Role of Different Imaging Modalities in Guidance for Musculoskeletal Biopsy

Essay

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ABSTRACT

Image-guided percutaneous biopsy of musculoskeletal lesions is a safe and useful procedure for diagnosing and managing patients who have suspected bone and soft tissue lesions. Preprocedural careful planning is required, however, including completion of staging before biopsy and being absolutely certain of the biopsy track. Employment of the appropriate imaging technique to guide biopsy, needle selection, specimen handling, adopting a meticulous approach, and being aware of potential complications are advocated.

Fluoroscopy, ideally biplanar, is used most often to guide biopsy in long bones. Positioning is usually more comfortable for the patient. Patient movement does not degrade image quality as severely as for CT or MR imaging. Fluoroscopy is also more widely available, is cheaper, and delivers a lower radiation dose compared with CT for the same imaging duration. Visualization of small intramedullary lesions and soft tissue component of bone tumors, however, is poor. Also, small lesions in complex-shaped bones (eg, pelvis and vertebrae) may be difficult or hazardous to access on fluoroscopic guidance. Ultrasound is used most frequently to guide biopsy of soft tissue lesions. Ultrasound also can be used for lesions on or near a bone surface, especially if there is an associated soft tissue component.

CT-guided biopsy has been shown to be accurate, low in complications, cost-effective, and relatively pain-free for the patient. It has become the preferred method for biopsy of musculoskeletal lesions in most tumor treatment centers.

CTF has been a practical clinical tool that facilitates effective performance of percutaneous musculoskeletal biopsies, allowing for more direct control of needle placement. The benefits of real-time imaging and increased operator needle placement control come at the cost of increased radiation dose to the patient and personnel.

MRI is now the modality of choice for detecting, characterizing, and defining the anatomic extent of most musculoskeletal neoplasms. Several non randomized, retrospective case series of MRI-guided biopsies have demonstrated diagnostic yields similar to other modalities. Lack of ionizing radiation makes MR-guided biopsy desirable for pediatric and pregnant patients.

Key Words.

Image guided musculoskeletal biopsy – CT guided musculoskeletal biopsy – ultrasound guided interventions – MRI guided musculoskeletal biopsy – biopsy needles – core biopsy – fine needle aspiration biopsy and cytology – cutting needles – CT Fluoroscopy guided biopsy.

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Sampling of bone and marrow for analysis has been recognized for millennia **(Parapia LA, 2007),** however, image guided bone biopsy is a relatively recent development. Since the description of percutaneous biopsy for diagnosis of skeletal lesions by Coley in 1931**(deSantos et al, 1978)**, and fluoroscopic-guided procedures by Lalli in 1970 **(Lalli AF, 1970)**, image-guided bone biopsy has developed significantly, led by innovations in imaging and intervention. It has become an essential part of managing musculoskeletal lesions, including primary and secondary bone tumors **(Palombini L, 1980)** and infections **(Michel SC et al, 2006)**.

Although early reports dismissed minimally invasive bone biopsy only as a ‘‘simple, primary diagnostic procedure’’ with significant inconclusive or misleading results **(Akerman M, 1976)**, later reports increasingly recognized their low morbidity, lower cost (compared with open biopsy) **(Ward WG Sr, 2000)**, high accuracy, and repeatability in the event of an inconclusive result **(Vieillard MH et al, 2005)**. This has led to greater importance of image-guided bone biopsy, which has replaced open surgical biopsy in many instances. The advantages of the procedure even have translated to veterinary applications **(Vignoli M et al, 2004)**. The accurate characterization based on the small tissue samples obtained is often challenging, however **(Domanski HA, 2007)**.

Image guidance allows safe passage of needles, often into small and otherwise inaccessible lesions, and into the portions of the lesion most likely to yield useful samples, while avoiding damage to important structures. The presence of a bony or soft tissue lesion does not automatically imply the need for histology. Clinical information, laboratory findings, and imaging features may be sufficient to provide high diagnostic confidence for certain lesions, allowing for a conservative management or therapeutic trial. In addition, a clearly benign lesion for which therapy is not indicated does not require biopsy. A range of benign bone lesions has been described in the literature and familiarity with these may help avoid an unnecessary biopsy **(Destombe C et al, 2007)**.

The history, physical examination, and laboratory and imaging findings for each patient should be reviewed thoroughly and the case discussed with the referring clinicians. The indication and approach to image-guided biopsy must be tailored for each patient **(Gogna A et al, 2008)**.

Anatomy

Anatomy

The general framework of the body is built up mainly of a series of bones, supplemented, however, in certain regions by pieces of cartilage; the bony part of the framework constitutes the skeleton **(Standring S, 2004).**

In the skeleton of the adult there are 206 distinct bones, as follows:-

-Axial skeleton:-

Total: 74

-Appendicular skeleton:-

Total: 126

-Auditory ossicles:-6

-Total: 206

-The patellae are included in this enumeration, but the smaller sesamoid bones are not **(Standring S, 2004).**

Bones are divided into 4 classes:

1-Long bones:

The long bones are found in the limbs. Each consists of a body or shaft, and 2 extremities. The body is cylindrical, with a central cavity named the medullary canal; the wall consists of dense compact tissue. The extremities are generally expanded; for the purposes of articulation and muscular attachment.

