Artefacts and Pitfalls – Bone and Joint

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Bone scintigraphy remains an important imaging modality in nuclear medicine and forms the cornerstone for the diagnosis, staging and response monitoring of a myriad of bone diseases and conditions (van den Wyngaert et al., *Eur J Nucl Med Mol Imaging,* 2016). The advantage of bone scintigraphy, compared to conventional radiological imaging techniques, is that it can detect with a high sensitivity early changes in bone remodelling. Although this procedure is commonly performed in clinical practice, nuclear medicine physician, technologist, and medical physicists should be aware of the many pitfalls and artefacts that can arise during the procedure, leading to possible misinterpretation and misdiagnosis of the images and or reduced diagnostic quality of the images. Therefore, it is of pivotal importance to recognize various instrumental, technical, radio-pharmaceutical, and patient-related artefacts that can occur while performing bone scintigraphy.

Traditionally, bone scintigraphy is performed with phosphate analogues that are labelled to technetium-99m (^{99m}Tc). Phosphate analogues have favourable pharmacokinetics, with a relatively high uptake in areas with elevated bone remodelling and fast clearance from soft tissues, yielding high contrast images (van den Wyngaert et al., *Eur J Nucl Med Mol Imaging,* 2016). There are a number of steps required for a successful execution of a bone scintigraphy procedure. The first important step is appropriate labelling of the radiotracer and regular quality control of the steps involved during production. Labelling of the phosphate analogues is relatively simple for which standardized kits can be obtained from different manufacturers. Furthermore, regular quality control of the gamma camera is essential to early detect technical malfunctions of the imaging equipment. Standardized testing using phantoms are required to test aspects such as camera sensitivity, spatial and energy resolution, spatial linearity, and uniformity (Zanzonico, *J Nucl Med,* 2008). If left unattended, technical defects can arise unnoticed and result in artefacts during imaging. Instrument-related artefacts that have been reported include photomultiplier tube (PMT) defects, improper photopeak window setting, and incorrect alignment of static images (zipper artefact) (Agrawal et al., *Semin Nucl Med,* 2015).

Although bone scintigraphy is a sensitive technique for detecting disease, it is not indicated for conditions that are characterized by enhanced osteolytic activity (e.g. osteolytic metastases). Consequently, patients that are referred for bone scintigraphy should always be evaluated for eligibility by the nuclear medicine physician. When bone scintigraphy is indicated, the patient can be imaged at the department of nuclear medicine. Before administration of the radiotracer, it is important to obtain a complete history of the patients by means of anamnesis, since previous treatments (chemotherapy, radiotherapy, and surgery), co-morbidity, specific pathological conditions, and recent trauma can significantly influence the bio-distribution of the radiotracer

and induce focal increased uptake that can mimic pathology (Peller et al., *Radiographics*, 1993). Another source of potential artefacts is related to the injection of the radiotracer, where radiotracer extravasation, and intra-arterial injections can result in masking of pathology and alternative uptake patterns. Furthermore, numerous patient-related conditions can result in artefacts, including presence of metallic items (e.g. belt buckles, jewellery, and prosthesis), patient movement, and urine contamination. Additionally, nuclear medicine physicians and technologists should be aware of normal variations in uptake in different patient groups. Some examples include the 'hot skull phenomenon' in postmenopausal women, degenerative changes, increased physiological uptake in the skull base and physeal growth plates in paediatric patients. Furthermore, the presence of comorbidity (e.g. impaired renal function and malignant ascites) or specific pathological conditions can also result in alternative uptake patterns that can hinder appropriate diagnosis. In addition, clinicians should also be aware of conditions that can lead to a false-negative diagnosis, such as diffuse uptake in the entire skeleton ('super scan') (Liu, *Clin Nucl Med*, 2011) and small lesions with low uptake in complex anatomical areas.

The fact that artefacts in bone scintigraphy can arise from many sources emphasizes the importance of recognizing technical failures, normal variations and uptake due to comorbidity by the nuclear medicine physician and technologist. Many artefacts can be solved by means of additional imaging (i.e. acquiring detailed spot views at different angles, and tomographic imaging by means of SPECT/CT) (Even-Sapir et al., *J Nucl Med,* 2006) or adapting the imaging protocol. Furthermore, correlation with other imaging modalities (PET, CT, MRI) can provide the nuclear medicine physician with information that can assist in making a more accurate diagnosis (Jambor et al., *Acta Oncol,* 2016).

References:

1. Chiesa C, Mira M, Maccauro M, Romito R, Spreafico C, Morosi C, Camerini T, Carrara M, Pellizzari S, Negri A, Aliberti G, Sposito C, Bhoori S, Facciorusso A, Civelli E, Lanocita R, Padovano B, Migliorisi M, Seregni E, Marchianò A, Crippa F, Mazzaferro V Radioembolization of Hepatocarcinoma with 90-Y Glass Microspheres: Development of an Individualized Treatment Planning Strategy based on Dosimetry and Radiobiology Eur J Nucl Med Mol Im 2015;42:1718–1738
2. Lam MG, Goris ML, Iagaru AH, Mittra ES, Louie JD, Sze DY. Prognostic utility of 90Y radioembolization dosimetry based on fusion 99mTc-macroaggregated albumin-99mTc-sulfur colloid SPECT. J Nucl Med. 2013;54(12):2055–61
3. Kokabi N, Galt JR, Xing M, Camacho JC, Barron BJ, Schuster DM, and Kim HS, A Simple Method for Estimating Dose Delivered to Hepatocellular Carcinoma after Yttrium-90 Glass-Based Radioembolization Therapy: Preliminary Results of a Proof of Concept Study J Vasc Interv Radiol 2014;25:277–287
4. D'Arienzo M, Chiaramida P, Chiacchiararelli L, Coniglio A, Cianni R, Salvatori R, Ruzza A, Scopinaro F, Bagni O. 90Y PET-based dosimetry after selective internal radiotherapy treatments. *Nucl Med Commun* (2012) 33:633-40