dexamethasone, 2–4 mg; non-ionic water-soluble contrast dye, 5 mL
Tools:	For ultrasound: ultrasound diagnostic device, 2–5 Hz convex probe, sterilized probe cover
For X-ray fluoroscopy:	Metal forceps, C-arm X-ray fluoroscopic device

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76.5 Procedures and Techniques

Although the landmark method may be used to block the posterior/medial branches of spinal nerve, the fluoroscopic or the ultrasound-guided approach will be more accurate.

76.5.1 X-ray Fluoroscopy-Guided Method

Lay the patient in the prone position with the chest on a pillow. Determine the intervertebral joint level corresponding to the tender point.

The needle insertion site should be in the caudal end of the inferior pedicle of the vertebral arch of the intervertebral joint. Place the needle tip at the center of the pedicle of vertebral arch and slowly move it in the cranial direction. Inject the contrast dye when sliding of the needle tip is felt. Inject the local anesthetic or the steroid mixture when the ring-shaped articular capsule is shown in the image (Fig. 76.2).

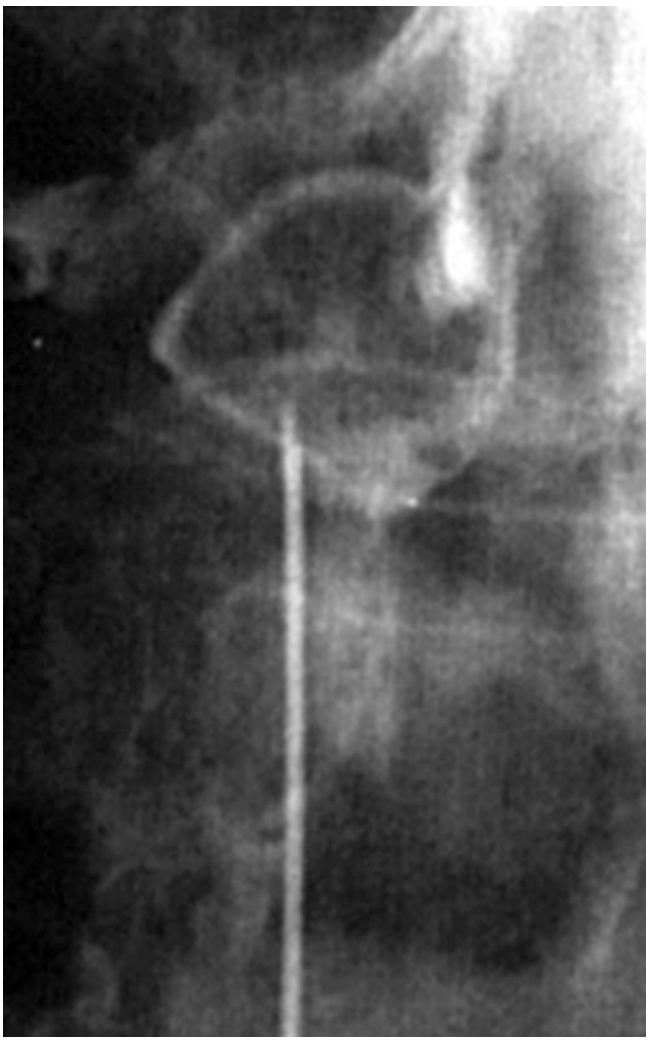

Fig. 76.2 X-ray fluoroscopy: thoracic fact arthrography

76.5.2 Ultrasound-Guided Method

Inject the drug into the tender intervertebral joint. Count the ribs from the 12th rib in the sagittal section to confirm the high spinal position. Insert the needle caudally into the intervertebral space between the superior and the inferior articular processes to inject the drug. Move the probe in the cranial direction from the tip of the spinous process to find the intervertebral joint at the base of the spinous process in the transverse section. Rotate the probe at 90 degrees to see the intervertebral discs as high-intensity lines in the sagittal section. The superior and inferior articular processes will be found in the recessed area between the discs. The space between the articular processes should be the target of the nerve block (Fig. 76.3).

Insert the needle parallel to the probe from the caudal side. Inject the local anesthetic or the steroid mixture when the needle tip reaches the interprocess space. An injection volume of 1–1.5 mL will be sufficient.

76.6 Complications

1. Pneumothorax: Pneumothorax may occur if the needle tip is moved outside the level of the pedicle of the vertebral arch.
2. Spinal tap, epidural block, and subarachnoid block: These complications may occur if the needle tip is moved too far inside. Perform contrast radiography to confirm the

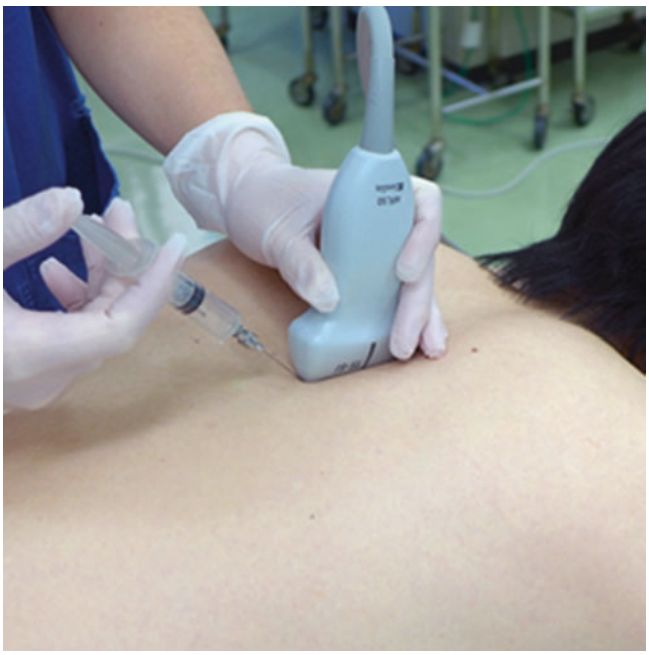

Fig. 76.3 Ultrasound-guided approach

absence of subarachnoid or epidural blockage or aspiration of spinal fluid.

3. Nerve root puncture: Nerve root puncture may occur if the needle tip is moved downward and outward from the pedicle of the vertebral arch. Watch for pain radiating to the chest.

References

1. Manchikanti L, et al. An update of evaluation of therapeutic thoracic facet joint interventions. Pain Physician. 2012;15:E463–81.
2. Sehgal N, et al. Systematic review of diagnostic utility of facet (zygapophysial) joint injections in chronic spinal pain: an update. Pain Physician. 2007;10:213–28.

Radiofrequency Thermocoagulation of the Posterior Medial Branch of the Thoracic Spine (X-Ray Guided)

77

Keiichi Omote

77.1 Introductions

77.1.1 Overview

The thoracic facet joints are formed by the articulation of the superior and inferior articular facets of the adjacent vertebrae. The joints are true joints in that they are lined with synovium and possess a joint capsule. This capsule is richly innervated and supports the notion of the facet joint as a pain generator [1]. In the patients who receive only temporary relief from therapeutic intra-articular facet block or who have pain that is more diffuse, requiring treatment at numerous levels, radiofrequency coagulation of the posterior medial branch of the thoracic spine can produce pain relief [2].

77.2 Indications

Facet joint-related pain: thoracic facet syndrome, secondary thoracic facet joint syndrome associated with thoracic compression fracture, metastatic thoracic spine tumor, or joint sprain

77.3 Anatomy

Each thoracic facet joint receives innervation from two spinal levels. Each joint receives fibers from the dorsal ramus at the same level as the vertebra as well as fibers from the dorsal ramus of the vertebra above. This fact has clinical impact in that it provides an explanation for the ill-defined nature of facet-mediated pain and explains why the dorsal nerve from the vertebra above the offending level must often also be blocked to provide complete pain relief. At each level, the dorsal ramus provides a medial branch that typically crosses the superolateral corners of the transverse processes and then passes medially and inferiorly across the posterior surfaces of the transverse processes (Fig. 77.1). At mid-thoracic levels (Th5–Th8), the curved course remains the same, but the inflection occurs at a point superior to the superolateral corner of the transverse process.

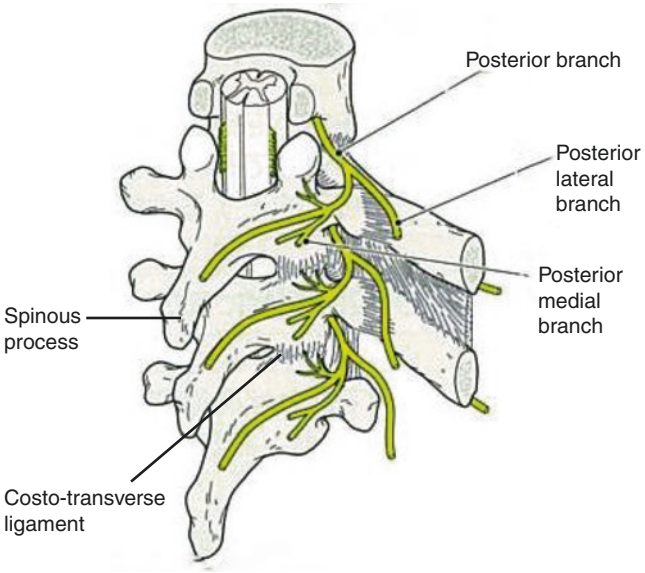

Fig. 77.1 Innervation from two spinal levels at each thoracic facet joint

77.4 Instruments and Drug Solutions

1. Needle: 6 cm 23-gauge needle, or 23-gauge spinal needle, 18-gauge drawing needle
2. 22-gauge, 10-cm radiofrequency needle
3. 1% mepivacaine, dexamethasone
4. Iodinated contrast
5. Radiofrequency generator

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77.5 Procedures and Techniques (X-Ray Fluoroscopy-Guided Method)

The patient lies prone, with the head turned to one side. The C-arm is positioned over the thoracic spine without angulation. The transverse processes of the thoracic vertebrae are best seen from this angle at both high and low thoracic levels. The thoracic level can be identified by counting downward from Th1 or upward from Th12.

Following sterilizing the skin, the skin and subcutaneous tissue overlying the facet target where the block is to be carried out are anesthetized with 1% mepivacaine, using a 23-gauge needle. A 22-gauge, 10-cm radiofrequency needle with 4-mm active tip is placed through the skin and advanced until it is seated in the tissues in a plane that is coaxial with the axis of the X-ray path. The needle is adjusted to remain coaxial and advanced toward the superolateral margin of the transverse process and is seated on the bony margin (Fig. 77.2). Once the radiofrequency needle is seated against the superior margin of the transverse process, the cannula is walked superolaterally off the transverse process and advanced 2–3 mm to position the active tip along the course of the medial branch nerve (Figs. 77.3 and 77.4). Proper testing for sensory-motor dissociation is conducted (the patient should report pain or tingling during stimulation at 50 Hz at less than 0.5 V and have no motor stimulation to the affected myotome of the chest wall at 2 Hz at no less than three times the sensory threshold or 3 V). Each level is anesthetized with 0.5 mL of 1% mepivacaine, and lesions are created at 90 °C, 90 s.

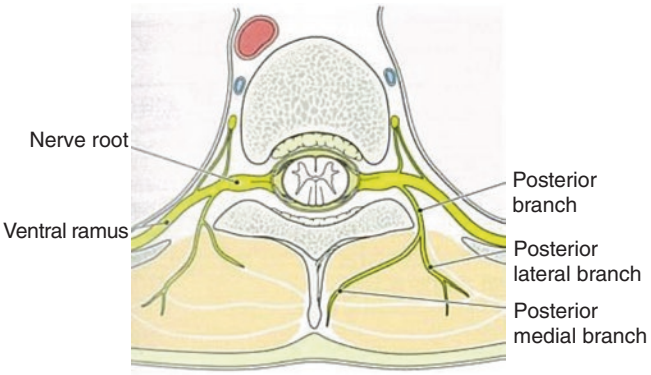

Fig. 77.2 Posterior medial branch of the thoracic spine

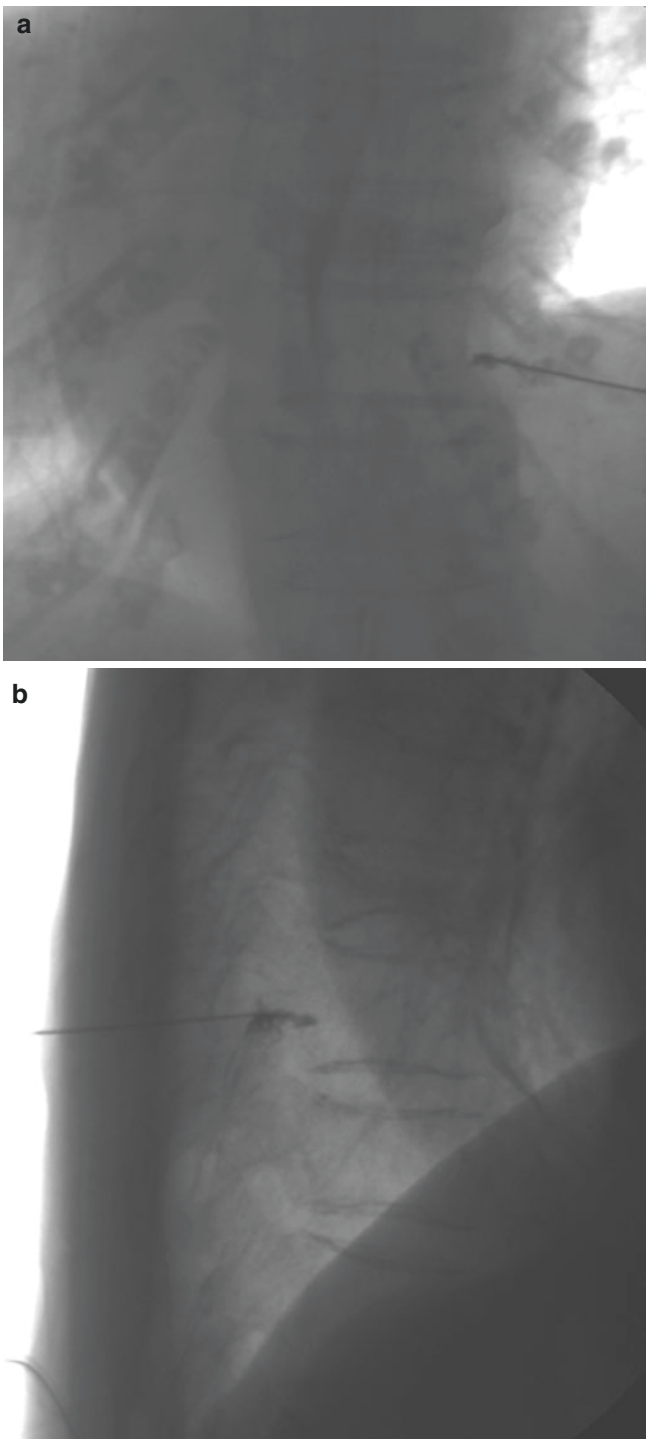

Fig. 77.3 Radiofrequency needle position and contrast image on radiofrequency thermocoagulation of the posterior medial branch of the thoracic spine. (**a**) Frontal view and (**b**) lateral view

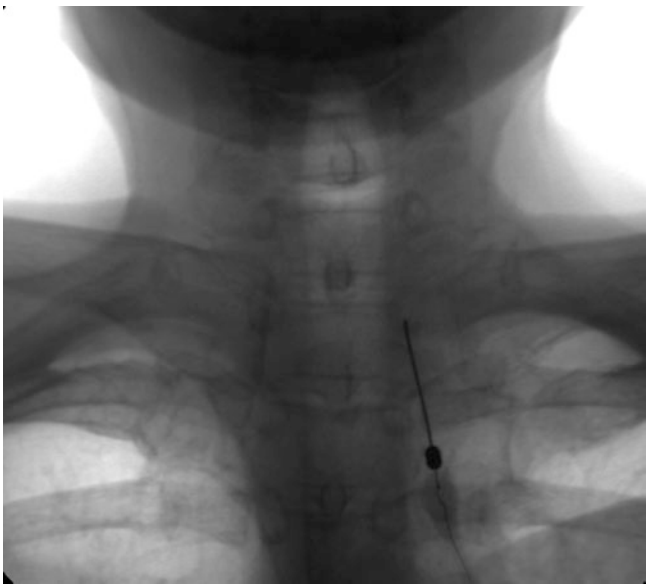

Fig. 77.4 Radiofrequency thermocoagulation of the posterior medial branch of the upper thoracic spine

77.6 Complications

Exacerbation of back pain following radiofrequency treatment, which lasts from several days to a week or more

Trauma to nerve roots due to placing the needle too deep between the transverse processes

Pneumothorax

Weakness of back muscle strength

References

1. Dreyfuss P, Tibilette C, Dreyer SJ. Thoracic zygapophysial joint pain patterns: a study in normal volunteers. Spine. 1994;19:807–11.
2. Mikeladze G, Espinal R, Finnegan R, et al. Pulsed radiofrequency application in treatment of chronic zygapophyseal joint pain. Spine J. 2003;3:360–2.

Lumbar Spine Facet Block (Ultrasound-Guided and X-Ray Fluoroscopy-Guided)

78

Keiichi Omote

78.1 Introductions

78.1.1 Overview

Facet joint is one causative mechanism in the etiology of low back pain. Facet joint blocks have long been used in the diagnosis and management of spinal pain syndrome. Osteoarthritis of the spine is ubiquitous and an inevitable part of aging. The degenerative cascade that leads to degeneration of the intervertebral discs causes progressive disc dehydration and loss of disc height. Disc degeneration leads to increased mobility of adjacent vertebrae and increased shear forces in the facet joints themselves. These problems may manifest clinically as ill-defined back pain that radiates into the hips, buttocks, and thighs in a non-dermatomal pattern [1, 2]. An understanding of facet-related pain syndromes and the methods for placing medication directly within the facet joint proves useful.

78.2 Indications

Lumbar spine facet block using the intra-articular technique is indicated primarily as a diagnostic maneuver to prove that a specific facet joint is in fact the source of pain. Lumbar spinal fact block is suitable for most clinical applications, including the treatment of painful conditions involving trauma, arthritis, or inflammation of the lumbar spinal facet joints.

78.3 Anatomy

The lumbar spine facet joints are paired diarthrodial synovial joints formed by the inferior articular process of one vertebra and the superior articular process of the subjacent vertebra (Fig. 78.1). A tough fibrous capsule is present on the posterolateral aspect of the facet joint. It is composed of several layers of fibrous tissue and a synovial membrane, separated by a layer of loose areolar tissue. The synovium and joint space normally extend a variable distance along the superior or inferior articular process and under the capsule. There is no fibrous capsule on the vertebral aspect of the joint. Instead, in its place, there exists the ligamentum flavum, which is in direct contact with the synovial membrane. The adipose tissue in the superior recess of the facet joint is in direct contact with the adipose tissue surrounding the spinal nerve, thereby providing a direct route to the epidural space. In fact, owing to the small

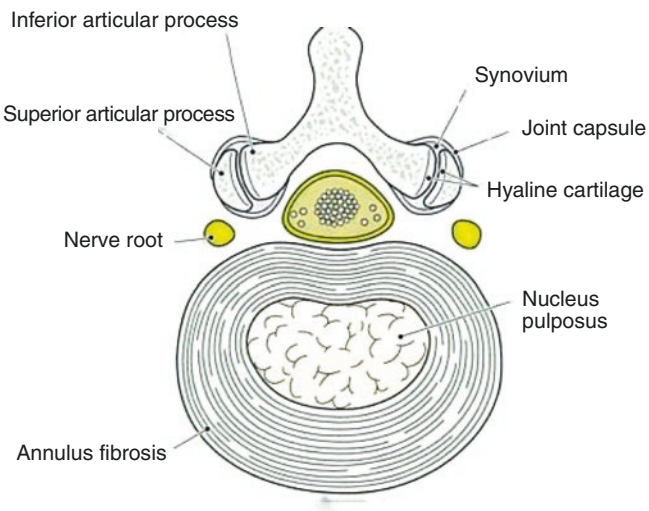

Fig. 78.1 Horizontal anatomical aspect of lumbar facet joints

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volume of the lumbar facet joint space, approximately 1.0–2.0 mL, volumes of therapeutic agent in excess of this amount may extravasate into the epidural space by this route (Fig. 78.1).

The lumbar facet joints are angled with a somewhat oblique orientation, allowing for flexion, extension, and rotation that is greater than that in the thorax but less than in the cervical region (Fig. 78.2).

78.4 Instruments and Drug Solutions

1. Needle: 6 cm 23-gauge needle or 23-gauge spinal needle, 18-gauge drawing needle
2. 1% mepivacaine, dexamethasone
3. Iodinated contrast (under the fluoroscopy)
4. 20-gauge needle (under the ultrasound-guided)

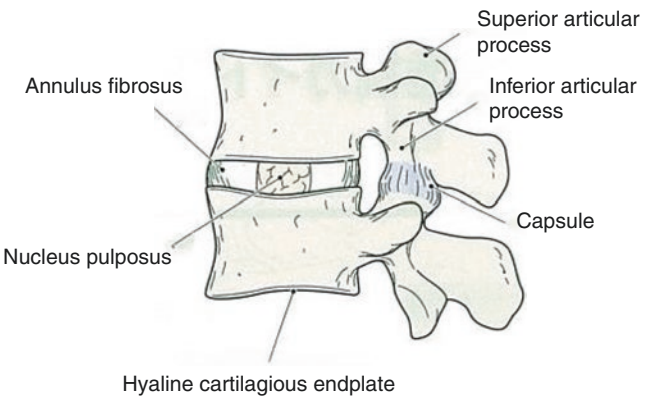

Fig. 78.2 Sagittal diagram depicting the components of the lumbar facet joint

78.5 Procedures and Techniques

78.5.1 Ultrasound-Guided Method

The patient is placed in the prone position, and a low-frequency curvilinear transducer is used. First, a longitudinal midline sonogram is obtained to identify the correct spinal level. The dorsal surface of the sacrum is easily identified, and the lumbar spinal processes can be counted from caudal to cephalad. By sliding the transducer laterally, a longitudinal paravertebral image is obtained, and the corresponding transverse processes can be easily seen (Fig. 78.3). Once the appropriate level is identified, the transducer can be rotated transversely to obtain a short-axis view showing the facet joint space between the inferior and superior articular processes (Fig. 78.4). The target is the midpoint of the joint space. After preparation of the skin with antiseptic solution, a skin wheal of 1% mepivacaine is raised at the site of 23-gauge needle insertion. A 20-gauge needle is advanced in-plane with the US beam from lateral to medial under real-time ultrasound image aiming toward the target (Fig. 78.4). Often it is difficult to see the entire needle shaft clearly while it is advanced because the needle angle is usually between 45 and 60°. 1% mepivacaine and dexamethasone are injected (1 mL).

78.5.2 X-Ray Fluoroscopy-Guided Method

The patient is placed prone with the hips supported by pillows. C-arm is angled obliquely 25–35° from the sagittal plane and without caudal angulation. This angle allows direct visualization of the facet joint (Fig. 78.5). After preparation of the skin with antiseptic solution, a skin wheal of 1% mepivacaine is raised at the site of 23-gauge needle

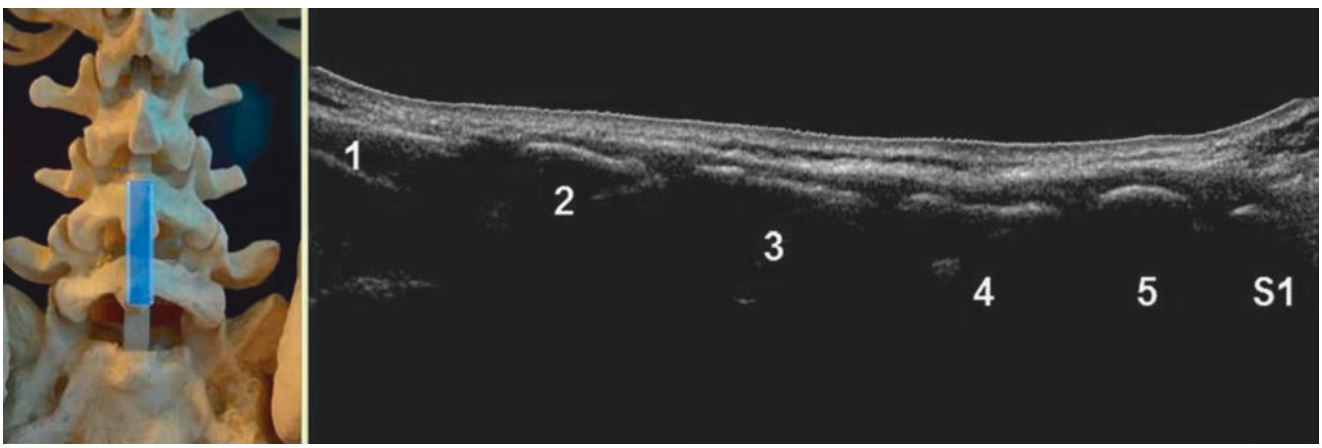

Fig. 78.3 Longitudinal midline sonogram of lumbar spinous processes

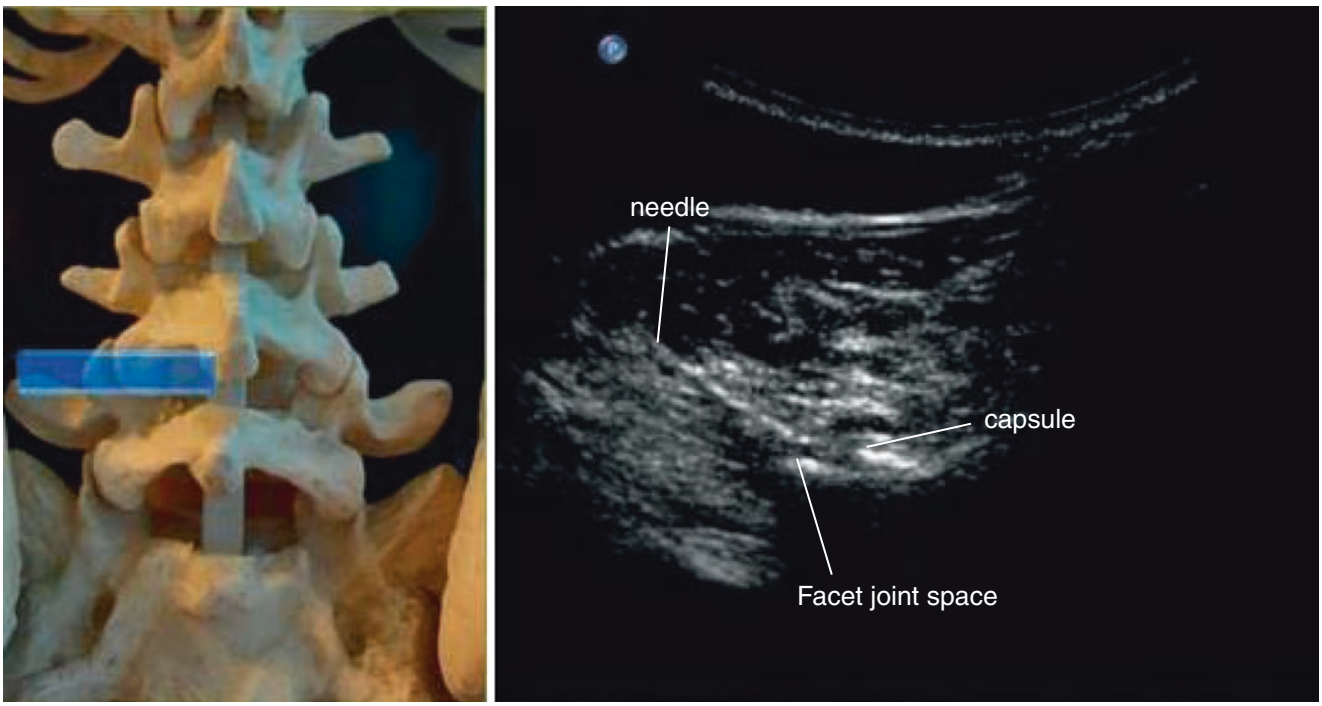

Fig. 78.4 Short-axis view of the lumbar facet joint. The sonogram shows the needle placed in the joint

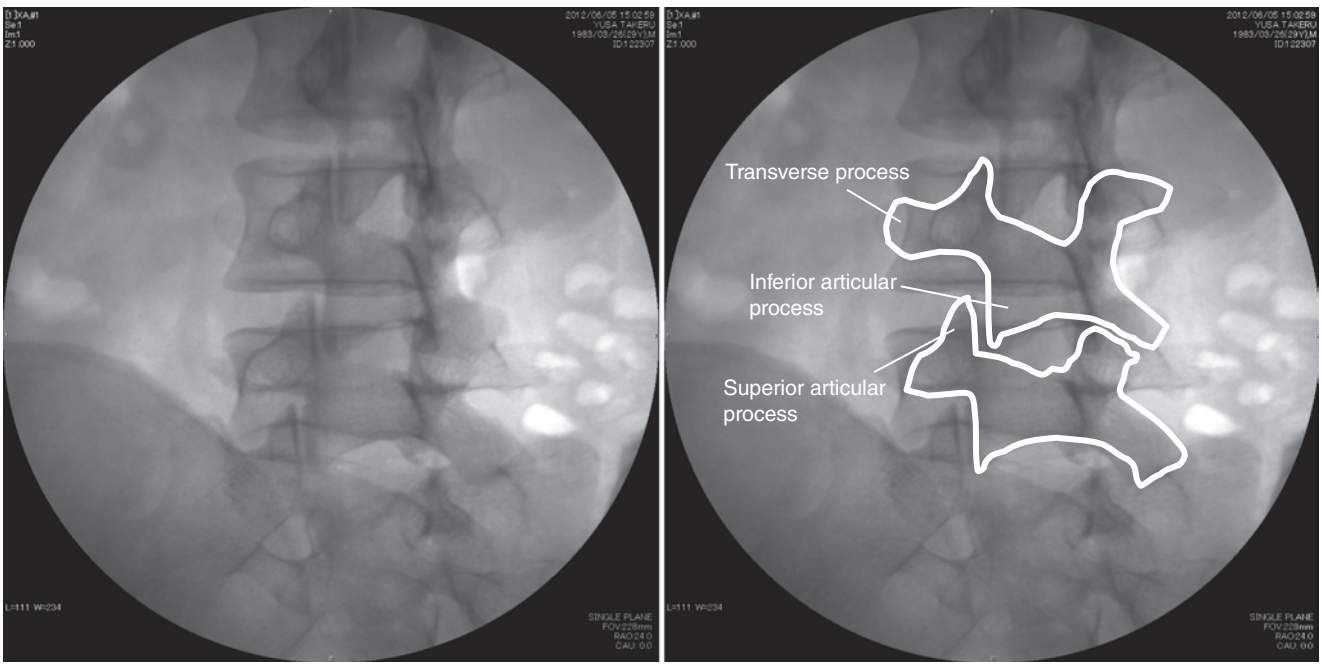

Fig. 78.5 Oblique fluoroscopic image for the lumbar spinal facet block

insertion. A 23-gauge, 6 cm needle is inserted at the insertion site to serve as an introducer. The fluoroscopy beam is aimed directly through the introducer needle, which will appear as a small point on the fluoroscopy screen. The needle is then adjusted to remain coaxial and advanced toward the joint space (Fig. 78.6). The lumbar spine facet joint itself holds only limited volume (<1.5 mL), and placing contrast in the joint limits the ability to place mepivacaine

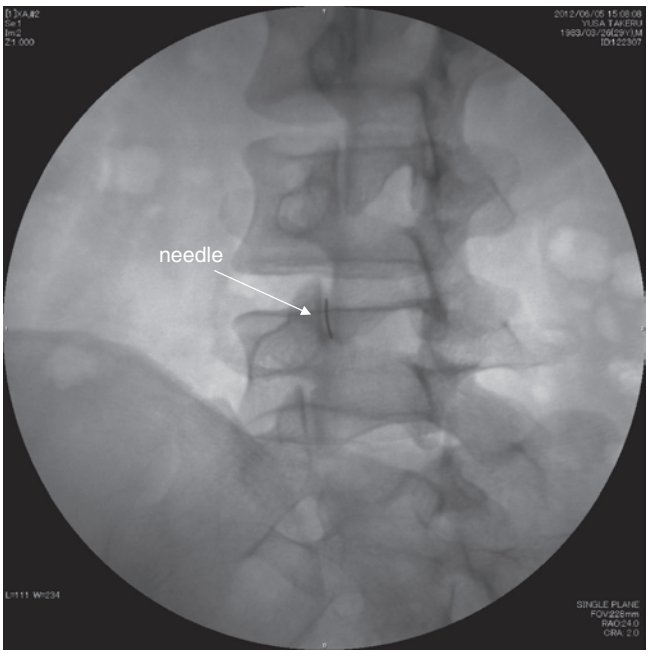

Fig. 78.6 Fluoroscopic image showing the needle inserted for the facet block

and dexamethasone within the joint. Nonetheless, intra-articular injection of contrast medium is commonly carried out at the lumbar levels (Fig. 78.7). Once needle position has been confirmed, a solution containing 1% mepivacaine and dexamethasone is placed. To block the lumbosacral facet joint, it may be necessary to move the needle insertion point slightly more inferior and lateral to avoid the posterior superior iliac crest.

78.6 Complications

Complications associated with lumbar spine facet block are uncommon. The most likely complication is exacerbation of pain. The joint space is narrow and advancing the needle within the joint can abrade the articular surface, causing increased pain.

Infection can also occur, leading to abscess within the paraspinous musculature, but the incidence is extremely low.

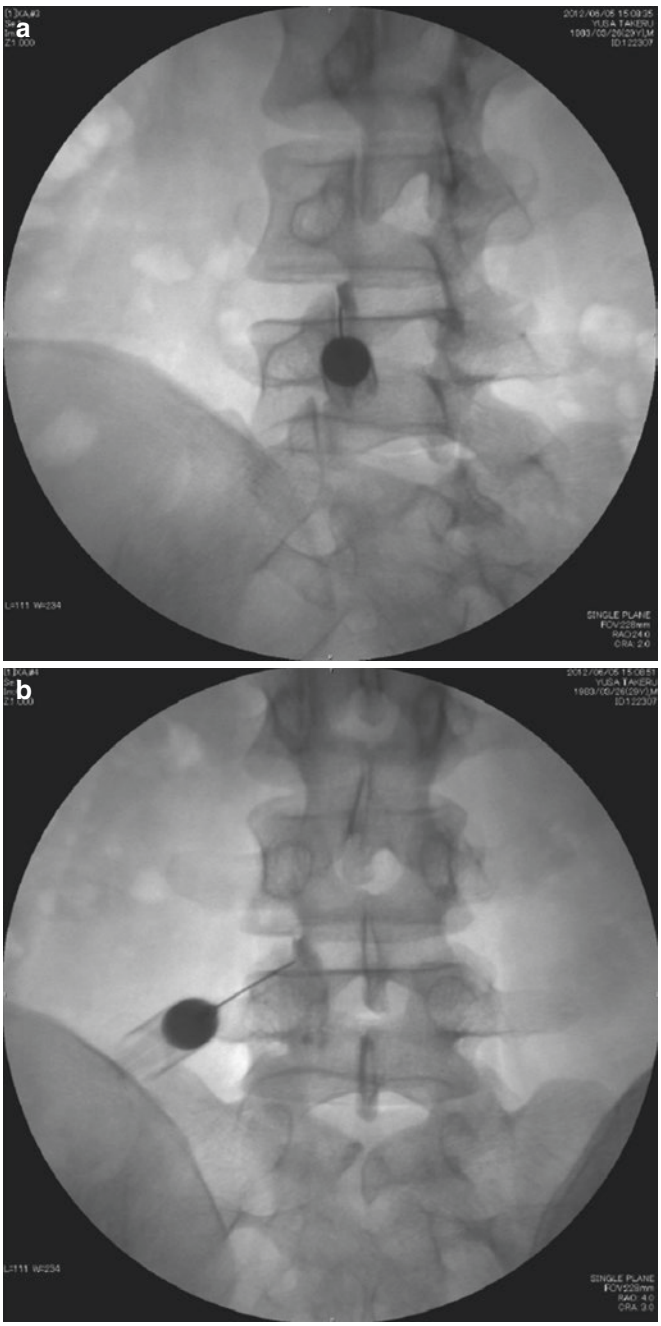

Fig. 78.7 Radiograph after injection of radiographic contrast medium into the facet joint. (**a**) Oblique view. (**b**) Anteroposterior view

References

1. Marks R. Distribution of pain provoked from lumbar facet joints and related structures during diagnostic spinal infiltration. Pain. 1989;39:37–40.
2. Schwarzer AC, Aprill CN, Derby R, et al. Clinical features of patients with pain stemming from the lumbar zygapophysial joints: is the lumbar facet syndrome a clinical entity? Spine. 1994;19: 1132–7.

Radiofrequency Thermocoagulation of the Posterior Medial Branch of the Lumbar Spine (X-Ray Guided)

79

Keiichi Omote

79.1 Introduction

79.1.1 Overview

The joint capsule of facet is richly innervated and supports the notion of the facet joint as a pain generator [1]. Each facet joint receives innervation from two spinal levels involving branches from the dorsal ramus at the same segmental level as well as fibers from the dorsal ramus of the suprasegmental level above. Prognostic lumbar facet block with local anesthetic is useful in predicting whether radiofrequency lesioning of the affected facet joint will provide long-lasting relief of painful conditions [2].

79.2 Indications

Facet joint-related pain: lumbar facet joint syndrome, secondary lumbar facet joint syndrome associated with spondylosis deformans, spondylolisthesis, lumbar spinal canal stenosis, lumbar compression fracture, and trauma, arthritis, or inflammation of the lumbar facet joints.

79.3 Anatomy

The sensory innervation to the facet joints is predictable, and the sensory nerves are easily accessible from the back. The spinal nerve at each level exits the intervertebral foramen and divides into anterior and posterior primary rami (Fig. 79.1). The posterior primary ramus divides into a lateral branch that provides innervation to the paraspinous musculature and a small, variable sensory distribution to the skin overlying the spinous processes, whereas the medial branch courses over the base of the transverse process, where it joints with the superior articular process of the facet joint and courses along the articular process to supply sensation to the joint (Fig. 79.1). Each facet joint receives sensory innervation from the medial branch nerve at the same vertebral level, as well as from a descending branch from the vertebral level above; thus two medial branch nerves must be blocked for each facet joint (e.g., medial branch blocks at the base of the L4 and L5 transverse processes are needed to block the L4/L5 facet joint) (Fig. 79.1).

