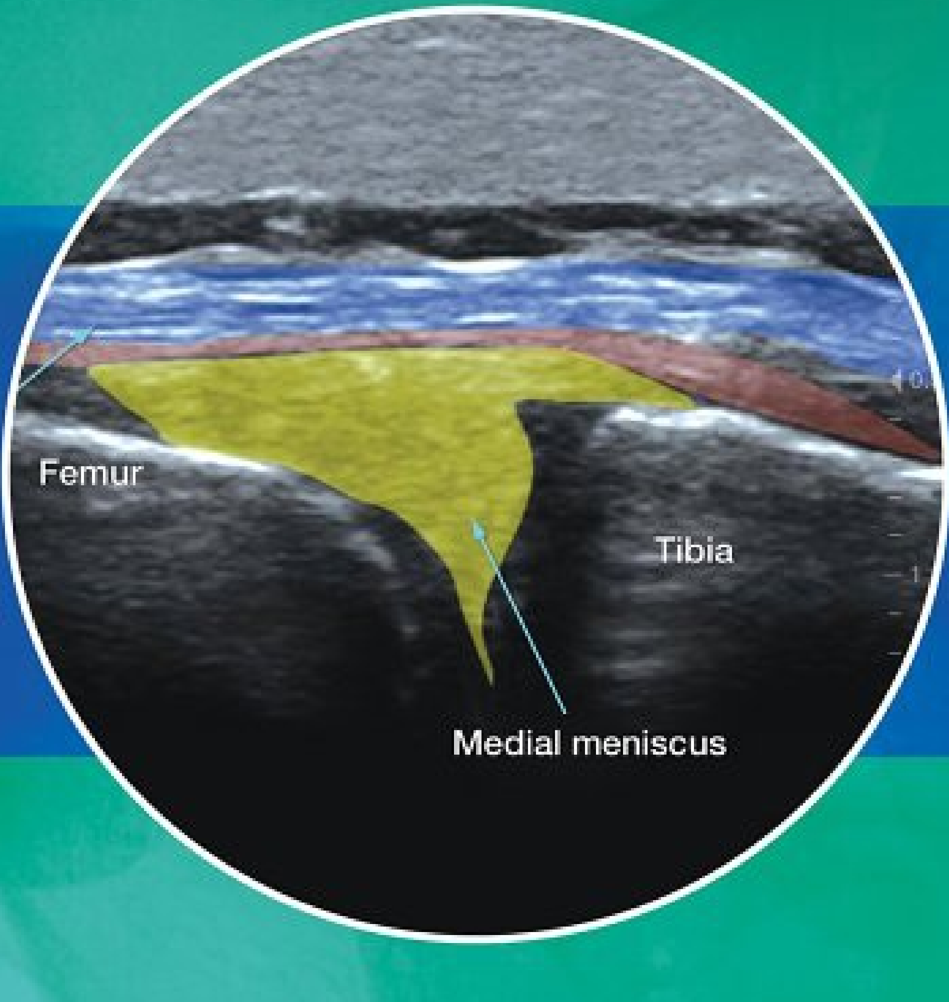
COMPREHENSIVE ATLAS OF

Ultrasound-Guided Pain Management Injection Techniques

SECOND EDITION



Wolters Kluwer

Steven D. Waldman

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This book is dedicated to

Reid Alexander Waldman, MD,

caring physician,

innovator,

researcher,

author,

foodie.....

And generational talent!

Dad

PREFACE

It's getting better all the time

Better, better, better

It's getting better all the time

Better, better, better

From

Getting Better

Sgt. Pepper's Lonely Hearts Club Band

By The Beatles

A lot has happened in the world of ultrasound since the first edition of *Comprehensive Atlas of Ultrasound-Guided Pain Management Injection Techniques* was published in 2014. As hard as it is to believe, at that point in time, the use of ultrasound to guide pain management injection techniques was still quite controversial. Fast forward a mere 6 years and the use of ultrasound guidance has become an essential element of contemporary pain management care. The use of ultrasound-guided pain management injections now encompasses the entire continuum of painful conditions from acute to chronic and is now being used by an increasingly diverse number of medical and surgical specialties. The reason for this almost universal acceptance of ultrasound guidance is the rapidly growing body of evidence supporting its use. This evidence includes:

1. **Ultrasound leads to better diagnosis.** Ultrasound is unique in that it not only gives the clinician a real-time snap shot of the painful area, it often provides diagnostic information that really augments the findings gleaned from the all—important history and physical examination. Nerve entrapments, fluid collections, tendinopathy, infection, foreign bodies, arthritis, etc., are all easily observed. Ultrasound also allows the clinician to observe the anatomic structure in question dynamically……,for

example, observing the bicipital tendon sublux during flexion and extension of the biceps, the sciatic nerve becoming entrapped by the piriformis muscle, etc. This real-time dynamic information leads to better clinical correlation and diagnosis, which ultimately yields better and safer treatment plans.

2. **Ultrasound leads to better treatment.** Much of the praise surrounding ultrasound-guided pain management procedures centers around "more accurate needle placement." While there is no question in my mind that with many pain management procedures, ultrasound guidance enhances needle placement……..to me the real unsung hero of ultrasound-guided procedures is when the information gleaned from an ultrasound exams tells the clinician NOT to inject a painful condition……., for example, when there is significant tendinopathy that includes significant acute inflammation and substantial tendon tears indicating that even a careful injection would put the tendon at risk of rupture.
3. **No radiation.** It is my belief that many pain management specialists have become inured to the significant risk that daily use of fluoroscopy poses to the pain management specialists. It is a real pleasure to avoid this health risk, not to mention dispensing with the inconvenience and discomfort of lead aprons, lead glasses, etc.
4. **Ultrasound is great for teaching.** The ability to easily bring the ultrasound machine to the patient…..in the office, at the bedside, or in the operating room, makes many procedures into great teaching moments for our staff, residents, and students. Dynamic imaging of the functional anatomy of the rotator cuff or the relationship of the carotid artery to Chassaignac tubercle when performing stellate ganglion block really helps the student learn and remember what they need to know when performing pain management procedures. It also reminds even the most seasoned pain management specialist how easily a needle can go awry.
5. **The equipment keeps improving.** Just compare the digital images in this book to ultrasound images in earlier texts devoted to ultrasound and you will see what I mean. Each new generation of ultrasound machines not only produces images of infinitely better quality, but the ultrasound machines are lighter, more reliable, and often less expensive. 3D and 4D ultrasound modalities continue to improve and hold promise in better patient care, teaching, and patient education.
6. **The use of ultrasound enhances the connection between the clinician**

and the patient. In this time of electronic medical records, telemedicine, and a host of other technologies that impinge on the clinician/patient relationship, the use of ultrasound when performing pain management injections does just the opposite. Ultrasound-guided pain management injections are up close and personal. Ultrasound guidance requires the clinician to be at the bedside next to his or her patient. It requires constant interaction between the patient and clinician as the injection is performed. It requires the “laying on of the hands.” Ultrasound guidance in fact enhances the human interaction that is so essential to patient care.

It is my hope that you will find this book useful as you care for your patients in pain and that you enjoy using it as much as I enjoyed writing it.

Steven D. Waldman, MD, JD
June 2019

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Iwould like to acknowledge the following individuals:

Dr. Michael Meng, clinician, diagnostician, and ultrasonographer extraordinaire. Mike produced many of the amazing ultrasound images in this book and in the process taught all of us the “art of ultrasound,” creating images of unsurpassed quality and clarity.

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The Society for Pain Practice Management Faculty whose expertise and teaching ability is an inspiration. With thanks and friendship to Andres Betts, MD; Ken Candido, MD; Ian Fowler, MD; Robert Mendez, DO; Michael Meng, DC; Thomas Moran, DO; Antoin Nader, MD; Philip Peng, MBBS; Maunak Rana, MD; Michael Verdolin, MD; Erik Voogd, MD.

John Carmody, medical photographer and long time friend, whose expertise and efficiency made producing the hundreds of original color photographs used in this text doable. John is always ready to go the extra mile and knows how to keep us moving.

Bernie Kida, certified medical illustrator, and his team at Kida Media Art produced many of the original full color figures for this book. Bernie has the unique ability to translate the technical written word into art that is not only beautiful to look at, but, at a glance illustrates sometimes difficult concepts, anatomy, and procedures.

Keith Donnellan, acquisition editor at Wolters Kluwer Health/Lippincott Williams & Wilkins, who saw the need for a comprehensive text on ultrasound-guided procedures and Sean McGuire, development editor at

Wolters Kluwer Health, who shepherded this second edition from conception to completion…….and not without some weeping and gnashing of teeth. Sean used his exquisite attention to detail to ensure that all was as it should be, which is not a simple task in a figure-rich text such as this.

And last, but certainly not least, my friend Mark Escarcida of Diagnostic Instruments/Mindray who convinced me of the need for a comprehensive textbook of ultrasound-guided pain management procedures, and then, put his money where his mouth was by not only providing the state-of-the art Mindray ultrasound machines and transducers used to produce the stunning images in this book but also provided Continued encouragement to all during the writing of this book.

Thanks to all!