Examples: The humerus ,radius, ulna, femur, tibia, fibula, metacarpals, metatarsals ,and phalanges **(Standring S, 2004).**

2-Short bones:

Intended for strength and compactness, combined with limited movement, as in the carpus and tarsus. It consists of cancellous tissue covered by a thin crust of compact substance. The patellae, together with other sesamoid bones, are regarded as short bones **(Standring S, 2004).**

3-Flat bones:

For extensive protection, or the provision of broad surfaces for muscular attachment, as in the skull and the scapula. These bones are composed of 2 thin layers of compact tissue enclosing between them a variable quantity of cancellous tissue **(Standring S, 2004).**

4-Irregular bones:

They consist of cancellous tissue, Enclosed within a thin layer of compact bone. Examples: vertebrae, sacrum and coccyx **(Standring S, 2004).**

A) THE AXIAL SKELETON (THE VERTEBRAL COLUMN)

The vertebral column forms the central axis of the skeleton. The greater strength of the column comes from the size and architecture of the bony elements, the vertebrae, and the strength of the ligaments and the muscles that hold them together. This great strength is combined with great flexibility.

The vertebrae are thirty three in number. They are seven in the cervical region, twelve in the thoracic, five in the lumbar, five in the sacral, and four in the coccygeal. The vertebral column is the posterior part of the trunk where its average length in the male is about 71 cm **(Clemente, 2006).**

General features of a vertebra

A vertebra has basically a ventral body and a dorsal vertebral or neural arch. They enclose between them the vertebral foramen (vertebral canal is the collective name given to the whole series of foramina when the vertebrae are strung together as a column).From the neural arch three processes diverge; in the posterior midline, the spinous process or the spine, and on the either side the transverse processes. The part of the neural arch between the spinous process and transverse process is called the lamina. The part between the transverse process and the body is called the pedicle **(Standring S, 2004).**

At the junction of the lamina and pedicle lie the articular processes. The articular processes are paired, superior and inferior. Articular processes of adjacent vertebrae form small synovial apophyseal joints. These joints permit limited movements between the vertebrae. The body is composed of cancellous tissue, covered by a thin coating of compact bone. **(Standring S, 2004).**

Blood supply of the vertebrae

The vertebrae are supplied segmentally by the vertebral, ascending and deep cervical, intercostals, lumbar, and lateral sacral arteries, which give multiple small branches to the vertebral bodies. Vertebral body drains into the internal vertebral venous plexus, which lies inside the vertebral canal. It drains into the external vertebral venous plexus which then drains into the regional segmental veins (vertebral, posterior intercostals, lumbar and sacral veins) **(Standring S, 2004).**

Vertebral joints

Adjacent vertebrae are held together by strong ligaments and small joints.

Joints between the bodies:

The bodies of adjacent vertebrae are held together by the strong intervertebral disc, and by the anterior and posterior longitudinal ligaments **(Standring S, 2004).**

Intervertebral disc:

An intervertebral disc is a secondary cartilaginous joint.
The intervertebral discs are connected to the anterior and posterior longitudinal ligaments.The normal intervertebral disc can be divided into 2 components: the nucleus pulposus and the annulus fibrosus.These are intimately related to the cartilaginous end plate of the vertebral body.The intervertebral disc collagen is primarily of type I and type II collagen, both of which have similar molecular structures **(Sinnatamby, 1998)**.

Functions of the intervertebral discs:

The two primary functions of the intervertebral disc are weight bearing (especially in the lumbar spine) and flexibility assisting in force distribution and shock absorption (mechanically protecting the vertebrae). Human intervertebral discs are thickest at the cervical and lumbar levels, where movements of the vertebral column are greatest **(Sinnatamby CS, 1998).**

Joints between the arches:

The pedicles of adjacent vertebrae are not attached to one another, so leaving a space, the intervertebral foramen, for the emerge of the spinal nerve. All other parts of the neural arch are joined to their adjacent companions :The articular processes by synovial joints , and the remainder by ligaments,of which the most important are the ligamentum flavum and the supraspinous ligament.The joints between the articular facets of the superior articular processes of one vertebra and the articular facets of the inferior articular processes of the vetebra above are termed the apophyseal joints (or simply known as facet joints),they are synovial in nature. Although most of the weight transmission by the vertebral column takes place via the vertebral bodies and intervening discs ,a small amout does occur through these joints **(Clemente, 2006)**.

1) The cervical vertebrae

Are the smallest of the true vertebræ, and can be readily distinguished from those of the thoracic or lumbar regions by the presence of a foramen in each transverse process (Fig. 1). The first, second, and seventh present exceptional features **(Standring S**, **2004).**

The first cervical vertebra is named the **atlas** because it supports the globe of the head. Its chief peculiarity is that it has no body. Its other peculiarities are that it has no spinous process (Fig. 2), is ring-like, and consists of an anterior and a posterior arch and two lateral masses **(Standring S, 2004).**

The second cervical vertebra is named the **axis** because it forms the pivot upon which the first vertebra, carrying the head, rotates. The most distinctive characteristic of this bone is the strong odontoid process which rises perpendicularly from the upper surface of the body (Fig. 3) **(Standring S, 2004).**

The most distinctive characteristic of the seventh vertebra is the existence of a long and prominent spinous process, hence the name vertebra prominens. This process is thick, nearly horizontal in direction (**Standring S, 2004).**