79.4 Instruments and Drug Solutions

1. Needle: 6-cm 23-gauge needle or 23-gauge spinal needle, 18-gauge drawing needle
2. 22-gauge, 10-cm radiofrequency needle
3. 1% mepivacaine, dexamethasone
4. Iodinated contrast (under the fluoroscopy)
5. Radiofrequency generator

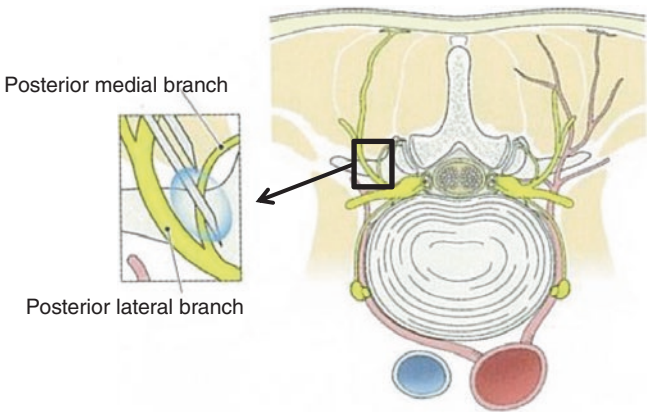

Fig. 79.1 Posterior medial branch of the lumbar spine

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79.5 Procedures and Techniques

The patient lies prone, with the head turned to one side. A pillow is placed under the lower abdomen in an effort to tilt the pelvis backward and swing the iliac crests posteriorly away from the lumbosacral junction. The C-arm is positioned over the lumbar spine with oblique angulation so the facet joints, as well as the junction between the transverse process and the superior articular process, are clearly seen (Fig. 79.2). Following sterilizing the skin, the skin and subcutaneous tissue overlying the facet target where the block is to be carried out are anesthetized with 1% mepivacaine, using a 23-gauge needle. The lumbar level can be identified by counting upward from the sacrum. A 22-gauge, 10-cm radiofrequency needle with 4-mm active tip is used. Once the needle is seated against the superior margin of the transverse process, called the eye of Scottie dog (Fig. 79.2), where it joins the superior articular process of the facet, the needle is walked off the superior margin of the transverse process and advanced 2–3 mm to position the active tip along the course of the medial branch nerve (Fig. 79.3). Proper testing for sensory-motor dissociation is conducted (the patient should report pain or tingling during stimulation at 50 Hz at less than 0.5 V and have no motor stimulation to the affected myotome at 2 Hz at no less than three times the sensory threshold or 3 V). Each level is anesthetized with 1% mepivacaine, and lesions are created at 90 °C for 90 s.

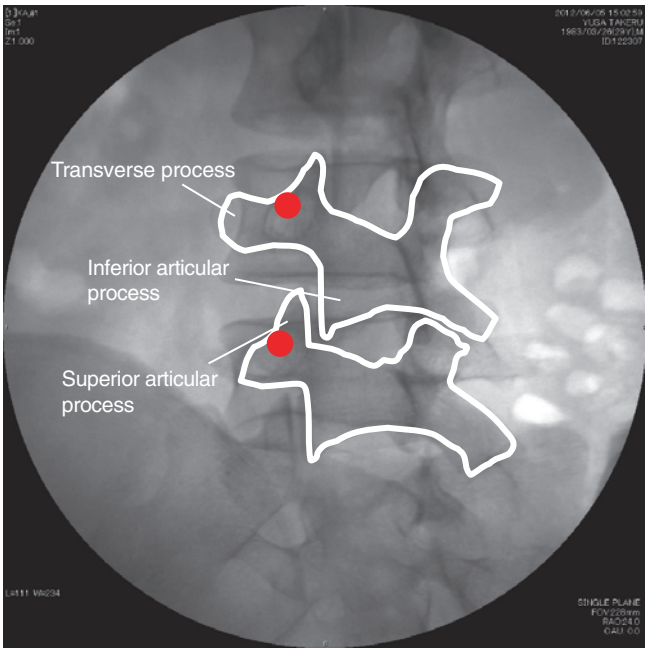

Fig. 79.2 The eye of the Scottie dog which overlies the posterior medial branch

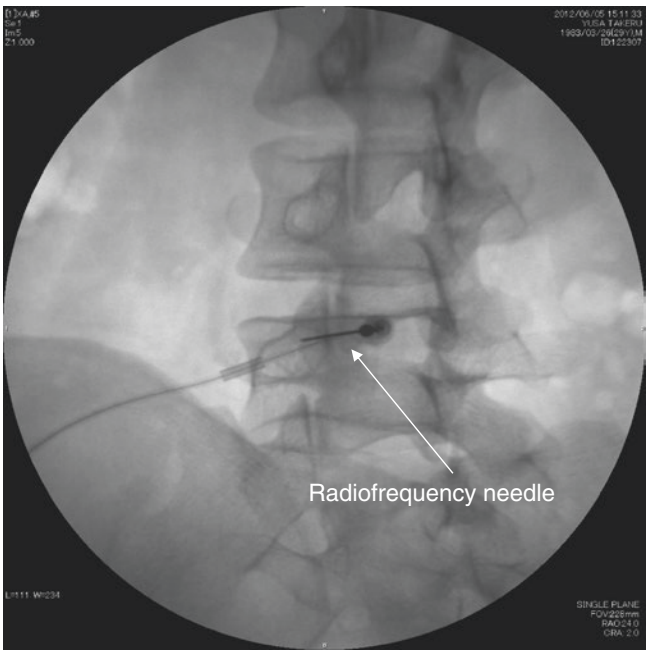

Fig. 79.3 Radiofrequency needle position for the radiofrequency thermocoagulation of the posterior medial branch of the lumbar spine

79.6 Complications

Exacerbation of lumbar pain following radiofrequency thermocoagulation, which lasts from several days to a week or more.

Uncomfortable dysesthesia: sunburned feeling of the skin overlying the spinous processes at the level of treatment, often accompanied by allodynia, due to partial denervation of the lateral branch of the posterior primary ramus.

References

1. Schwarzer AC, Aprill CN, Derby R, et al. The relative contributions of the disc and zygapophysial joint in patients with chronic low back pain. Spine. 1994;19:801–6.
2. Slipman CW, Bhat AL, Gilchrist RV, et al. A critical review of the evidence for the use of zygapophysial injections and radiofrequency denervation in the treatment of low back pain. Spine J. 2003;3:310–6.

Comment

80

Keiichi Omote

The medial branches of the dorsal rami of the spinal nerves, which innervate the facet joints, carry pain signals from the facet joints in the cervical, thoracic, and lumbar spine and the sacroiliac joint to the central nervous system. When facet joint syndrome is diagnosed, application of high-frequency thermocoagulation or pulse radiofrequency to these nerves under radiologic guidance is highly effective.

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Part XVI

Nerve Root Block (X-Ray-Guided, Ultrasound-Guided)

Cervical Nerve Root Block

81

Hisashi Date and Tomofumi Chiba

81.1 Introductions

81.1.1 What Is a Cervical Nerve Root Block?

A cervical nerve root block is a blocking procedure used to eliminate symptoms with local anesthesia and steroid injections into the cervical nerve roots (C1–C8) running through the intervertebral foramens to the outside of the spinal canal or in areas surrounding the nerve roots.

81.2 Indications

1. Cervical vertebra diseases, including cervical intervertebral disk herniation, cervical spondylotic radiculopathy, traumatic cervical syndrome, and thoracic outlet syndrome
2. Cervicobrachial postherpetic neuralgia
3. Complex regional pain syndrome in the upper limb region
4. Headache, including tension headache and cluster headache
5. Cancer pain in the cervicobrachial region

81.3 Anatomy (Fig. 81.1a, b)

There are eight pairs of cervical nerves. The C1–C7 nerve roots branch out from the C1–C7 vertebrae and their cranial cervical vertebrae. The C8 nerve root, however, passes between the seventh cervical vertebra and the first thoracic vertebra. Because the atlas and axis, which are the first and second cervical vertebrae, respectively, differ in structure from other vertebral bodies, the courses of the C1 and C2 spinal nerves differ from those of C3 and the more caudal spinal nerves. Although the course of the C1 nerve root is slightly medial to the groove for the vertebral artery, the rice-grain-sized C1 spinal ganglion, which measures about 2 mm, is located in the posterior nerve root at a site before the confluence of the C1 spinal ganglion and the anterior root. The C2 spinal ganglion is present slightly medial to the center of the posterior surface of the atlantoaxial joint. The C3–C7 vertebral bodies have transverse processes, and the transverse processes of the third to sixth cervical vertebrae have a U-shaped watershoot-like structure that is open toward the cranial side. The ventral side of this structure is called the anterior tubercle, and the dorsal side is called the posterior tubercle. The C3–C6 nerve roots run through this watershoot-like neural groove. The transverse processes of the third to sixth cervical vertebrae have transverse foramens, through which the vertebral artery runs toward the cranial and caudal sides. The transverse processes of the seventh cervical vertebra do not have anterior tubercle or transverse foramen, and the neural groove is shallow, short, and broad. The C7 nerve root and the vertebral artery run ventral to the transverse processes.

81.4 Instruments and Drug Solutions

1. Puncture needle: 23-G 6-cm block needle (for C2, 23-G 8-cm block needle)
2. Three 5-mL syringes (local anesthesia, contrast agent)
3. Drug solutions: 0.5–1% lidocaine, water-soluble steroid [1]

81.5 Procedures and Techniques

The cervical nerve root blocking technique for the C1 and C2 nerve roots is different from that for the C3 and the lower nerve roots because of their different anatomies. Nerve root blocks for C3 or the lower nerve roots are conducted under X-ray fluoroscopy-guided or ultrasound-guided method.

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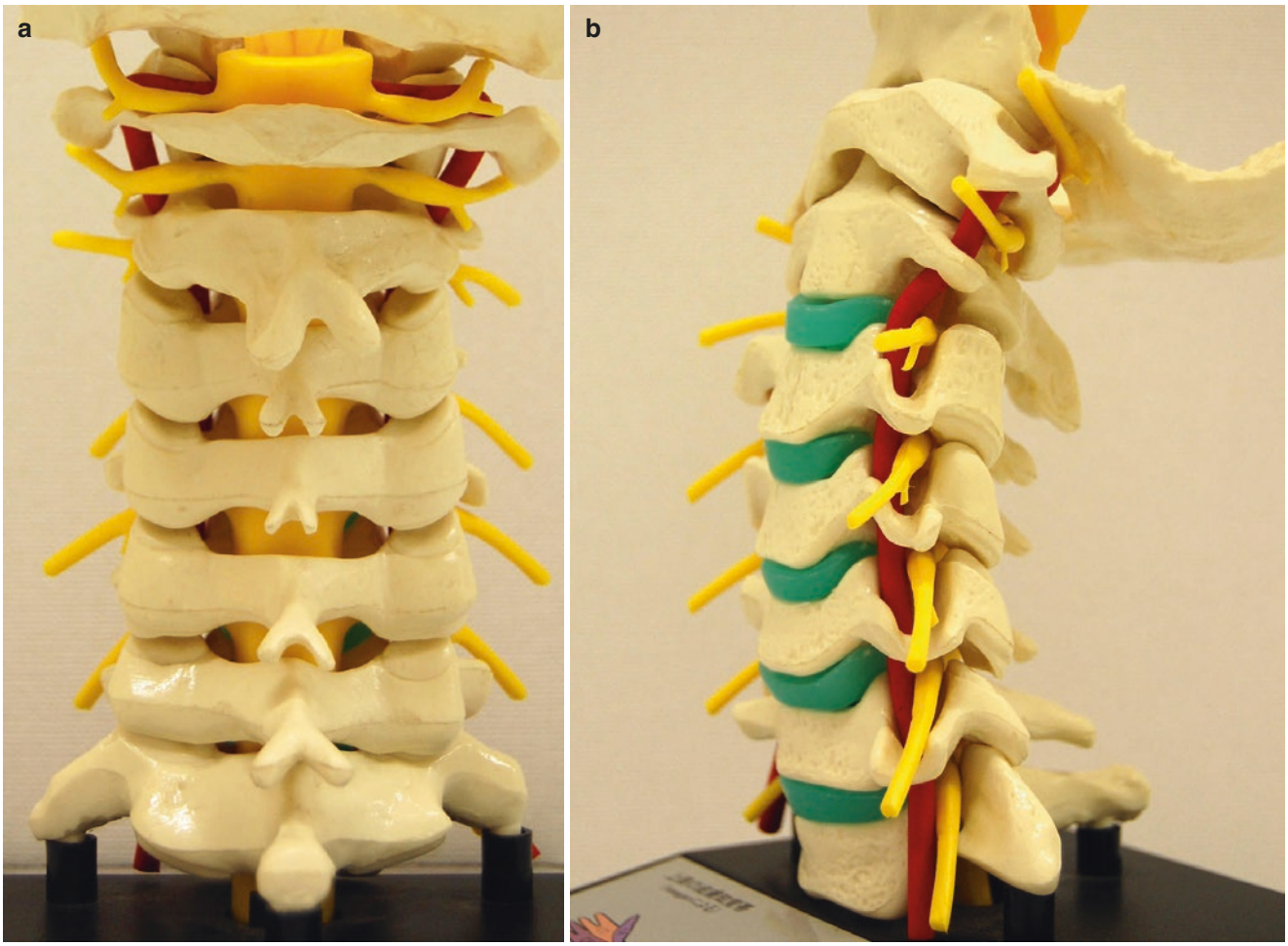

Fig. 81.1 Anatomy of the cervical nerve root. (**a**) From the dorsal side and (**b**) oblique view

81.5.1 C1 and C2 Spinal Ganglion Blocks

C1 nerve root blocks are difficult and may cause serious complications. Therefore, they should be avoided if possible.

When performing C2 nerve root blocks, the incident angle for the radiation and the height of the pillow should be adjusted in order to maintain the posterior arch of the atlas on the cranial side of the atlantoaxial joint. The point of insertion should be the skin projection point at the center of the atlantoaxial joint. After disinfection of the skin and local anesthesia infiltration, the needle should be inserted toward the slightly cranial and medial side of the center of the atlantoaxial joint. When the needle tip reaches the nerve ganglion (Fig. 81.2), radiating pain occurs toward the posterior auricle or occipital region.

Once radiating pain occurs, the contrast agent should be injected after confirming that aspiration causes no blood or spinal fluid reflux. Contrast imaging shows that the C1 and C2 nerve ganglions run horizontally and rather caudally from the pedicle of the vertebral arch. After confirming that proper images of the nerve ganglions are obtained and that there are no abnormal findings, such as enhanced blood vessels or subarachnoid injections, 1 mL of local anesthetic and steroid should be injected. After the needle is removed, pressure hemostasis should be implemented for about 5 min, followed by a 90-min period of rest and follow-up observation.

81.5.2 X-Ray-Guided C3–C8 Nerve Root Blocks (Posterior Method)

The patient should be placed in a hemilateral position with the affected side up. Adjustment is necessary so that the end plates forming the target intervertebral foramen overlap, resulting in an incident angle of radiation that best facilitates visualization of the intervertebral foramen. When that is achieved, the superior articular process should be located at the center of or

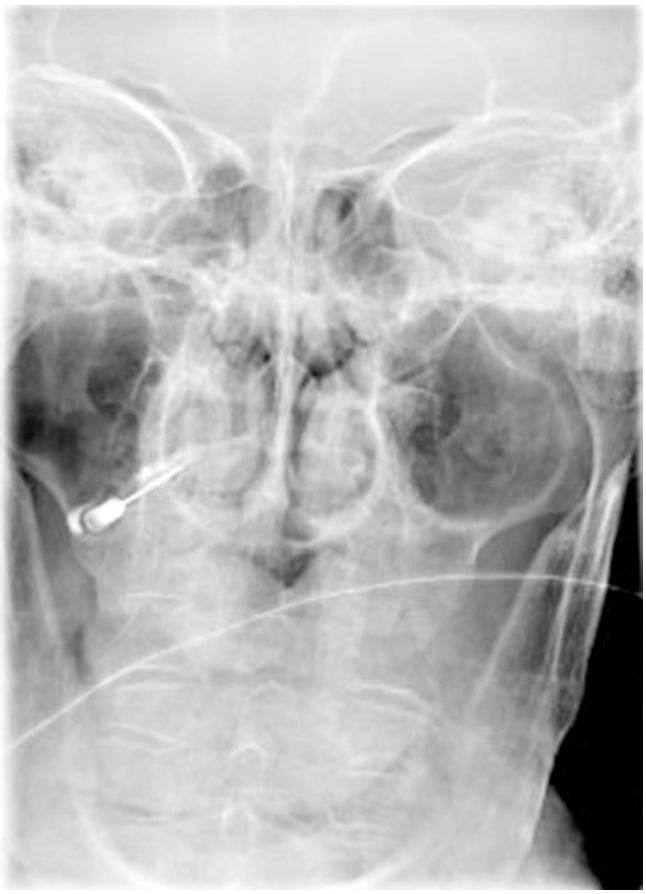

Fig. 81.2 C2 nerve root block

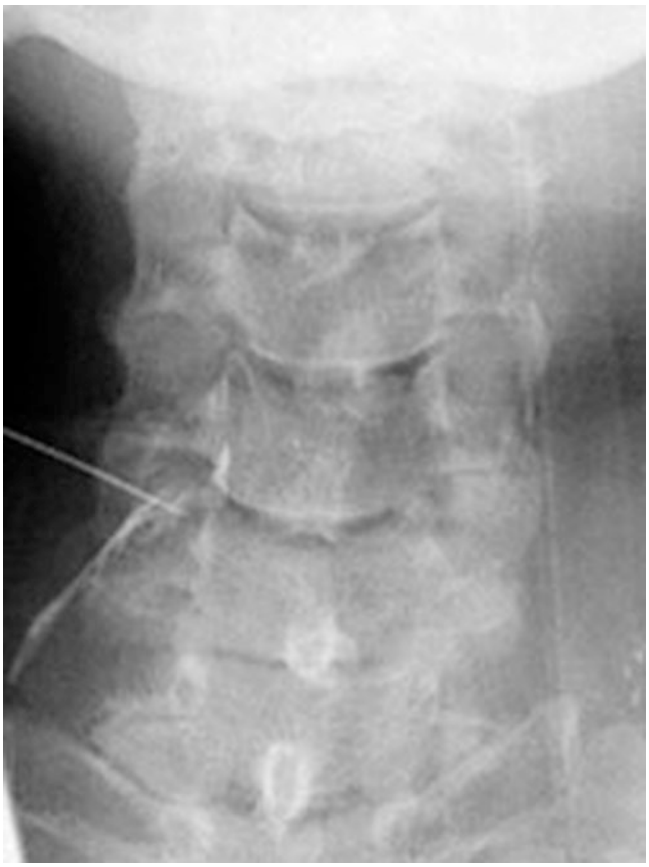

Fig. 81.3 X-ray-guided C6 nerve root block

slightly posterior to the intervertebral foramen. The point of insertion should be about 1 cm cranial and dorsal to the superior articular process on a line drawn from the inferior border of the intervertebral foramen to the superior articular process.

After disinfection, local anesthesia infiltration should be implemented at the site of insertion, and the block needle should be inserted from the point of insertion toward the superior articular process until it is reached. The needle should be advanced for another several millimeters by sliding it along the superior articular process to achieve puncture of the nerve root and produce radiating pain.

Once radiating pain occurs, the contrast agent should be injected after confirming that there is no blood or spinal fluid reflux in the frontal view (Fig. 81.3). After confirming visualization of the target nerve root and no evidence of enhanced blood vessels or subarachnoid injection, the drug solution should be injected. After the needle is removed, pressure hemostasis should be implemented for about 5 min, followed by a 90-min period of rest and follow-up observation.

This method of puncture is advantageous in that it is relatively safe because the block needle does not enter the spinal canal, minimizing the risk of puncture in the subarachnoid space or vertebral artery. However, this method may be difficult in some patients who have a short neck or square lower jaw.

81.5.3 Ultrasound-Guided C3–C8 Nerve Root Blocks

A 10–13-Mz high-resolution linear probe is used. The patient's position is a 45°–60° lateral position with the affected side up. First, a prescan is conducted. A short-axis view of the cervical region should be obtained with the probe applied horizontally to the lateral cervical region. The depth and gain of the ultrasound apparatus should be adjusted according to the physique of the patient. The depth should be adjusted to be deep because the lower nerve roots are located rather deeply. The common carotid artery and internal jugular vein should be identified, and the cervical transverse processes located on their outer side should be confirmed. At this point, the C6 transverse processes that have anterior and posterior tubercles and the C7 transverse processes that have

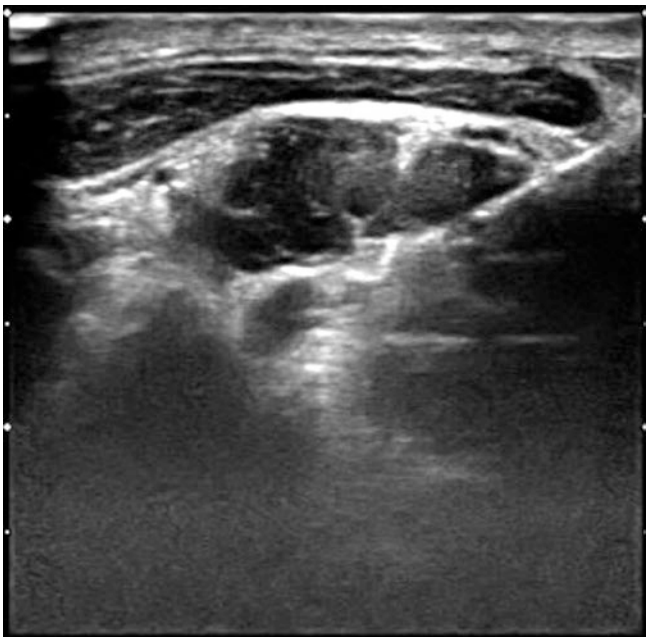

Fig. 81.4 Ultrasound-guided C6 nerve root block

only a posterior tubercle should be identified as guide marks. The probe should be moved up to the cranial side and the anterior and posterior nodules of C5, C4, and C3 confirmed. At this point, it can be observed that the C3–C6 nerve roots have round hypoechoic areas between the anterior and posterior nodules. The C7 nerve root is located just ventral and medial to the C7 posterior nodule. The C8 nerve root is identifiable at the first rib. The presence/absence of blood vessels in the vicinity of the target nerve root and along the puncture route should be confirmed for the sake of safety, using Doppler echo concomitantly if appropriate. When considering puncture from the outside of the probe with the parallel method, the angle of the hemilateral position of the patient should be adjusted.

The site of puncture should be disinfected broadly, and the target nerve root should be scanned with a probe that is covered by a sterilized cover (Fig. 81.4). After local anesthesia infiltration at the site of puncture, puncture is implemented by the parallel method from the outside of the probe. Once the needle reaches the target nerve root, the drug solution is injected after confirming the absence of blood reflux. After the needle is removed, the site of puncture should be compressed, followed by a 90-min period of rest and follow-up observation.

81.5.4 Cervical Nerve Root Block with a High-Frequency Generator

The nerve root block technique using local anesthesia alone was discussed above. In cases involving nerve root block with radiofrequency thermostimulation (root pulse), proper contrast images should be obtained. Subsequently, a small volume of low-concentration local anesthetic should be injected into the nerve root and radiofrequency thermocoagulation conducted. After the 2-min radiofrequency stimulation is complete, the drug solution is injected. The original Sluijter method does not use local anesthetic before stimulation, but this may be painful for the patient. Therefore, patients often feel more comfortable if a low-concentration local anesthetic, such as 1 mL of 0.3% lidocaine, is injected just before the stimulation. Because cervical nerve roots include motor nerves, neurodestruction may cause motor paralysis. Therefore, thermal neurodestruction (root thermocoagulation) should be avoided, excluding special situations.

81.6 Complications

81.6.1 Intravenous Injection

This can be confirmed by contrast agent injection. When it occurs, the block needle should be removed and reinserted.

81.6.2 Intra-Arterial Injection

If the course of the block needle is too medial, puncture of the vertebral artery may occur. It is necessary to confirm in the frontal view before contrast imaging that the needle tip is not medial to the lateral border of the pedicle of vertebral arch. Local anesthetic injection in the artery may cause toxic symptoms, such as dizziness or spasm. The administration of diazepam or respiratory management is necessary. It is also possible that bubbles could be injected into the vertebral artery.

81.6.3 Subarachnoid Injection

Complication is likely to occur when the tip of the block needle enters the medial side of the intervertebral foramen. If this complication is confirmed during contrast imaging, the block needle should be removed and reinserted; major problems can be avoided with this procedure. The injection of local anesthetic may cause total spinal subarachnoid anesthesia, leading to the occurrence of hypotension and dyspnea. Circulatory and respiratory management with a vasopressor or assisted respiration may be required.

81.6.4 Nerve Injury

Nerve root injury or spinal cord injury may occur. Rough movement of the needle, repeated puncture of the same nerve root within a short period, and direct puncture of the spinal

cord because of a medially deviated needle tip may cause this complication. Pain, numbness, and motor paralysis can be induced. Nerve injury is often temporary in the majority of patients, as it typically disappears during the period of follow-up observation. However, when symptoms are prolonged, possible treatments include oral medications and small-dose intravenous injections of ketamine. It is important to manipulate the block needle gently.

Reference

1. Slipman CW, et al. Therapeutic spinal corticosteroid injections for the management of radiculopathies. Phys Med Rehabil Clin N Am. 2002;13:697–711.

Thoracic Nerve Root Block (X-Ray Guided)

82

Masataka Ifuku and Masako Iseki

82.1 Introduction

82.1.1 About Thoracic Nerve Root Block

Thoracic nerve root block is a technique for ameliorating or treating pain in areas innervated by the thoracic nerve roots that branch from the thoracic spinal cord (Fig. 82.1) by blocking perceptive or pain sensations with the injection of drugs (mainly topical analgesics) into the target roots. While thoracic nerve root block is not used as frequently as its cervical or lumbar counterparts, neurolytic blocks may be used with fewer reservations in patients in whom topical anesthetics provide only temporary pain relief, based on the lower risk of damage to motor nerves in this region. This chapter describes the oblique approach performed under X-ray fluoroscopy-guided method, the loss of resistance technique, which is useful for reducing pain during the block procedure, including neurolytic blocks.

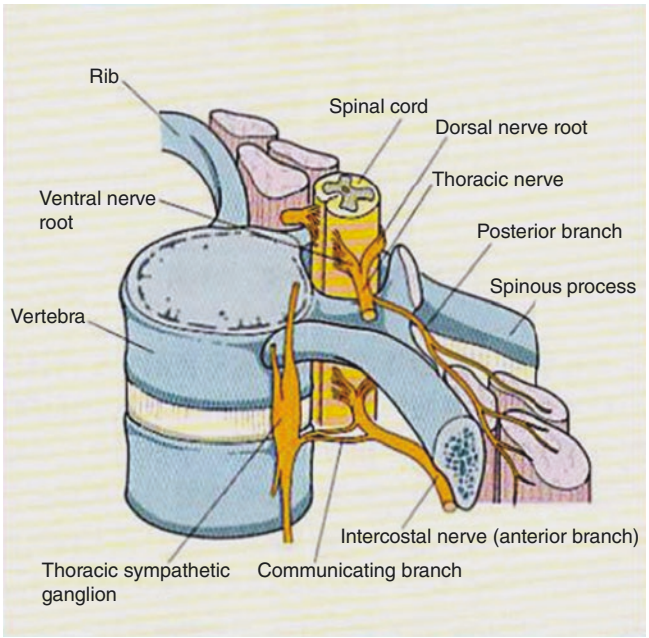

Fig. 82.1 Thoracic nerve root and surrounding tissues

82.2 Indications

Herpes zoster-associated pain in the chest: The use of a combination of topical anesthetics with steroids is very effective under conditions of strong acute nerve inflammation.

Thoracic nerve root diseases: While such diseases are not observed as frequently as those affecting the cervical or lumbar roots, this technique is appropriate for patients with thoracic compression fractures or root diseases associated with ossification of the thoracic yellow ligament.

Post-thoracotomy pain syndrome: Thoracotomy is often associated with damage to the intercostal nerves resulting in prolonged neuropathic pain. In addition to topical anesthetics, neurolytic block performed via radiofrequency thermocoagulation may provide long-lasting pain relief.

Cancer pain: In addition to blocks with topical anesthetics, radiofrequency thermocoagulation may be used to obtain long-lasting pain relief in cancer patients with pain in the thoracic region.

82.3 Instruments and Drug Solutions

1. Puncture needles: 8-cm 23-G block needle, 9-cm 21-G spinal needle or insulated block needle (used in radiofrequency thermocoagulation)

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2. Three 5-mL syringes (for the administration of local anesthesia, contrast agents, and/or drug solutions)
3. Drug solutions: 1% lidocaine, water-soluble steroids
4. Instruments for radiofrequency thermocoagulation (e.g., Neuro Therm JK3®)

82.4 Procedures and Techniques

82.4.1 Benefits and Drawbacks of the Frontal and Oblique Approaches

With the frontal approach, the needle is inserted 4–5 cm outside of the center of the spine and then advanced along the underside of the transverse process (Fig. 82.2) until the patient feels radiating pain when the nerve root is pierced, after which the drug is injected after confirming that the needle tip is located inside the nerve root by injecting a contrast medium. The benefit of this approach is that it can be performed by referencing only frontal images, as the centrum of the responsible nerve root is easier to recognize with a clear view of the transverse process and space between the ribs. The drawback is that this approach is more demanding with respect to the skill and experience of the operator because the required angle and distance of insertion vary depending on the patient and which thoracic vertebra is involved, and only slight deviation from the optimal angle or distance may damage the spinal cord or induce pneumothorax.

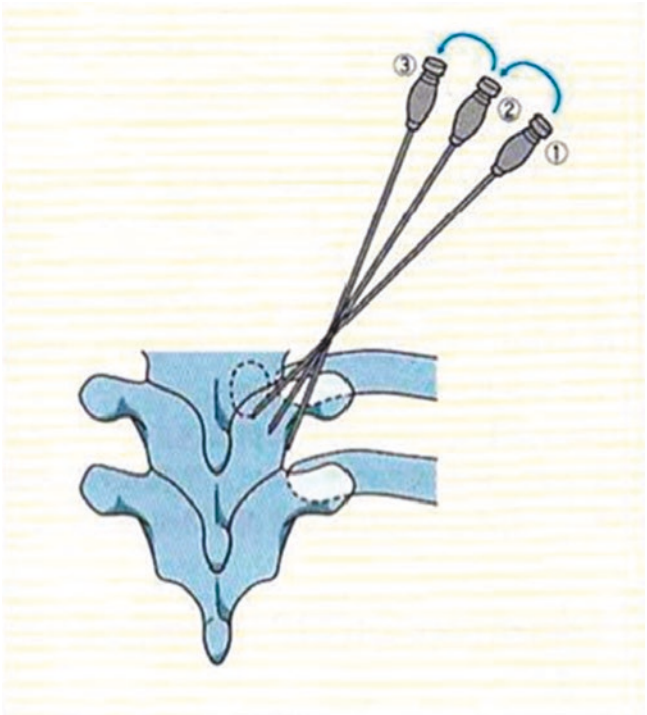

Fig. 82.2 Frontal approach

With the oblique approach, the needle is pointed at the caudal intervertebral foramina after drawing an image of the rib head and transverse process and subsequently advanced straight from this position. The angle of the needle and distance of the tip are not as critical as in the frontal approach, and the tip can be directly advanced into the nerve root exposed from the intervertebral foramen. However, adjustments to the direction of insertion always require X-ray fluoroscopy-guided method.

In this section, we explain the oblique approach, which requires less dexterity, in detail (see Note 1).

82.4.2 Patient Position and X-Ray Photography

The semi-prone position with the insertion point facing up is employed. In order to create maximum curvature along the target vertebrae to allow for a sufficient opening for needle insertion, padding is commonly placed underneath the patient.

As the first step, the responsible nerve root and vertebra must be confirmed on a frontal photograph. The axis of the camera is then tilted toward the insertion point until both the rib head and transverse process appear as circles. The point of needle insertion is caudal to both the rib head and transverse process but slightly close to the rib head, corresponding to the intervertebral foramen through which the nerve root is exposed (Fig. 82.3).

82.4.3 Block Procedure and X-Ray Imaging (Fig. 82.4)

1. After sterilizing the insertion point and surrounding area with alcohol, provide topical anesthesia using a 27-G needle and subsequently insert and advance the block needle along the axis confirmed under X-ray guidance. In order to avoid pneumothorax, care must be taken to prevent the needle tip from pointing toward the outside, i.e., the lung side of the vertebra.
2. Once the patient feels radiating pain in the same area as the original pain, inject a small amount of contrast medium and confirm that the nerve root can be visualized.
3. After observing the nerve root on an oblique image, check the frontal image as well to confirm that the target vertebra has been correctly identified.
4. Inject the drug while watching to see whether the contrast medium flows out along the nerve root. Once the desired quantity of the drug is injected, remove the needle to complete the procedure.

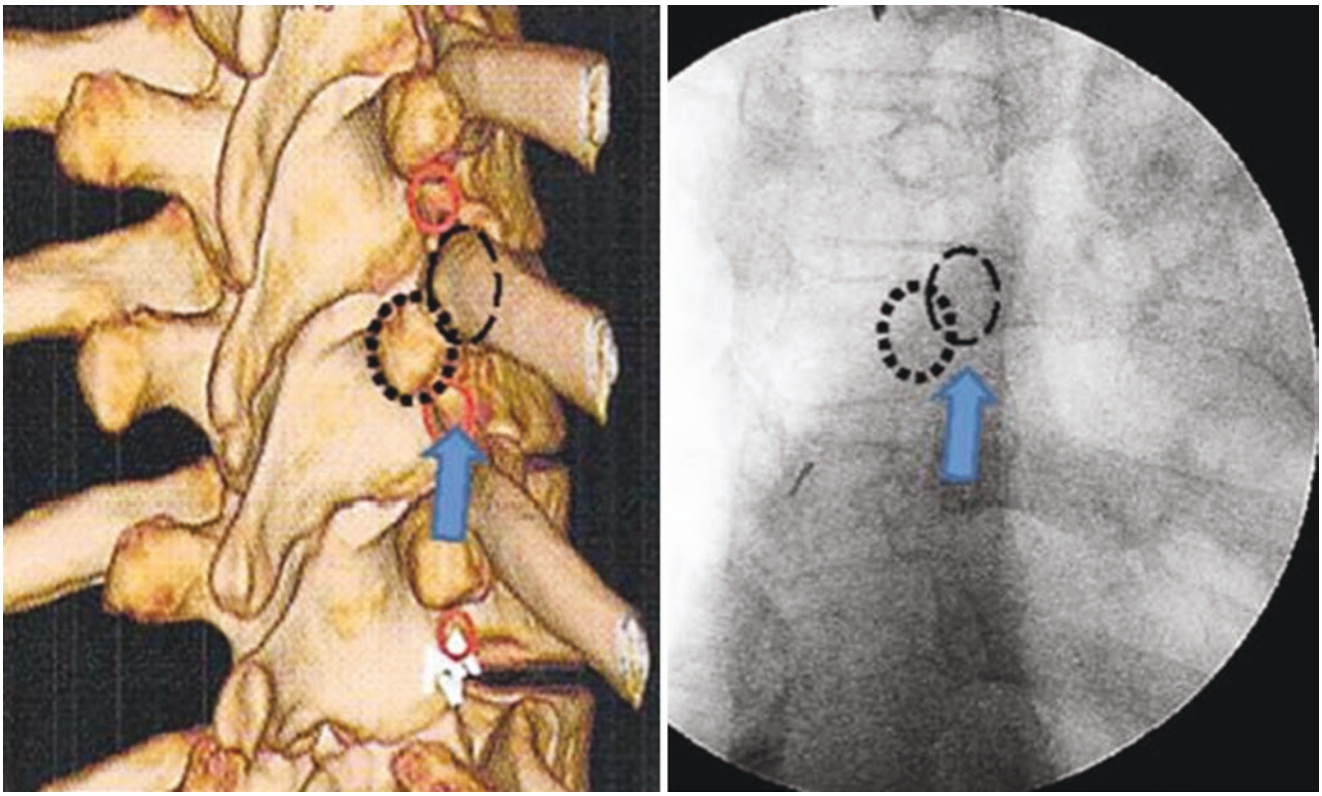

Fig. 82.3 Positional relationship of the nerve root (arrow), rib head, and vertebral arch root on oblique images

82.4.4 Loss of Resistance Technique (see Note 1)

As traditional nerve root blocks involve the direct insertion of the needle into the nerve, the patient often feels strong pain when the needle tip pierces the nerve root. Instead, it is recommended to use the loss of resistance technique, in which the drug is delivered into the space surrounding the target nerve root [1].

Although the area between two vertebral arches is surrounded by multiple ligaments, the epidural-like space between the ligaments and nerve roots can be located by feeling the loss of resistance when injecting saline into the space (Figs. 82.5 and 82.6).

82.4.5 Electric Stimulation Technique

Before applying nerve blocks with topical anesthetics and steroids, the electric stimulation technique may be used to locate the target area by applying an electrical current of a frequency that stimulates the sensory and motor nerves using a radiofrequency thermocoagulation apparatus and an insulated needle. The target nerve root may be identified more easily with the electric stimulation technique than with the commonly used needle and radiating pain technique.

82.4.6 Nerve Root Thermocoagulation

For chronic nerve root symptoms, the effectiveness of blocks with topical anesthetics may only be temporary. Because blocking motor nerves in the thoracic region does not affect the patient's daily life as significantly as blocking cervical or lumbar nerves, neurolytic blocks employing the thermocoagulation apparatus may also be considered (Fig. 82.7) (see Note 2).

82.5 Complications

Pneumothorax: The frontal approach is considered to be more prone to causing pneumothorax. Therefore, the oblique approach is advisable, taking care that the needle tip does not point toward the lung side when advancing the needle.

Injection into arteries: Because the radicular arteries run close to the nerve roots, topical anesthetics may accidentally be injected into one of the arteries, causing intoxication with the drug. In order to prevent such incidents, the lack of blood backflow must be confirmed before injecting the drug. When applying contrast medium, be sure to check that no medium is observed in the artery.