Steven D. Waldman, MD, JD

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SECTION I

Head

CHAPTER 1

Ultrasound-Guided Atlanto-Occipital Block

CLINICAL PERSPECTIVES

The atlanto-occipital joint is an often overlooked source of upper posterior neck pain and suboccipital headache. The joint is susceptible to arthritis and is frequently traumatized during acceleration/deceleration injuries. The pain following such injuries is often initially attributed to soft tissue injury such as muscle strain and/or bruising. The pain is ill defined and dull in nature, involving the upper neck and occipital region (Fig. 1.1). Pain emanating from the atlanto-occipital joint is exacerbated with lateral range of motion and flexion and extension of the upper cervical spine. It frequently coexists with pain from the atlantoaxial joint. The patient suffering from pain from the atlanto-occipital joint will frequently complain of neck pain, occipital and suboccipital headaches, preauricular pain, and limited range of motion. The patient may experience an exacerbation of pain at extremes of range of motion as well as sleep disturbance, nausea, and difficulty in concentrating.

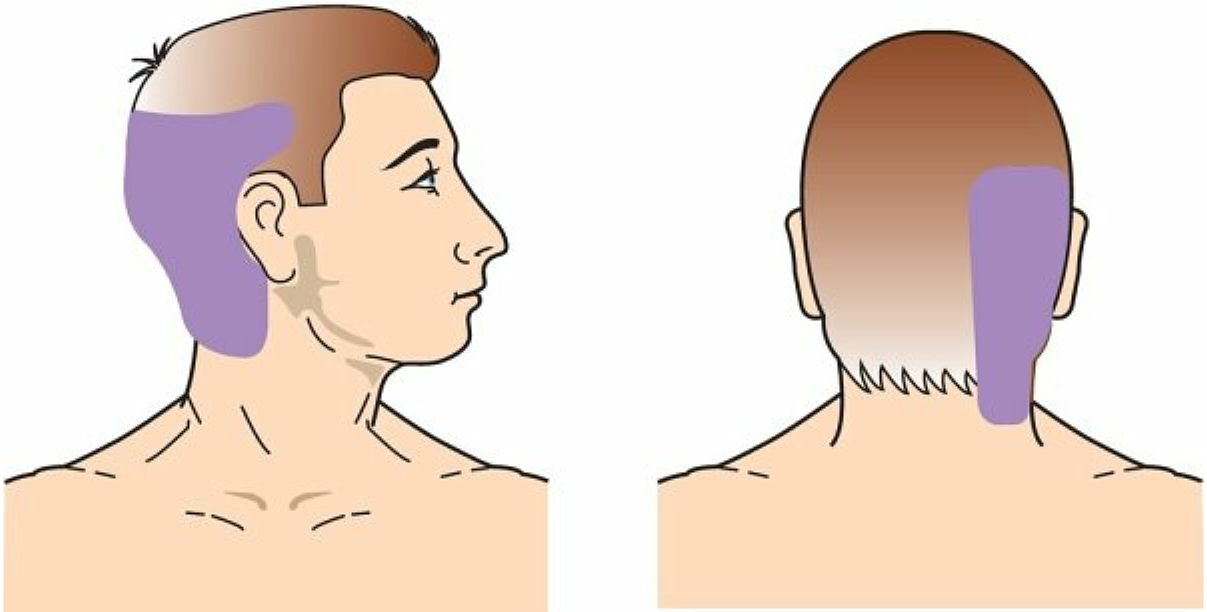

FIGURE 1.1. Distribution of pain emanating from the atlanto-occipital joint.

CLINICALLY RELEVANT ANATOMY

The atlanto-occipital joint serves as the articulation between the occiput of the skull and atlas (Fig. 1.2). The atlanto-occipital joint possesses a well-developed joint capsule, cartilage, and synovium. This modified V-shaped joint has a limited range of motion of 35 degrees and functions to aid in the positioning of the sense organs by allowing the head to nod forward and backward. It differs from the true facet joints of the lower cervical spine in that it lacks a true posterior articulation. The atlanto-occipital joint also lacks classic intervertebral foramina. The joint lies anterior to the posterolateral columns of the spinal cord (Fig. 1.3). The vertebral artery ascends within the cervical spine via the transverse foramen and then exits the C1 transverse foramen and turns medially to course diagonally across the posteromedial aspect of the atlanto-occipital joint to join with the contralateral vertebral artery at the level of the medulla to form the basilar artery, which enters the foramen magnum in the midline (Fig. 1.4). The diagonal course of the vertebral artery provides an important landmark when performing ultrasound-guided atlanto-occipital nerve block (Fig. 1.5). The C1 nerve root, which is also known as the suboccipital nerve, exits between the skull and C1 vertebra and lacks the characteristic dorsal sensory root seen with other spinal nerves in most patients. It provides motor innervation to the suboccipital muscles and interconnects with fibers of the C2 and C3 nerves, which may explain the overlapping pain symptomatology when any of these nerves are traumatized or inflamed.

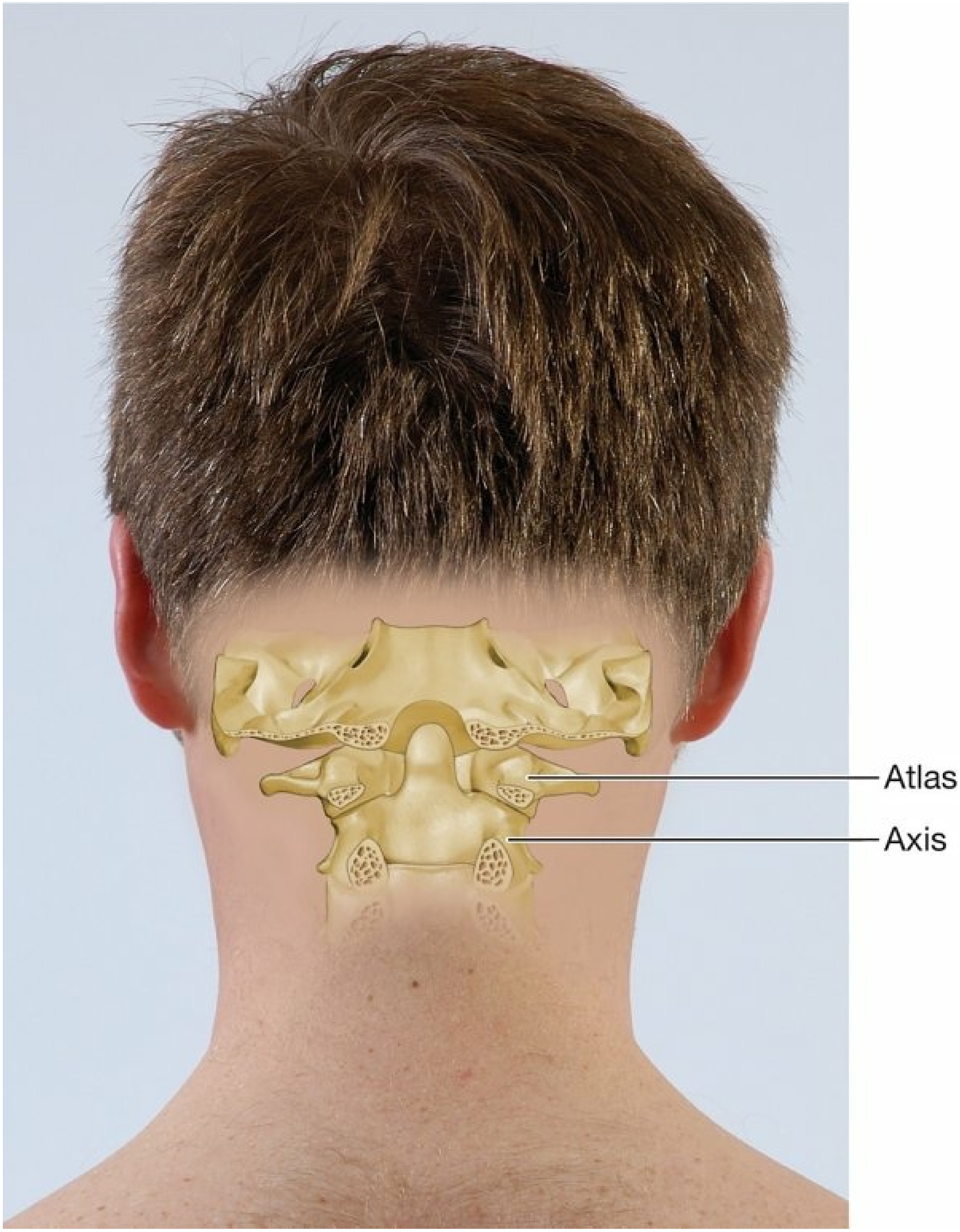

FIGURE 1.2. The atlanto-occipital joint serves as the articulation between the occiput of the skull and atlas. (Moorcroft C. *Myology and Kinesiology Manual for the Massage Therapist*. Philadelphia:

Wolters Kluwer Health/Lippincott Williams & Wilkins; 2012.)

