Chapter 7

THE CONTRIBUTION OF NUCLEAR MEDICINE IN THE DIAGNOSIS OF BONE METASTASES

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Abstract: Nuclear medicine plays a relevant role in the diagnosis and therapy of bone metastases. Imaging of the bone has been one of the first nuclear medicine techniques applied in humans and still is one of the major requests from physicians. Indeed the sensitivity of this technique is such (>90%) that it is superior to any other available imaging method. On the other hand the specificity is rather low and interpretation of scans needs to be carefully evaluated by expert physicians together with other biological, anatomical and clinical information. In this chapter we will briefly start by describing bone physiology and pathophysiology as these are basic aspects for nuclear medicine imaging of bone metastases and their therapy with radiopharmaceuticals. This is followed by a short overview of epidemiology and distribution of bone metastases. The basics of nuclear medicine imaging and the different cameras and techniques will be explained. We will then review all available radiopharmaceuticals for diagnostics with particular regard to metastases from prostate, breast and lung cancer. The last paragraph presents the use of radiopharmaceuticals for the palliation of metastatic bone disease.
7.1 Introduction

Nuclear medicine plays an important role in the diagnosis of bone metastases, with bone imaging being one of its first applications in humans. The sensitivity of nuclear medicine techniques is remarkably high, exceeding 90%. On the other hand, the specificity is rather low and interpretation of scans needs to be carefully evaluated by expert physicians in combination with other biological, anatomical and clinical information or other imaging modalities. In this chapter, we will start by briefly discussing bone anatomy and physiology and pathophysiology and epidemiology of metastatic bone disease. We will then review all available radiopharmaceuticals used for diagnostic and therapeutic purposes, giving emphasis to bone metastases from prostate, breast, and lung cancer.

7.2 Anatomy and Physiology of Bone and Pathophysiology and Epidemiology of Bone Metastases

7.2.1 Anatomy of Bone

A typical long bone consists of the following parts: the diaphysis (the shaft of the bone), the epiphysis (the bone located from the growth plate to the articular surface), the metaphysis (the region where the diaphysis joins the epiphysis), the articular cartilage, the periosteum (fibrous covering around the surface of bone), the medullary cavity and the endosteum (a layer of progenitor cells and osteoblasts that lines the medullar cavity and also contains scattered osteoclasts).

Bone is an organ consisting mainly of minerals (roughly 65%) and organic matrix (35%), being the storehouse for the body’s calcium, phosphorus, sodium, magnesium and calcium. Mineralised bone is called osteoid. The organic part of matrix is mainly composed of type I collagen (90–95%), and also contains various growth factors (like cytokines and growth factors) that play a role in modulating the bone turnover. The bone-forming cells include the osteoprogenitor cells, osteoblasts and osteocytes, whereas the bone-re-absorbing cells are the osteoclasts.

7.2.2 Bone Physiology and Remodelling

In normal healthy bone, continuous remodelling takes place in response to mechanical stress via dynamic interactions of osteoclasts and osteoblasts. Osteoclasts are responsible for bone resorption and osteoblasts for bone formation. The mineralized bone matrix contains numerous growth factors that are released during this process, stimulating osteoblasts to form new bone. Systemic factors, such as the parathyroid hormone, and local factors such as cytokines, promote osteoclastic activity.