Hematoma formation and infection: The development of a hematoma as a result of piercing one or more arteries may

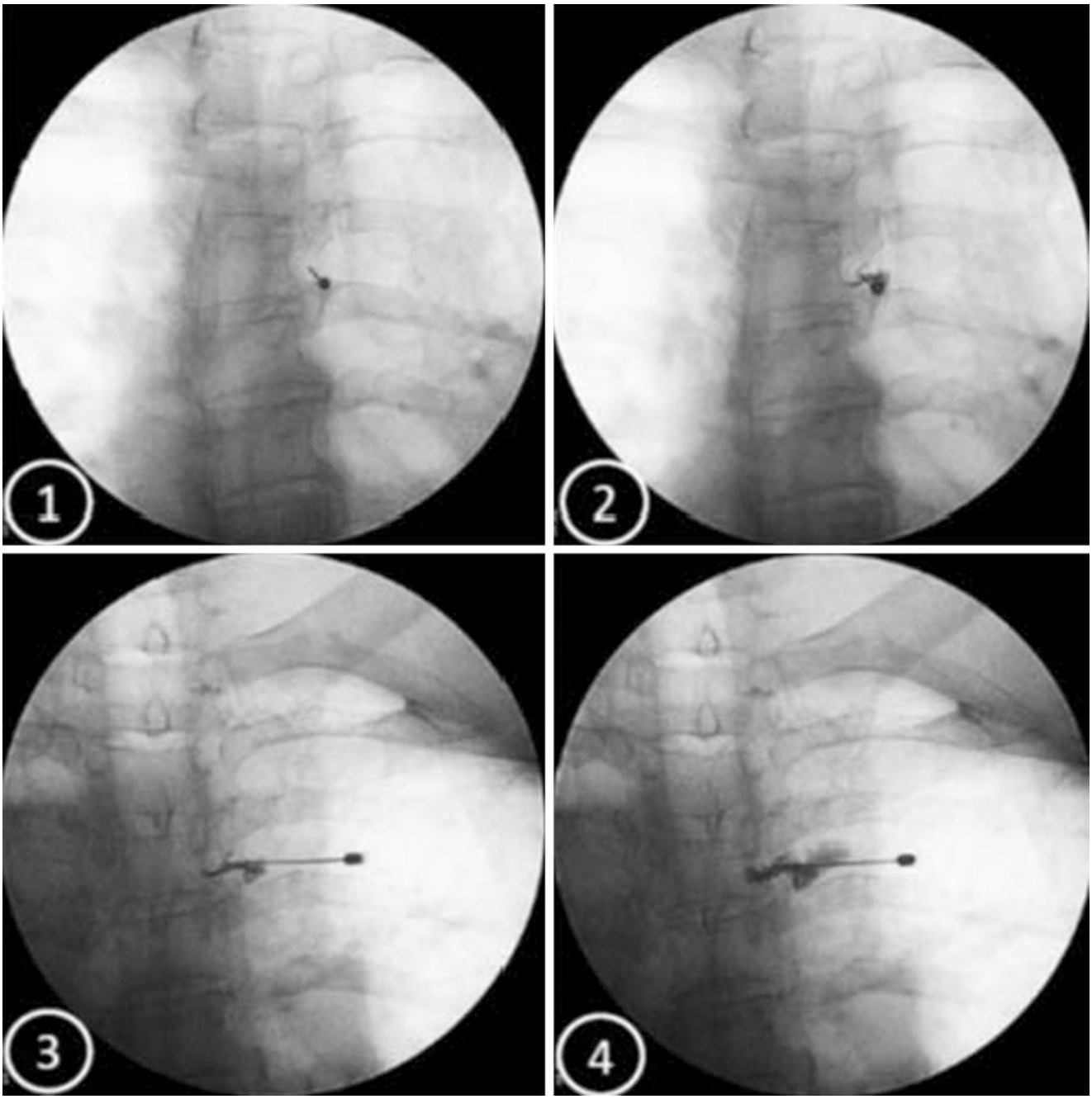

Fig. 82.4 Block sequence and X-ray images of each step

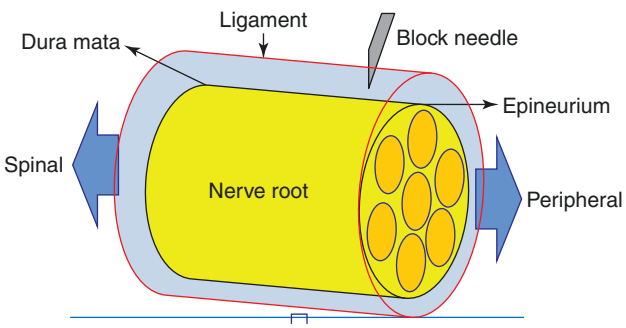

Fig. 82.5 Diagram of the loss of resistance method

provide a source of infection. Therapy with antiplatelet and/or anticoagulant agents should be withdrawn during the course of block treatment. Diabetic patients and those receiving immunosuppressants, including steroids, should be assessed carefully before considering whether to apply the block technique, as these patients are susceptible to infection.

Nerve damage: Excessive piercing of the nerves may cause damage to the target nerves.

Others: Puncture of the spine or allergic reactions to the contrast medium may occur during block treatment, albeit very rarely.

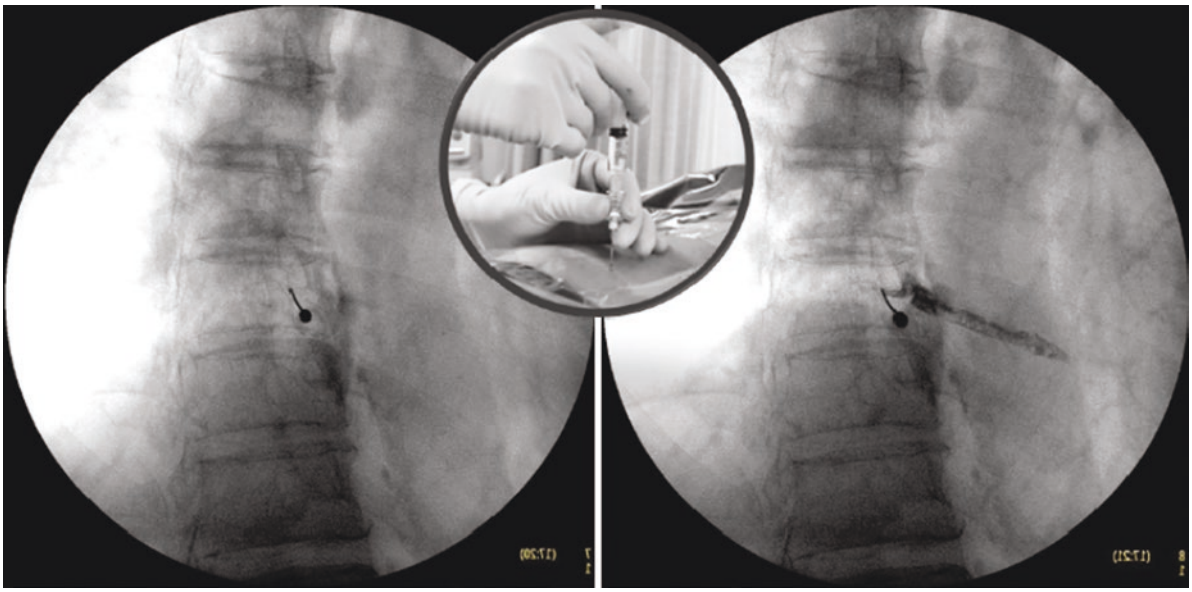

Fig. 82.6 Thoracic nerve root block using the loss of resistance method

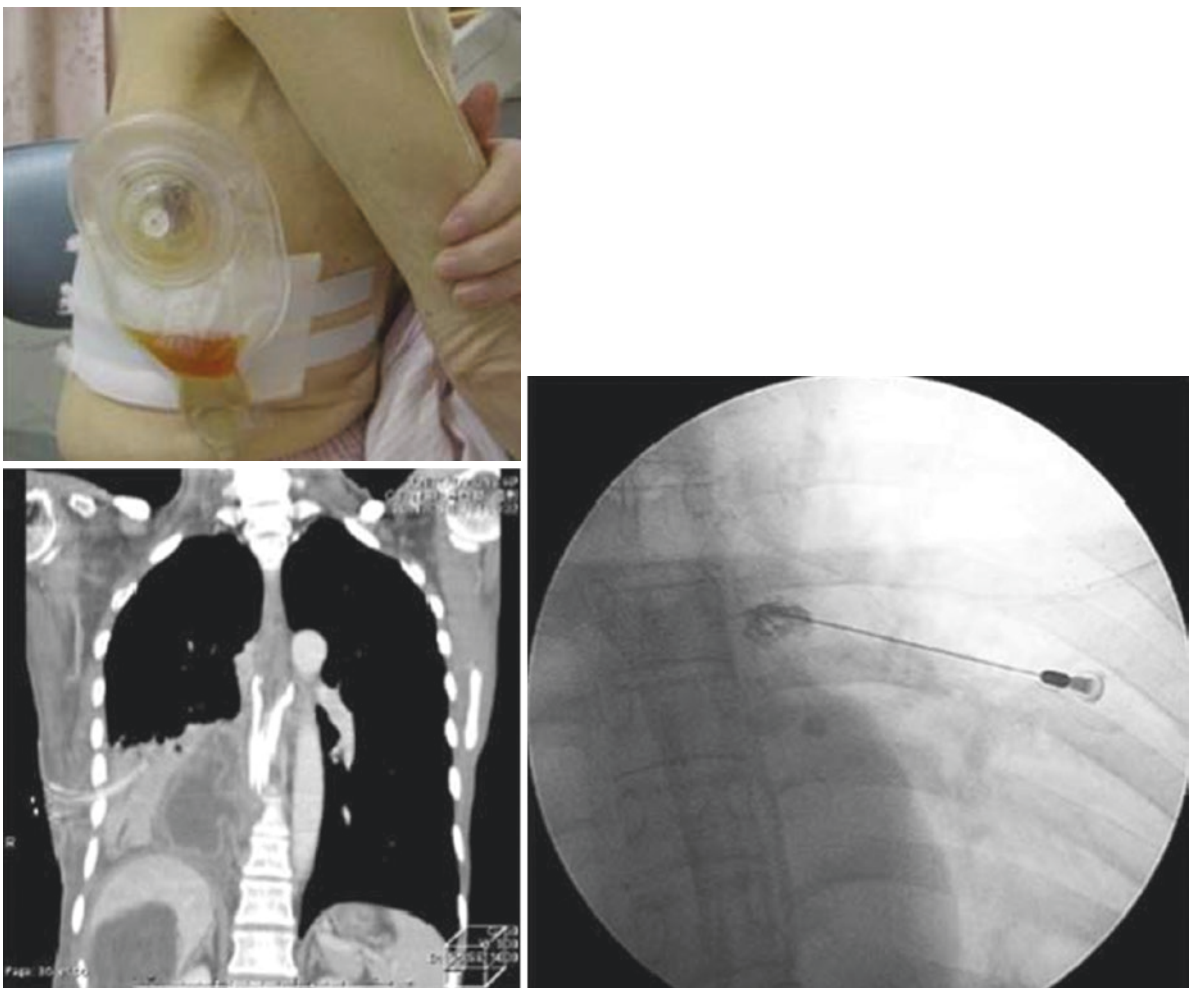

Fig. 82.7 A case of thoracic nerve root radiofrequency thermocoagulation for persistent pain as a result of the prolonged placement of a chest cavity drain for an esophageal stromal tumor that enabled long-term pain alleviation after thermocoagulation. Upper left, the patient and the drain. Lower left, a chest X-ray image showing the drain inserted from underneath the left sixth rib. Upper right, X-ray image obtained during the thermocoagulation procedure

82.6 Notes

1. While block treatment involves a three-dimensional (3D) operation, it would be far easier for the operator to consider only two-dimensional (2D) aspects of manipulation. We consider the oblique approach to be more desirable than the frontal approach in this respect, as it frees the operator from concern regarding 3D aspects, including the angle or length of movement of the needle, thus allowing him/her to avoid complications, such as pneumothorax or spinal damage, as long as the point and direction of insertion are correct.
2. Radiofrequency thermocoagulation to the thoracic nerve roots is not indicated for all patients in whom topical anesthetics provide only temporary pain. Neurolytic procedures are not expected to be very effective if the pain is not associated with hypersensitivity, such as allodynia, and the patient's sensory perception is already reduced, even in those exhibiting postsurgical pain after thoracotomy or thoracic postherpetic neuralgia. Neurolytic techniques must be applied only after carefully evaluating whether desensitization of the responsible nerve root will contribute to alleviating the patient's pain.

Reference

1. Ifuku M, et al. The incidence of neuralgia after lumbar nerve block traditional or LOR (loss of resistance) approach. Pain Clinic. 2013;34:393–89. (in Japanese)

Lumbar Nerve Root Block

83

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83.1 Introduction

83.1.1 What Is a Lumbar (Sacral) Nerve Root Block?

If the site of pain in the lower back or lower limb is along the dermatome, the nerve root responsible for the pain can be easily identified. However, when patients describe unclear symptoms, the cause of pain may be uncertain. In such cases, amelioration of symptoms by nerve root block helps identify the site(s) responsible, leading to appropriate treatment. Simultaneous contrast radiography allows for morphological diagnoses, such as compression [1]. Although previous techniques used the induction of radiating pain to determine the position of the needle tip, techniques that avoid radiating pain are now widely used.

83.2 Indications

1. Lumbosacral radiculopathy (lumbar intervertebral disc herniation, spinal canal stenosis, herpes zoster in the buttocks and lower limbs, and vertebral canal stenosis).
2. In cases of complex regional pain syndrome in the lower limb, techniques that do not cause radiating pain are used with caution.

83.3 Anatomy (Fig. 83.1a, b)

There are five pairs of lumbar nerve roots, and they branch from the intervertebral foramens on the caudal side of the lumbar vertebrae of the same level. The posterior root, emerging from the posterior lateral sulcus of the spinal cord, forms the ampulla and converges with the anterior root, from the anterior lateral sulcus, in the intervertebral foramen to form the spinal nerve. The spinal nerve that emerges from the intervertebral foramen soon branches into anterior (ventral) and posterior (dorsal) branches. The lumbosacral region is constantly under stress from body weight, posture, or body movement. As the nerve in the intervertebral foramen has no sheath, it is susceptible to mechanical stress. In addition, the frequency of L5–S1 nerve root injuries is high because their paths, from the dural bifurcation to the intervertebral foramen, are long. Therefore, L5 or S1 nerve root blocks are conducted frequently in patients with lower back and lower limb pain.

83.4 Instruments and Drug Solutions

1. Puncture needles: 8 cm 23G block needle, 9 cm 21G spinal needle
2. Three 5 mL syringes (local anesthesia, contrast agent, drug solution injection)
3. Drug solutions: 1% lidocaine, water-soluble steroid

83.5 Procedures and Techniques

83.5.1 Practical Aspects of the Technique

All lumbar nerve root blocks are performed under X-ray fluoroscopy-guided method. In the past, the tip of the block needle was moved close to the nerve root, and radiographic images of intraneural patterns were analyzed. However, because this technique can result in radiating pain and minute nerve injury, this technique has recently been revised. In 2001, Pfirrmann et al. [2] reported that contrast radiographic images, with and without visualization of nerve root fibers, were also associated with similar effects. After this report, the use of procedures that did not produce radiating pain became widespread.

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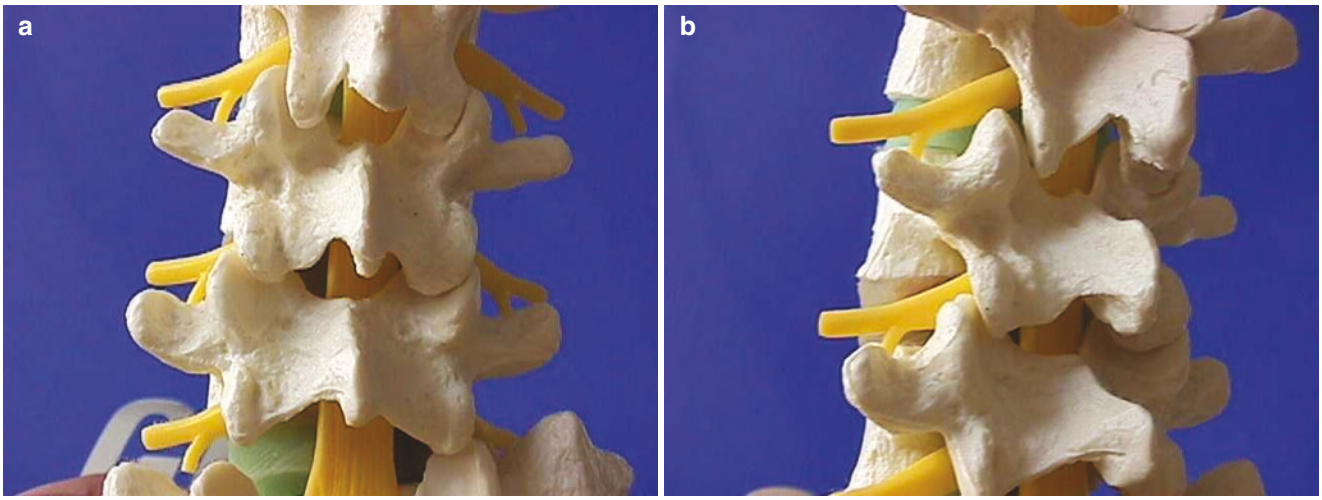

Fig. 83.1 Anatomy of lumbar nerve root. (**a**) From the back and (**b**) oblique view

83.5.1.1 X-Ray Fluoroscopy-Guided Block in the Prone Position

This is the basic approach for performing lumbar nerve root blocks and is carried out while the patient is in the prone position and observed from the frontal view. The curvature of the lumbar vertebrae should be reduced by inserting towels under the abdominal region. After the body position is fixed and the spinous process in the center of the vertebral body is located in the radiographic image, the X-ray tube bulb should be swung in a cranial direction, in order to arrange the end plate of the vertebral body in question in a narrow, straight line. The point of insertion should be level with the inferior border of the base of the transverse process, 4–5 cm lateral to the midline. Sufficient local anesthesia is applied subcutaneously, and the block needle is injected toward the base of the transverse process. Using the depth and angle of insertion as indices, the block needle should be pulled back slightly and then moved forward slowly toward the medial and caudal side, sliding along the inferior border of the transverse process. Sharp radiating pain is usually produced in the lower limb when the needle is advanced approximately 1–1.5 cm from the depth of the transverse process. When radiating pain is detected, ~1 mL of contrast agent is injected, and nerve root contrast radiographic images can be obtained (Fig. 83.2). If the needle tip is in a good position, radiating pain will also probably be produced at the time of injection of the contrast agent. After confirming that the needle tip is in a good position, local anesthetics and steroids should be injected. The patient may complain of sharp radiating pain again, but the pain will rapidly diminish following the injection. After the block, the patient should rest in bed for a sufficient period of time (~1.5 h). The presence/absence of weakness and numbness of the nerve in question should be checked at the end of the rest, and rest should be prolonged if necessary.

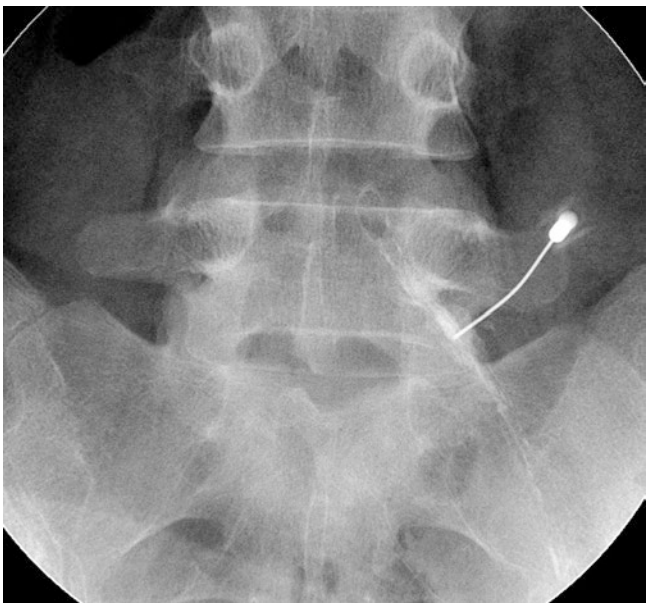

Fig. 83.2 L5 nerve root block in the prone position

83.5.1.2 X-Ray Fluoroscopy-Guided Oblique Method: Producing Radiating Pain (Fig. 83.3)

The oblique method is characterized by incremental progression of the block needle that allows beginners to insert the needle easily in the correct direction, when there is no impediment visible in the radiographic view. However, there is an issue with X-ray exposure, as fingers enter the projection area. Therefore, it is necessary to hold the needle with Pean's forceps, or use intermittent radiography during this technique. The body is positioned obliquely, with the affected side facing the ceiling. The oblique position can be maintained with a pillow placed under the iliac bone on the affected side. The angle of the oblique position should be

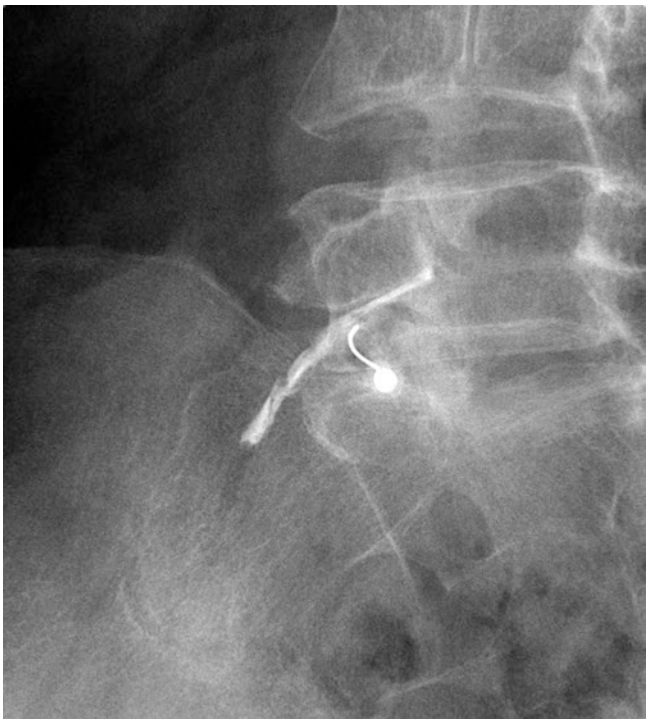

Fig. 83.3 L5 nerve root block in the oblique position

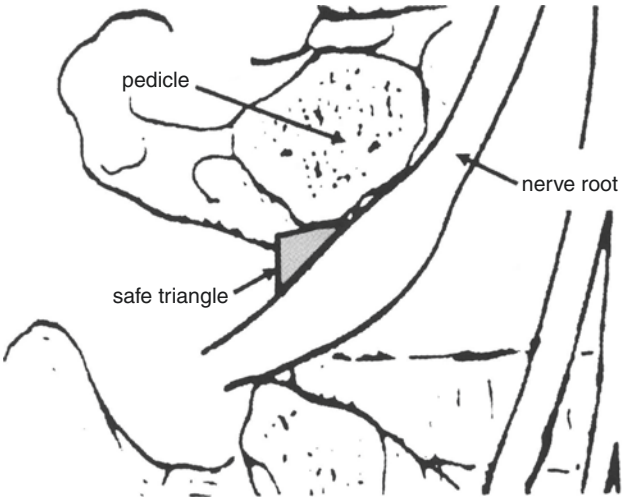

Fig. 83.4 Safety triangle. The safety triangle refers to the triangle formed by the nerve root, the pedicle of the vertebral arch, and the lateral side of the vertebral body [2]

adjusted to obtain a clear view of the face of the "Scotty dog," a radiographic guide mark, after which the end plate of the targeted vertebral body should be adjusted. The nerve root is located anterior to the superior articular process, corresponding to an ear of the dog, and inferior to the pedicle of the vertebral arch, corresponding to the dog's face. Local anesthesia should be applied just above the image of the nerve root. When the block needle is moved toward the area under the pedicle of the vertebral arch, it reaches the nerve root, producing radiating pain. If no radiating pain is produced, the needle should be moved to the cranial and caudal sides, level with the vertebral body. In elderly patients with radicular pain, the nerve root often runs beneath the pedicle of the vertebral arch, and the nerve root is likely to be reached when the needle is moved toward the cranial side.

83.5.1.3 X-Ray Fluoroscopy-Guided Oblique Method: Safety Triangle Method

In this method of oblique position nerve root block, the needle does not come into direct contact with the nerve root and does not produce radiating pain. This technique was proposed by Pfirrmann et al. [3]. Radiating pain is usually not produced when the needle is moved toward a target "safe triangle" (Fig. 83.4). Since publication of a study demonstrating that this method is equally as effective as techniques that induce radiating pain, this method has spread and been adopted very quickly. Although there is no puncture pain, radiating pain may occur at the time of the injection of the local anesthetic or contrast agent, if the needle tip is placed in an area adjacent to the nerve root.

83.5.1.4 X-Ray Fluoroscopy-Guided Transforaminal Approach

The direction of needle insertion is determined in the oblique position, and the movement of the needle tip is adjusted using the lateral radiographic view. As the needle tip is guided by radiographic apparatus, with no change in the patient's position, C-arm apparatus is required. The patient is placed in the complete prone position. After the end plate of the target vertebral body is adjusted, the X-ray tube bulb should be swung in an oblique direction. The point of insertion is determined at the site anterior to the superior articular process, corresponding to an ear of the "Scotty dog," and inferior to the pedicle of the vertebral arch corresponding to the dog's face, which is the same as the approach used for the oblique method. The block needle should be advanced to make the needle tip appear as a dot. The direction of the needle tip should be stabilized. The tube bulb is then swung in the lateral direction, to obtain a complete lateral radiographic view. When the needle tip is moved to the outer margin of the intervertebral foramen (Fig. 83.5), the bulb should be changed in order to obtain a frontal view. As with the usual prone position, the end plate should be adjusted, and needle tip position confirmed. At this point, fine adjustments may be necessary to correct deviations in the position of the needle tip. In most cases, the position of the needle tip will remain unchanged, but the needle may be moved by up to 1 mm. A small amount (~0.5 mL) of contrast agent should then be injected. If images comparable to contrast radiography of the epidural space or nerve root surroundings are obtained (Fig. 83.6), the needle tip is probably in the area surrounding

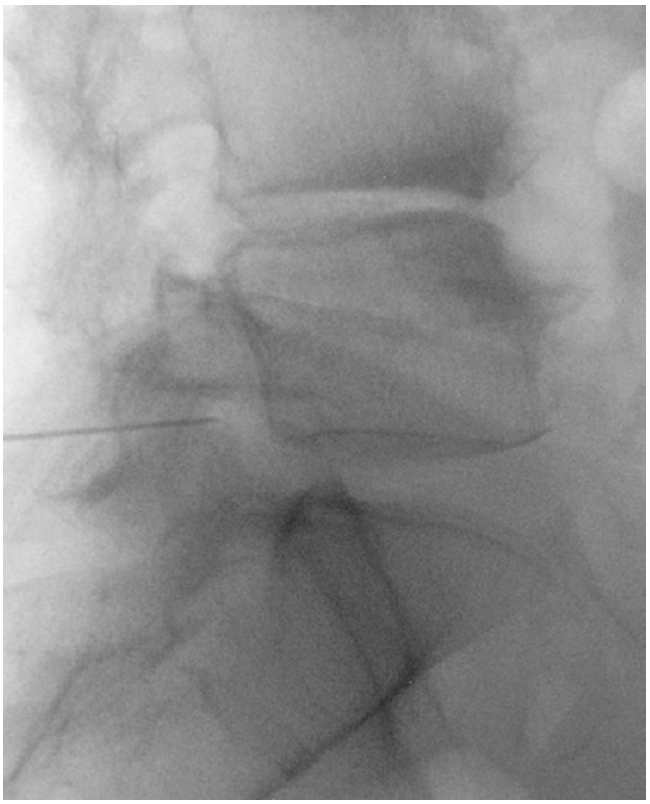

Fig. 83.5 Lateral view of the trans-foraminal approach. The needle should be advanced until the outside of the intervertebral foramen is in the lateral radiographic view

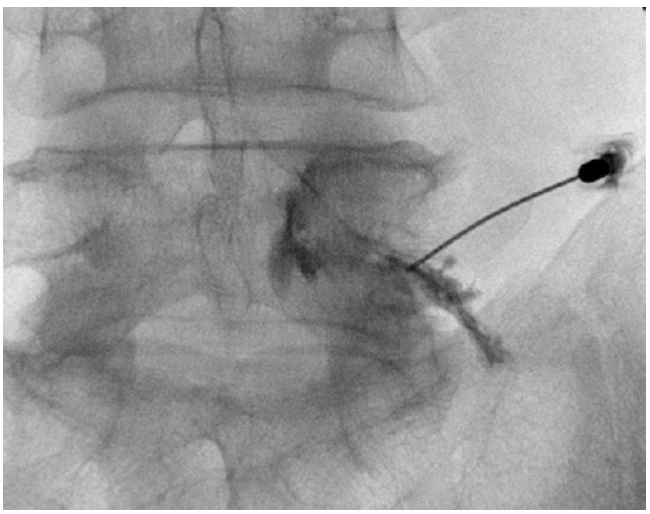

Fig. 83.6 Frontal view of the trans-foraminal approach. Contrast images of the epidural region and nerve roots are shown

the nerve root. Although it is rare that radiating pain is produced following the injection of contrast agent, radiating pain may occur when the needle tip is very close to the nerve root. If the contrast agent streams transversely or vertically, the needle tip may still be far from the nerve root, and, therefore, the needle should be moved forward by 1–2 mm.

83.5.2 Lumbar Nerve Root Blocks Using High-Frequency Apparatus

Nerve root block techniques using local anesthesia alone have been described above. In cases of nerve root blocks using radiofrequency thermostimulation (root pulse), proper contrast images should be obtained. A small volume of low-concentration local anesthetic should then be injected into the nerve root and radiofrequency thermocoagulation performed. After 2 min of radiofrequency stimulation, the drug solution is injected. The original Sluijter method uses no local anesthetic prior to stimulation, but the stimulation may cause pain. Therefore, patients often feel more comfortable if low-concentration local anesthetic, e.g., 1 mL of 0.3% lidocaine, is injected just prior to stimulation. As lumbar nerve roots include motor nerves, neurodestruction may cause motor paralysis. Therefore, thermal neurodestruction (root thermocoagulation) should be avoided, excluding special situations.

83.6 Complications

Serious complications [3] are rare.

1. Nerve injury: This condition is likely to occur when punctures into the nerve, to produce radiating pain, are repeated.
2. Hyperglycemia: Blood glucose levels increase several hours after the operation because of the steroids used. However, this condition does not cause any serious problems, except in patients with diabetes mellitus. Peak blood glucose is reached 5–6 h after nerve block, requiring caution. Steroid doses should be adjusted for patients with diabetes mellitus.
3. Infection: It is necessary to change the site of insertion if there is rash or infection in the puncture site.
4. Bleeding: Bleeding is not a problem for the usual techniques. However, once hematomas occur, they may be found in the nerve root area, causing nerve injury. Caution is necessary for patients who are taking oral anticoagulants or antiplatelets.
5. Rebound pain: This describes the phenomenon whereby pain that is ameliorated after nerve root block returns, more severely, several hours after the block. This phenomenon has been attributed to mild injury of the nerve root.
6. Neuropathic pain: Although very rare, newly occurring neuropathic pain may be reported following nerve root block. The usual techniques may also result in this condition, and much remains unclear about its pathogenic mechanism.

References

1. Macnab I. Negative disc exploration. An analysis of the cause of nerve root involvement in sixty-eight patients. JBJS. 1971;53-A:891–903.
2. Pfirrmann CW, Oberholzer PA, Zanetti M, et al. Selective nerve root blocks for the treatment of sciatica: evaluation of injection site and effectiveness – a study with patients and cadavers. Radiology. 2001;221:704–11.
3. Brouwers PJ, et al. A cervical anterior spinal artery syndrome after diagnostic blockade of the right C6-nerve root. Pain. 2001;91:397–9.

Sacral Nerve Root Block (X-Ray Fluoroscopy-Guided Method, Ultrasound-Guided Method)

84

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84.1 Introduction

Sacral nerve root block (SNRB) is a method to be used in nerve roots through the posterior sacral foramina [1]. SNRB, which involves an injection of therapeutic agents (local anesthetics and steroids), radiofrequency (RF), or pulsed radiofrequency (PRF), is used for diagnosis and pain management. The essential point in this block is to identify posterior sacral foramina. The following section will discuss SNRB using fluoroscopy-guided and ultrasound-guided methods.

84.2 Indications

- Lumbosacral radiculopathy for disk herniation, spinal canal stenosis, and postherpetic neuralgia
- Cancer pain
- Rectal or perineal pain

84.3 Anatomy (Fig. 84.1)

The sacrum consists of five sacral vertebrae that fuse secondarily into a single bone. There are four pairs of foramina in the ventral and dorsal opening, it is called anterior/posterior sacral foramina. Sacral nerve roots (S1–S4) are through on each anterior sacral foramen. Dorsally, there are Three crests: the median sacral crest, intermediate sacral crest, and lateral sacral crest. Posterior branches of sacral nerves are through on the posterior sacral foramina, which exit outside the intermediate sacral crest. There is a sacral hiatus with a dorsocaudal surface of S5 nerve roots and coccygeal nerve going through it.

Sacral lumbarization and lumbar sacralization sometimes exist, which can lead to misidentification of the target.

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84.4 Instruments and Drug Solutions

1. 5 mL syringe (local anesthetic for skin)
2. 5 mL syringe (treatment agents: local anesthetics and steroids)
3. 5 mL syringe (water-soluble, nonionic contrast)
4. Needle: 21–22 gauge spinal needle (blunt Coudé needle)

RF/PRF: additional equipment

- 99 mm radiofrequency thermocoagulation needle
- Electrode

84.5 Procedures and Techniques

84.5.1 X-Ray Fluoroscopy-Guided Method (Fig. 84.2)

There are two methods – a prone approach and oblique approach [2]. The prone approach is often used in S1–S2 SNRB. S3–S5 SNRB is often difficult in the prone approach, so sacral epidurography (contrast injected in the epidural space via the sacral hiatus) or an oblique view is useful to identify S3–S5 posterior sacral foramina.

84.5.1.1 Prone Approach

Set patient in prone position. Put a bolster under the abdomen as needed; this will cause the lumbar spine to straighten (Fig. 84.3). Adjust the fluoroscopic image to the end plate of L5 and S1 to become parallel. This makes it possible to identify the anterior sacral foramina and the dorsal sacral foramina. The dorsal foramina often can be confirmed in the superior medial of the anterior sacral foramina under the fluoroscopy-guided method. In the case of S1 SNRB, the point of puncture is approximately 4 cm from the midline and inferior border of the pedicle of the vertebral arch. After administering local anesthesia, the nerve block needle is advanced in the direction of the posterior sacral foramina. To touch the

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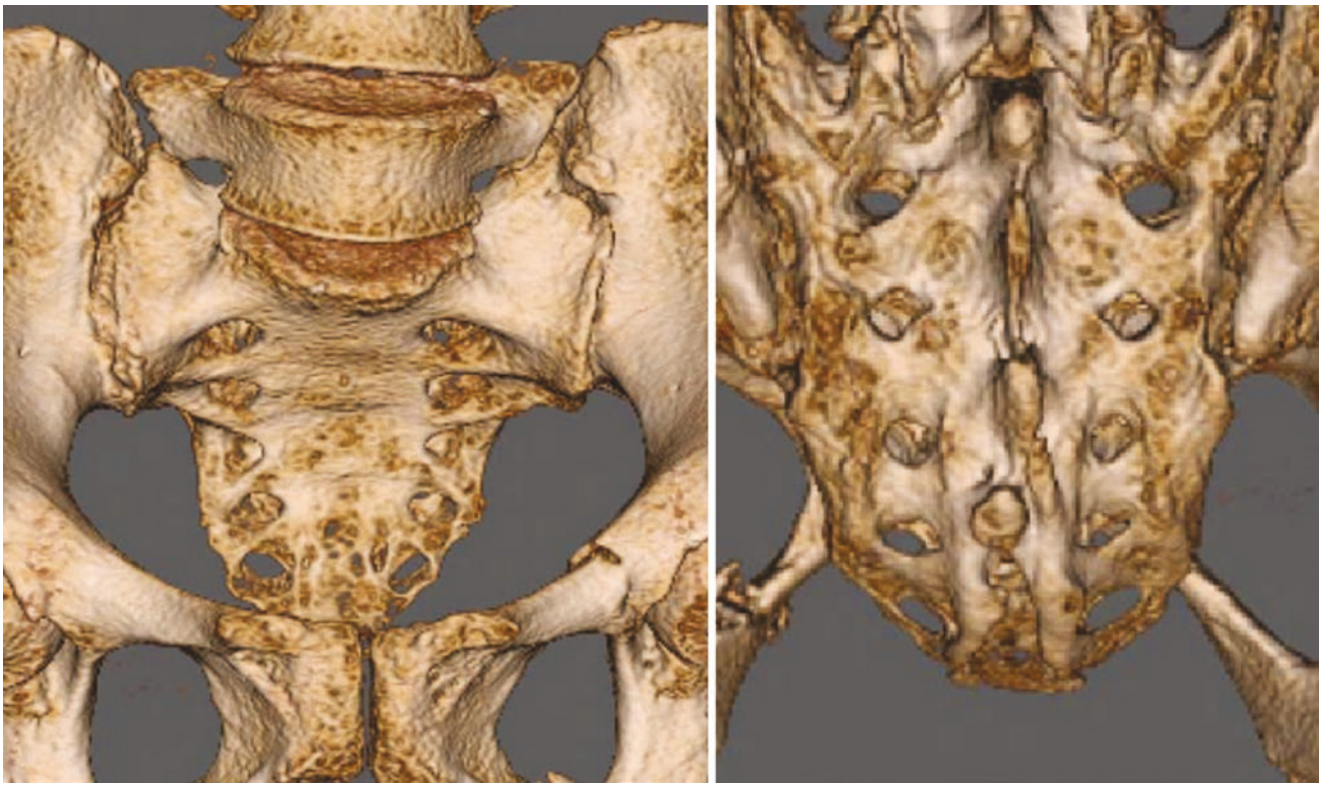

Fig. 84.1 Anatomy: anterior and posterior views in 3D CT

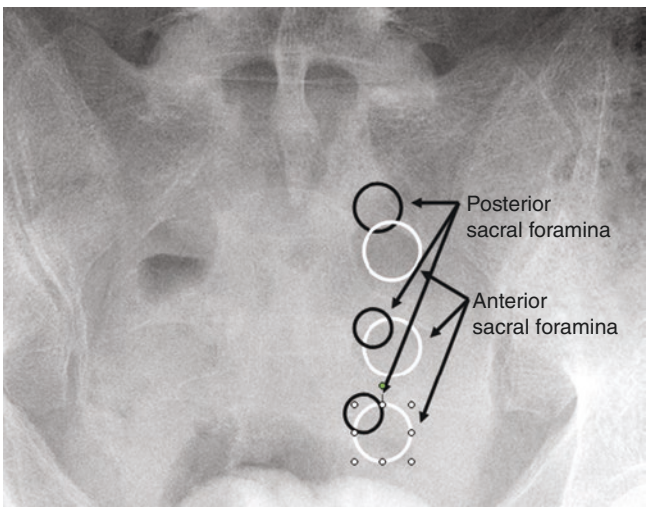

Fig. 84.2 X-ray fluoroscopic image

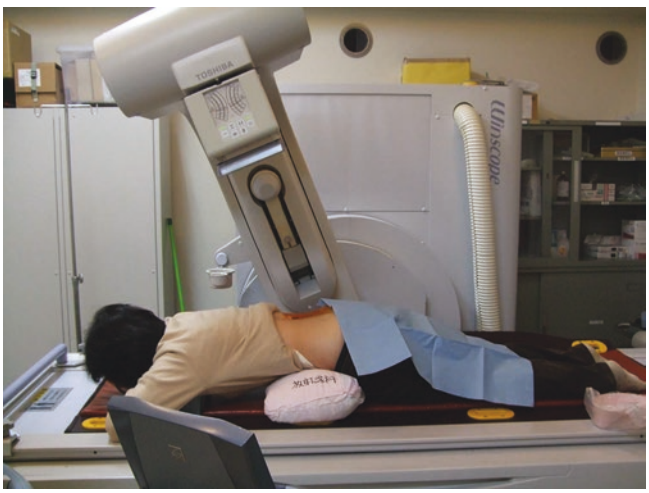

Fig. 84.3 Position under X-ray fluoroscopy

posterior sacral foramina, slowly advance the needle to 0.5–2 cm. When radiating pain is felt, the needle must be stopped. It can be more useful to use the loss-of-resistance method with normal saline to reduce radiating pain.