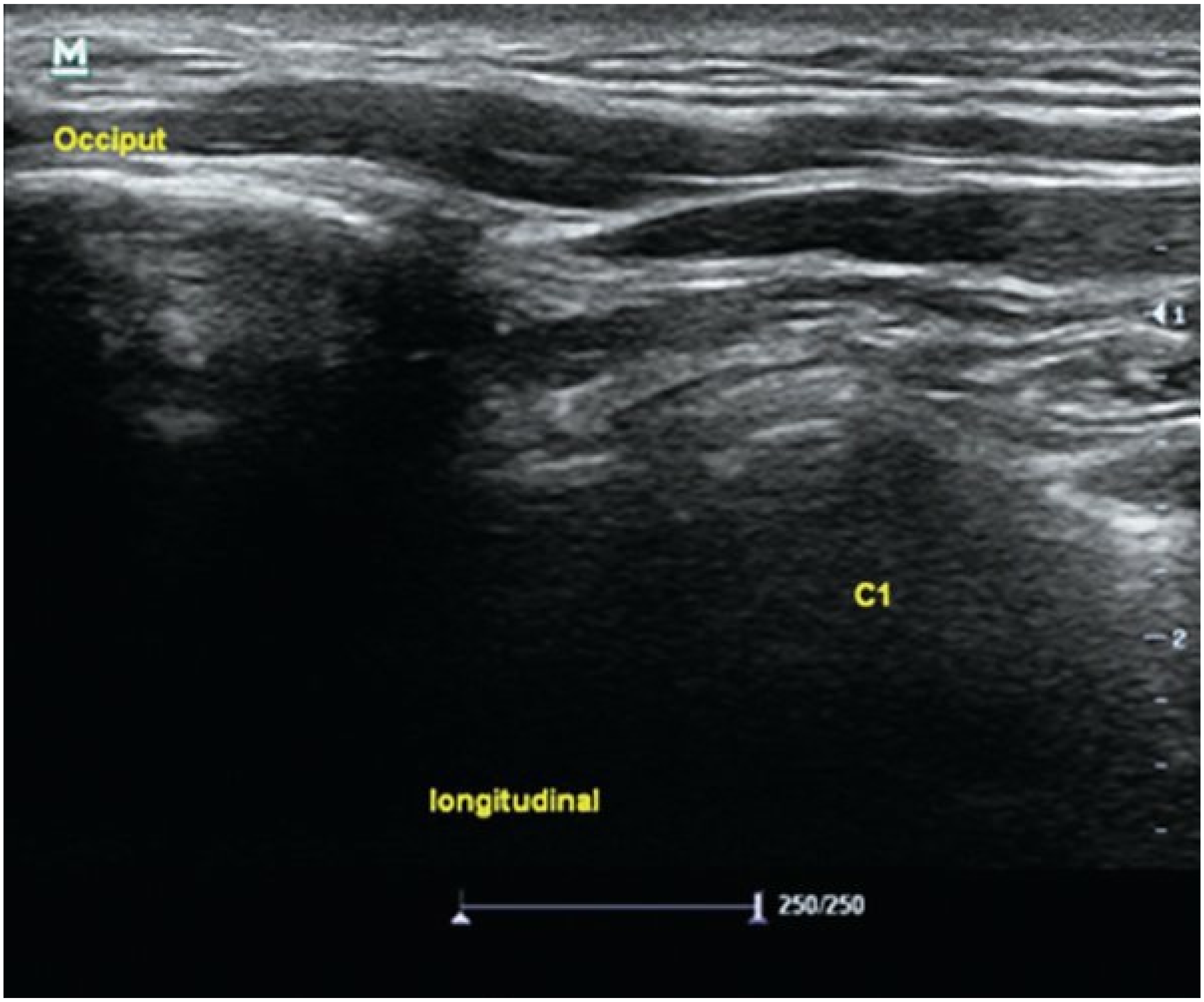

FIGURE 1.3. Longitudinal ultrasound image of the atlanto-occipital joint.

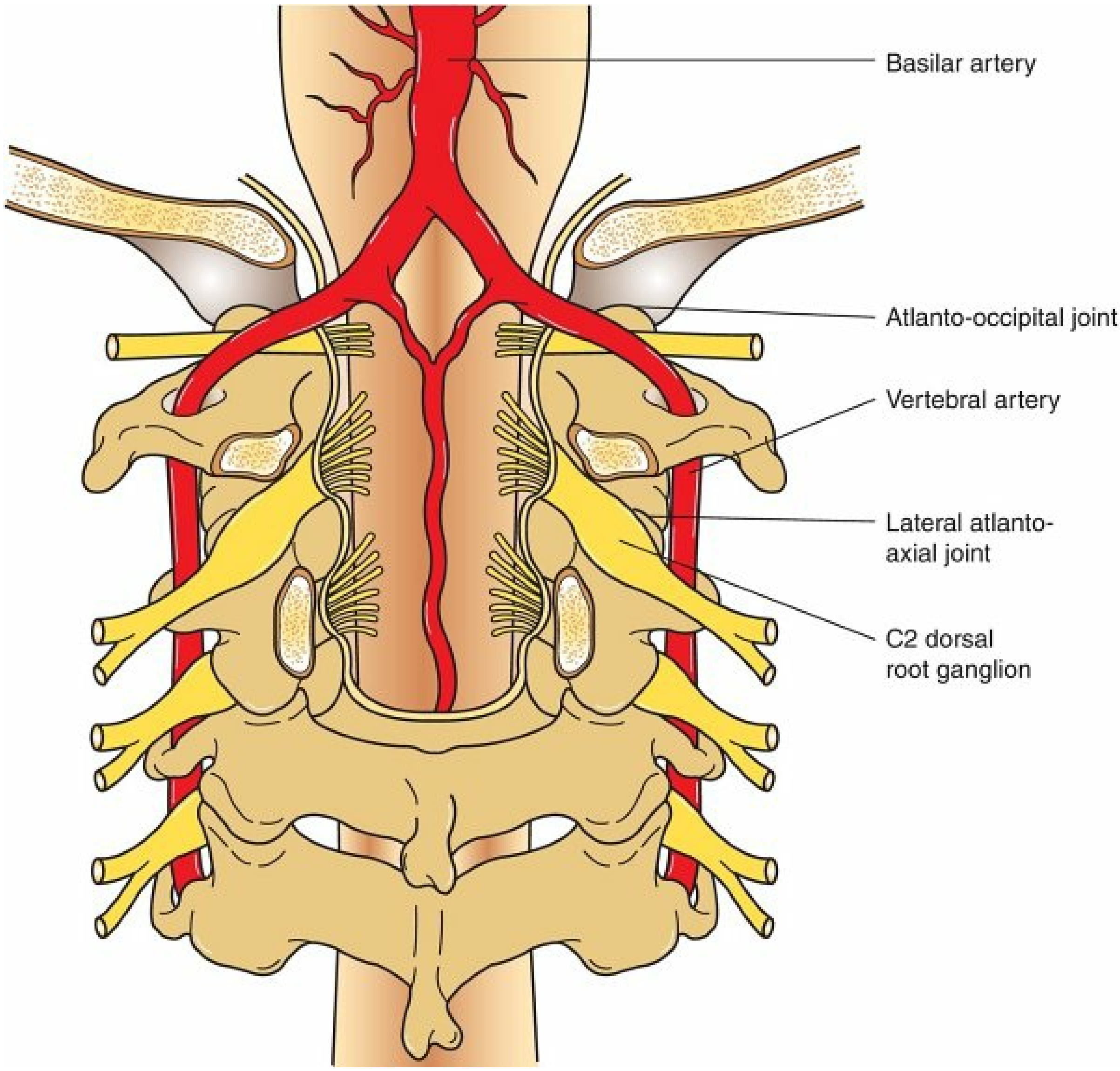

FIGURE 1.4. The relationship of the vertebral artery to the atlanto-occipital joint.

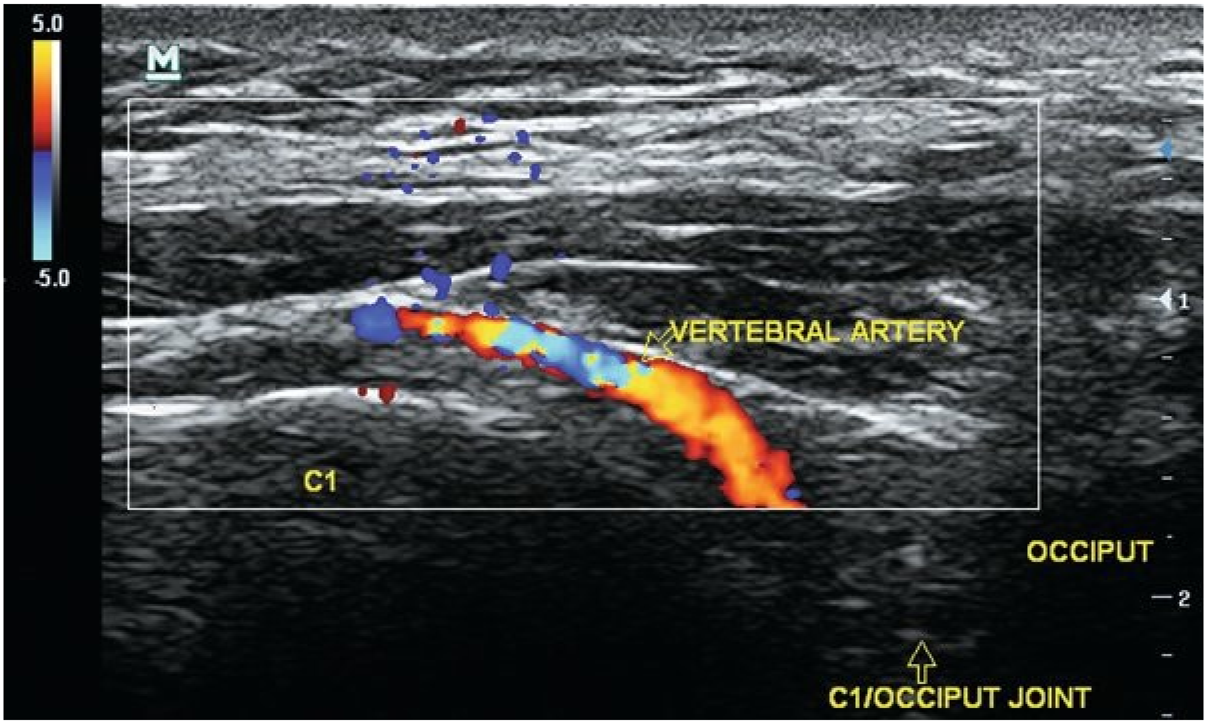

FIGURE 1.5. The vertebral artery ascends within the cervical spine via the transverse foramen and then exits the C1 transverse foramen and turns medially to course diagonally across the posteromedial aspect of the atlanto-occipital joint to join with the contralateral vertebral artery at the level of the medulla to form the basilar artery that enters the foramen magnum in the midline. This diagonal turn provides an excellent landmark when performing ultrasound-guided atlanto-occipital nerve block.