Following confirmation of neural injection with contrast (Fig. 84.4), the therapeutic agent is injected. S3–S5 SNRB is often difficult, so it is useful to confirm nerve tract for sacral epidurography.

84.5.1.2 Oblique Approach

Take the patient in the prone position, and rotate the fluoroscopic C-arm 10–20° toward the affected side. Otherwise set the patient in an oblique position with the affected side raised 10–20° by putting a bolster under the lower abdomen on the affected side. Make sure anterior sacral foramina and posterior sacral foramina on the target accord under fluoroscopic image. The puncture point is center and

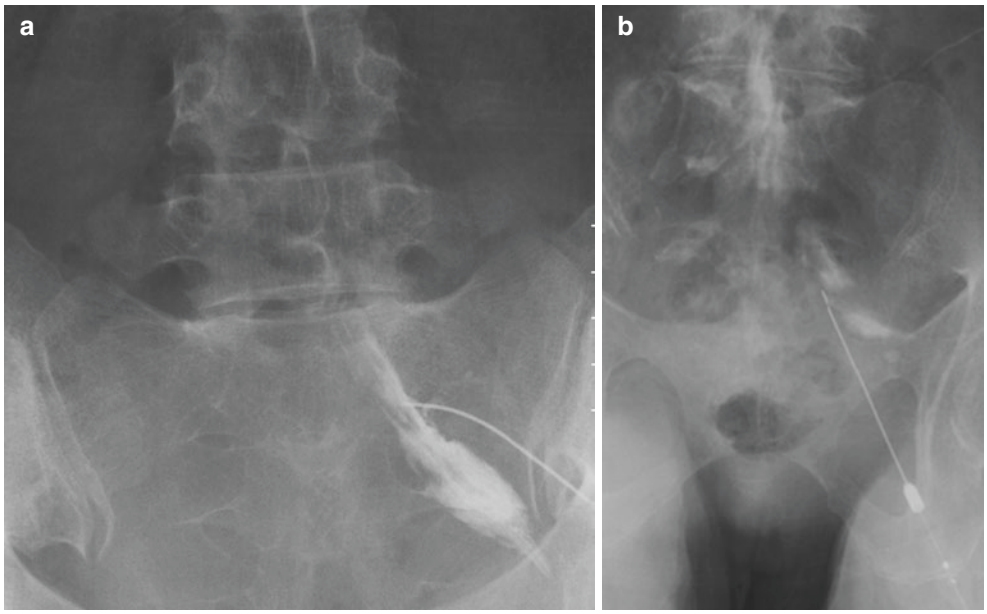

Fig. 84.4 (**a**) S1 block. (**b**) S2 block using sacral epidural contrast

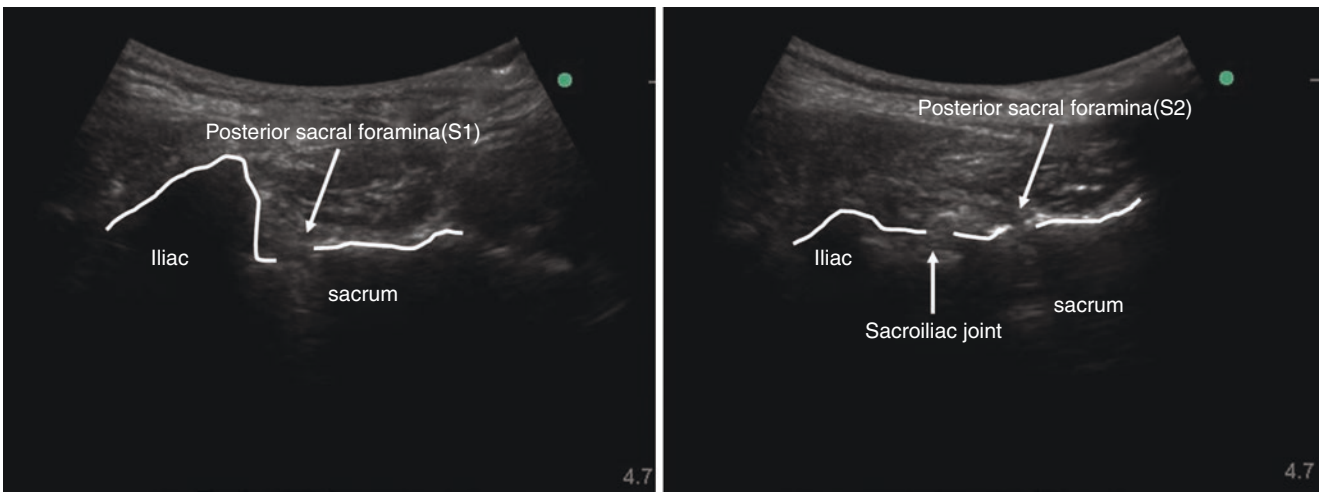

Fig. 84.5 Ultrasound image of posterior sacral foramina and surrounding structures

some lower side at the posterior sacral foramina. The nerve block needle is advanced like "a point." When radiating pain is felt, the needle must be stopped. Following confirmation of neural injection with contrast, the therapeutic agent is injected.

84.5.2 Ultrasound-Guided Method

The nerve root cannot be directly drawn under the ultrasound-guided method. Alternatively, posterior sacral foramina can be drawn, and the needle is advanced. It is useful to use a nerve stimulator or the fluoroscopy-guided method to confirm the nerve root [3].

It is easier to perform nerve blocking using a micro convex probe.

84.5.2.1 Position

Put the patient in the prone position. To manipulate the ultrasound probe easily, the bolster should be inserted under the upper abdomen to straighten the spine.

84.5.2.2 Image of Ultrasounds (Fig. 84.5)

The transducer is placed in middle the back to obtain long-axis image of the spinous process. It is gradually moves outside, then L5 transverse process and sacral dorsal surface are drawn. Turn rotate into 90° positition (short-axis view) on the base of sacrum level and gradually move to the side of

the apex of the sacrum. Posterior sacral foramina have been confirmed as places that ultrasound can go inside the sacrum.

84.5.2.3 Procedures and Techniques

Take the nerve block needle on the lateral side parallel to the transducer (in plain). When the needle tip reaches the inlet of the posterior sacral foramina, make a slowly advanced approximately 0.5–2 cm into the posterior sacral foramina until paresthesia is elicited. The therapeutic agent is slowly injected.

84.6 Complications

Bleeding and infection are commonly cited complications. The following are other complications:

Nerve root damage: The needle should be gradually advanced. If paresthesia or radiating pain is felt, movement of the needle should be stopped. The needle tip moves slightly when resistance to injection is high.

Visceral injury: It is possible to injure internal organs when the needle tip is passed through the anterior sacral foramina. It is must be careful to insert the needle too far even in the absence of paresthesia. It is safe to advance the needle into the posterior sacral foramina within 1.0 cm at S2 SNRB and 0.5 cm at S3 SNRB.

Spinal block: It can occured in S1 SNRB, when the needle is advanced inside too deeply. Before therapeutic agents are injected, it must be confirmed that spinal fluid has not been recalled.

References

1. Rathmell JP. Atlas of image-guided intervention in regional anesthesia and pain medicine; 2012 p. 64–79.
2. Fukui M. Sacral nerve root block. Pain Clinic. 2011;32:282–90. (in Japanese)
3. Sato M, Mikawa Y, Matuda A. Ultrasound and electrical nerve stimulation-guided S1 nerve root block. J Anesth. 2013;27(5):775–7.

Comment

85

Hisashi Date and Masako Iseki

85.1 Nerve Root Block

While nerve root blocks are useful for both diagnostic and therapeutic purposes, some of the techniques are associated with radiating pain, causing some patients to avoid receiving repeated block treatments after their unpleasant initial experiences.

With the recent arrival of less invasive techniques, it is now possible to choose techniques that are less uncomfortable to patients. For example, cervical nerve root blocks may be administered without causing radiating pain by using an ultrasound imaging device to make sure the needle tip is held within the perineural area. Likewise, radiating pain associated with lumbar nerve root blocks may be minimized with the use of the safety triangle method or the intervertebral foramen approach [1].

Although the diagnostic usefulness of nerve root blocks has been decreasing with more use of MRI, they are still useful for identifying the responsible nerve root out of multiple nerve root lesions.

Reference

1. Pfirrmann CW, Oberholzer PA, Zanetti M, et al. Selective nerve root blocks for the treatment of sciatica: evaluation of injection site and effectiveness—a study with patients and cadavers. Radiology. 2001;221:704–11.

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Part XVII

Intradiscal Therapy (X-Ray-Guided, CT-Angiography)

Cervical Disc Contrast Radiography and Block

86

Hisashi Date and Mitsuhiko Ohata

86.1 Introduction

86.1.1 What are Cervical Disc Contrast Radiography and Block?

Cervical disc contrast radiography allows not only the examination of disc status but also the identification of the disc responsible for pain, which can be determined by the presence/absence of radiating pain following injection of the contrast agent [1]. Therapeutic effects may be induced following injections of local anesthetic and steroids.

86.2 Indications

Cervical disc herniation, neck-shoulder pain, back pain, and neck-shoulder-arm pain, presumably related to intervertebral disc disorders (including cervical spondylosis, cervical spondylotic radiculopathy, and cervical disc herniation)

86.3 Anatomy (Fig. 86.1a, b)

The cervical intervertebral joint has a concave shape, with upturned lips on both sides, as the intervertebral body has bank-like margins at the right and left ends of the cranial side. On the front side of the inferior surface, the cervical intervertebral joint has a down-turned lip. The intervertebral disc is located between the upper and lower intervertebral discs, and its upper and lower surfaces are hyaline plates, with a nucleus surrounded by the annulus fibrosus.

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The trachea and esophagus are present on the anterior side of the intervertebral disc, and the sternocleidomastoid muscle, carotid artery, and jugular vein are present on the anterolateral side. Manual pressure can move the trachea and sternocleidomastoid muscle apart.

86.4 Instruments and Drug Solutions

1. Puncture needle: 6 cm 23G block needle
2. Syringes: 5 mL syringe (local anesthesia)
3. Two 1 mL syringes (for contrast agent and injection of drug solution)
4. Drug solutions: 1% lidocaine, water-soluble steroid

86.5 Procedures and Techniques

Prior to the block, antibiotics are administered to the patient via drip infusion. The patient is placed in the supine position, and no pillow is used. The neck is moved into a slightly extended position. A thin pillow may be placed under the shoulder blades according to the physique of the patient. The X-ray tube bulb is moved toward the caudal side, to ensure the anterior and posterior lines of the target vertebral body end plates overlap. The cervical region is broadly disinfected with chlorhexidine, or other disinfectant, and covered with cloth. The operator, if right-handed, should stand on the patient's right side. The operator's index and middle fingers should be raised and inserted between the sternocleidomastoid muscle and the trachea. The anterior tubercle of the transverse process is held, while the carotid artery is pushed away. After using radiography guidance to confirm that the target intervertebral disc is between the index and middle fingers, fingers should be moved to the approximate midline, with finger tips on the vertebral body (Fig. 86.2). After subcutaneous local anesthesia is applied,

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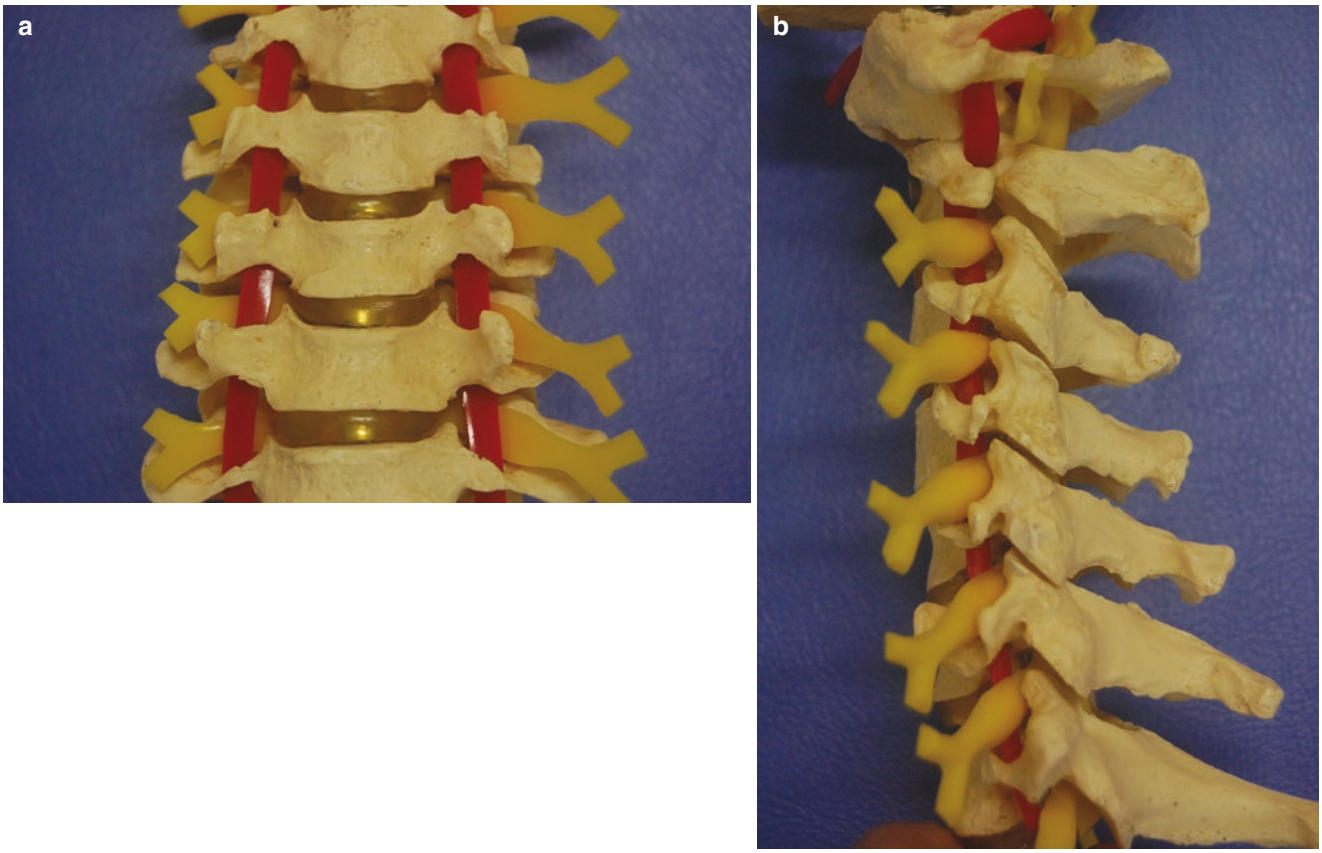

Fig. 86.1 Anatomy of the cervical intervertebral disc. (**a**) Frontal view and (**b**) lateral view

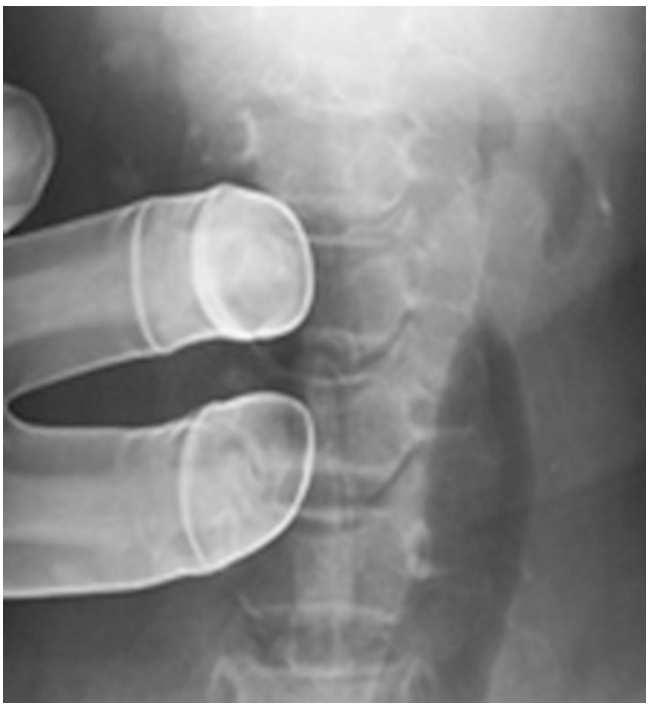

Fig. 86.2 Displacement by digits. The trachea and esophagus are pushed medially and the blood vessel laterally

depth is confirmed by moving the block needle from between the index and middle fingers to the superior border of the vertebral body on the caudal side of the target intervertebral disc [2]. The needle should be pulled back and then inserted several millimeters into the intervertebral disc, in a slightly cranial direction. Due caution is necessary in order to avoid penetration and spinal cord injury as, unlike lumbar disc punctures, it is difficult to sense the needle in the cervical disc. If the right side is affected, the needle should be raised and the needle tip placed on the right side of the intervertebral disc. If the left side is affected, the needle tip should be adjusted and placed on the left side of the disc, by crossing the needle tip over the midline. The needle tip should be adjusted so that it is located approximately one-fourth posterior to the vertebral body in the radiographic lateral view. Using the frontal view, the position of the needle tip should be confirmed as slightly deviated toward the affected side. Under observation in the lateral view and with caution to avoid needle tip movement, the syringe should be connected firmly to the block needle and contrast agent injected slowly. The volume of the injected drug solution is generally 0.1–1.0 mL. If injection resistance is high at the beginning, it is recommended to rotate the bevel, and try again. If possible, any

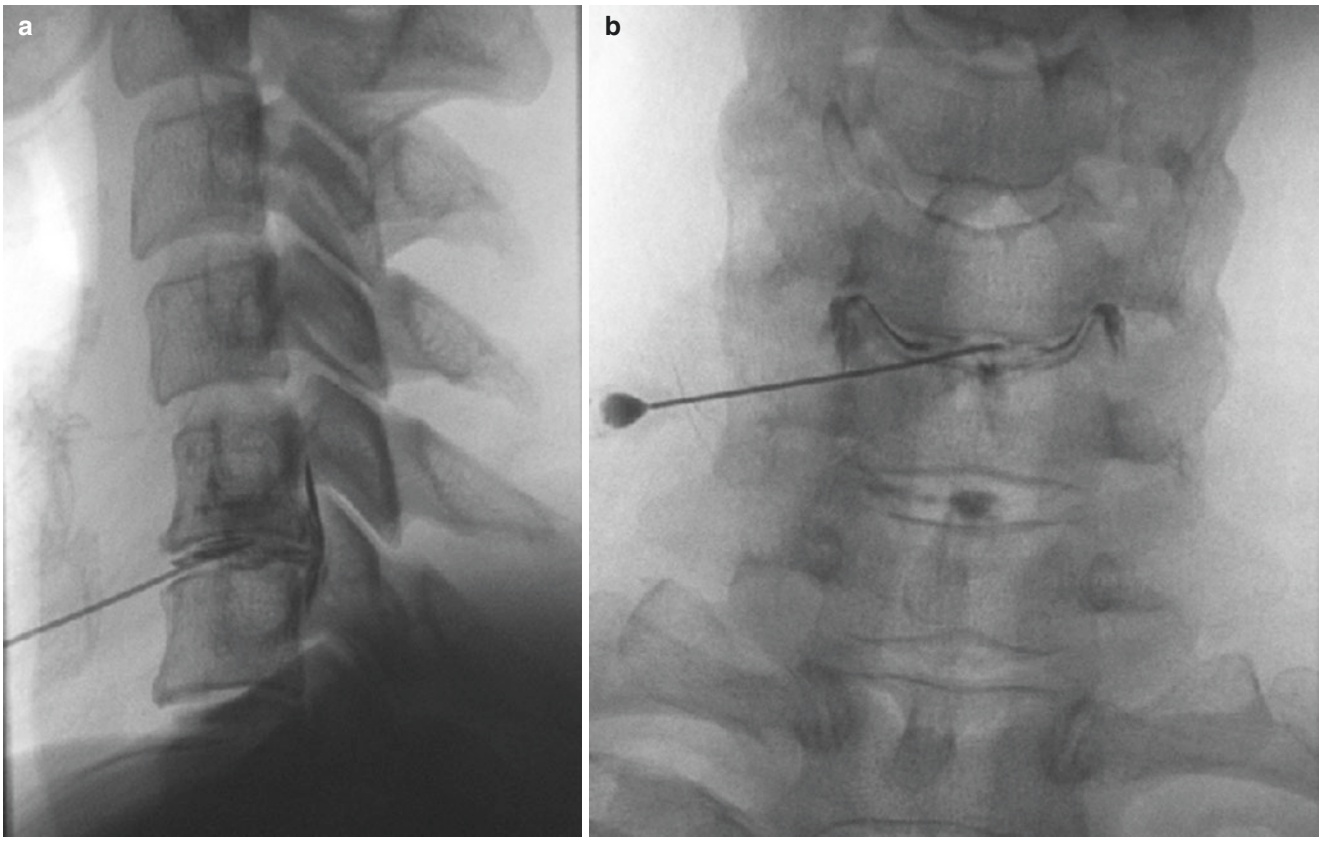

Fig. 86.3 Cervical disc contrast radiography. (**a**) Lateral view and (**b**) frontal view

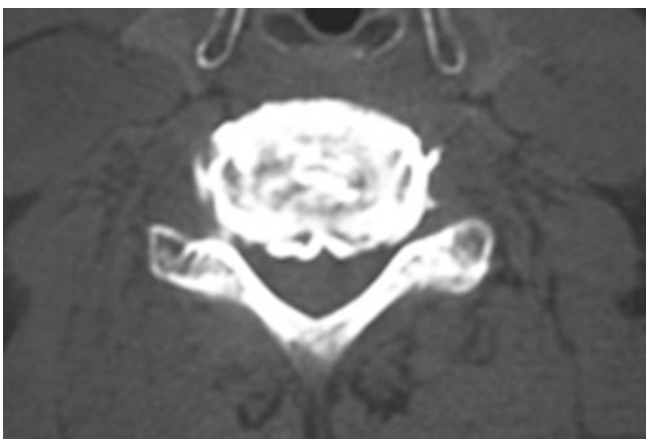

Fig. 86.4 CT discography. Herniation is visualized

additional injection should be given until the injection resistance increases or injection pain occurs. X-rays should be taken from lateral and frontal projections (Fig. 86.3a, b). Local anesthetic and steroids should be injected and the needle removed. When computed tomography (CT) is used concomitantly, CT images should be taken immediately (Fig. 86.4). Pressure hemostasis should be performed for at least 5 min by applying gauze directly to the injection site. Bed rest (90 min) is required.

86.6 Complications

1. Infection (diskitis): Due caution is necessary in order to avoid infection; if infection was to occur, it would likely be intractable. Thorough aseptic technique and avoiding esophageal punctures are important, and antibiotic therapy both before and after the operation is essential.
2. Hematoma: Hematomas are usually unlikely, but punctures may cause this complication if blood vessels are not sufficiently displaced. Punctures in the carotid or vertebral arteries may occur.
3. Nerve root injury: Nerve root injury occurs when the nerve root is punctured at the time of needle insertion. To prevent these injuries, it is necessary to ensure good body position. When the shoulder overlaps the area, the arm should be pulled down and the site of insertion reaffirmed before needle insertion.
4. Spinal cord injury: As the intervertebral disc is small and gives only a minimal sense of puncture, disc penetration can occur easily, resulting in spinal cord injury. It is important to confirm the depth of puncture in the lateral view when the initial intervertebral disc puncture is sensed.
5. Transient pain aggravation: In cases of high disc pressure, pain may worsen temporarily after injection of the drug

but will decrease within several days. Epidural blocks and analgesic drugs may be used to treat this pain.

6. Hoarseness: This condition occurs due to paralysis of the recurrent laryngeal nerve by the local dermal anesthesia. Hoarseness will disappear approximately 2 h following the procedure.

References

1. Cloward RB. Lesion of the intervertebral disks and their treatment by interbody fusion methods. The painful disk. Clin Orthop Rel Res. 1963;27:51.
2. Bogduk N, Windsor M, Inglis A. The innervations of the cervical intervertebral discs. Spine. 1988;13:2–8.

Thoracic Disc Block

87

Hisashi Date

87.1 Introduction

87.1.1 What Is a Thoracic Disc Block?

Thoracic disc block is a method of block where local anesthetic or steroids are injected into the intervertebral disc; this block is usually carried out simultaneously with discography. Although the use of thoracic disc blocks is extremely rare in comparison to lumbar or cervical disc blocks, they are indispensable for the diagnosis and treatment of thoracic disc herniations. This block technique can target the intervertebral disc that, given clinical symptoms or magnetic resonance imaging findings, is deemed responsible. This method has diagnostic value, allowing confirmation of reproduced pain at the time of injection of the drug and can provide therapeutic effects when given to patients who have no nerve root symptoms

87.2 Indications

Thoracic disc herniation, disc-related back pain, and thoracic discopathy

87.3 Anatomy (Fig. 87.1)

The point of a thoracic disc block is that the needle should be inserted into the target intervertebral disc without touching the nerve root or lung (pleura). Thoracic nerve roots emerge from the vertebral canal through an intervertebral foramen comprised of the vertebral body of the same level and the caudally adjacent vertebral body. The nerve root then runs slightly toward the cranial side in the upper thoracic vertebrae, almost laterally in the middle thoracic vertebrae, and slightly caudal in the lower thoracic vertebrae. If the needle is moved forward while it is in contact with the superior articular process, it will never touch the nerve root. In cases where the target is Th10/11, or further caudal discs, the route of injection may be the same as that used for lumbar disc contrast radiography. However, when the target disc is more cranial, the point of injection should not be lateral, as the target disc might be adjacent to the lungs.

87.4 Instruments and Drug Solutions

1. Puncture needles: 23G Cattelan needle (local anesthesia) and 12–14 cm 21G needle (block)
2. Syringes: 10 cc syringe (local anesthesia)
3. Three 5 cc syringes (contrast agent, intervertebral disc injection)
4. Drug solutions: 1% lidocaine and steroid

87.5 Procedures and Techniques

Prior to a block, antibiotics are administered to the patient via drip infusion. The patient is placed in essentially an oblique prone position, with a cushion placed under the thoracic region [1]. The X-ray tube bulb is swung toward the cranial and caudal sides in order to align the target intervertebral end plates. Body position and C-arm are adjusted so that the midpoint between the rib head and the superior articular process is located practically at the center of the vertebral body (Fig. 87.2). Sufficient local anesthesia, with 1% lidocaine, is applied to the skin around the site of injection. Local anesthesia of deeper tissue is performed using a Cattelan needle. The block needle should then be applied to the superior articular process, located caudal to the target intervertebral disc, and moved forward by sliding

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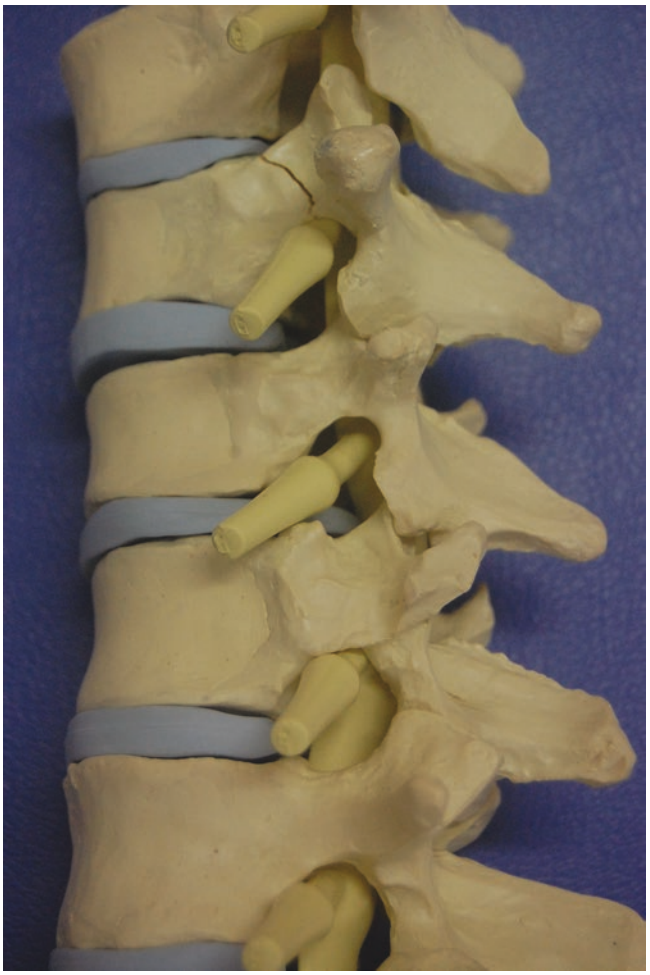

Fig. 87.1 Thoracic intervertebral disc. It is important to puncture the disc while avoiding the nerve root

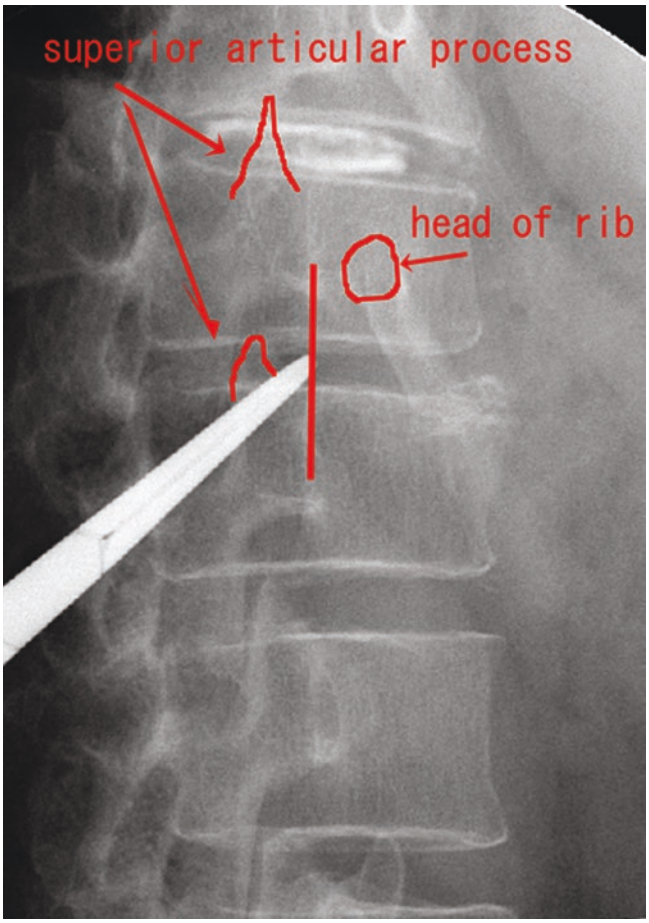

Fig. 87.2 Point of insertion. The midpoint between the head of the ribs and the superior articular process should be adjusted so that it aligns with the practical center of the vertebral body

the needle along the outer border, until it reaches the target disc (Fig. 87.3). Middle or lower thoracic intervertebral discs can be identified relatively easily as they give the sense of injecting into a rubber eraser. When the needle reaches the intervertebral disc, the needle should be moved slightly forward, and the position of the needle tip is confirmed by two different projections, i.e., the lateral and frontal views. In the lateral projection, a complete lateral view that shows overlap of the right and left ribs should be obtained. After confirming that the needle tip is not at the margins of the intervertebral disc, a contrast agent is injected in small increments. Injection should be carried out under X-ray fluoroscopy-guided method in the lateral view, in order to detect any drug leakage in the epidural space. Injection should be stopped if/when the patient reports radiating pain. If the site of the radiating pain is consistent with the site of the reported, usual pain, it is highly likely that the intervertebral disc in question is responsible. Injections should be discontinued when contrast agent leaks into the epidural space. Even when disc pressure is not very high and radiating pain is not induced, it is advisable to limit the volume of injected contrast agent to 2–3 mL.

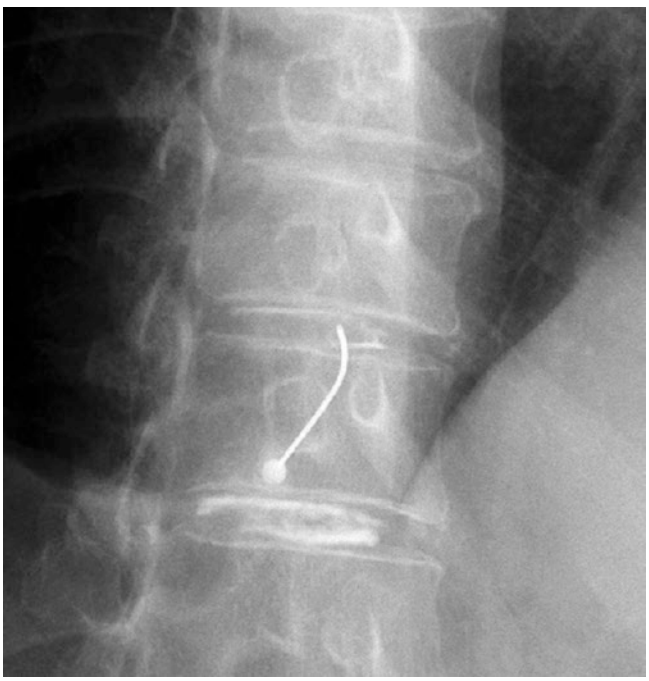

Fig. 87.3 Technique of insertion. The needle should be moved forward by sliding it along the outer border of the superior articular process

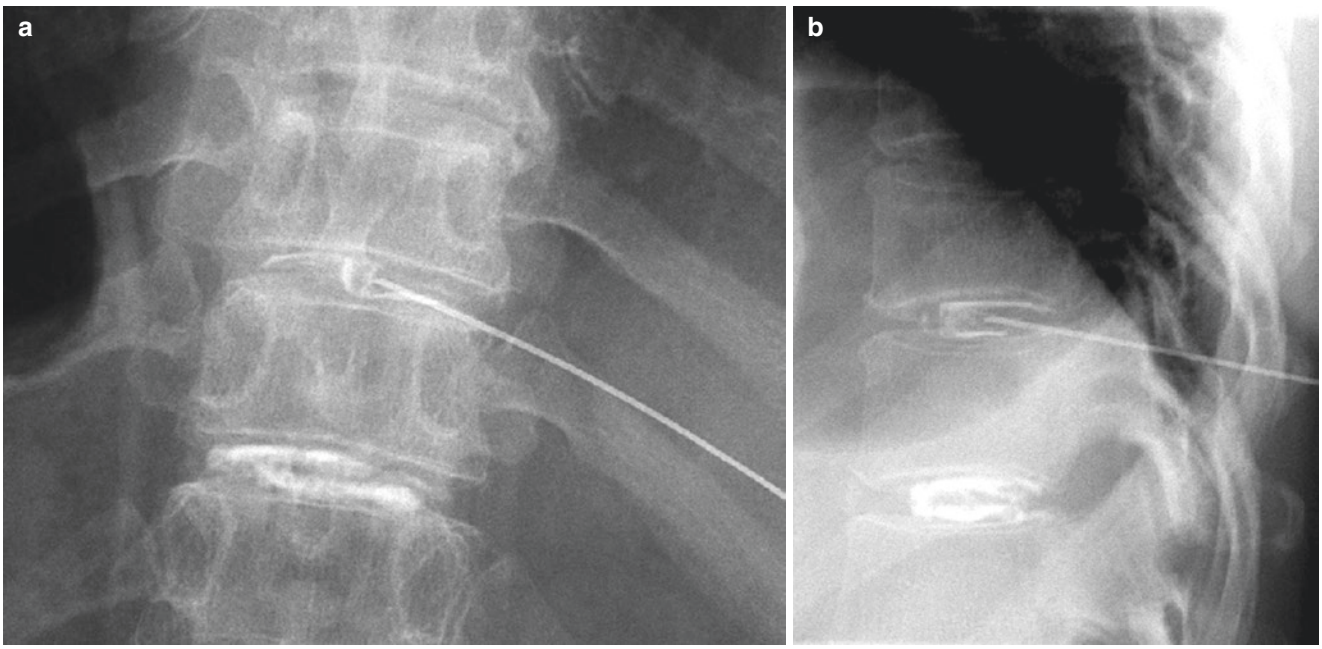

Fig. 87.4 Discography. (**a**) Frontal view, (**b**) lateral view

Two different projections, i.e., frontal and lateral (Fig. 87.4a, b), should be viewed when the contrast agent is injected. Then, 1 mL of local anesthetic and steroid should be injected. The patient should rest in bed for 90 min following the block and be checked for weakness and lightheadedness at the end of the rest.

87.6 Complications

1. Infection (diskitis): New drug vials or ampules should be used. Antibiotics, via drip infusion, should be given to patients for the sake of prophylaxis.
2. Nerve root injury: This type of injury occurs when the nerve root is punctured at the time of needle insertion. Although not usually a major problem, repeated puncture is more likely to cause nerve injury. Moving the puncture needle forward by sliding it along the superior articular process, while the patient is in a good position, reduces the possibility of injury.
3. Pneumothorax: In cases of intervertebral discs at Th9/10 (or more cranial), points of insertion should be up to 4–5 cm lateral to the spinous process. If the point of insertion is only determined using the radiographic view, depending on the body position, the actual insertion site may be more lateral, and the possibility of pneumothorax may be higher. Therefore, it is desirable to determine the point of insertion based on the distance from the spinous process and to find an oblique angle that allows the needle to appear as a point, using either the C-arm or a pillow.
4. Temporary aggravation of symptoms: When disc pressure is high, injection of the drug may further increase this pressure, leading to temporary aggravation of symptoms. However, such symptoms will usually improve by the following day. This possibility should be explained to the patient in advance.

Reference

1. Date H. Nerve block under Xray fluoroscopy-guided, ultrasound and CT guided. Tokyo: Igakusyoin; 2009. p. 92–5. (in Japanese).

Lumbar Disc Block

88

Hiroaki Yamagami and Yukiyo Shiomi

88.1 Introduction

88.1.1 What Is the Intervertebral Disc Block?

It is a procedure to treat pain attributable to the intervertebral disc by injecting a drug solution to relieve localized inflammation, decrease internal pressure on the intervertebral disc, and facilitate intervertebral disc denaturation.

88.2 Indications

Herniated disc, discopathy, and complex spinal column stenosis. Patients with pain attributable to degenerative disc disease are indicated for this treatment. It is performed for the responsible intervertebral discs expected from diagnosing clinical manifestation and other diagnostic images.