ULTRASOUND-GUIDED TECHNIQUE

The patient is placed in the prone position with the patient's cervical spine slightly flexed and the skin prepped with antiseptic solution. A total of 3 mL of preservative-free dilute local anesthetic is drawn up in a separate 5-mL sterile syringe. When the pain being treated is thought to be secondary to an inflammatory process, a total of 2.5 mg of nonparticulate dexamethasone is added to the local anesthetic with the first block, and 1.5 mg of nonparticulate dexamethasone is added with subsequent blocks. A high-frequency linear transducer is placed in the transverse position slightly off the midline over the upper cervical vertebra, and the vertebral artery is identified as it passes through the transverse foramina (Fig. 1.6). The artery is then traced cranially by slowly moving the transducer in a cranial direction until the vertebral artery is seen to turn medially in front of the atlanto-occipital joint (Fig. 1.7). In most patients, a needle can be placed into the joint just lateral to the point where the artery makes its turn. In an occasional patient, the vertebral artery blocks the entire extent of the joint as it courses from lateral to medial to join the contralateral vertebral artery, rendering safe needle placement virtually impossible.

FIGURE 1.6. The ultrasound transducer is placed in the transverse plane just off the midline at the level of the upper cervical vertebra, and the vertebral artery is identified.

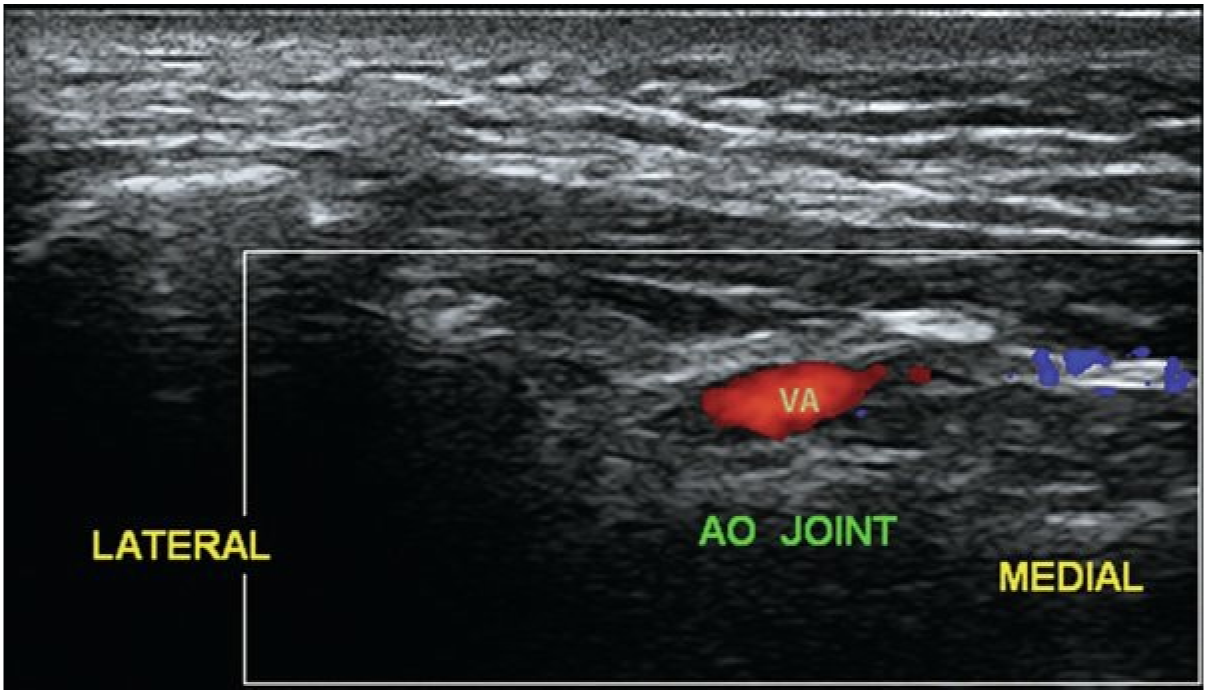

FIGURE 1.7. Color Doppler imaging facilitates identification of the vertebral artery (VA) as it traverses the transverse processes of the cervical vertebral bodies.

COMPLICATIONS

The proximity of the vertebral artery, spinal cord, exiting nerve roots, brain stem, and foramen magnum makes complete knowledge of the relevant clinical anatomy essential to avoid disaster. Even in the most experienced hands, the procedure carries the risk of significant complications. Because in some patients, the vertebral artery completely covers the atlanto-occipital joint as it turns medially to join the contralateral vertebral artery to form the basilar artery, safe needle placement is impossible. Even small doses of local anesthetic inadvertently injected into the vertebral or basilar artery can result in immediate local anesthetic–induced seizures and central nervous system toxicity. The particulate nature of steroids can also cause significant side effects if intra-arterial injection occurs. The proximity of the exiting C2 nerve root makes the inadvertent injection of local anesthetic into the dural sleeve with resultant total spinal anesthesia an ever-present possibility.

CLINICAL PEARLS

Given the significant overlap and cross-connections of the fibers of the C1, C2, and C3 nerves, blockade of addition neural structures, including the greater and lesser occipital nerves as well as the third occipital nerve, may be required to provide the patient with complete pain relief. Blockade of the atlantoaxial joint may also be beneficial, especially if the patient has also sustained trauma to that joint.

The ability of ultrasound imaging to identify the precise position of the vertebral artery relative to the atlanto-occipital joint when performing atlanto-occipital nerve block suggests a significant theoretical advantage over the use of fluoroscopic guidance that more clearly defines the joint but does not delineate the relative position of the artery. Injection of small amounts of iodinated contrast media suitable for use in the central nervous system may help identify intravascular or subdural or subarachnoid placement prior to the injection of local anesthetic if fluoroscopy is utilized concurrently with ultrasound guidance.

SUGGESTED READINGS

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CHAPTER 2

Ultrasound-Guided Atlantoaxial Block

CLINICAL PERSPECTIVES

The atlantoaxial joint is an often overlooked source of upper posterior neck and suboccipital headache pain. The joint is susceptible to arthritis and is frequently traumatized during acceleration/deceleration injuries. The pain following such injuries is often initially attributed to soft tissue injury such as muscle strain and/or bruising. The pain is ill defined and dull in character involving the upper neck and occipital region (Fig. 2.1). Pain emanating from the atlantoaxial joint is exacerbated with lateral rotation and flexion and extension of the joint and surrounding upper cervical spine. It frequently coexists with pain from the atlanto-occipital joint and the C2/C3 facet joints due to convergence of fibers from these anatomic structures with trigeminal afferent fibers via the trigeminocervical nucleus.