88.3 Anatomy (Fig. 88.1)

The anatomy of the needle insertion process involves the skin, subcutaneous site, paravertebral muscle, superior articular external border, ligament, fiber ring, and vertebral pulp. The nerve roots run ventrally from the ventral border of the superior articular process.

88.4 Instruments and Drug Solutions

Syringe: 5 mL syringe, 2.5 mL syringe (contrast agent), and 2.5 mL syringe (1% lidocaine 1 mL + aqueous steroid)

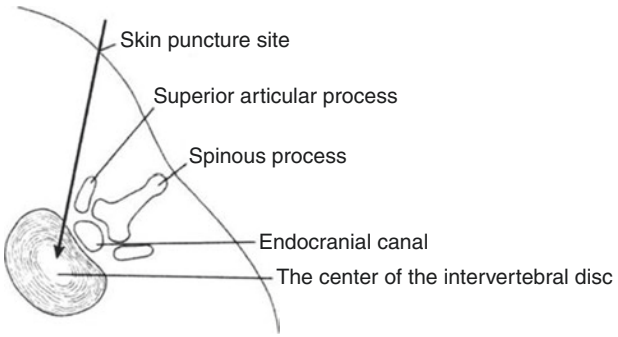

Fig. 88.1 Anatomical chart at the time of discography. Schematic illustration in slightly oblique presentation against the X-ray fluoroscopic stand

Needle: 23–25G x 6 cm disposable needle and 21–22G x 12–14 cm nerve block needle

Agent: 0.5–1% lidocaine, contrast agent, and aqueous steroid

88.5 Procedures and Techniques: Practice of Procedure

88.5.1 Under X-Ray Fluoroscopy-Guided Method

88.5.1.1 Posture and Photography

Put a pillow under the flank (waist) in the oblique presentation to decrease the lateral curvature of the targeted vertebral body (Fig. 88.2). You may not necessarily puncture from the unaffected side. Some patients cannot take the posture unless the affected side is upward. In addition, you should often puncture from the affected side for pain treatment.

From the lateral position, gradually tilt the body forward to the oblique presentation (Fig. 88.2). Adjust the posture to the angle where the anterior border of the superior articular process of the lower vertebra is positioned dorsal to the center of the intervertebral disc anteroposterior diameter (about

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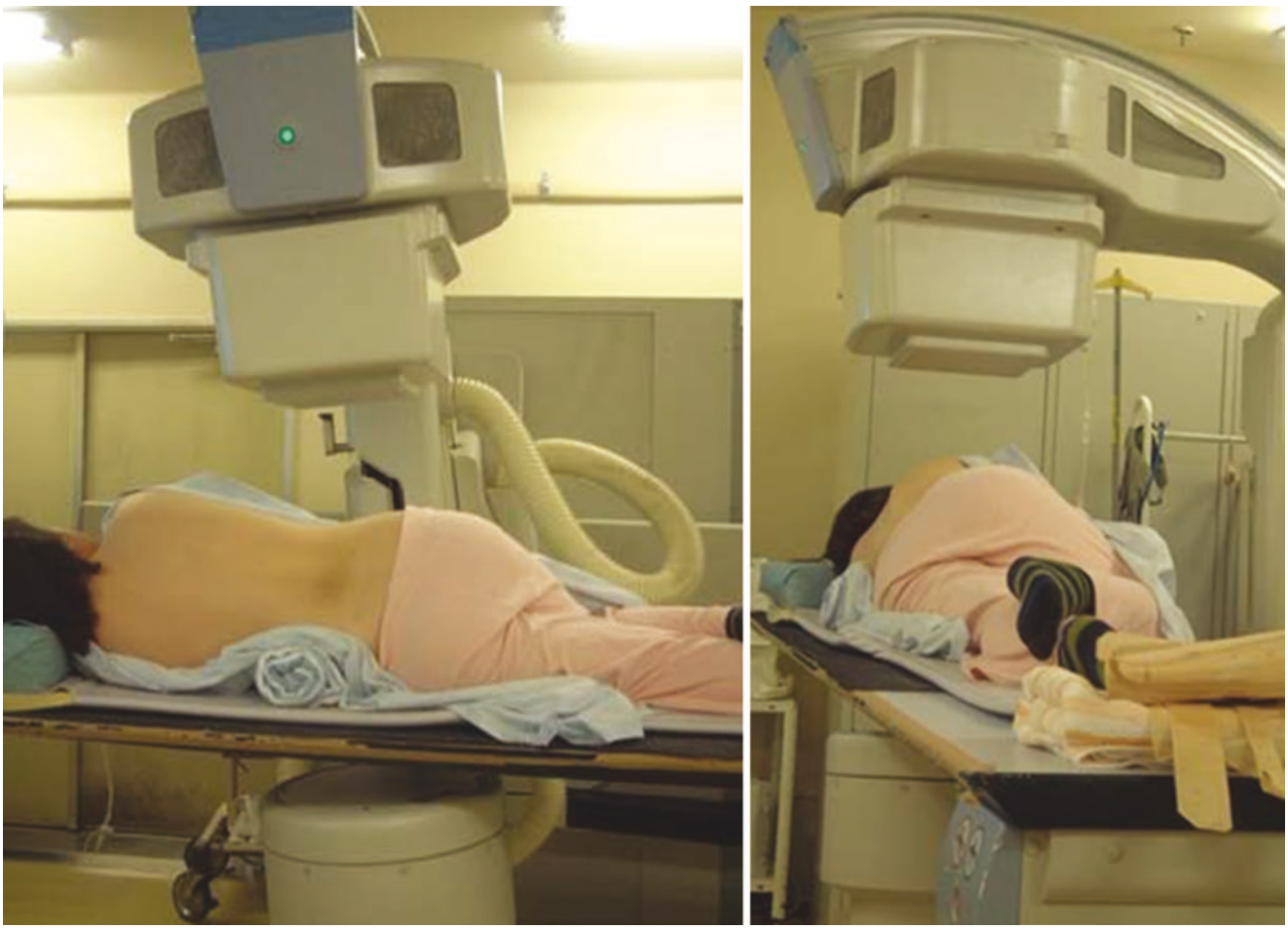


Fig. 88.2 Posture at the time of the discography. A patient should be in the lateral position but in a slightly oblique presentation

one-third to one-quarter of the dorsal region), confirmed on the fluoroscopic screen.

88.5.1.2 Puncture and Drug Injection

Set the angle of the X-ray tube parallel to the target intervertebral disc, which means that the cranial end plate and the caudal end plate should lie along the same straight line. For the L4/5 and L5/S intervertebral discs, the X-ray tube lens is often on the cranial side (Figs. 88.2 and 88.4). The puncture site should be located on the anterior border of the superior articular process of vertebra and dorsal to the center of the intervertebral disc (about one-third to one-quarter of the dorsal region), confirmed on the fluoroscopic screen (Fig. 88.4). Using a 23–25G × 6 cm disposable needle, administer local anesthesia from the skin to the superior articular process with 2–3 mL of 1% lidocaine. Following local anesthetic infiltration, insert a nerve block needle forward until it reaches the superior articular process. In the process of advancing the needle forward, watch the fluoroscopic screen; unless the needle tip passes through the superior articular process into the ventral side, the needle tip never touches the nerve roots. After the needle tip reaches the superior articular process, let the needle tip slide along the lateral border and puncture the intervertebral disc (Fig. 88.3) [1]. In this procedure, the needle often changes its direction somewhat central to the superior articular process. Taking that into account, we adjust the initial posture to the position where the anterior border of the superior articular process of the lower vertebra is positioned dorsal to the center of the intervertebral disc anteroposterior diameter (about one-third to one-quarter of the dorsal region), confirmed on the fluoroscopic screen. By inserting the needle to touch the superior articular process, you can determine the distance from the skin to the superior articular process and estimate the depth to the intervertebral disc. Furthermore, it brings the benefit that you can easily watch the needle tip and avoid radiation exposure to the hands because it is puncturing somewhat from the dorsal. When the needle has touched the nerve root during the operation, adjust the position of the needle tip somewhat to the dorsocaudal aspect.

When the needle is inserted into the intervertebral disc, resistance is felt, and when the sensitivity of the fiber ring increases, the patients complain of lumbago. In the case of mild pain, puncture at a stretch. However, in the case of acute pain,

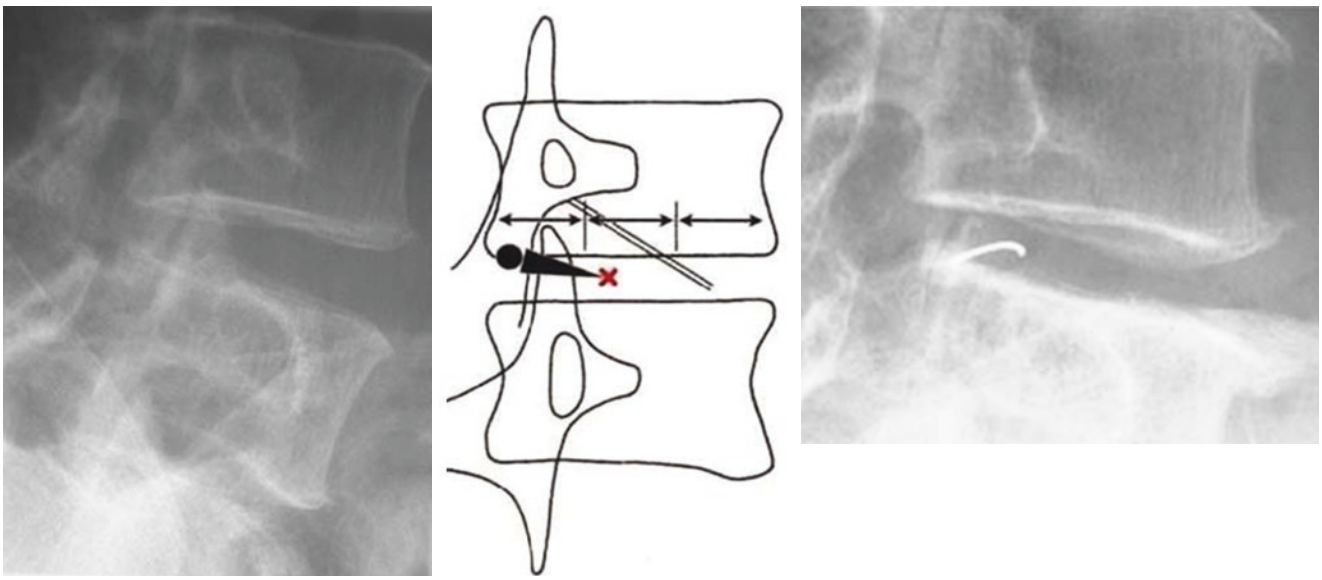


Fig. 88.3 Practice of lumbar discography (L4/5). Left: adjust the slope of the X-ray tube so that the cranial and caudal end plates of the target intervertebral lie along the same straight line. Middle: schema of puncturing of a nerve block needle. Right: puncture of a nerve block needle into the target intervertebral disc

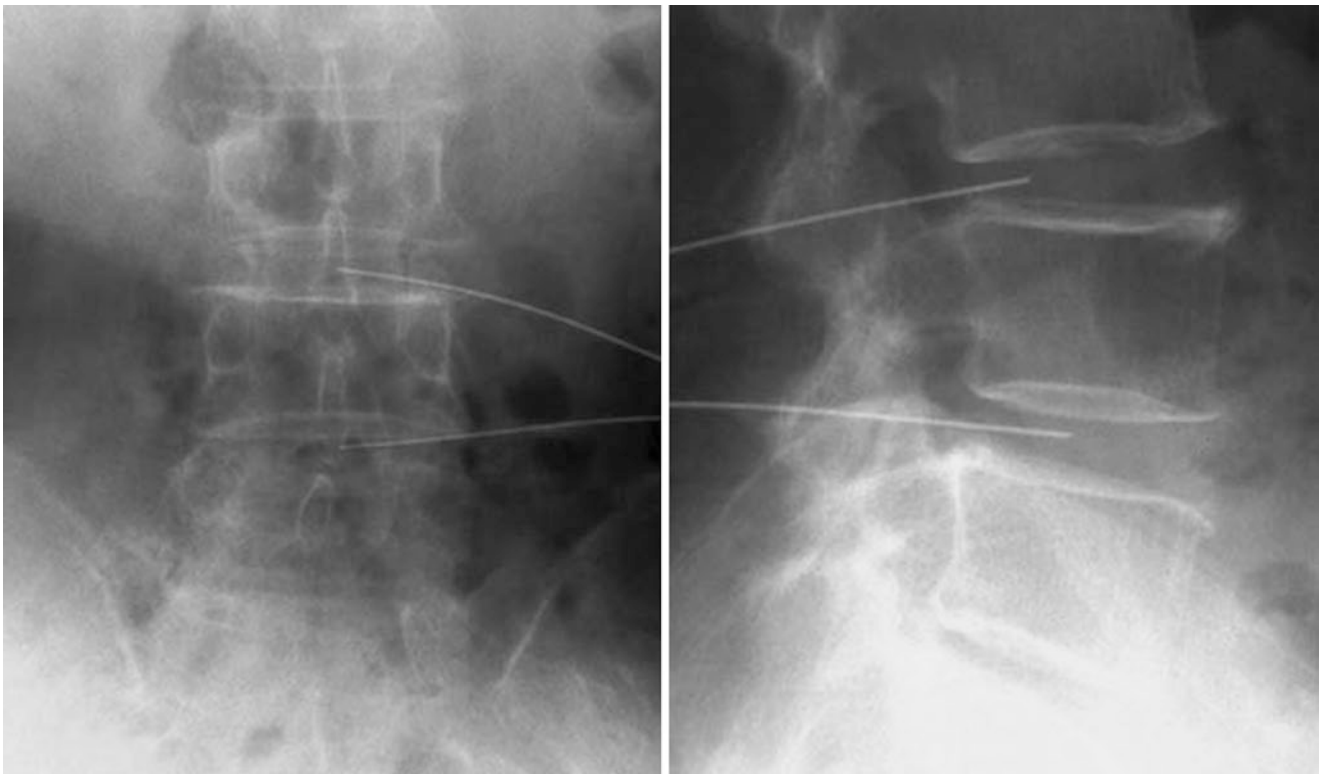
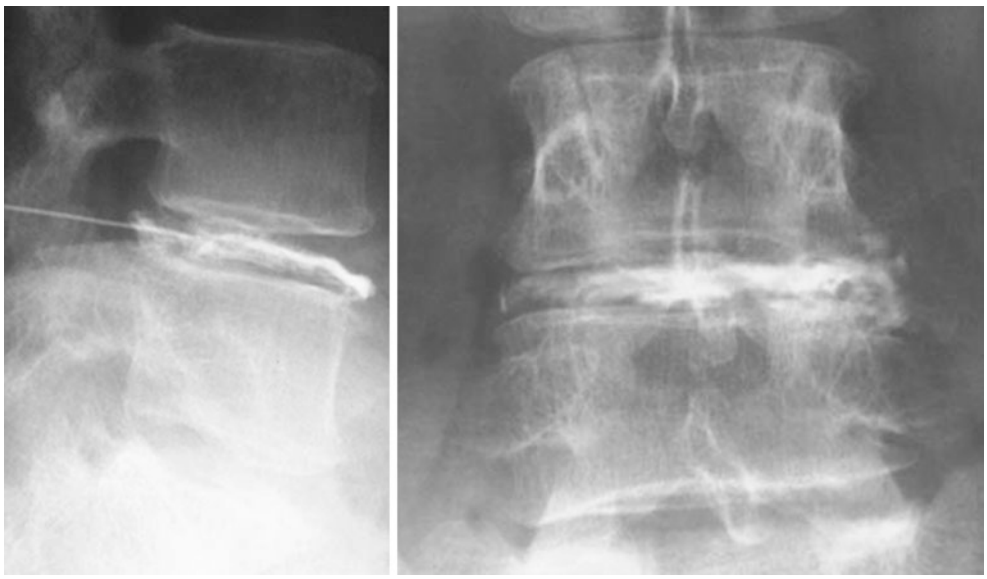


Fig. 88.4 Localization of the needle tip in the lumbar discography (L3/4 L4/5). Good position of a nerve block needle tip is the center of the frontal fluoroscopic image and the dorsal to the center of the lateral fluoroscopic image

inject 0.2–0.5 mL of 1% lidocaine to resolve the pain. Return the posture to the lateral position to check the location of the needle tip, and rotate the X-ray tube to watch the frontal fluoroscopic image. (If the X-ray tube cannot be rotated, the posture should be the prone position.) Adjust the posture so that the position of the spinous process comes to the center of the vertebral body on the frontal fluoroscopic image. While watching the fluoroscopic image, advance the needle tip forward to the intervertebral disc. After that, change the fluoroscopic image back to the lateral fluoroscopic image (return the posture from

the prone position to the lateral position). Overlapping the bilateral 12th rib under fluoroscopy provides the accurate lateral fluoroscopic image. Good position of a nerve block needle tip is the center of the frontal fluoroscopic image and the dorsal to the center of the lateral fluoroscopic image (Fig. 88.4). While confirming irradiating pain, inject the contrast agent by 0.5 mL to perform X-ray radiography. After the injection, photograph the frontal image and lateral image (Fig. 88.5). Subsequently, add the contrast agent by 0.5 mL, and confirm reproducibility of the pain. If the pain is observed, discontinue the further injection of the contrast agent. Inject an aqueous steroid and a local anesthetic for therapeutic purpose, and withdraw the needle. Finally, perform a CT photography. After withdrawing the needle, rest and follow-up the patient for 1–2 h. In the case of L5/S1 intervertebral, when a triangle surrounded by the three elements that are L5 end plate, the S1 anterior border of the superior articular process, and the superior border of the iliac crest can be seen on the fluoroscopic screen, advance a nerve block needle toward this triangle (Fig. 88.6). When this triangle cannot be seen, assume that the puncture site should be located

Fig. 88.5 L4/5 discography



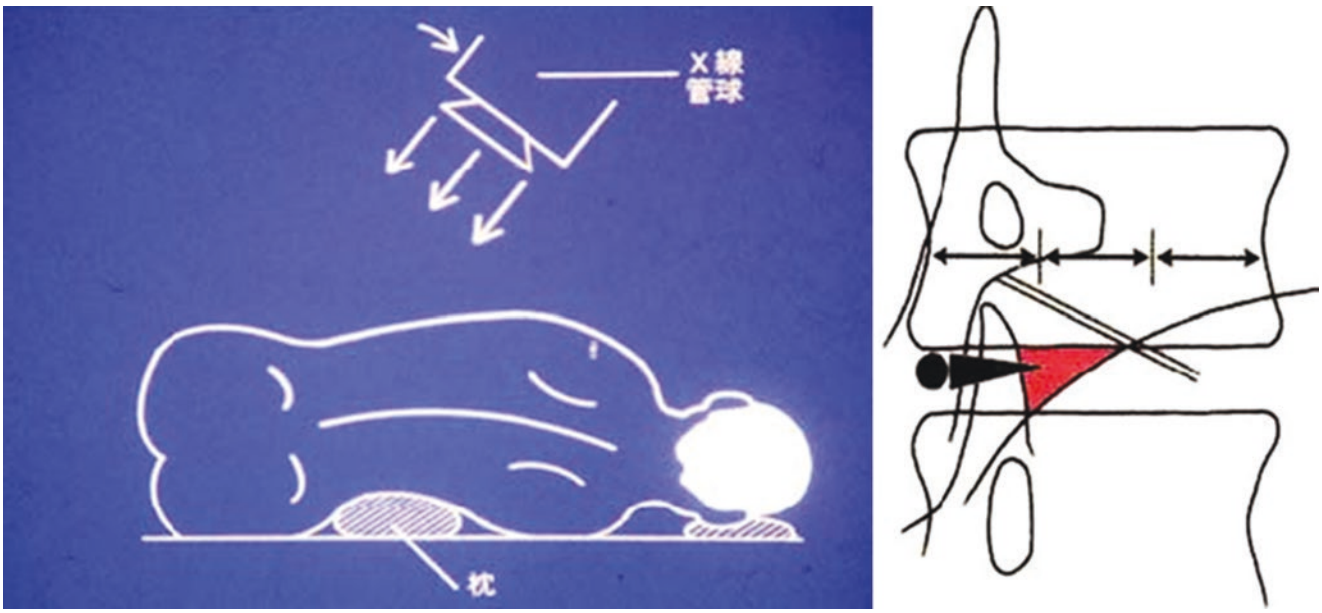


Fig. 88.6 The puncture site at the time of the L5/S discography. Left: slope of posture and the X-ray tube. Raise the height of the waist pillow, and tilt the X-ray tube to the cranial side, because the iliac crest is located as a barrier. Right: schema of the needle puncture. Confirm the triangle surrounded by the L5 caudal end plate of the vertebral body, the S1 anterior border of the superior articular process, and the superior border of the iliac crest. Assuming that the puncture site should be around the intervertebral joint, advance the needle tip toward the triangle, and then puncture the intervertebral disc at the site near the anterior border of the superior articular process. A black dot indicates the puncture site. A black arrow indicates the penetrated part in the intervertebral disc

cranial to the superior border of the iliac crest, and advance the nerve block needle toward the caudal. Ideally, the superior articular process of S1 is positioned dorsal about one-third of the dorsal region to the center of the intervertebral disc antero-posterior diameter. It is often positioned dorsal half of the dorsal region because of the iliac crest. The puncture site should be located a little nearer to the intervertebral joint from the border of the superior articular process of S1, confirmed on the fluoroscopic screen. Advance the nerve block needle toward the lateral border of the superior articular process. After the needle tip reaches the superior articular process, let the needle tip slide along the lateral border (Fig. 88.7). Advancing the needle tip toward the cranial side rather than toward the center of the intervertebral disc, eventually, it is easy to advance a needle tip toward the center of the intervertebral disc because the direction of the X-ray tube leans to the cranial side. For male patients, the iliac crest may cover the view to make it impossible to advance the needle tip. In the case of a male patient, the iliac crest may cover the view to make it impossible to advance the needle tip forward. When it is difficult even if you enlarge the waist pillow, assume that the puncture site should be located on the superior border of the iliac crest, and slide the needle into the inside of the iliac crest. After the nerve block needle was inserted in the intervertebral disc, the procedure is similar to others (Figs. 88.8 and 88.9).

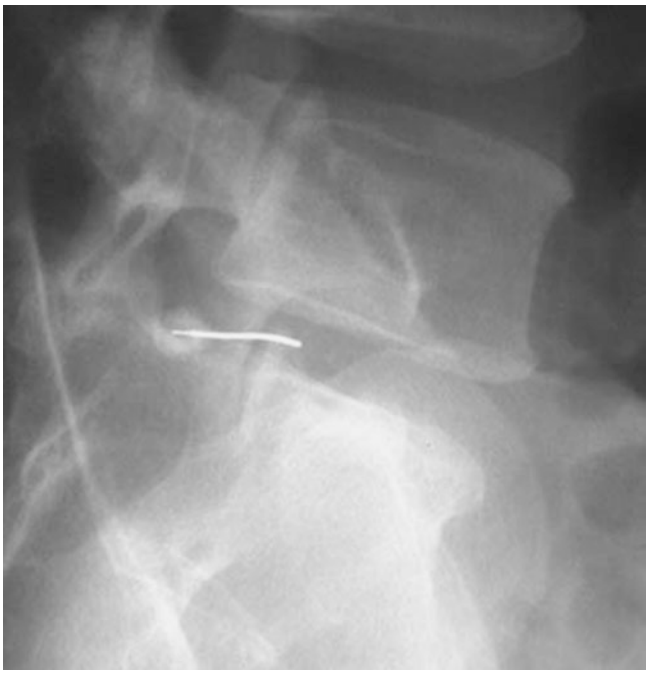


Fig. 88.7 Puncture at the time of L5/S discography. The puncture site should be located a little nearer to the intervertebral joint from the border of the superior articular process, confirmed on the fluoroscopic screen. After the needle tip reaches the superior articular process, let the needle tip slide along the anterior border into the intervertebral disc

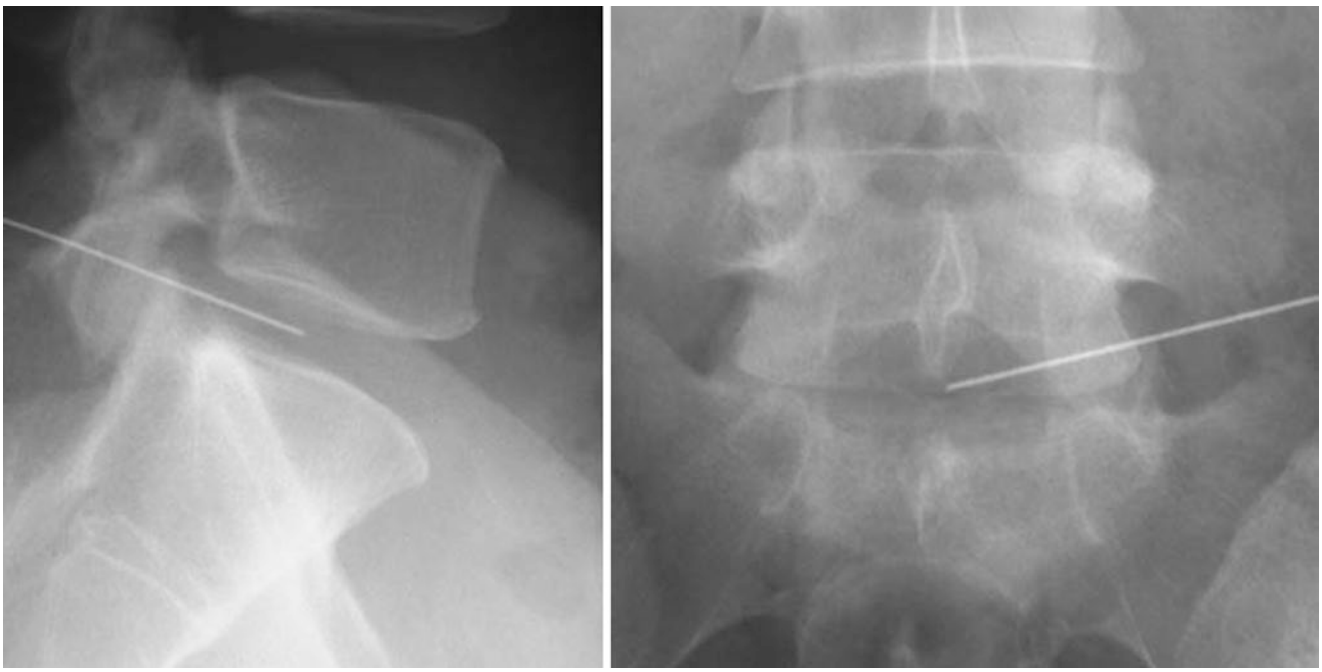


Fig. 88.8 Confirmation of the needle tip at the time of the L5/S discography. Good position of a nerve block needle tip is the center of the frontal fluoroscopic image and the dorsal to the center of the lateral fluoroscopic image

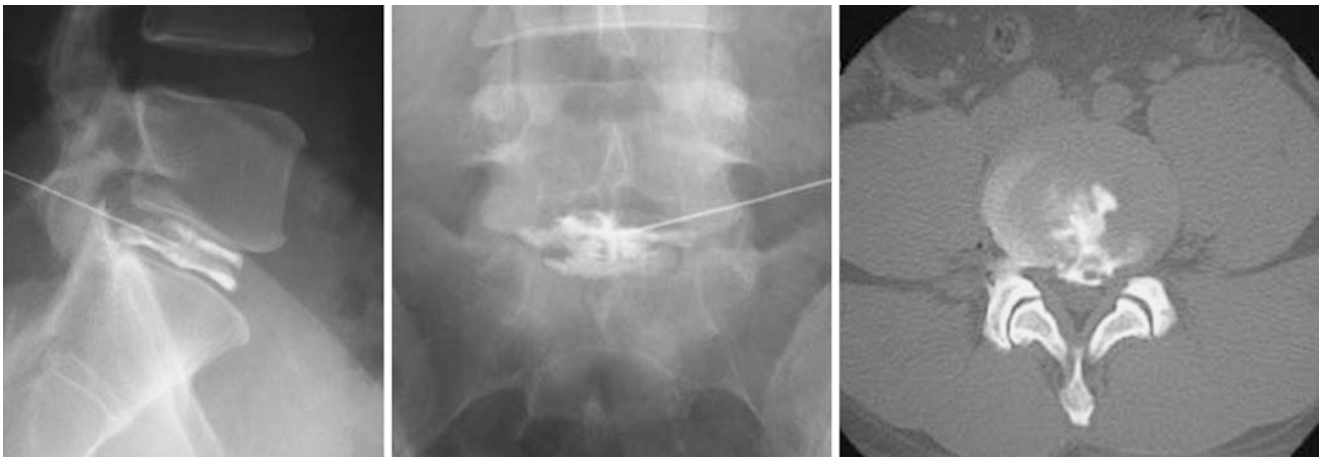


Fig. 88.9 L5/S discography and post-discography CT

88.6 Complications

Infection (vertebral body, intervertebral discitis): although uncommon, once the disease occurs, it may need surgery. Prophylaxis is the most important, and a preoperative antibiotic regimen, an adequate disinfection of the operative field, and intraoperative thorough cleaning operation are necessary. Perform intravenous infusion of the antibiotic 30–60 min before the block is performed.

Nerve damage: if a needle tip leans to the ventral, nerve root injury may occur.

Pain: it is the transient exacerbation of chief complaint. In the case of projecting type, patients often appeal exacerbation of the original symptom until the contrast agent is absorbed. After performing discography, epidural block should be addressed [2].

References

1. Yamagami H, Shiomi Y. Lumbar disc block. In: Ohseto K, editor. Nerve block method under fluoroscopy. Tokyo: Igaku-shoin; 2009. p. 130–3. (in Japanese).
2. Yamagami H, Fukushima T, Yanaidani F. Management of pain induced by discography. Pain Clinic. 2002;23(1):211–6. (in Japanese)

Disc Interventional Therapy

89

Sei Fukui

89.1 Introduction

89.1.1 Nerve Block for Disc Interventional Therapy

Nerve block for disc interventional therapy includes intervertebral disc block, intradiscal electrothermal therapy (IDET), and intervertebral disc pulsed radiofrequency (PRF).

89.2 Intradiscal Electrothermal Therapy (IDET)

A SpineCath catheter (unapproved, St. Jude Medical) (Fig. 89.1) is prepared for fluoroscopy-guided radiofrequency thermocoagulation and then is inserted into the posterior fibrous ring in the intervertebral disc. Thus, the nerve causing discogenic low back pain is treated with radiofrequency thermocoagulation [1].

89.2.1 Indication

Intractable chronic discogenic low back pain

Discogenic low back pain is exacerbated by a posture which increases intradiscal pressure, causing patients not to be able to sit for a prolonged period. It is positively diagnosed when pain is reproduced at a low pressure by discography or by injecting a small volume of contrast medium (1.25 mL or less). It is also important to observe pain reduction by disc block with the injection of a small volume of an anesthetic (about 0.5 mL or 2% mepivacaine). Since the indication of IDET is chronic low back pain, psychological and social factors are involved in its exacerbation and progression to an intractable state in many cases. Psychosocial evaluation before its application is essential.

Normally, there is no nerve in the intervertebral disc, but when the fibrous ring is ruptured and the intervertebral disc is degenerated, nerve fibers enter the intervertebral disc and the outer layer of the fibrous ring, increasing the load on the fibrous ring and stimulating pain fibers. This increased stimulation of the pain fibers is considered to be the cause of discogenic low back pain [1].

89.2.2 Instruments and Drug Solutions

1. Coil for radiofrequency thermocoagulation, SpineCath catheter (unapproved, St. Jude Medical)
2. Radiofrequency thermocoagulation apparatus, NT1100 (unapproved, St. Jude Medical) (Fig. 89.1)

89.2.3 Procedures and Techniques of IDET

It is applied to a patient while in a prone position. Under local anesthesia, a 17-G guide needle is inserted in a region slightly posterior to the center of the intervertebral disc with X-ray fluoroscopy-guided method. When there is laterality of low back pain or the symptoms are unilateral, the guide needle is inserted from the healthy side (Fig. 89.1). A SpineCath catheter is inserted into the guide needle and then into the intervertebral disc, going around and along the outer margin of the nucleus pulposus. The catheter is slowly and gently inserted while being rotated by the fingers to avoid bending. X-ray fluoroscopy-guided method is then used to confirm the catheter has retained its coil-like state in the intervertebral disc (Fig. 89.1). In order to observe the catheter coil, markers are set at both ends, and the position of the coil region of the catheter posterior to the fibrous ring is confirmed (Fig. 89.1).

The temperature is then elevated for 12 min from 60 to 90 °C using a radiofrequency thermocoagulation apparatus,

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and radiofrequency thermocoagulation is applied at 90 °C for a period from 4 min and 30 s to 5 min.

89.2.4 Complications

Transient exacerbation of pain: Patients may complain of the exacerbation of low back pain for several days after treatment, but it remits within 1 week in most cases. Other complications are the same as those of discography and blocks.

89.3 Intradiscal Pulsed Radiofrequency (PRF)

Pulsed radiofrequency (PRF) is applied in an intervertebral disc to treat discogenic low back pain, in which a TOP NEUROPOLE Needle with a 20-mm exposure (approved, Top Corp) is advanced to the center of the intervertebral disc.

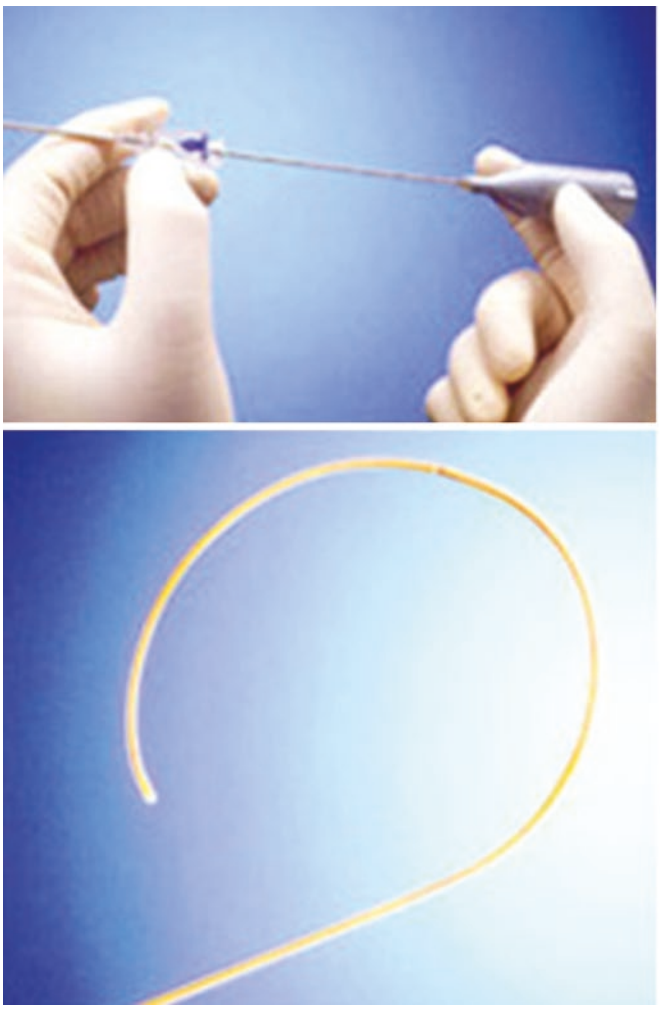
IDET is not recommended for discogenic low back pain for several reasons. Insertion of the catheter is difficult in some patients, the technique itself is complex, and treatment takes time. Currently, a Diskit needle is advanced to the center of the intervertebral disc, and PRF is applied in the disc. It has been reported that the therapeutic outcome of intradiscal PRF is similar to that of IDET and other forms of intradiscal radiofrequency thermocoagulation, but fewer adverse events develop [2].

89.3.1 Indication

The same as that of IDET

89.3.2 Anatomy

It is omitted because it is the same as that for discography and block.



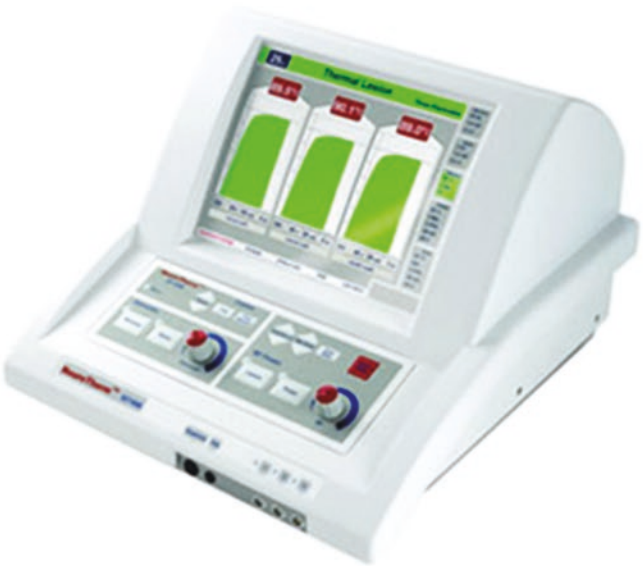


Fig. 89.1 Instruments and procedure of IDET. SpineCath catheter (St. Jude Medical), radiofrequency thermocoagulation apparatus (NT1100, St. Jude Medical), insertion of 17-G guide needle into a region slightly posterior to the center of the intervertebral disc, frontal and lateral views of SpineCath catheter insertion on intraoperative fluoroscopy

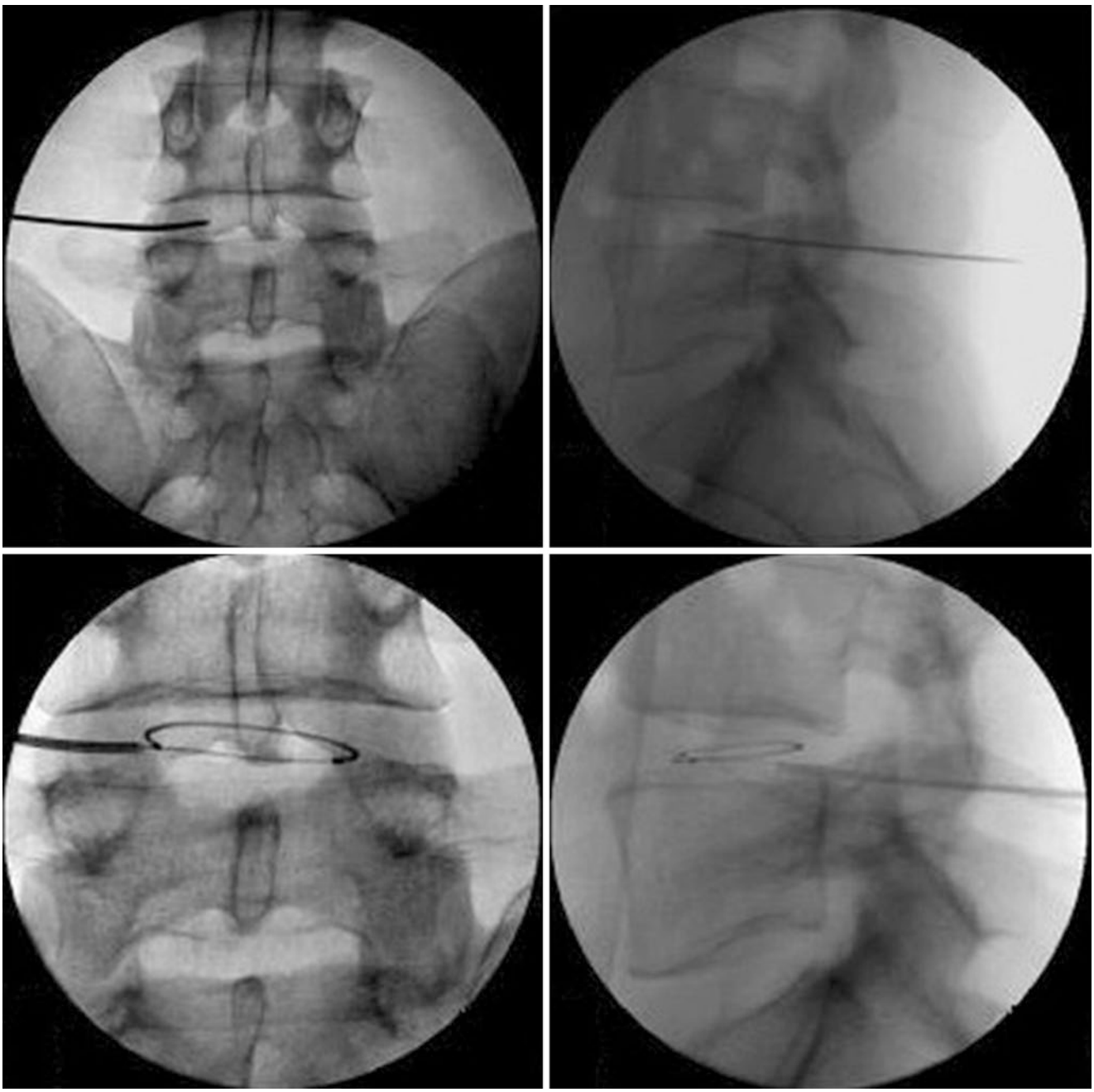


Fig. 89.1 (continued)

89.3.3 Instruments and Drugs

1. Diskit needle (unapproved, St. Jude Medical)
2. Radiofrequency thermocoagulation apparatus, NT1100 (unapproved, St. Jude Medical) and TLG-10 (TOP Corp)

89.3.4 Procedures and Techniques

Under local anesthesia in a prone position on a fluoroscopy table, a Diskit needle is inserted into the intervertebral disc bilaterally with fluoroscopic guidance. The Diskit needle in the intervertebral disc is advanced to the center of the disc. It is placed closer to one side when the target is unilateral (Fig. 89.2), followed by intradiscal PRF at 40 °C for 15 min.

89.3.5 Complications

Complications are the same as those of discography and block.

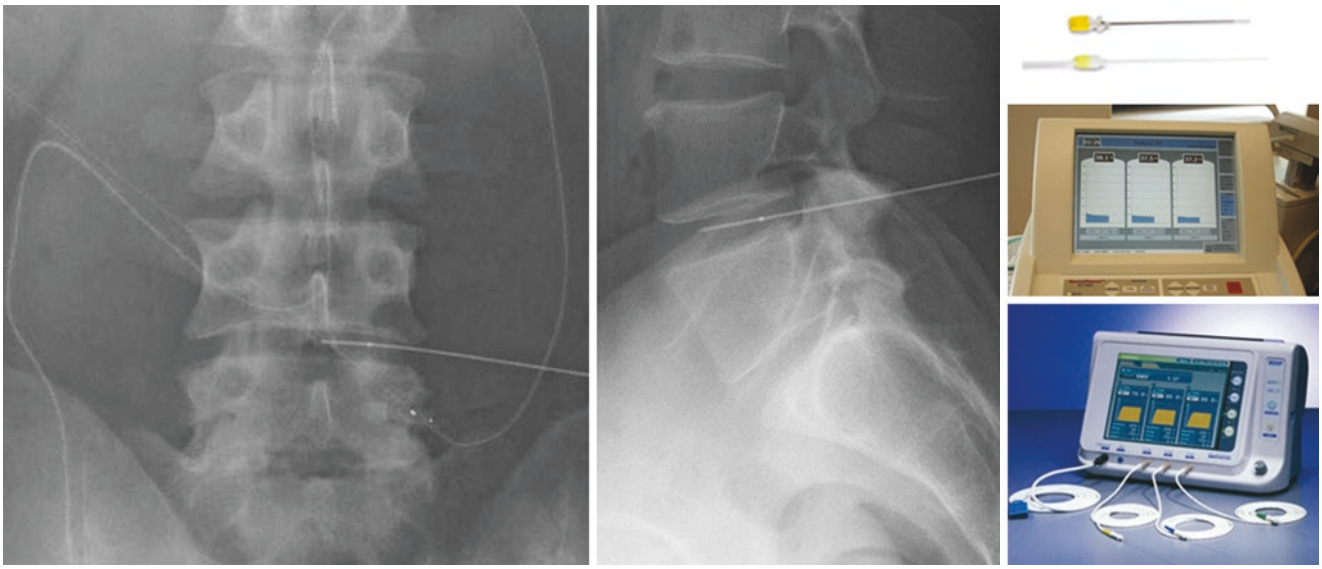


Fig. 89.2 Intradiscal PRF using Diskit. Frontal and lateral views of Diskit needle (St. Jude Medical) insertion into the center of the intervertebral disc on intraoperative fluoroscopy, Diskit needle, radiofrequency thermocoagulation apparatus NT1100 and TLG-10 (TOP Corp)

89.4 Nucleoplasty (Radiofrequency Disc Decompression)

The nucleus pulposus in the intervertebral disc is constricted by radiofrequency thermocoagulation at a low temperature (up to 70 °C) to reduce the intradiscal pressure [3]. Although the SpineWand catheter and the exclusive radiofrequency thermocoagulation apparatus have been approved, they have not been applied widely in Japan because they are not covered by national health insurance. However, they are widely used in other countries.

89.4.1 Indications

Lumbago and lower extremity pain induced by bulging disc herniation

89.4.2 Anatomy

It is the same as that of discography and block.

89.4.3 Instruments and Drugs

SpineWand catheter (ArthroCare): a catheter with a 1.1-mm diameter for radiofrequency thermocoagulation (Fig. 89.3) and exclusive radiofrequency thermocoagulation apparatus (ArthroCare)

89.4.4 Procedures and Techniques

Under local anesthesia in a prone position, a guide needle is inserted percutaneously with an X-ray fluoroscopic guide and placed so that it enters the fibrous ring of the intervertebral disc from the side with symptoms. A SpineWand catheter with a 1-mm tip diameter is repeatedly advanced into the intervertebral disc from the guide needle while cutting at 0.5 cm/s and returning while applying coagulation repeated in six directions. The position of the SpineWand catheter is checked in the anteroposterior, lateral, and oblique images of fluoroscopy, and thermocoagulation is applied in six directions: 2, 4, 6, 8, 10, and 12 o'clock directions (Fig. 89.3). The frequency in the 8–12 o'clock directions is selected corresponding to the severity of symptoms.

It is the least invasive among the disc decompression methods and can be safely and simply applied because a thin catheter is used at a low temperature and the procedure can be completed within a short time.

89.4.5 Complications

Complications are the same as those of discography and block.

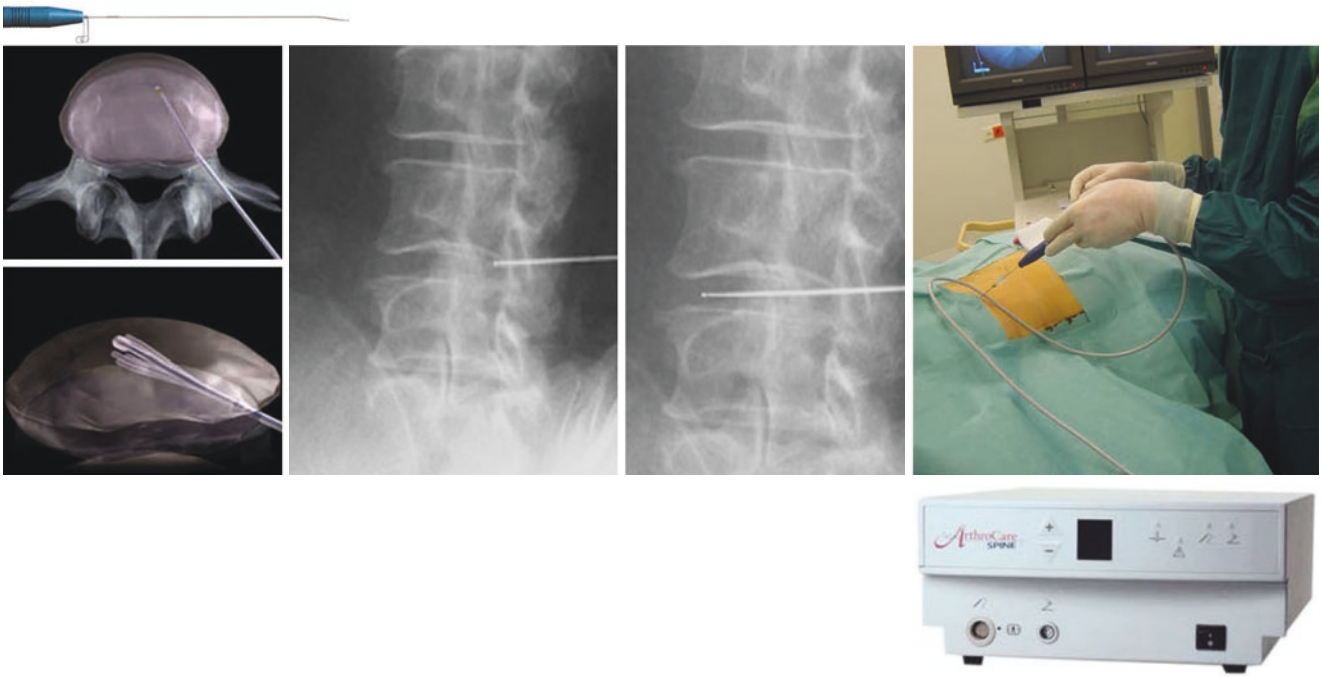


Fig. 89.3 Nucleoplasty. SpineWand catheter, schema of the nucleoplasty procedure, actual application in an oblique image of fluoroscopy, radiofrequency thermocoagulation apparatus

89.5 Procedure of CT Fluoroscopy-Guided Nerve Block: Intervertebral Disc Block

89.5.1 Indication

Disc herniation and discogenic low back pain

89.5.2 Anatomy

Refer to fluoroscopy-guided disc block.

89.5.3 Instruments and Drug Solutions

The same as those for normal intervertebral disc block.

89.5.4 Procedures and Techniques

A patient is placed on a CT fluoroscopy table in a prone position. A pillow is positioned under the abdomen to set the target intervertebral disc perpendicular to the gantry on CT. Slices parallel to the target intervertebral disc are acquired, and the intervertebral disc, vertebra, vertebral arch, and nerve root are confirmed. Based on CT fluoroscopic images, the optimum puncture site and angle are measured and marked on the skin to set a puncture site (Fig. 89.4).

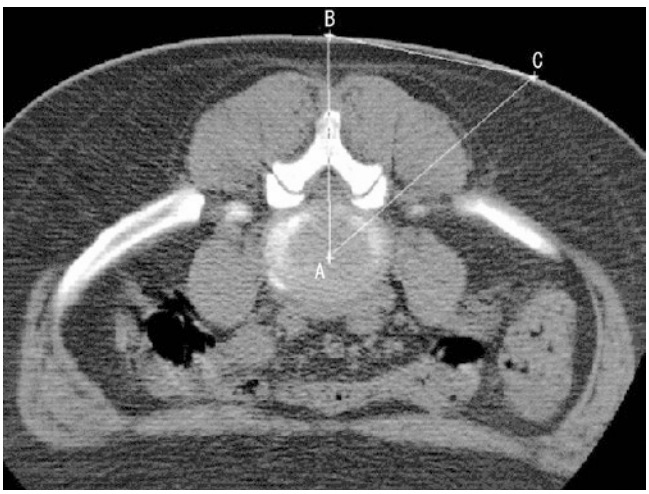


Fig. 89.4 CT-guided setting of the needle insertion site and angle for intervertebral disc block. The puncture angle (∠BAC), site (C), and depth (AC) to puncture the center of the nucleus pulposus of the intervertebral disc are measured on CT fluoroscopy

The procedure can be visualized in almost real time by CT fluoroscopy-guided method. The needle is advanced, and the intervertebral disc is punctured while observing the monitor. The puncture pathway is confirmed, and the puncture is

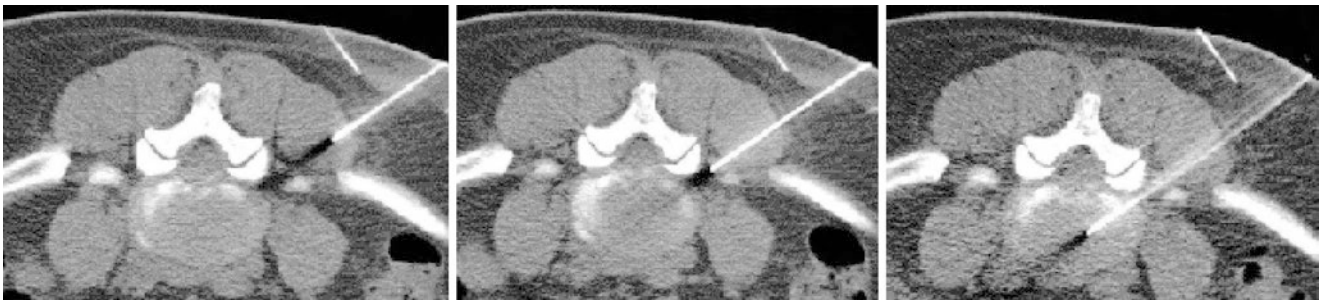


Fig. 89.5 CT fluoroscopy-guided approach of intervertebral disc block. The intervertebral disc is punctured while confirming the position of the puncture needle tip in real time under CT fluoroscopy. The positions of the CT fluoroscopy-guided block needle tip are the lumbar muscles (left), outer margin of the disc space (center), and intervertebral disc (right)

applied to the center or at a slightly posterior site of the disc through the outer margin of the disc space at the puncture angle and depth determined beforehand (Fig. 89.5). Under CT fluoroscopy-guided method, the center or a slightly posterior site of the disc can be accurately punctured [4].

Contrast medium is injected while observing the monitor of CT fluoroscopy-guided method to perform discography (Fig. 89.5), and a local anesthetic and water-soluble steroid are injected to block the intervertebral disc. CT fluoroscopy-guided method facilitates accurate judgment of the direction of nucleus pulposus prolapse and type of disc herniation.

89.5.5 Complications

Complications are the same as those of fluoroscopy-guided intervertebral disc block.

References

1. Appleby D, Andersson G, Totta T. Meta-analysis of the efficacy and safety of intradiscal electrothermal therapy (IDET). Pain Med. 2006;7:308–16.
2. Fukui S, Nitta K, Iwashita K, Tomie T, Nosaka S, Rohof O. Intradiscal pulsed radiofrequency for chronic lumbar discogenic low back pain: a one year prospective outcome study using discoblock for diagnosis. Pain Physician. 2013;16: E435–42.
3. Manchikanti L, Falco FJ, Benyamin RM, Caraway DL, Deer TR, Singh V, Hameed H, Hirsch JA. An update of the systematic assessment of mechanical lumbar disc decompression with nucleoplasty. Pain Physician. 2013;16:SE25–54.
4. Kluner C, Kivelitz D, Rogalla P, Putzier M, Hamm B, Enzweiler C. Percutaneous discography: comparison of low-dose CT, fluoroscopy and MRI in the diagnosis of lumbar disc disruption. Eur Spine J. 2006;15:620–6.

Comment

90

Sei Fukui

90.1 Intradiscal Therapy

Lateral disc herniation seems to respond quickly to intradiscal therapy because it is highly likely that a lateral hernia can be resected under the guidance of radiography or computed tomography. Of the therapeutic strategies used for discopathy causing lumbar pain, intradiscal electrothermal therapy seems likely to cause recurrence of lumbar pain.

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Part XVIII

Intracentrum Theapy (X-Ray-Guided, CT-Angiography)

Vertebral Body Perforation (Percutaneous Transpedicular Vertebral Body Perforation)

91

Masahiro Ogihara

91.1 Introduction

Vertebral body perforation for alleviating severe pain during body movements in patients with a vertebral body fracture is a low-cost, simple, and safe therapeutic method; pain relief is obtained immediately after the operation. However, since the mechanism underlying the relief of pain afforded by this procedure still remains unknown, accumulation of more patients and further studies are needed.

91.2 Indications

Vertebral body fracture without damage to the posterior wall of the vertebral body or the vertebral arch (laminae, pedicles) and pseudoarthrosis after vertebral body fracture

91.3 Anatomy [1–4]

Each vertebra consists of a vertebral body and a vertebral arch. The vertebral arch, the ring-like structure that projects posteriorly from the vertebral body, consists of the pedicles joined to the vertebral body and the vertebral laminae, which look like bent plates, located posteriorly. The pedicles, which are narrowed by the superior and inferior vertebral notches, are fused to the vertebral body at the superior end of the posterior surface of the vertebral body. The space between the superior and inferior vertebral notches forms the intervertebral foramina, which allow the passage of the spinal nerves and arteries and veins. The superior articular processes, inferior articular processes, and transverse processes project from the transition of the pedicle to the lamina.

The vertebral foramen is a short tubular structure surrounded by the vertebral laminae posteriorly, the pedicles laterally on the left and the right side, and the posterior surface of the vertebral body anteriorly. The vertebral foramen allows the passage of spinal nerves and arteries and veins. Its form in transverse section is almost circular from the fourth to the tenth thoracic (T4–T10) vertebrae; horizontally elliptic at the level of T11, T12, the first lumbar (L1), and second lumbar (L2) vertebrae; and almost triangular, with the base on the posterior face of the vertebral body, from the L3 vertebra downward. In other words, the pedicles are thin from T4 to T10, being fused almost vertically to the posterior surface of the vertebral body, with the left and right pedicles almost parallel to each other. The diameter of the pedicles become relatively large at the level of T11, T12, L1, and L2, where they are fused to the posterior surface of the vertebral body in almost the same manner as at the T4–T10 levels. The diameter of the pedicles becomes even larger from L3 vertebra downward; the transition of the pedicle to the lamina is positioned laterally to the superior lumbar spine, being fused with the left and right superiolateral parts of the posterior surface of the vertebral body. In the lumbar spine, the interpedicular distance becomes wider caudally.

Recognition of the differences in the anatomical structures of the vertebral body and the pedicles is important for safe bone perforation.

As long as an operation is intravertebral, not much attention needs to be paid to the vascular system or nervous system. Since the pedicle diameters of the superior and middle thoracic vertebrae are small, intrapedicular operations are difficult in some cases. However, in such cases, no vascular or neurological complications occur even if the external puncture route of the pedicle is in the lateral side where the pedicle fuses with the vertebral body and the medial articular surface of the head of a rib (the site called the "costotransverse foramen" [1] where the costotransverse ligament is present), as long as the medial wall of the pedicle is not penetrated.

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K. Ohseto et al. (eds.), *Nerve Blockade and Interventional Therapy*, https://doi.org/10.1007/978-4-431-54660-3_91

91.4 Mechanism Underlying the Occurrence of Pain in Cases of Vertebral Body Fracture [5] and Vertebral Body Perforation [6–9]

Although the mechanism underlying the occurrence of pain in cases of vertebral body fracture has not yet been established, it is presumed that increases and changes in the internal pressure of the vertebral body resulting from a destabilized vertebral body due to collapse of the support mechanisms for the anterior vertebral body, as well as changes in the environment in the vertebral body (bone marrow) resulting from vertebral body injury, stimulate nociceptive fibers and receptors in the bone marrow and periosteum and spinal nerves, which results in pain (Fig. 91.1).

Vertebral body perforation refers to the creation of a hole in the fractured vertebral body under the conditions described above. Creation of a hole decompresses the vertebral body, reducing the internal pressure and stabilizing the pressure changes, resulting in improved circulation and normalization of the environment in the vertebral body, which result in attenuation of the pain (Fig. 91.2).

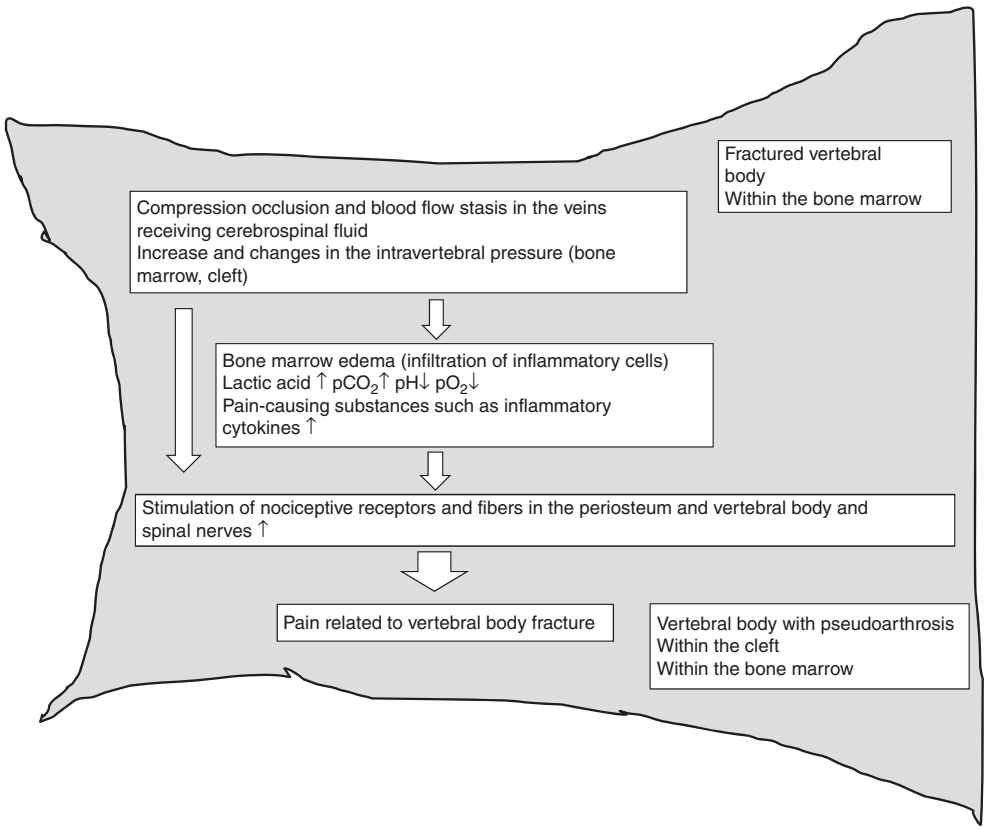


Fig. 91.1 Hypothesis for the mechanism underlying the occurrence of pain in cases with a fractured vertebral body (Cited and revised from Reference [8]). The mechanism of pain development in cases with vertebral body fracture has not been clearly elucidated yet. It is presumed that the destabilized vertebral body resulting from the collapse of the support mechanisms for the anterior vertebral body increases in vertebral body internal pressure, and the changes in the environment in the vertebral body and bone marrow stimulate the nociceptive fibers and receptors in the periosteum and bone marrow and the spinal nerves, resulting in pain. Pain in patients with pseudoarthrosis formation is presumed to be caused by similar changes in the cleft and the vertebral body

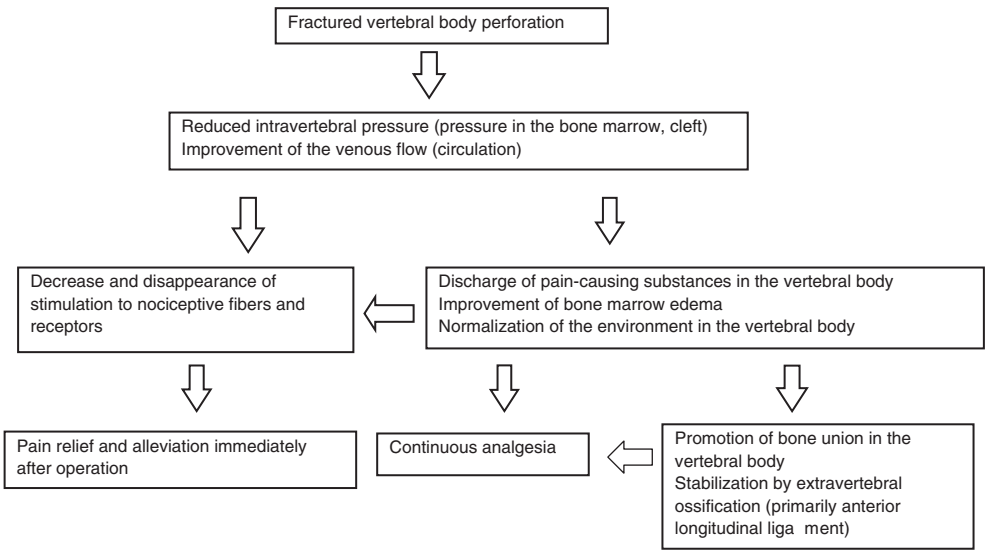


Fig. 91.2 Mechanism of analgesia obtained with vertebral body perforation (cited and revised from Reference [7]). Indications include freshly fractured vertebral body and old fractured vertebral body (fractured vertebral body with delayed union, vertebral body pseudoarthrosis)

The mechanism of pain development described above is also considered to apply to pseudoarthrosis developing after vertebral body fracture; in this case, it is necessary to consider the increase in the pressure in the pseudoarthrosis cavity (hereinafter cleft) and the surrounding inflammatory reaction [4].

91.5 Instruments and Drug Solutions

(a) X-ray fluoroscopy system: A fluoroscopy system with at least bidirectional fluoroscopic capability.
(b) A pillow for keeping the body position: A thick pillow stuffed with Oume cotton (made in-house, H 60 cm × W 40 cm × D 15 cm) (Fig. 91.3).
(c) Adhesive plaster to fix the body position: 5 cm in width.
(d) Bone perforation needle: 13G or 14G bone needle Ossiris® (hereinafter bone needle).
(e) Micro-bone wire insertion tools (drill chuck®, pin vice®, hereinafter drill chuck, pin vice): To be used when inserting the 1.2 mm Kirschner wire (hereinafter the K-wire) that comes with a bone needle (Fig. 91.4).
(f) Sterilized tray.
(g) Luer lock disposable syringe: Two 5 mL syringes (for cerebrospinal fluid aspiration, contrast-enhanced imaging) and two 10 mL syringes (for local anesthesia).
(h) Injection needles: two 27G needles (for skin and subcutaneous anesthesia) and two 23G Cathelin needles (for bone and periosteal anesthesia).
(i) Extension tube: Two 0.2 mL tubes (to be used during peritoneum imaging).
(j) Disinfectant and forceps for disinfection: Two bottles of Isodine Field Solution® and two bottles of 0.5% Hexizac Alcohol Solution®.
(k) Square cloths with disposable tapes (drape) (90 cm × 90 cm): Four sheets. Those with adhesive tapes on one side are more convenient to use. Using the cover cloth tapes, the drapes hanging down from the left and right are fixed to the bottom face of the fluoroscopy table.
(l) Local anesthetics, physiological saline.
(m) Contrast media: Two bottles of iotrolan 240, around 5 mL per injection.
(n) Antibiotics.
(o) Wound dressing: Two sheets of film dressing with a pad.
(p) Others: Sterilized surgical gown and gloves, sterilized X-ray protective gloves, and sterilized cover for the X-ray device.

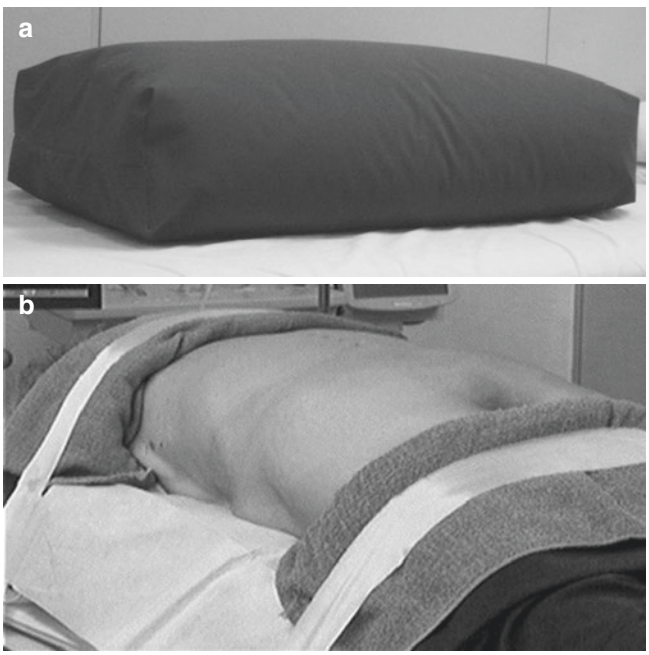


Fig. 91.3 Pillow for keeping the body position and surgical body position (Copied from Reference [7]). (**a**) A thick pillow stuffed with Oume cotton with the pillow case made of a rubber sheet (H 60 cm × W 40 cm × D 15 cm). (**b**) The patient lies on the pillow in the prone position with his/her face turned on the convenient side. The patient is fixed to the fluoroscopy table with the 5-cm-wide adhesive plasters

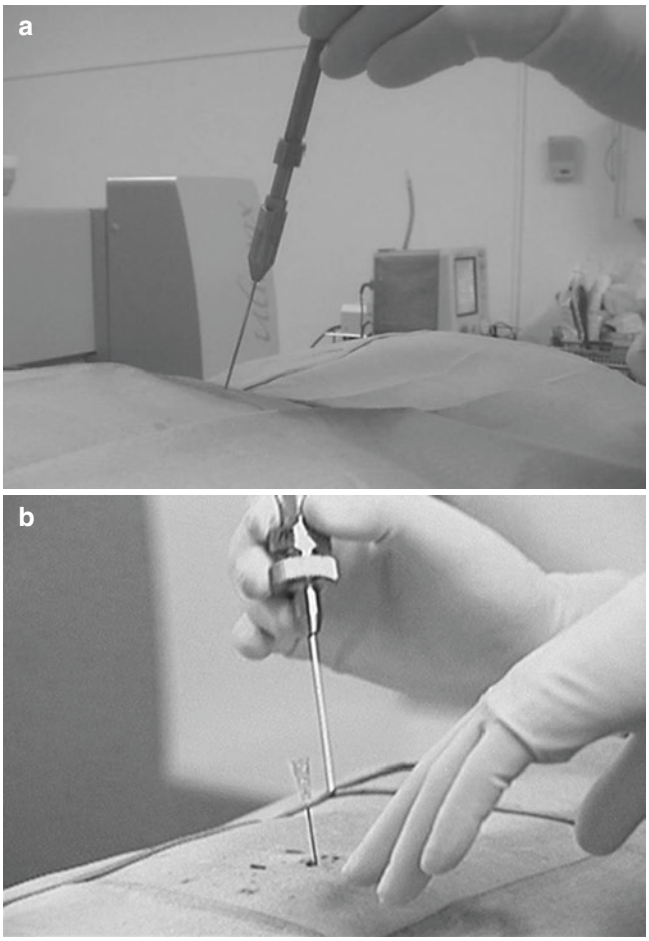


Fig. 91.4 K-wire insertion using a micro-bone wire insertion tool (reprint from References [6, 7]). (**a**) Drill chuck in use. (**b**) Pin vice in use. The use of a drill chuck is recommended in terms of ease of use

91.6 Procedures and Techniques

(1) Patients can receive the treatment as outpatients or inpatients (2-night stay).
(2) The patient lies in a prone position using a pillow for keeping the body's position (Fig. 91.3). Confirm the vertebral body that needs to be operated.
(3) Confirmation of the axial angle for X-ray irradiation. Under fluoroscopy-guided method, confirm the left and right irradiation angles, where the images of the left and right pedicles become symmetric with the spinous process at the center in a frontal view. In the same view, confirm the angles of the cranial and caudal sides where the images of the left and right pedicles become the largest circle or ellipse. Next, in a lateral view, confirm the irradiation angle where the images of the left and right pedicles overlap, i.e., the shadows of the left and right inferior vertebral notches overlap.
(4) Fix the trunk to the fluoroscopy table by fixating the trunk and buttocks using wide adhesive plasters (Fig. 91.3).
(5) Under fluoroscopy-guided method, mark the skin so that the marking is coincident with the image of the pedicle. In the lateral view, confirm the vertebral body (vertebral body to be operated) coincident with the marked points and the line passing through the image of the pedicle.
(6) Attach a tube and a detector to the X-ray fluoroscopy system, and place a sterilized cover on the arm.
(7) Disinfect twice using Isodine Field Solution®. Disinfection should be performed by a person other than the operators.
(8) During that time, the operator washes his/her hands and puts on the surgical gown and sterilized gloves.
(9) To perform bilateral vertebral body perforation, place the drapes on the four sides around the operative field of 20 cm × 20 cm. A person other than the operators with sterilized gloves affixes the drapes hanging down from the left and right sides to the bottom face of the fluoroscopy table using cover cloth tapes.
(10) The operator performs disinfection twice using 0.5% Hexizac Alcohol Solution®.
(11) Using a 27G needle, administer local anesthesia in and under the marked skin coincident with the fluoroscopic image of the pedicle on one side.
(12) Under bidirectional fluoroscopy-guided method, insert a 23G Cathelin needle in the pedicle until touching the vertebral lamina while confirming the direction into the vertebral body, and administer local anesthesia in the periosteum of the vertebral lamina and the insertion route while removing the needle.
(13) By using the insertion site, direction, and angle of the Cathelin needle at the time of local anesthesia as a guide, insert a K-wire attached to a drill chuck into the skin slightly toward the lateral side of the pedicle under frontal-plane fluoroscopy-guided method until touching the vertebral lamina on the outer circumference in the (elliptic) circular image of the pedicle. At that time, ensure that the K-wire is advanced into the vertebral body in the lateral image of the vertebral body, under lateral-plane fluoroscopy-guided method.
(14) Under fluoroscopy-guided method, insert the K-wire attached to the drill chuck by drilling into the pedicle while maintaining a fixed direction. The key point in safe transpedicular perforation (intrapedicular operation) is a bone perforation located within the vertebral body with the needle tip passing the center of the pedicle in the frontal view and slightly passing the posterior wall of the vertebral body in the lateral view (Fig. 91.5). Although reproduced pain is noted when the K-wire reaches the posterior wall of the vertebral body, this pain often disappears when the K-wire enters the vertebral body. Although the depth of the K-wire insertion into the vertebral body depends on the form of the vertebral body fracture, insert the K-wire under fluoroscopy-guided method until its tip is located well within the vertebral body. In the case of a cleft, insert the K-wire so that the tip is located well within the cleft.
(15) Detach the drill chuck, and confirm that the K-wire is inserted into the pedicle and the vertebral body by bidirectional imaging.
(16) Using the K-wire as a guide, insert a 13G or 14G external bone needle into the vertebral lamina (Fig. 91.6a).
(17) Advance the external bone needle into the pedicle while rotating it in a clockwise manner. Although reproduced pain may be noted when the external bone needle reaches the posterior wall of the vertebral body, similar to the case described in (14) above, this reproduced pain often disappears when the external bone needle enters the vertebral body. Since the K-wire also sometimes advances during the insertion of the external bone needle, pay attention to the depth of the K-wire tip under lateral-plane fluoroscopy-guided method. To ensure safety, remove the K-wire once the tip of the external bone needle is sufficiently within the vertebral body (Fig. 91.6b).
(18) Insert the internal needle (an internal needle for a double structure, a middle internal needle for a triple structure) into the external needle, and advance the bone needle into the vertebral body in a clockwise rotation under lateral-plane fluoroscopy-guided method. The depth of insertion is the location of the K-wire tip recorded at the time of the operation in (15) above (Fig. 91.6b).
(19) Repeat the operations (11) to (18) on the opposite side. The effective procedure is to move to operations (16) to (18) after placing the K-wire on both sides in the process

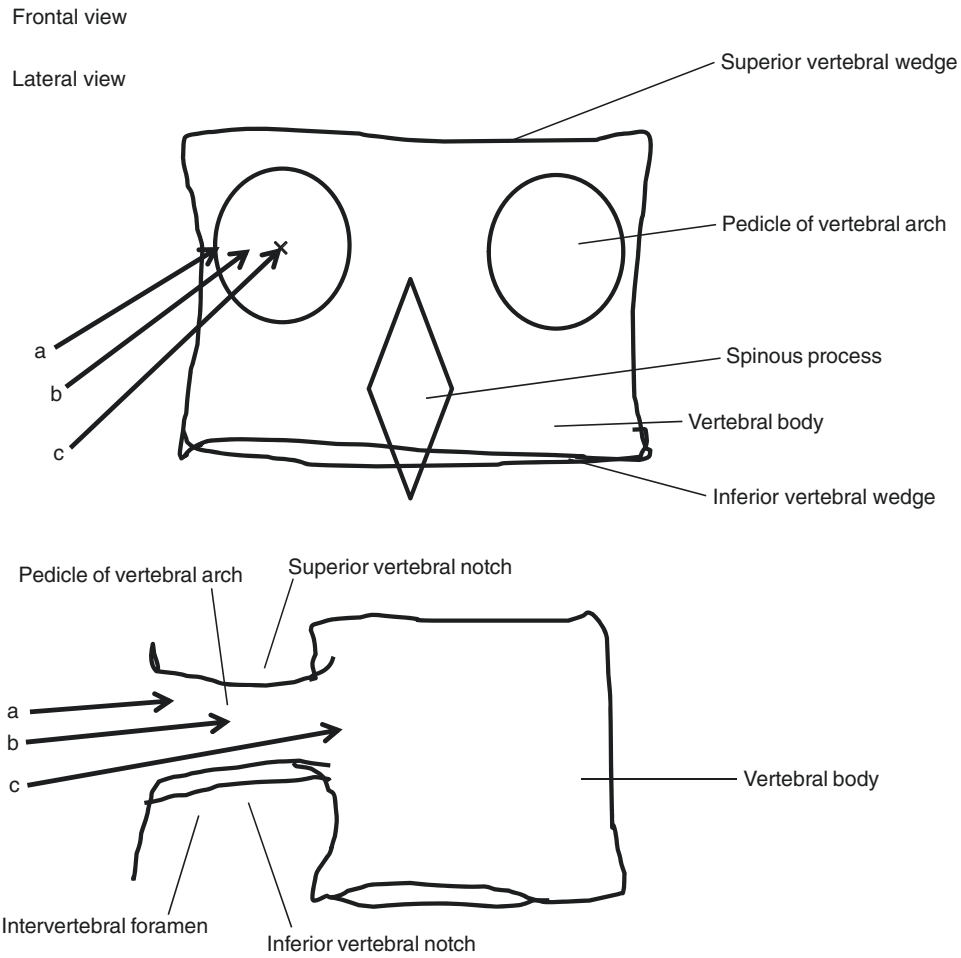


Fig. 91.5 Fluoroscopic images of safe transpedicular vertebral body perforation. (**a**) A perforation needle (K-wire, bone needle) inserted into the vertebral lamina. (**b**) Needle advancing in the pedicle. (**c**) Needle being inserted into the posterior wall of the vertebral body. Safe transpedicular perforation is performed, while the bone perforation needle is advanced in this manner. The × mark indicates the center of the pedicle image. The tip of the perforation needle reaches the posterior wall of the vertebral body mostly within the external radius of the circular pedicle image

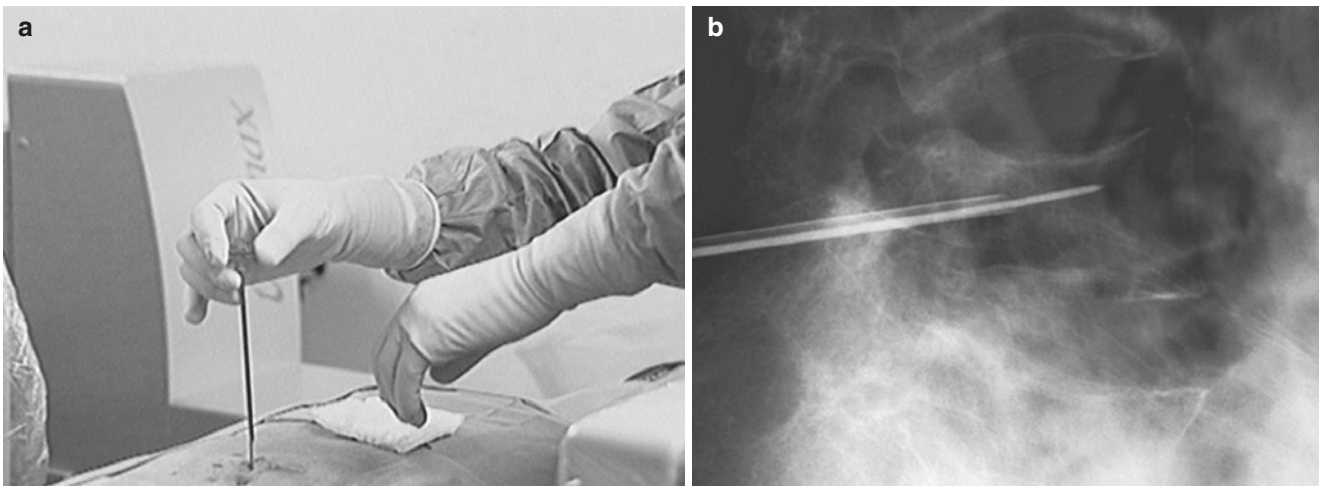


Fig. 91.6 Insertion of external needle of bone needle (Copied from Reference [6]). (**a**) Insert an external needle into K-wire. (**b**) Insert the external needle while rotating it in a clockwise manner. Pay attention to simultaneous advancement of the tip of K-wire when the needle is inserted into the vertebral body. As shown in (**b**), remove the K-wire when the tip of the external needle passed the posterior wall of the vertebral body and entered in the vertebral body

of operations (11) to (15) where the K-wire is inserted. At the time of insertion of the first bone needle, use the tip of K-wire on the opposite side as a guide for judging the insertion depth of the bone needle (Fig. 91.7). As Fig. 91.8 shows, it becomes difficult to judge the insertion depth of the bone needles when bone needles are placed on both sides because of the overlapping shadows of the needles. Therefore, it is better to remove the internal (middle) needle of the bone needle placed first when the first bone needle is placed on one side, so that the insertion depth of the bone needle on the opposite side can be observed fluoroscopically.