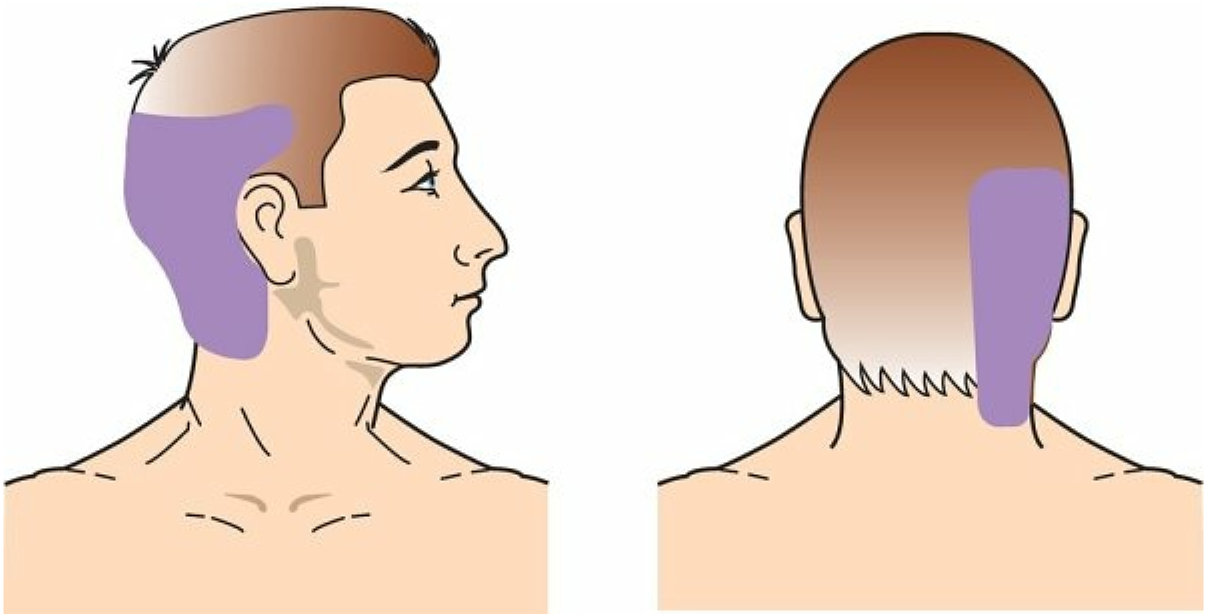
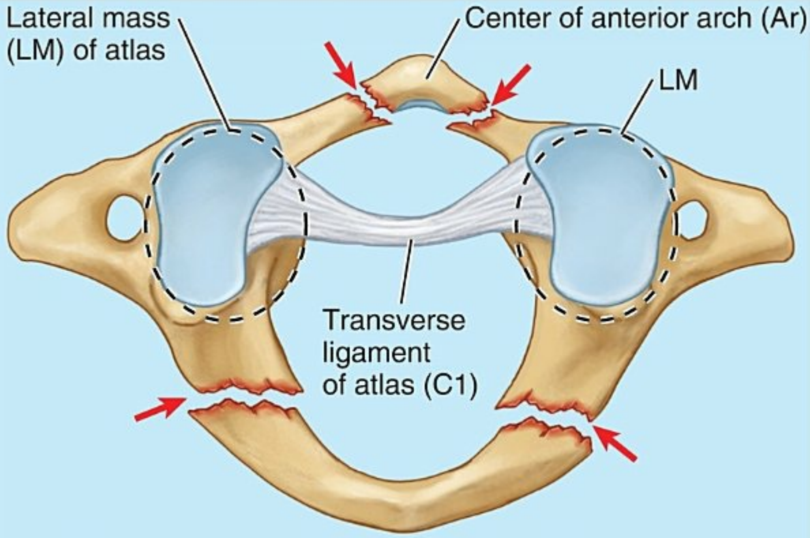


FIGURE 2.1. Distribution of pain emanating from the atlantoaxial joint.

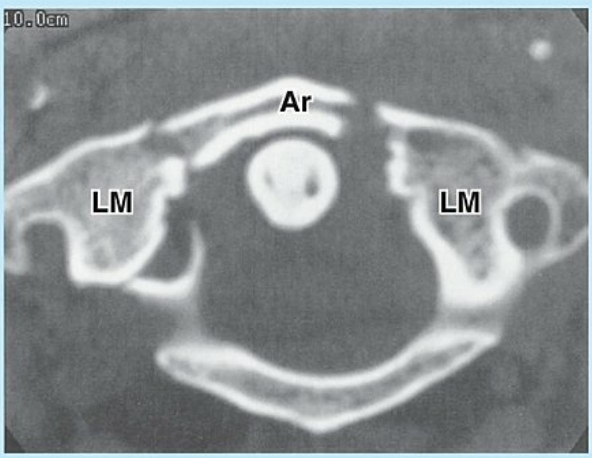
The patient suffering from pain from the atlantoaxial joint will frequently complain of neck pain, occipital and suboccipital headaches, preauricular pain, as well as a limited range of motion with exacerbation of pain at the extremes of range of motion. Sleep disturbance is common as is nausea and difficulty in concentrating. The unique anatomic structure of the atlantoaxial joint also makes it susceptible to instability, which may be exacerbated when the joint is subjected to trauma. A number of diseases are associated with atlantoaxial instability, and they are listed in Table 2.1. The clinician should look carefully for atlantoaxial joint abnormalities and/or instability in patients who have sustained trauma to the joint or who are suffering from the diseases listed in Table 2.1 as failure to identify fractures of the odontoid process and C2 vertebral body and/or disruption of the transverse ligaments with resultant joint instability can have disastrous consequences should the joint sublux (Figs. 2.2 and 2.3).

TABLE 2.1 Diseases Associated with Atlantoaxial Joint Instability

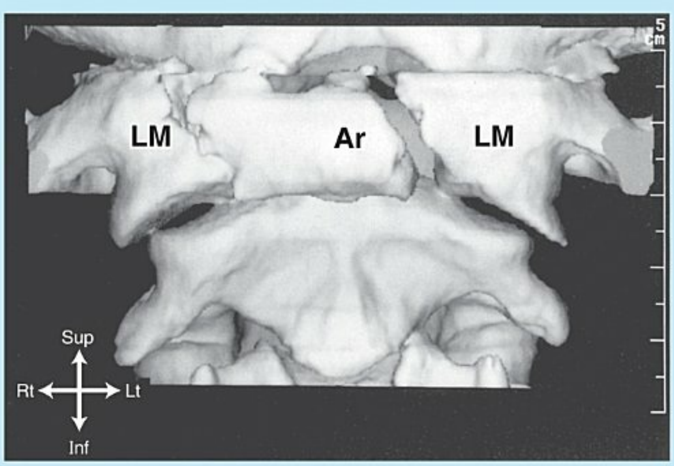
- Rheumatoid arthritis
- Down syndrome
- von Recklinghausen disease
- Osteogenesis imperfecta
- Congenital scoliosis
- Morquio syndrome
- Larsen syndrome
- Kniest dysplasia
- Congenital spondyloepiphyseal dysplasia
- Metatropic dysplasia



(A) Inferior view of Jefferson (burst) fracture of C1



(B) Inferior view of CT scan of Jefferson fracture



(C) Anterior view of reconstructed CT image of Jefferson fracture showing fragment of anterior arch (Ar) and outward (lateral) shift of lateral masses of C1 (LM)

FIGURE 2.2. Jefferson fracture. The classic Jefferson fracture, seen here schematically on the inferior view **(A)** CT image demonstrating an inferior view of a Jefferson fracture **(B)**. Anterior view of a reconstructed CT **(C)** showing a fracture of the anterior arch (Ar) and lateral shift of the lateral masses (LM) of C1. (Cervical Spine Research Society, Clark CR (ed): *The Cervical Spine*, 3rd ed., 1998.)

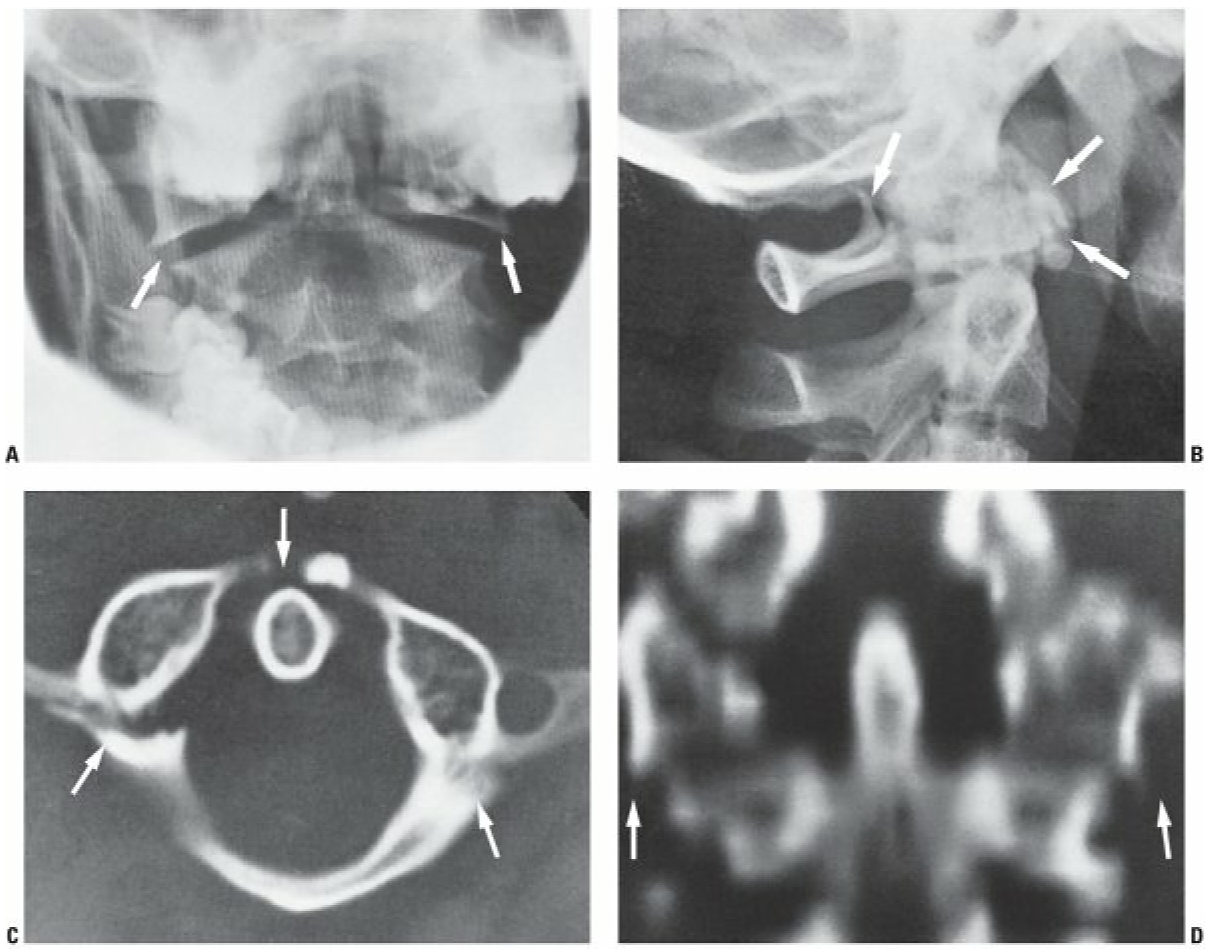


FIGURE 2.3. Jefferson fracture. A 19-year-old man sustained a neck injury while being mugged. **A:** Open-mouth anteroposterior view of the cervical spine shows lateral displacement of the lateral masses of the atlas (*arrows*), suggesting a ring fracture of C1. **B:** Lateral view demonstrates fracture lines of the posterior and

anterior arch of C1 (*arrows*). **C:** Computed tomography (CT) section demonstrates two fracture lines of the posterior arch and a fracture of the anterior arch (*arrows*). **D:** CT coronal reformation confirms lateral displacement of the lateral masses (*arrows*). (Reused from Greenspan A. *Orthopedic Imaging: A Practical Approach* . Philadelphia, PA: Lippincott Williams & Wilkins; 2011:381, with permission.)