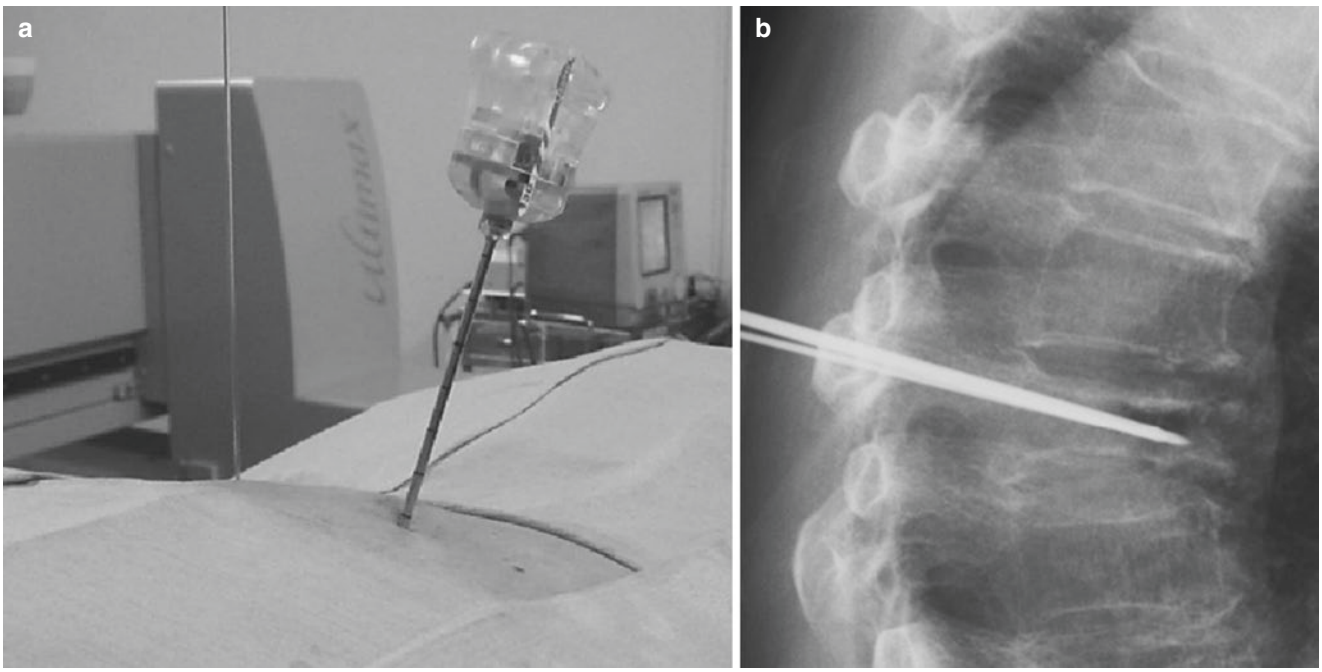


Fig. 91.7 Insertion of the bone needle (Copied from Reference [7]). (**a**) Insert an internal (middle) needle into the external needle, and advance the bone needle into the vertebral body (in the cleft in this case) under lateral-plane fluoroscopy-guided method. (**b**) Other lateral views. Insert the bone needle by using the location of the tip of K-wire on the opposite side as a guide

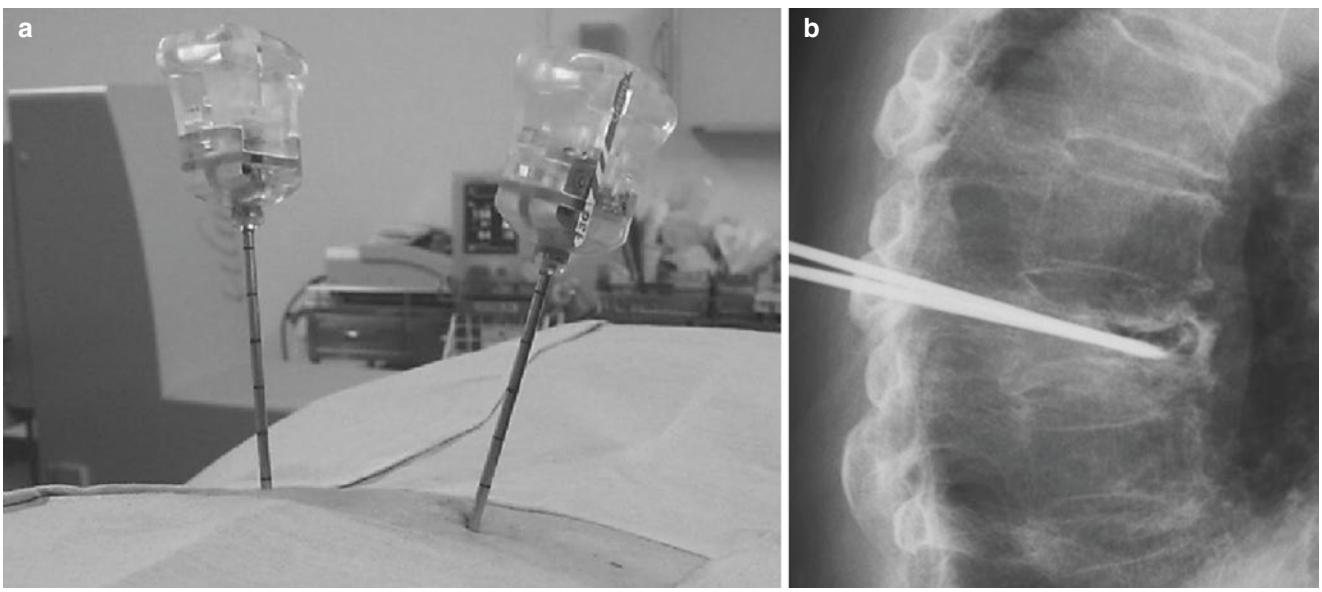


Fig. 91.8 Placement of the bone needle on both sides (Copied from Reference [7]). (**a**) Bone needles inserted via the pedicles of either side. (**b**) Lateral fluoroscopic image. The shadows of the left and right bone needles overlap, making it difficult to grasp the advancement status of the bone needle on the operation side. The bone needle on the operation side can be observed by removing the internal (middle) needle of the bone needle on the nonoperated side

(20) Remove the internal (middle) needle, and confirm whether cerebrospinal fluid can be aspirated. Cerebrospinal fluid cannot be aspirated in some cases even if the bone needle is sufficiently within the vertebral body. In such a case, physiological saline can be injected, causing reproduced pain at the time of the injection. When the needle tip is within the cleft, a small amount of slightly hemorrhagic serous fluid is aspirated in some cases, while nothing is aspirated in other cases.

(21) Contrast-enhanced imaging of the vertebral body bone marrow is performed for each side using iotrolan 240 to confirm the location of the bone needle based on the flow of the contrast medium and its accumulation. Since injection of contrast medium results in simultaneous imaging of the intravertebral and extravertebral veins (e.g., anterior, internal, and external vertebral veins, great vein, azygos vein), little contrast medium is retained in the vertebral body in many cases. However, the imaging findings obtained include retention in the vertebral body alone or mixed findings with contrast enhancement of the veins and clefts (Fig. 91.9).

(22) In the case of pseudoarthrosis, 20 mL of physiological saline is manually pressure-injected from one side using a syringe so as to allow the saline solution to squirt from the other end, to irrigate the clefts. Perform this irrigation with physiological saline on both sides.

(23) After inserting the internal (middle) needle of the bone needle, remove the bone needle by rotating it in a counterclockwise manner. In case of pseudoarthrosis, insert the internal (middle) needle into the bone needle on one side, and close it while removing the external needle of the bone needle on the opposite side under suction pressure by a syringe; thereafter, remove the bone needle inserted with the internal (middle) needle.

(24) Affix a wound dressing to the wound site. No compression to the wound is required.

(25) An hour rest on a bed is required after the operation. Thereafter, there is no behavior restriction or wearing of a brace.

(26) Antibiotics will be used for 4 days including the day of operation. On the day of operation, antibiotics will be intravenously administered from 1 h before the start of operation. The same dose of antibiotics will also be intravenously administered immediately after operation. Antibiotics will be orally administered for 3 days from the day after the operation.

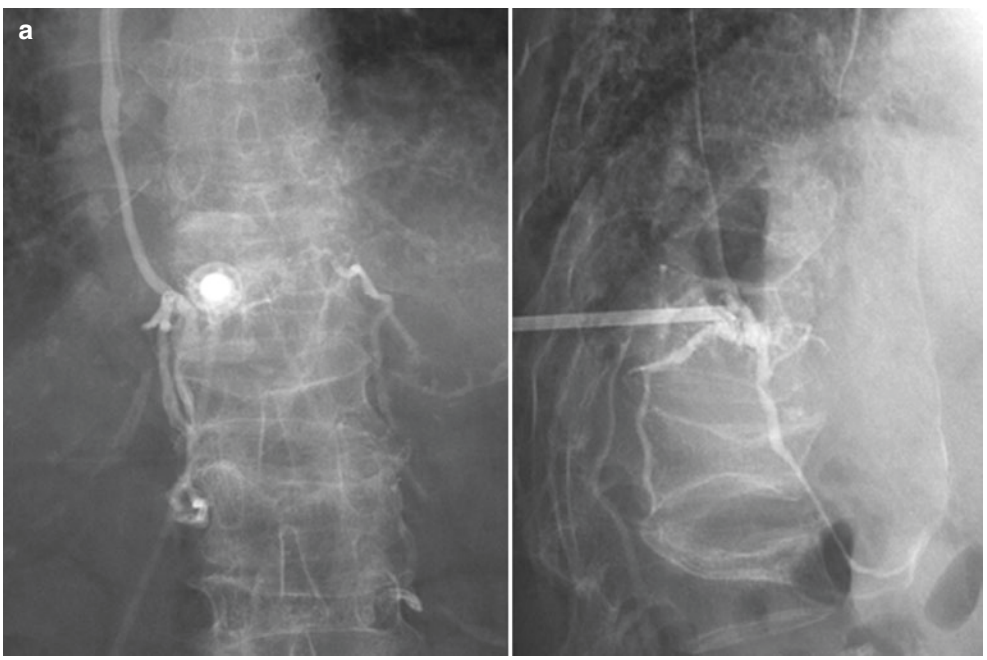


Fig. 91.9 Vertebral body imaging findings. (1) Frontal view. (2) Lateral view (**a**, **b**, and **c** copied from Reference [6], **d** from Reference [8]). (**a**) The intravertebral and extravertebral veins are imaged simultaneously after injection of the contrast medium. (**b**) Contrast retained within the vertebral body alone, with no enhancement of the intravertebral or extravertebral veins. (**c**) At the time of injection of the contrast medium on the left side, contrast leaked from the right bone perforation to the dorsal muscle layer and under the skin. (**d**) Patient with pseudoarthrosis. At the time of injection of the contrast medium on the left side, the contrast is discharged from the external needle of the bone needle placed on the right side. A similar imaging finding was obtained at the time of injection of the contrast medium on the right side. After imaging, 20 mL of physiological saline was manually pressure-injected using a syringe so as to cause the saline solution to squirt from the other end. This irrigation with physiological saline was performed on both sides. Thereafter, the bone needle was removed as described in the text

Fig. 91.9 (continued)

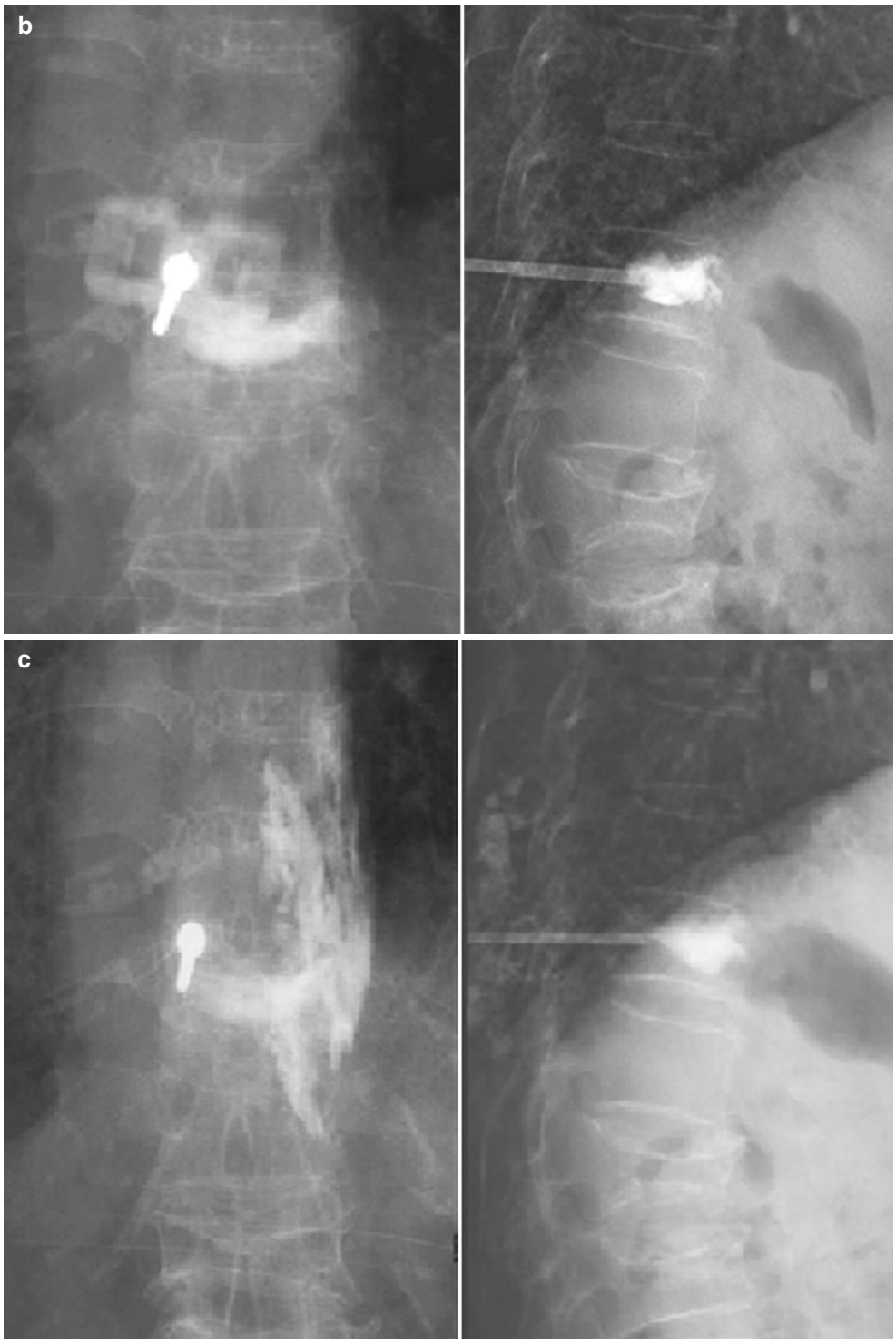
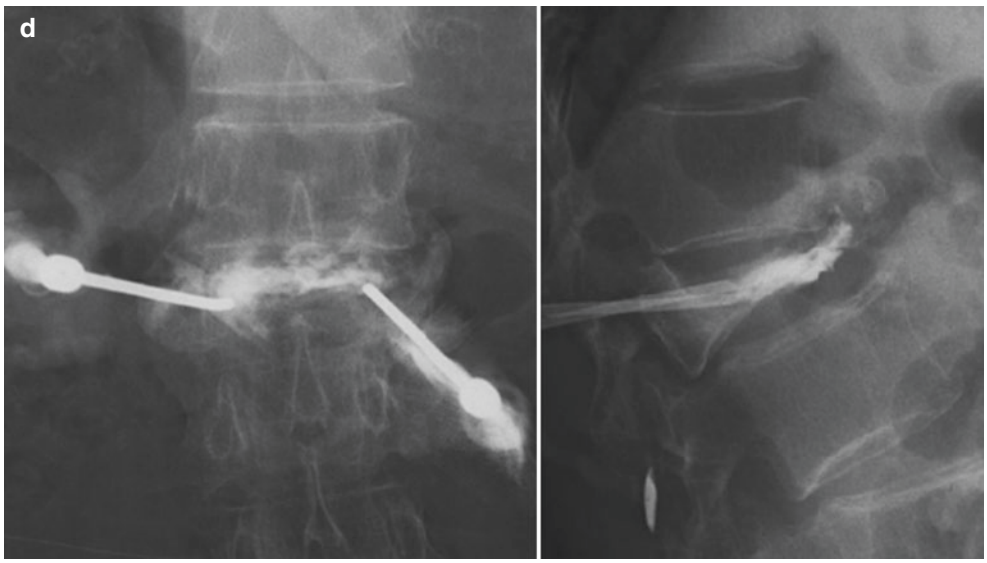


Fig. 91.9 (continued)



91.7 Complications [10, 11]

Possible complications include nerve damage such as the spinal cord and nerve root, retroperitoneal space and thoracic hematoma resulting from vascular damage, puncture site pain, and infection. As long as intraosseous operation is performed, complications of nerve damage and hematoma can be avoided.

References

1. Grant JCB. An Atlas of anatomy. Tokyo: Igaku Shoin Ltd; 1972. p. 357–90. (in Japanese).
2. Netter FH. Atlas of human anatomy. 3rd ed. Netter atlas of human anatomy 3rd ed, translated by Sadakazu Aiso. Tokyo: Nankodo; 2004. p. 146–78. (in Japanese).
3. Ito K, Iizuka Y, Musha Y, et al. Vascular anatomy of the spine and spinal cord. Spine and Spinal Cord. 2013;26:359–65. (in Japanese).
4. Mori O, Mori T. Osteology and study of ligament (Mori O, Hirasawa K, Ogawa T, et al. Anatomy 1). Tokyo: Kanehara & Co., Ltd.; 1972. p. 27–43. (in Japanese).
5. Ogihara M. Vertebral body fracture pain. Pain Science and Practice 7. In: Omote K, editor. Interventional treatment for pain. Tokyo: Bunkodo Co., Ltd.; 2014. p. 189–91. (in Japanese).
6. Ogihara M. Vertebral body decompression (Transpedicular vertebral body perforation). Pain Clinic. 2008;29:105–12. (in Japanese).
7. Ogihara M, Akamine T, Wakayama H, et al. Clinical results of percutaneous vertebral body perforation for osteoporotic vertebral fracture. J Minim Invasive Orthop Surg. 2012;64:29–36. (in Japanese).
8. Ogihara M, Akamine T. Experience of transpedicular vertebral body perforation for osteoporotic vertebral fracture pain. Journal of Musculoskeletal Pain Research. 2013;5:149–55. (in Japanese).
9. Kohashi Y, Matsuura K, Ishitani E, et al. Experience of vertebral body decompression for thoracolumbar spine compression fracture by osteoporosis. Orthopaedic Surgery and Traumatology. 2006;49:833–9. (in Japanese).
10. Yuda Y. Vertebral body decompression (transvertebral approach). Pain Clinic. 2006;27(Suppl):S628–40. (in Japanese).
11. Ogihara M, Tamura M, Fujisawa M, et al. Complications associated with intra-articular injection method, intra-intervertebral disk treatment, and bone marrow decompression (bone perforation). Pain Clinic. 2014;35:1625–36. (in Japanese).

Percutaneous Vertebroplasty (PVP)

92

Kenya Kamijima and Ryota Yanaizumi

92.1 Introduction

92.1.1 Percutaneous Vertebroplasty (PVP)

Once the vertebral trabecula is damaged by osteoporosis or a tumor, the vertebral body may collapse and fracture (compression fracture) and become unstable. The patient may become bedridden due to severe pain on movement. Compression fractures need to be properly treated since the pain will greatly affect the patient's quality of life. PVP is one of the appropriate treatment options for compression fractures [1].

Symptoms include pain in the upper or lower back upon any body movement, tenderness in the spine (the spinous process), and percussion tenderness at the site of the compression fracture.

Diagnostic imaging includes the following: (1) Vertebral radiographs easily find apparent bone lesions such as decreased vertebral height. However, the X-ray may not show any abnormalities because the vertebral height may remain unchanged for several days after the fracture. (2) Vertebral magnetic resonance imaging (MRI) is used for definitive diagnosis of acute compression fracture or bone metastasis. Contrast-enhanced MRI or short-TI inversion recovery (STIR) sequences should be performed. (3) Vertebral computed tomography (CT) will provide detailed information on the bone destruction. CT-based evaluation should be made prior to PVP.

PVP is performed after evaluating and diagnosing the patient. Cement is injected into the vertebral body to stabilize the spine from the inside to reduce pain [2, 3].

92.2 Indications

- Destruction of the back of the vertebral body or compression fracture without severe spinal canal narrowing.
- The general condition of the patient suggests that he/she will be able to maintain the prone position during the procedure.
- No sign of infection or a bleeding tendency.
- No pain relief with conservative treatment, including nerve blocks (the pain may be relieved for 2–12 weeks after the injury).
- No pain relief due to poor synostosis with cleft formation.

92.3 Anatomy

The anteroposterior vertebral vein in the center of the vertebral body connects to the outer veins and venous plexus. Watch for cement leakage to the anterior spinal canal through the vertebral vein pouring from the center of posterior vertebral wall into the spinal canal. The area of likely cement leakage should be identified by carefully evaluating the vertebral fracture based on CT and MRI.

92.4 Instruments and Drug Solutions

X-ray apparatus: X-ray fluoroscopy-guided alone, IVR-CT (angiography/CT-guided combination equipment), or CT-guided alone

Cement: Polymethyl methacrylate (PMMA), calcium phosphate cement, and hydroxyapatite

13 G bone needle (one to two needles per vertebral body)

Sterilized barium and sterilized cooling water, trays, and spatulas

10 mL disposable syringe, 1 mL Luer Lock pressure-resistant syringes (four to five syringes per vertebral body)

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92.5 Procedures and Techniques

The IVR-CT-guided PVP procedure is described below.

Position: Lay the patient in the prone position with a pillow under his/her abdomen to make the vertebral body parallel to the table. PVP should be performed under local anesthesia. Prepare the needle insertion route based on preoperative CT or MRI, and mark the needle insertion site based on the estimated distance from the midline.

1. After local anesthesia, insert the cement injection needle (bone needle) through the pedicle of the vertebral arch under X-ray fluoroscopy-guided method (we insert two needles, one on each side). Check the position of the needle tip on an X-ray or a CT image (Fig. 92.1).
2. Mix the dry heat-sterilized barium with the bone cement to enhance its visibility during cement injection under fluoroscopy. Connect the pressure-resistant syringe containing cement to the bone needle, and inject the cement slowly while carefully observing the process in the lateral radiography (Fig. 92.2). Check the position of the injected cement and extravertebral leakage on the CT image (Figs. 92.3 and 92.4). Two to three hours of bed rest will be required after cement injection.

Bedridden patients will often be able to walk the next day because PVP immediately relieves pain. However, prompt pain relief may not be achieved in cases of multiple compression fractures. In addition, PVP may not be effective for symptoms caused by bone components compressing the nerve.

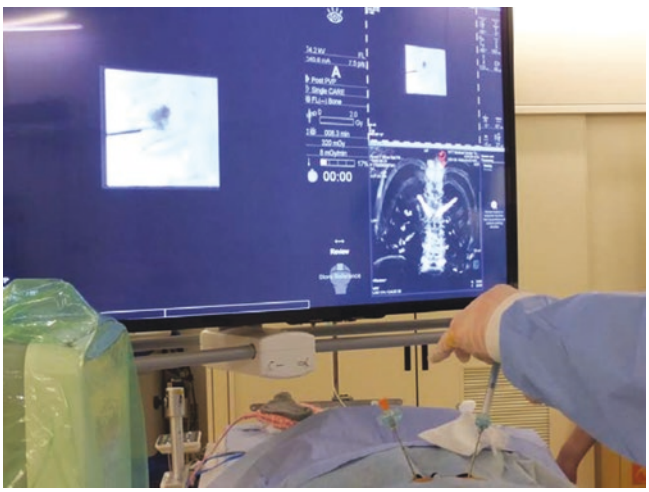

Fig. 92.1 Enforcement scenery of PVP

Pre- and Postoperative Precautions

Continue osteoporosis treatment before and after PVP for compression fracture, and have the patient wear a corset for

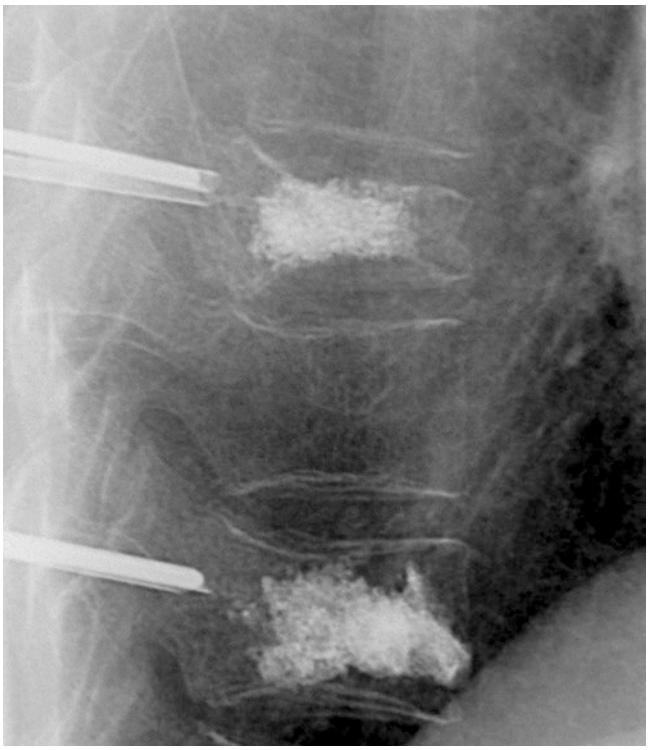

Fig. 92.2 PVP lateral view under X-ray fluoroscopy

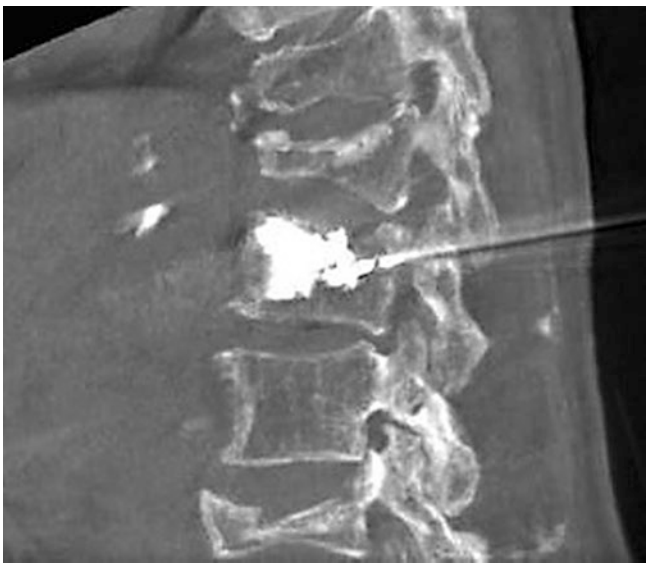

Fig. 92.3 Longitudinal CT

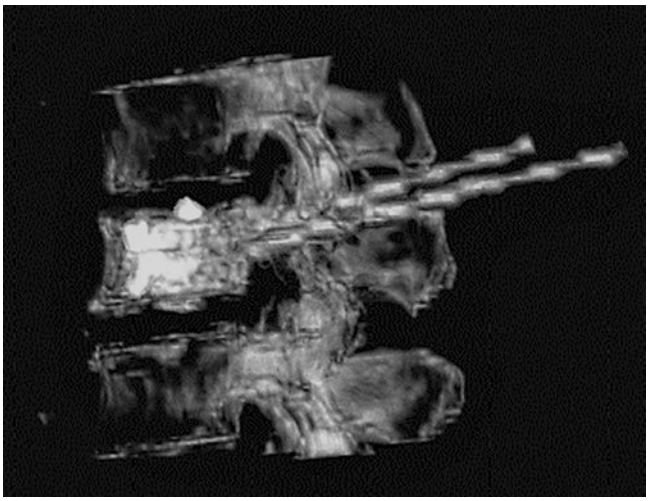

Fig. 92.4 3D CT of PVP

about 3 months to prevent progression of vertebral compression and secondary fractures.

Rehabilitation is recommended for prevention of disuse syndrome.

92.6 Complications

Bleeding, infection, nerve damage, pulmonary embolism due to cement leakage, myocardial infarction, cerebrovascular disease, spinal cord infarction, and fracture of adjacent vertebral bodies [4]

References

1. Clarençon F, Fahed R, Gabrieli J, et al. Safety and clinical effectiveness of percutaneous vertebroplasty in the elderly (≥80 years). Eur Radiol. 2015;26(7):2352–8.
2. DePalma MJ, Ketchum JM, Frankel BM, Frey ME. Percutaneous vertebroplasty for osteoporotic vertebral compression fractures in the nonagenarians: a prospective study evaluating pain reduction and new symptomatic fracture rate. Spine. 2011;36:277–82.
3. Masala S, Mammucari M, Angelopoulos G, et al. Percutaneous vertebroplasty in the management of vertebral osteoporotic fractures. Short-term, mid-term and long-term follow-up of 285 patients. Skelet Radiol. 2009;38:863–9.
4. Cosar M, Sasani M, Oktenoglu T, et al. The major complications of transpedicular vertebroplasty. J Neurosurg Spine. 2009;11:607–13.

Comment

93

Masahiro Ogihara

93.1 Intracentrum Therapy (X-Ray-Guided, CT Angiography)

Route for reaching the vertebral body: In addition to the transpedicular approach, a transvertebral body approach can also be used, as reported by Yuda [1]; however, the transpedicular approach is recommended to avoid the risk of hematoma formation [2].

Vertebral body perforation for pseudoarthrosis after vertebral body fracture: It is recommended that the bone needle be inserted into the cleft, so as to allow traffic between the left and right bone needles and the cleft [3].

References

1. Yuda Y. Vertebral body decompression (transvertebral approach). Pain Clinic. 2006;27(Suppl):S628–40. (in Japanese)
2. Ogihara M, Tamura M, Fujisawa M, et al. Complications associated with intra-articular injection method, intra-intervertebral disk treatment, and bone marrow decompression (bone perforation). Pain Clinic. 2014;35:1625–36. (in Japanese)
3. Ogihara M. Vertebral body fracture pain. In: Omote K, editor. Pain science and practice 7. Interventional treatment for pain. Tokyo: Bunkodo Co., Ltd.; 2014. p. 189–91. in Japanese.

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Part XIX

Lower Limb and Joint

Knee

94

Yosuke Usui

94.1 Introduction

Patients with medial knee osteoarthritis *become bow-legged with the leg externally rotated and the knee flexed and complain of pain on the medial side of the knee.* Injection into the knee joint capsule or the medial collateral ligament (MCL) bursa is described.

94.2 Indications

94.2.1 Puncture of the joint capsule through the suprapatellar bursa

1. Out-of-plane approach: only injection of the drug solution into the joint capsule
2. In-plane approach: both aspiration of the fluid in the joint capsule and injection of the drug solution

94.2.2 Injection into the MCL Bursa

Tenderness to palpation over the MCL

94.3 Anatomy

1. The suprapatellar bursa extending from the joint capsule is present between the prefemoral and suprapatellar fat pads.
2. The MCL bursa is present between the deep and superficial layers of the MCL.

94.4 Instruments and Drug Solutions

94.4.1 Injection into the Knee Joint Capsule

1. A 21–23 G short needle
2. 1% mepivacaine (2 mL) and hyaluronic acid

94.4.2 Injection into the MCL Bursa

1. A 27-G short needle
2. 1% mepivacaine (2 mL) and steroid

94.5 Procedures and Techniques

94.5.1 Injection into the Knee Joint Capsule

94.5.1.1 Landmark Method

1. Lateral infrapatellar puncture in the supine position is most frequently performed.
2. This puncture is performed with the knee in extension while the patella is compressed using a thumb or with the knee slightly flexed.
3. The other methods are medial infrapatellar puncture, which is a puncture from the medial side, and lateral infrapatellar puncture at a slightly cranial site.
4. The patella is elevated to the ventral side, and the needle is advanced to the dorsal side of the patella. When the needle enters the joint space, resistance decreases.

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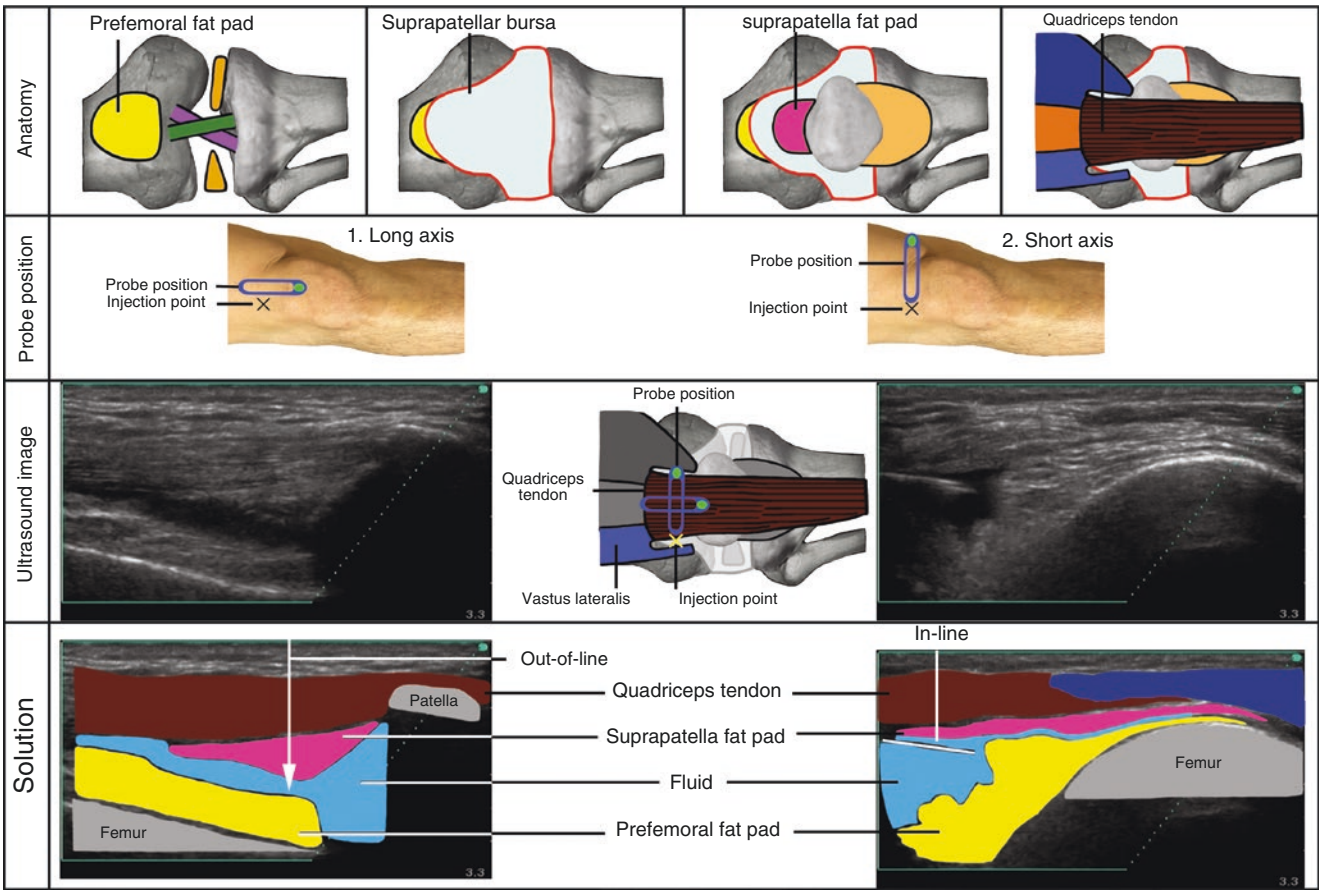

Fig. 94.1 Puncture of the knee joint capsule through the suprapatellar bursa. (1) The puncture site is between the quadriceps tendon and vastus lateralis oblique fibers. (2) When there is no fluid retention, the probe is placed parallel to the quadriceps, and the needle is advanced using the out-of-plane approach. (3) When there is fluid retention, the probe is placed perpendicular to the quadriceps, the needle is advanced using the in-plane approach, and the fluid is aspirated

94.5.1.2 Ultrasound (US)-Guided Method (Fig. 94.1)

1. Supine position.
2. The puncture site is between the quadriceps tendon and vastus lateralis oblique fibers.
3. When there is no fluid retention, the probe is placed parallel to the quadriceps, and the needle is advanced using the out-of-plane approach.
4. When there is fluid retention, the probe is placed perpendicular to the quadriceps, and the needle is advanced using the in-plane approach.