CLINICALLY RELEVANT ANATOMY

The atlantoaxial joint serves as the articulation between the C1 and C2 vertebra. The atlantoaxial joint possesses a well-developed capsule, cartilage, and synovium and, like the atlanto-occipital joint, does not possess classic intervertebral foramina seen in the lower cervical vertebrae. The joint allows lateral rotation of the skull of 72 degrees in either direction from the midline and functions to aid in the positioning of the sense organs. It also allows a limited degree of flexion and extension independent of the atlanto-occipital joint and other facet joints of the cervical spine. The vertebral artery ascends via the transverse foramen of the cervical spine, traveling across the lateral one-third of the atlantoaxial joint. The artery ultimately exits the C1 transverse foramen and turns medially to course diagonally across the posteromedial aspect of the atlanto-occipital joint to join with the contralateral vertebral artery at the level of the medulla to form the basilar artery. The basilar artery then ascends to enter the foramen magnum in the midline (Fig. 2.4). The course of the vertebral artery provides an important landmark when performing ultrasound-guided atlantoaxial nerve block (Fig. 2.5). The C2 nerve root exits above the C2 vertebra and provides some motor innervation to the suboccipital muscles. The fibers of the medial branch of the C2 nerve root dorsal primary ramus form the greater occipital nerve. Fibers from the C2 nerve root interconnect with fibers of the C1 and C3 nerves, which may help explain the overlapping pain symptomatology when any of these nerves are traumatized or inflamed.

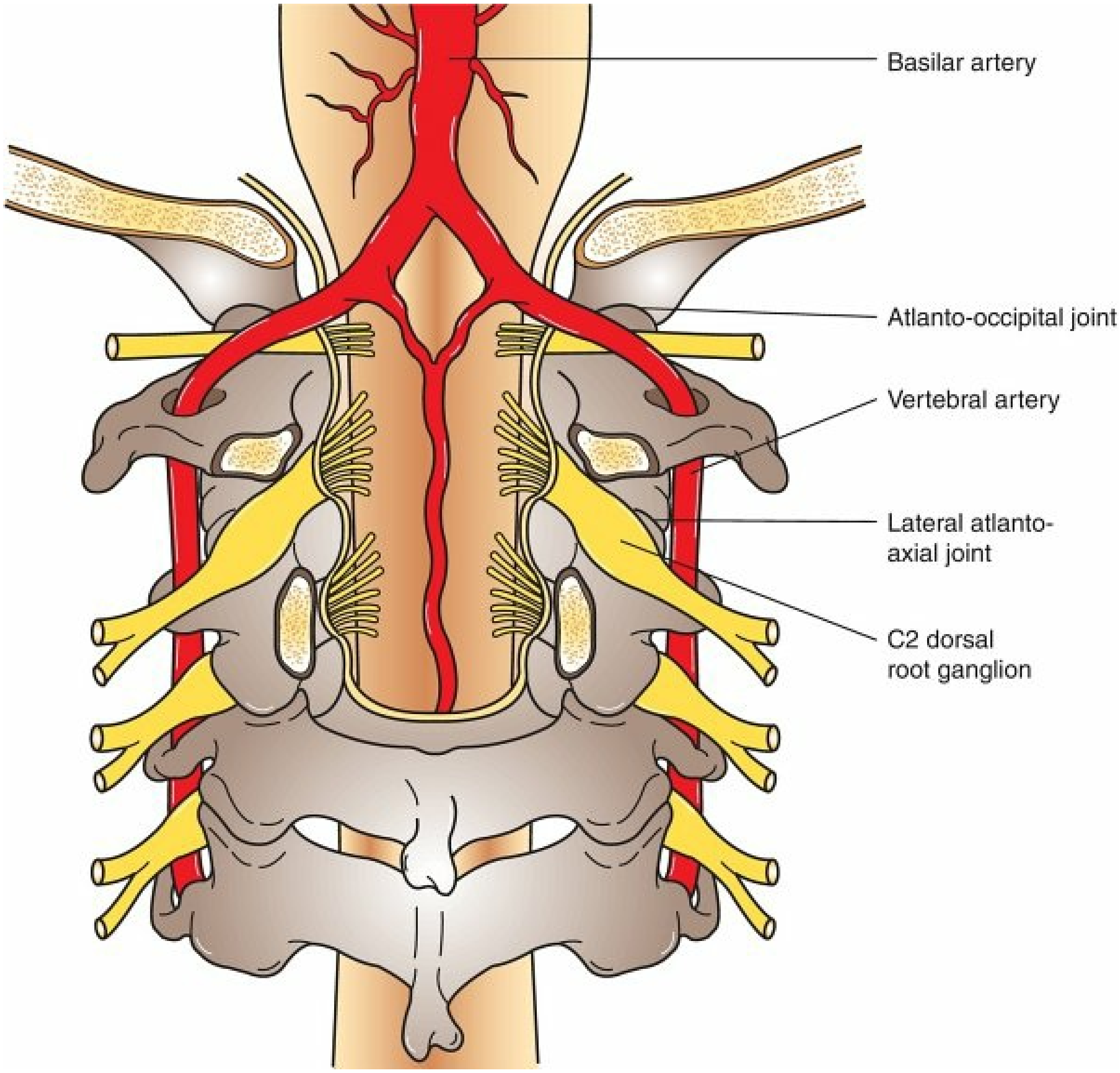


FIGURE 2.4. The relationship of the vertebral artery to the atlantoaxial joint.

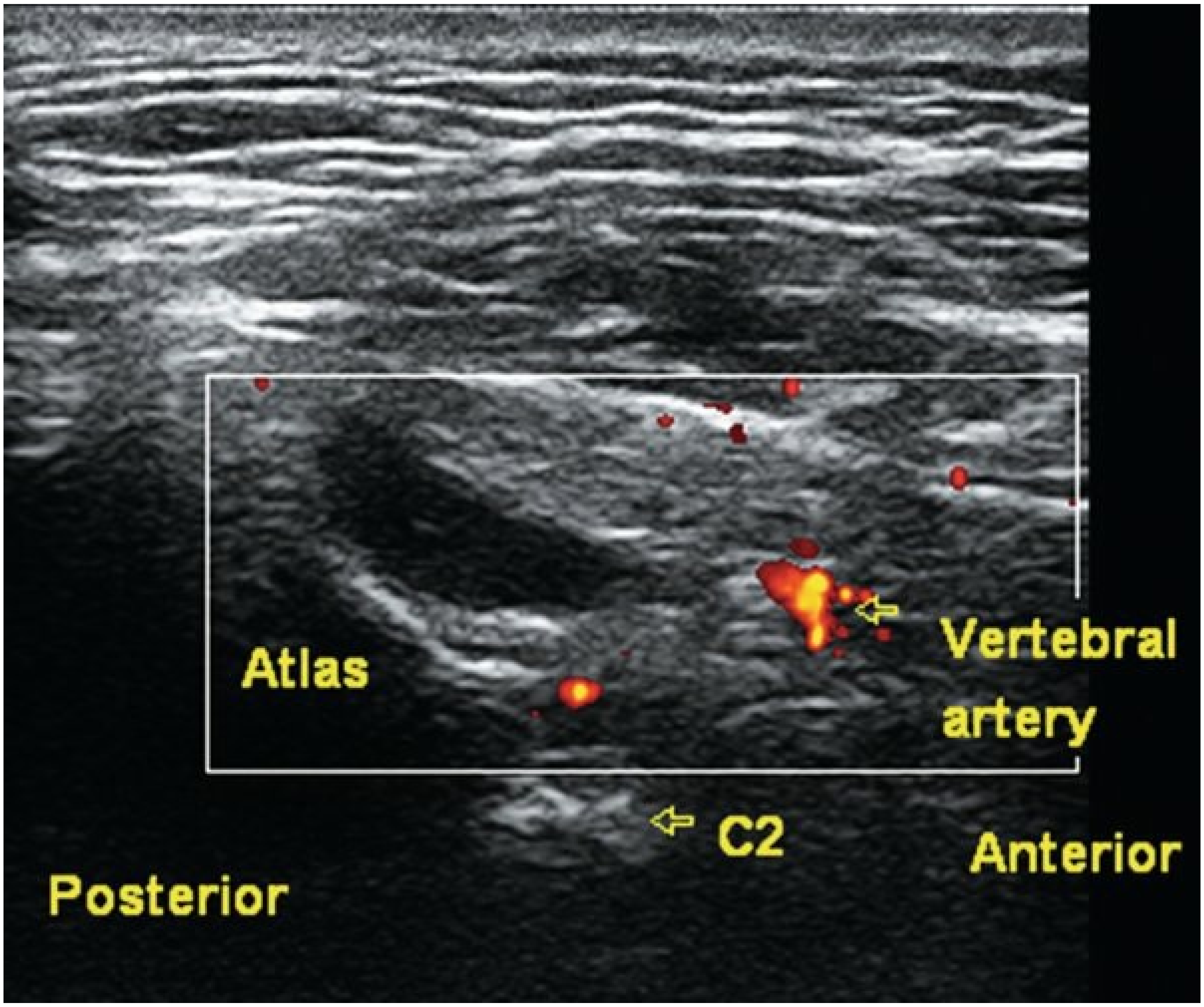


FIGURE 2.5. Ultrasound short-axis view showing the relationship of the vertebral artery to the atlantoaxial joint as it ascends through the transverse foramen.

ULTRASOUND-GUIDED TECHNIQUE

The patient is placed in prone position with patient's cervical spine slightly flexed and the skin prepped with antiseptic solution. A total of 3 mL of preservative-free dilute local anesthetic is drawn up in a separate 5-mL sterile syringe. When the pain being treated is thought to be secondary to an inflammatory process, a total of 2.5 mg of nonparticulate dexamethasone is added to the local anesthetic with the first block, and 1.5 mg of nonparticulate dexamethasone is added with subsequent blocks. A high-frequency linear transducer is placed in the transverse orientation in the midline at the level of the occiput (Fig. 2.6). The transducer is then slowly moved caudally to identify first the C1 and then the C2 vertebral bodies. The C1 vertebral body has only a vestigial spinous process, and the C2 vertebral body is the first cervical vertebral body with a bifid spinous process making its identification easier (Figs. 2.7 and 2.8). When the C2 vertebra is identified, the transducer is then moved laterally until the exiting C2 nerve root is identified (Figs. 2.9 and 2.10). The transducer is then moved slightly more laterally until the vertebral artery is identified. Color Doppler may be used if the vertebral artery is not readily apparent (Fig. 2.11). The atlantoaxial joint should then be easily identified in between the exiting C2 root and the vertebral artery. A 22-gauge, 3½-inch styletted spinal needle is then advanced into the atlantoaxial joint using an out-of-plane approach under real-time ultrasonography, while constant attention is paid to the location of the vertebral artery laterally and the C2 nerve root medially.

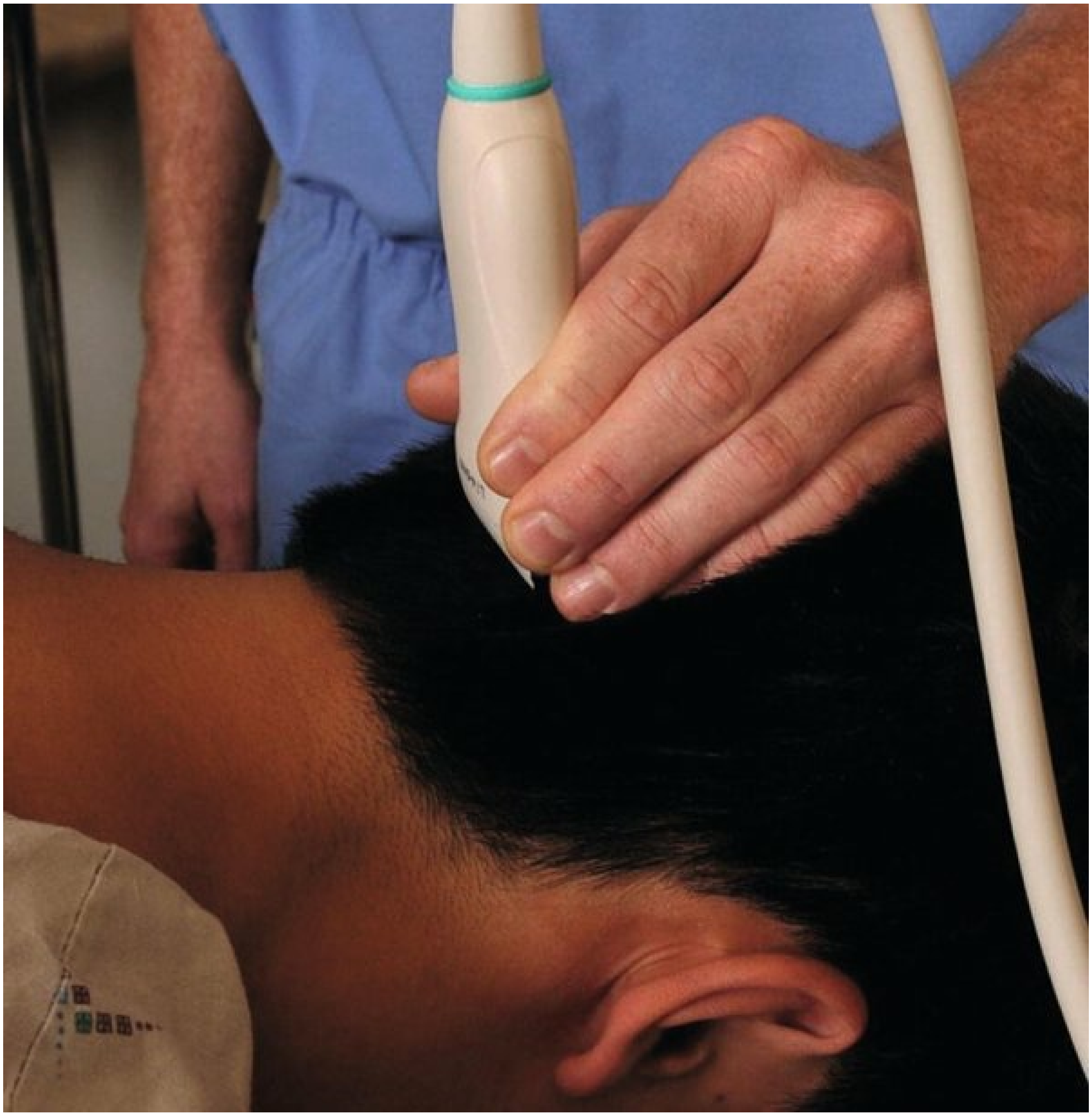


FIGURE 2.6. The ultrasound transducer is placed in transverse orientation in the midline at the level of the occiput and then moved caudally to identify the C1 and C2 vertebral bodies.

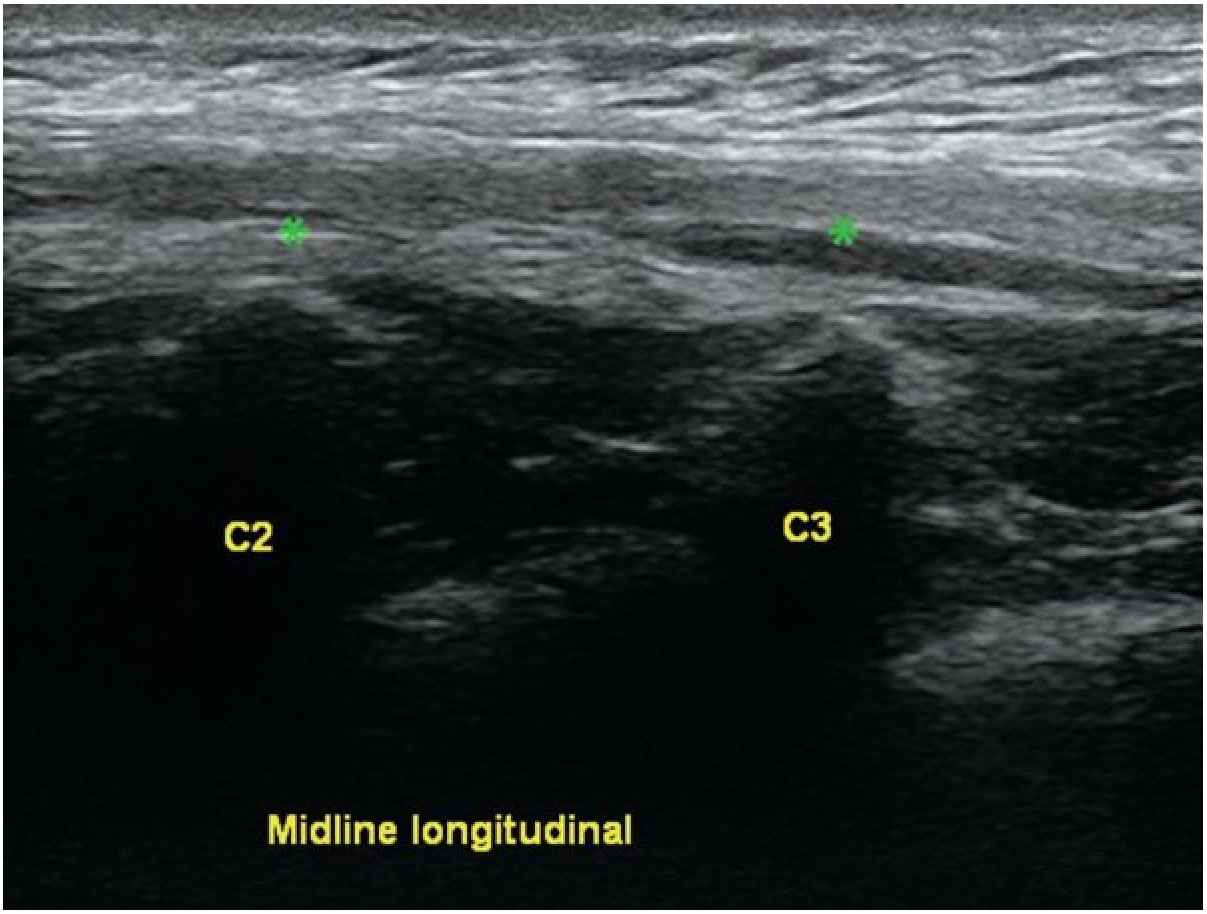


FIGURE 2.7. Midline longitudinal view of the spinous processes of the upper cervical vertebra. The C1 vertebra has only a vestigial spinous process as compared with C2 and C3 vertebrae, which have more classic bifid spinous processes (*green asterisk*) (see Fig. 2.8).