94.5.2 Injection into the MCL Bursa

94.5.2.1 Landmark Method

1. Since the deep layer of the MCL is attached to the medial meniscus, needle puncture should not be performed in the absence of fluoroscopy due to the risk of medial meniscus puncture.

94.5.2.2 US-Guided Method (Fig. 94.2)

1. Supine position.
2. The probe is placed parallel to the MCL, and the needle is advanced to the CML bursa using the out-of-line approach.

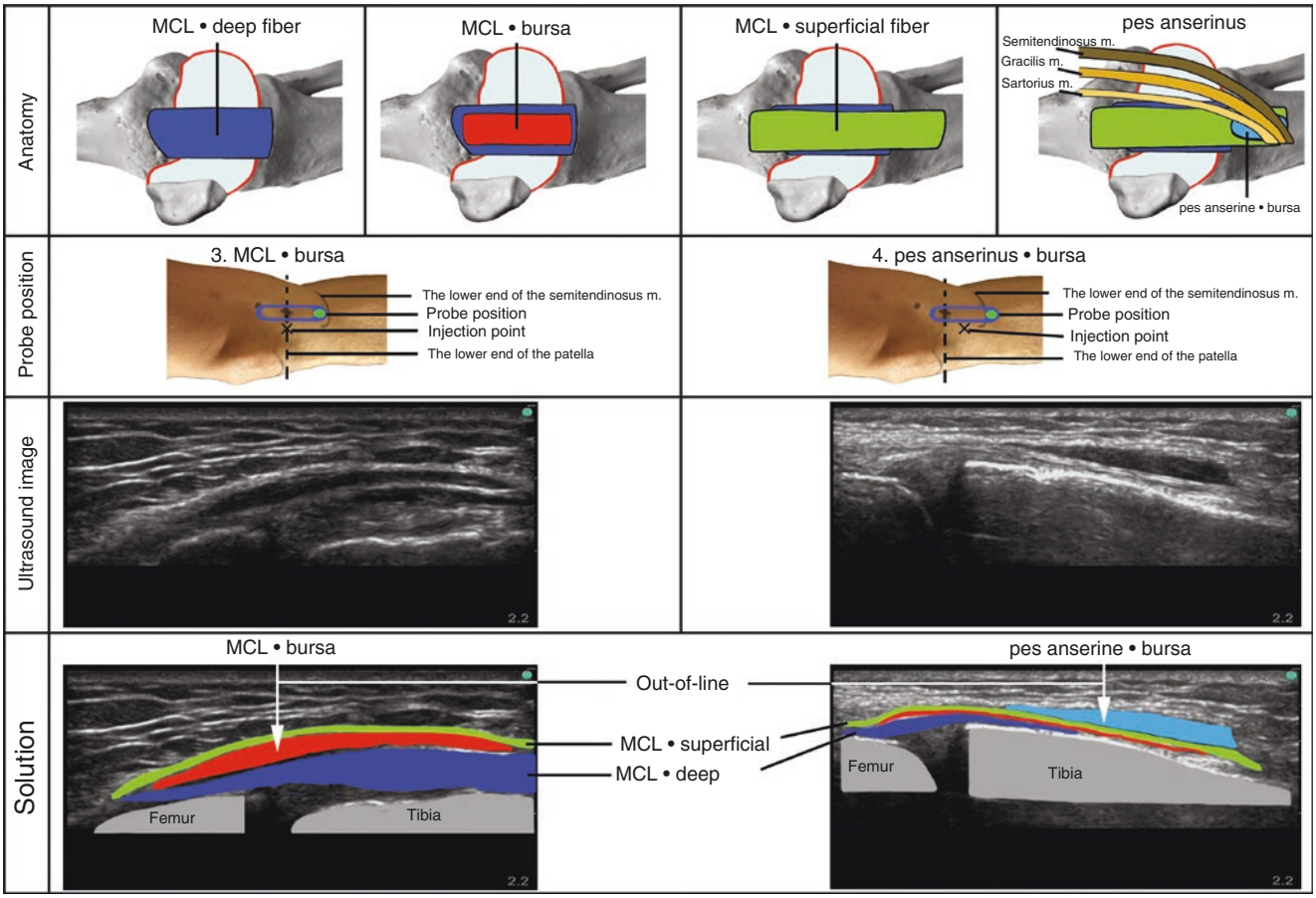

Fig. 94.2 Injection into the MCL bursa and the pes anserinus bursa. (1) The MCL bursa is present between the deep and superficial layers of the MCL. The probe is placed parallel to the MCL, and the needle is advanced to the CML bursa using the out-of-line approach. (2) The pes anserinus bursa is present between the superficial layers of the MCI and the sartorius muscle. (3) The probe is placed to the MCL, and the needle is advanced to the pes anserinus bursa using the out-of-line approach

94.6 Complications

Bleeding, injection, and nerve damage

High-Frequency Thermocoagulation in the Knee

95

Hideki Toyokawa

95.1 Introduction

95.1.1 About High-Frequency Thermocoagulation in the Knee

The peripheral nerves innervating the knee are treated with high-frequency thermocoagulation to relieve the knee pain.

95.2 Indications

High-frequency thermocoagulation is primarily indicated for osteoarthritis of the knee unresponsive to intra-articular injection or NSAIDs and inoperable due to complications. The procedure is also used for the treatment of rheumatoid arthritis or persistent pain after knee surgery [1].

95.3 Anatomy (Fig. 95.1)

The innervation of the knee joint includes the infrapatellar branch, lateral great muscle branch, and intermediate great muscle branch of the saphenous nerve in the front and articular branches of the obturator nerve, common fibular nerve, and tibial nerve in the back. Treatment of osteoarthritis of the knee generally targets the infrapatellar branch of the saphenous nerve or the tibial nerve branch that innervates the inner joint.

95.4 Instruments and Drug Solutions

Needles:	25 G needle (for local anesthesia) and 5.0–5.5 cm 22 G needle for high-frequency thermocoagulation (current-carrying part, 4–5 mm)
Injection syringes:	Two 5 mL syringes (for subcutaneous local anesthesia and nerve anesthesia)
Drugs:	0.5%–1% lidocaine, 5 mL; 2% lidocaine, 5 mL
Tools:	a high-frequency thermocoagulation apparatus

95.5 Procedures and Techniques

Lay the patient in the dorsal position with lower limbs straight and slightly rotated internally to align the patella with the midline of the femur. Referring to the anatomical innervation, select the needle insertion site in the sensory nerve branch coinciding with the tender point.

Provide local anesthesia in the needle insertion site after skin disinfection. Insert the needle for high-frequency thermocoagulation, and find the area of radiating pain under x-ray fluoroscopy-guided method. After confirming pain provocation with 50 Hz high-frequency electric stimulation, anesthetize the sensory nerve branch with 2% lidocaine 1–2 mL, and perform thermocoagulation at 80 °C for 90 s [2] (Fig. 95.2).

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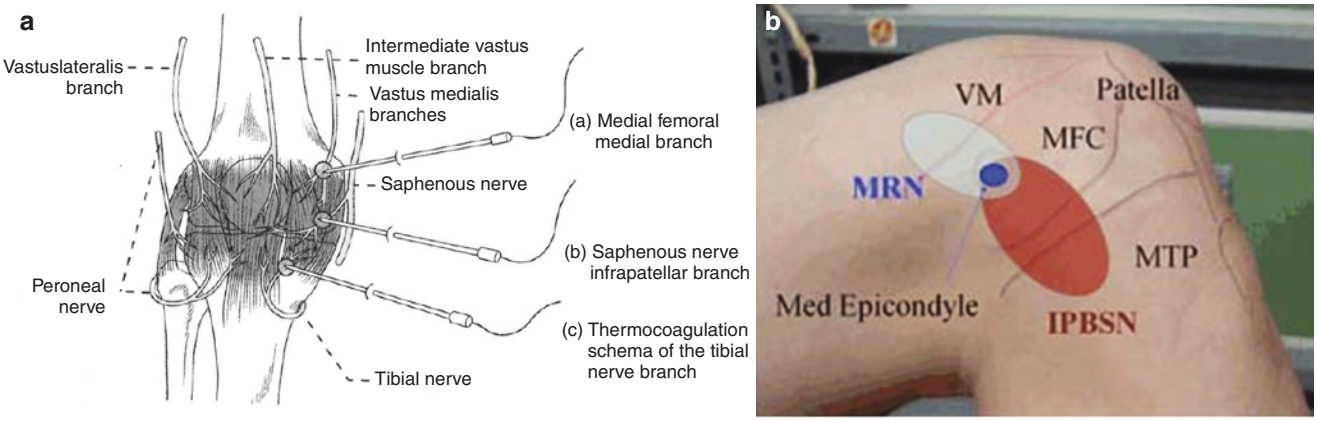

Fig. 95.1 Anatomy: the innervation of the knee joint. http://www.kochi-ms.ac.jp/~fm_ortop/pg167.html (Cited document)

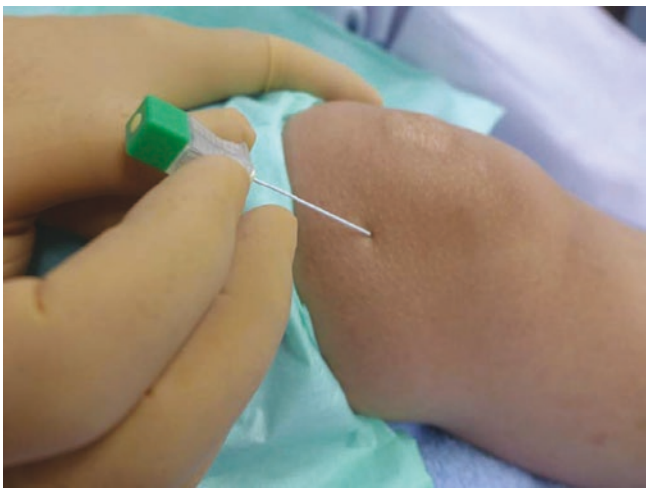

Fig. 95.2 High-frequency thermocoagulation in the knee

95.6 Complications

There are risks of local bleeding and infection. Charcot's joint may be induced because of sensory nerve block. Exercise, weight control, and muscle training will be required after the procedure [3].

References

1. Hashidume K, et al. Effectiveness and limitations of pain clinic for osteoarthritis of the knee. Pain Clinic. 2003;24:673–80. (in Japanese)
2. Hahidume K. Nerve block under X-ray, ultrasound and CT guided. Tokyo: Igakusyoin; 2009. p. 176–8. (in Japanese)
3. Ikeuchi M, et al. Percutaneous radiofrequency treatment for refractory anteromedial pain of osteoarthritic knees. Pain Med. 2011;10:546–51. (in Japanese)

Foot

96

Yosuke Usui

96.1 Introduction

We describe tibial nerve block in the tarsal tunnel for pain extending from the area behind the medial malleolus of the tibia to the sole, injection into the ankle joint for pain in the area anterior to the medial malleolus, and injection into the peroneal tendon sheath for pain in the area behind the lateral malleolus of the fibula.

96.2 Indications

1. For tarsal tunnel syndrome, in which pain extends from the area posterior to the medial malleolus to the sole due to tibial nerve entrapment by the flexor retinaculum, tibial nerve block in the tarsal tunnel is performed.
2. For anterior ankle impingement syndrome in which pain anterior to the medial malleolus occurs due to the impingement of the anterior border of the tibia against that of talus, injection into the ankle joint is performed.
3. For peroneal tendonitis or tenosynovitis in which pain posterior to the lateral malleolus of the fibula occurs, injection into the tendon sheath is performed.

96.3 Anatomy (Figs. 96.1 and 96.2)

1. The talocrural joint (ankle joint) consists of the talus and lower leg bone (tibia, fibula), and the subtalar joint consists of the anterior part of the talocalcaneal joint and the talonavicular bone.
2. Contraction of the muscle group dorsal to the motor axis of the ankle joint causes plantar flexion (flexion).
3. Contraction of the muscle group ventral to the motor axis of the ankle joint causes ankle dorsal flexion (extension).
4. Contraction of the muscle group medial to the motor axis of the subtalar joint causes inversion of this joint.
5. At the time of the inversion, the anterior talofibular ligament plays a role of stopper.
6. The peroneus brevis arises from the distal 2/3 of the lateral surface of the fibula, passes behind the external malleolus of the fibula, travels around the calcaneus peroneal trochlea, and is inserted into the tuberosity of the fifth metatarsal.
7. The peroneus longus arises from the head of the fibula and proximal 2/3 of the lateral surface of the fibula, passes the superficial layer of the peroneus brevis behind the lateral malleolus, turns to the sole near the calcaneus peroneal trochlea, and is inserted into the base of the first metatarsal and the medial cuneiform.

96.4 Instruments and Drug Solutions

1. A 27-G short needle
2. 1% mepivacaine (2 mL) and steroid

96.5 Procedures and Techniques

96.5.1 Tibial Nerve Block in the Tarsal Tunnel

96.5.1.1 Landmark Method

1. While the pulsation of the posterior tibial artery is felt posterior to the medial malleolus, the needle is advanced to the tibial nerve on the dorsal side.
2. Since the posterior tibial veins are present in this route, attention is paid so that the needle tip does not enter them.

96.5.1.2 Ultrasound (US)-Guided Method (Fig. 96.1a)

1. The probe is placed between the medial malleolus and Achilles tendon.

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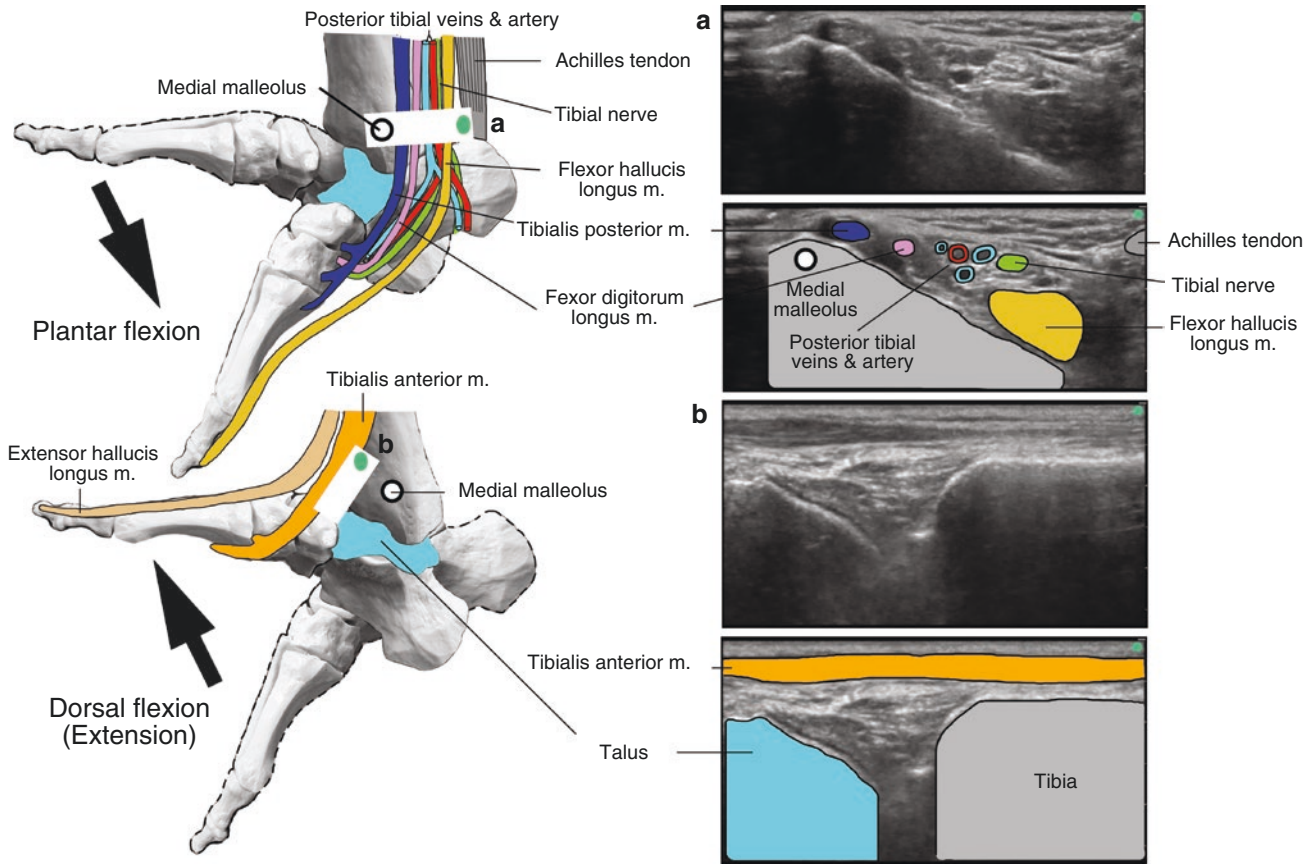

Fig. 96.1 Medial side of the ankle. (**a**) Tibial nerve block in the tarsal tunnel. (1) The probe is placed between the medial malleolus and tibialis anterior tendon. (2) The tibialis posterior tendon, flexor digitorum longus, and flexor hallucis longus tendon pass along the surface of the tibia posterior to the medial malleolus. (3) The medial side of the tibialis anterior tendon is the puncture site, and the needle is advanced toward the tibial nerve dorsal to the artery and veins using the in-plane approach. (**b**) Injection into the ankle joint. (1) The probe is placed parallel to the tibialis anterior tendon passing the anterior surface of the ankle. (2) The medial side of the tibialis anterior tendon is the puncture site, and the needle is advanced using the out-of-plane approach

2. On the tibial bone surface behind the medial malleolus, the tibialis posterior tendon, flexor digitorum longus, and flexor hallucis longus are present.
3. The puncture site is the medial side of the attachment of the Achilles tendon, and the needle is advanced toward the tibial nerve dorsal to the artery and veins using the in-plane approach.

96.5.2 Injection into the Ankle Joint

96.5.2.1 Landmark Method

1. In ankle dorsal flexion, the tibialis anterior tendon clearly emerges ventral to the medial malleolus.
2. The puncture site is the medial side of the tibialis anterior tendon at the lower end of the tibia, and the needle is advanced.
3. When the needle tip reached the inside of the joint capsule, resistance disappears.

96.5.2.2 US-Guided Method (Fig. 96.1b)

1. In ankle dorsal flexion, the probe is placed parallel to the tibialis anterior tendon.
2. The puncture site is the medial side of the tibialis anterior tendon, and the needle is advanced toward the site between the tibia and talus using the out-of-plane approach.

96.5.3 Injection into the Peroneal Tendon Sheath

96.5.3.1 Landmark Method

1. The positions of the area posterior to the lateral malleolus, the caudal side of the calcaneus peroneal trochlea, and the fifth metatarsal are confirmed, the peroneus brevis tendon and peroneus longus tendon are palpated, and the needle is advanced to the tender point.

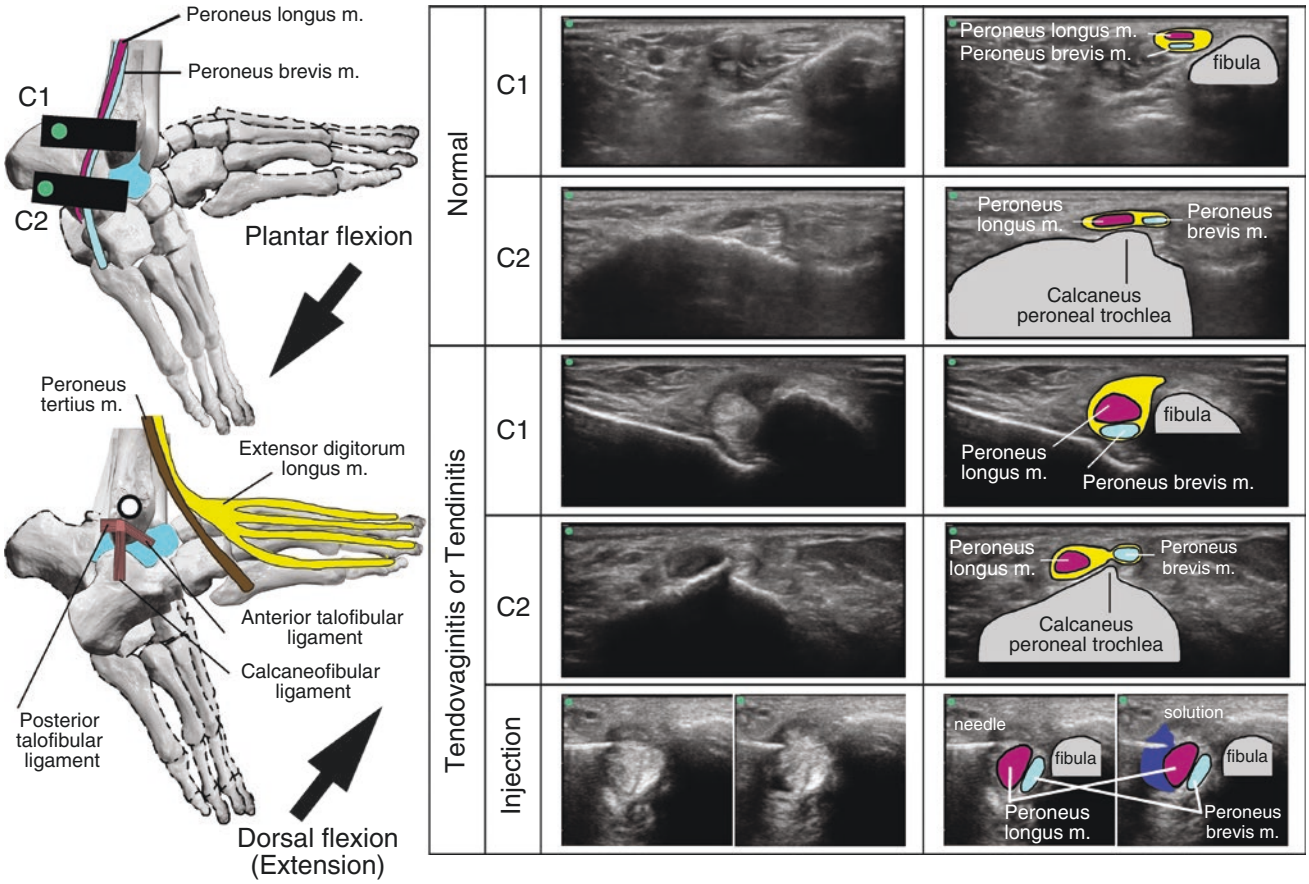

Fig. 96.2 Lateral side of the ankle joint. (1) A low-echo image is observed around the tendon if tendonitis or tenosynovitis is present. (2) The probe is placed behind the lateral malleolus. (3) The puncture site is the dorsal side of the peroneal tendon, and the needle is advanced toward the low-echo image using the in-plane approach

96.5.3.2 US-Guided Method (Fig. 96.2)

1. The probe is moved from the area posterior to the lateral malleolus to the fifth metatarsal, and the peroneus brevis tendon and peroneus longus tendon are observed.
2. Since a low-echo image is observed around the tendon if tendonitis or tenosynovitis is present, the needle is advanced using the in-plane approach.

96.6 Complications

Bleeding, infection, and nerve damage

Comment

97

Yosuke Usui

97.1 Lower Limb and Joint

In treatment of the joints of the knees, feet, etc., ultrasound guidance allows physicians to visualize anatomical conditions, facilitating diagnosis and appropriate injection of drugs into or around the affected joints.

For the treatment of knee pain, joint replacement is performed as an ultimate strategy. However, before joint replacement, ultrasound-guided drug injection is considered to be useful in patients who are reluctant to undergo surgery.

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Part XX

Motor Nerve (Landmark, Ultrasound)

Facial Nerve Block (FNB)

98

Yutaka Masuda

98.1 Introduction

A facial nerve block (FNB) is a therapeutic procedure performed as a nerve block therapy for hemifacial spasm and blepharospasm. FNB is also introduced in "The management of Pain" [1] written by Bonica. In this case, the author uses alcohol to acquire a long-term effect.

In Japan, the needle insertion method (Wakasugi's method) is used. First described by Wakasugi, this method has been performed as an effective method that does not use alcohol.

However, since neurovascular decompression [2] and botulinum toxin therapy has become increasingly popular, FNB is currently rarely performed.

98.2 Indications

FNB is a therapeutic procedure for hemifacial spasm. FNB is taken into consideration as a therapeutic procedure other than a botulinum treatment, in cases where musicians or athletes need to avoid the hearing loss and dizziness which are the complications of neurovascular decompression, and when general anesthesia cannot be performed due to complications.

In addition, FNB is also indicated for postparalytic spasm and blepharospasm.

98.3 Anatomy

The motor fibers arise from the motor nucleus of the seventh nerve, loop around the nucleus of the abducens, and eventually terminate to supply the stapedius muscles of the middle ear, facial expression muscles including those of the scalp and platysma, and the posterior belly of the digastric and styloid muscles. The sensory fibers arise from the unipolar cells in the geniculate ganglion and immediately divide into central fibers (nervus intermedius) and into peripheral branches, which terminate in the anterior two-thirds of the tongue via the chorda tympani.

The facial nerve emerges from the posterolateral angle of the pons, proceeds laterally to enter the internal auditory meatus, in which it traverses until reaching the medial wall of the epitympanic recess, where it suddenly curves posteriorly and inferiorly, and travels within the facial canal to make its exit from the skull by way of the stylomastoid foramen. While the nerve is within the facial canal, about 0.5 cm above the stylomastoid foramen, it gives rise to the chorda tympani. Blocking the nerve at the stylomastoid foramen, therefore, does not involve the chorda tympani.

After emerging from the stylomastoid foramen, the facial nerve advances anteriorly through the parotid gland, passing laterally to the styloid process and the external carotid artery to reach the posterior border of the ramus of the mandible, at which point it divides into its temporal, zygomatic, buccinators, mandibular, and cervical branches. These branches supply all the superficial muscles of the face, including the buccinators, platysma of the neck, and the muscles of the anterior portion of the head.

98.4 Instruments and Drug Solutions

Needles:	#22-gauge 5 cm block needle, #25-gauge needle for local anesthesia, and #26-gauge needle for the O'Brien methods.
Syringe:	1 ml and 5 ml.
Local anesthetic:	1% and 2% :epivacaine.
	Disinfectant: sterilization square cloth, and sterile absorbent gauze.
Drug:	Vasodilator.

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98.5 Procedures and Techniques

98.5.1 Position and Sterilization

A patient is placed in the dorsal position. The face is turned a little to the unaffected side, and if necessary, it puts a thin pillow under the shoulder, and enables the mastoid bone to be clearly seen.

A little earlobe is pulled up with a plaster.

The area adjacent to the mastoid process is sterilized.

98.5.2 Insertion Point and Direction of the Block Needle

The mastoid tip is identified. (Land-mark method).

A local anesthetic skin wheal is made approximately 5 mm anterior to the border of the mastoid process. A 22-gauge, 5 cm needle is inserted through this wheal in a parallel direction to the forehead-philtrum line, at an angle of approximately 30° against the median line (Fig. 98.1). The block needle is inserted to a depth of 3.0–4.0 cm until the needle tip hits the nerve trunk.

98.5.3 Physical Block of the Facial Nerve (Wakasugi's Method)

When the needle tip hits the nerve trunk, pain is produced, and instantaneous contracture of the facial muscles is seen. Immediately after that, facial palsy appears. The block needle is moved forward slightly, and it is checked that the facial palsy becomes strong. Approximately 10–15 min after this, and if paralysis is in a fixed state, the block needle is withdrawn.

98.5.4 Chemical Block of the Facial Nerve

The block needle is inserted in the same way as the physical block.

When the needle reaches near to the stylomastoid foramen, 0.1 ml of 2% mepivacaine is injected. If facial palsy appears immediately and there are no complications in the following 20 min, a small amount of neurolytic agent (alcohol) is also injected in the same place.

In the case of blepharospasm, the O'Brien method [3] is also effective.

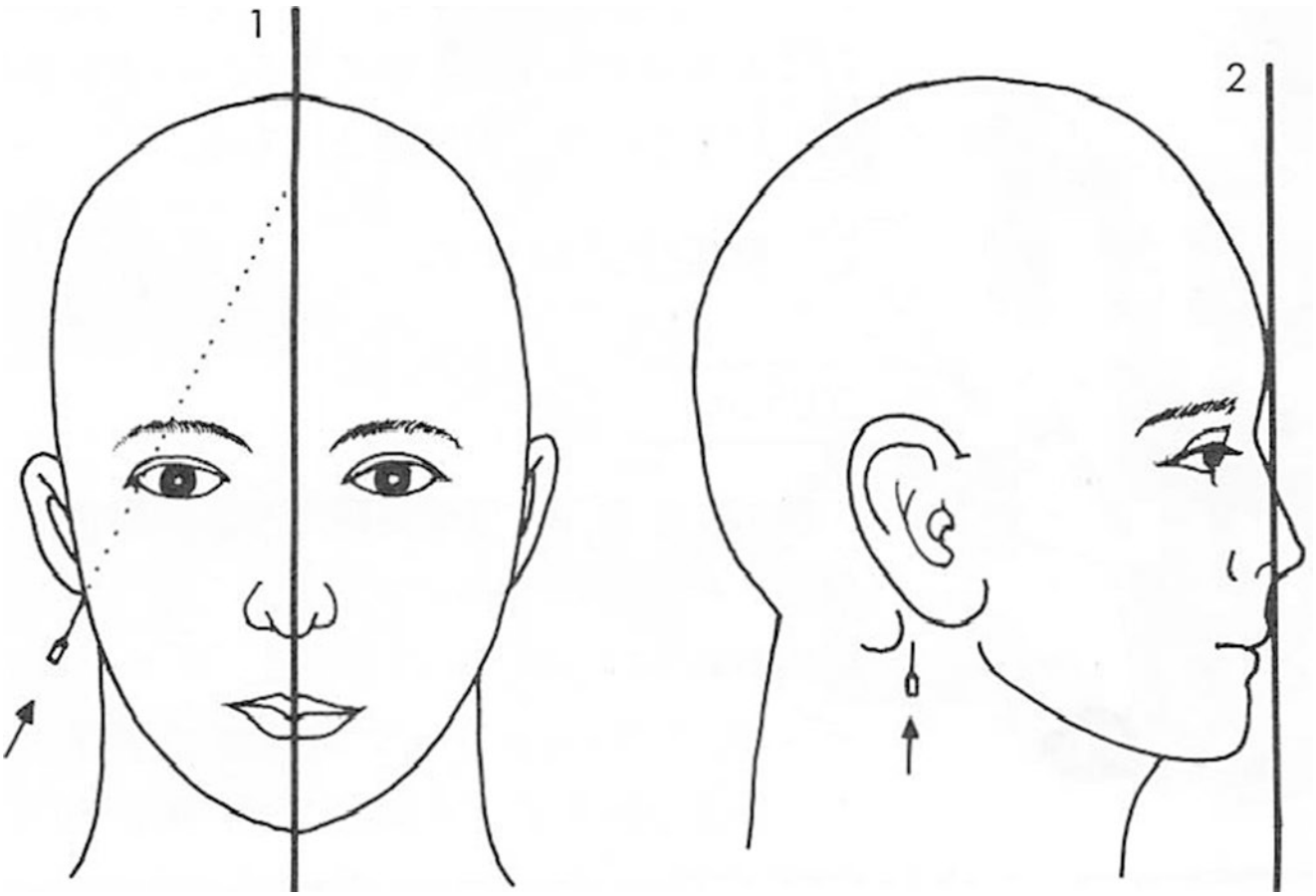

Fig. 98.1 Direction of the block needle. Insertion angle is about 30° against median line (1), and the direction of a block needle is towards the back wall of the external auditory canal, parallel to the forehead-philtrum line (2)

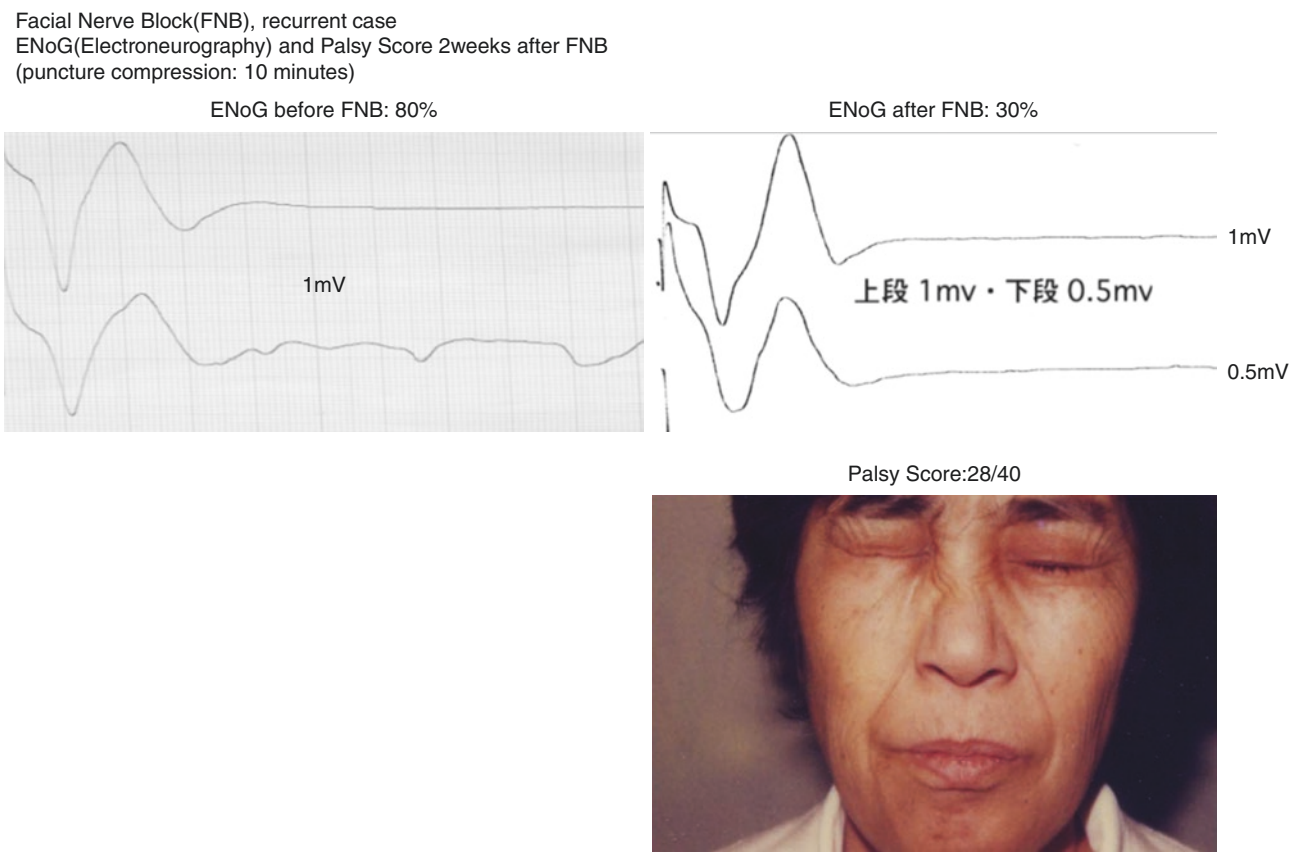

Fig. 98.2 Facial palsy and electroneurography (ENoG) after FNB. This is a recurrence case. The upper left picture shows ENoG before FNB (upper, healthy side; lower, affected side; ENoG value is 80%). The lower left picture shows ENoG after FNB (upper, healthy side; lower, affected side; ENoG value is 30%). The right image shows facial palsy 2 weeks after FNB. The palsy score is 20/40 points

On bisector lines which connect the lateral angle of the eye and the angle of the mouth from the tragus, a 26-gauge hypodermic needle is inserted approximately 1–2 cm from the tragus. Two percent mepivacaine 0.5 ml is injected. If both eyes are unable to close and the spasm disappears, an equivalent amount of pure alcohol is injected in the same place, after checking that there are no side effects.

98.6 The Effect of Physical Facial Nerve Block

After a successful nerve block, facial spasm stops immediately. The induced facial palsy disappears spontaneously within 1 month. After recovery from the facial palsy, the effect of the physical facial nerve block continues usually for 6–12 months. This period depends on the degree of nerve injury induced by the block (Fig. 98.2).

98.7 Complications

Ordinarily complications are seldom encountered. The following minor complications may occur:

Vertigo with nystagmus may occur when a local analgesic is injected near the stylomastoid foramen. This is the influence of the local anesthetic infusing into the internal ear. The patient recovers within 1 h, following rest.

Bleeding in the external auditory canal may occur when the skin of an external auditory canal is damaged with the block needle. There is no further trouble after this is cleaned.

References

1. Bonica JJ. The management of pain. Chapter 8 Technique of nerve blocking. In: Blocking the central nerves. B. Facial(VII cranial) nerve block. Philadelphia: Lee & Febiger; 1953. p. 274–6.
2. Wakasugi B. Facial nerve block in the treatment of facial spasm. Arch Otolaryngol. 1972;95:356–9.
3. O'Brien CS. Local anesthesia in ophthalmic surgery. JAMA. 1928;90:8–13.

Correction to: Stellate Ganglion Block

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In the original version of Chapter 22, one of the author names was inadvertently published as Motohiko Paku. The name of the author should be read as Kieun Park.

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Index

K. Ohseto et al. (eds.), *Nerve Blockade and Interventional Therapy*, https://doi.org/10.1007/978-4-431-54660-3