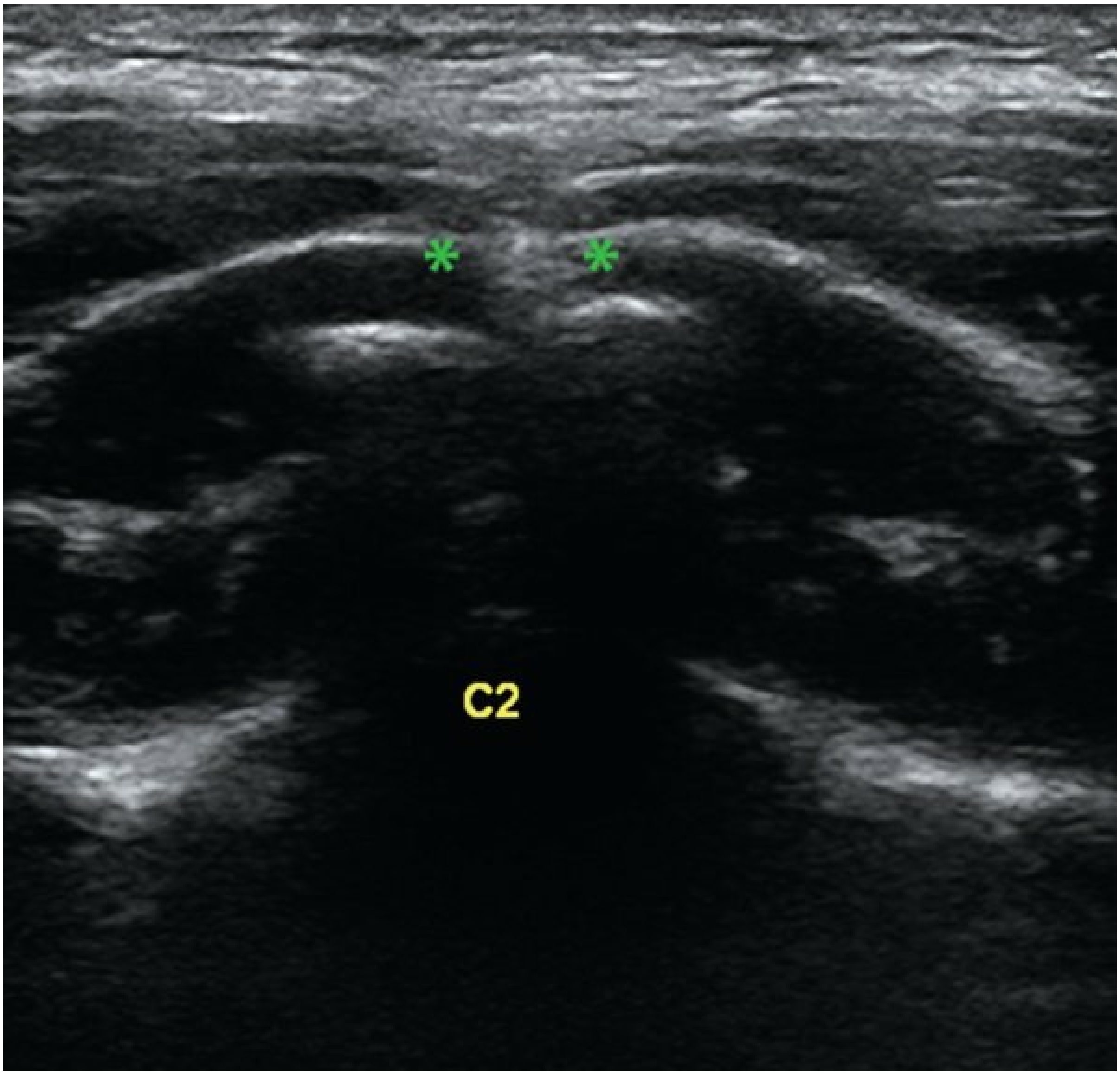


FIGURE 2.8. The more classic bifid process (*green asterisk*) of the C2 vertebra is clearly demonstrated on this transverse short-axis scan of the C2 vertebral body.

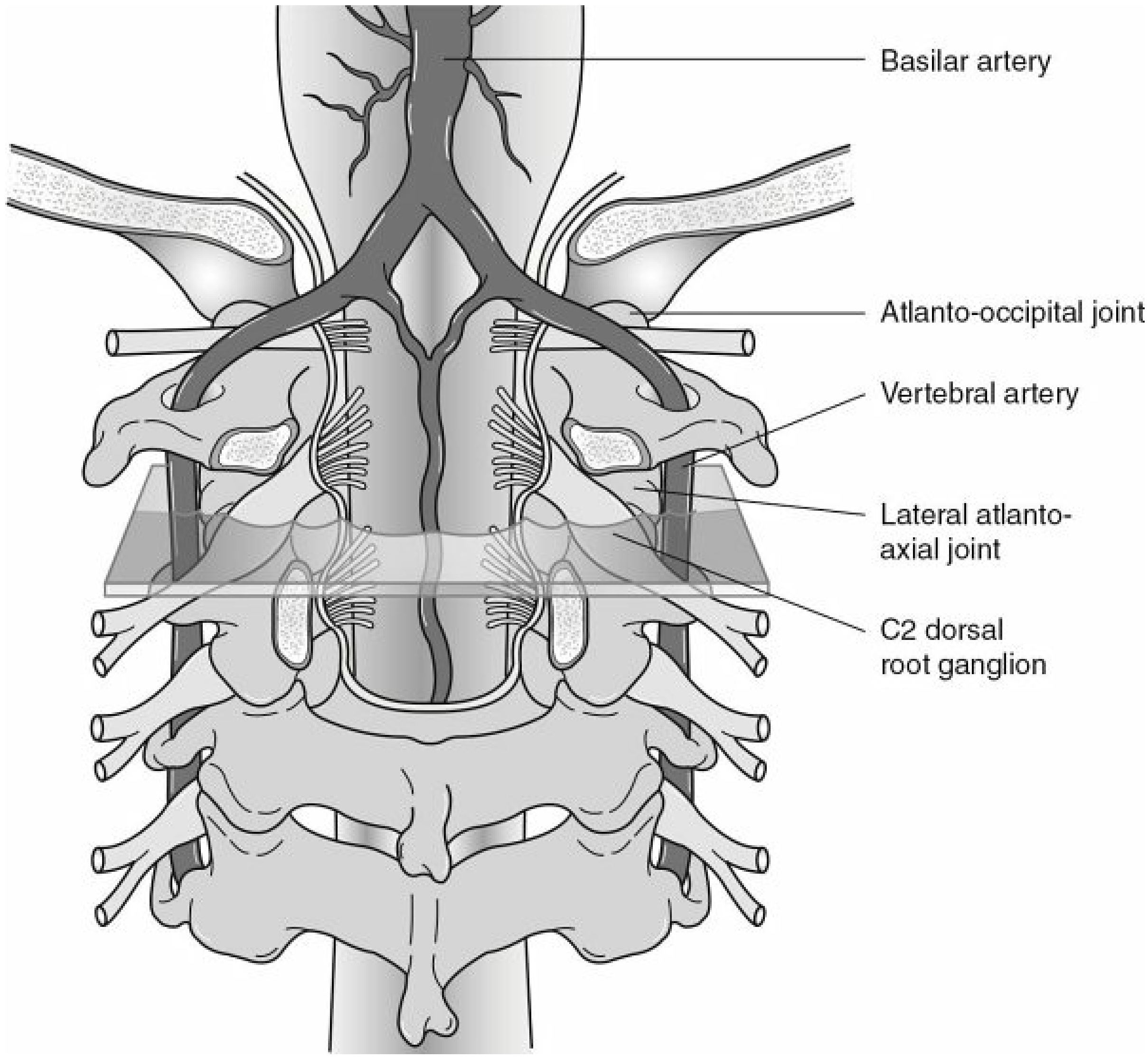


FIGURE 2.9. The relationship to the C2 nerve root, vertebral artery, and atlantoaxial joint.