THE CHILDREN'S MEDICAL CENTER OF DAYTON

Pediatric Clips

Pediatric Bone Density CT: precise diagnosis with the lowest radiation

By Elizabeth Ey, MD

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CASE STUDY

A 12-year-old male has had several fractures associated with relatively minor trauma. His past medical history is significant for previous treatment of acute lymphoblastic leukemia including steroid therapy and total body irradiation prior to bone marrow transplant. There is a clinical concern for osteopenia. The patient was referred for determination of bone density prior to consideration of biphosphonate therapy.

CASE DISCUSSION

There are currently three popular methods described in the literature for determining bone mineral density. The most popular and widely used technique is DEXA (dual energy x-ray absorbtiometry). It is very low radiation dose and has a number of published normal value ranges based on patient race, age, weight and height. It produces a result value based on two-dimensional assumptions of three-dimensional anatomy. The areas most frequently assessed for bone density are the spine and femoral neck; however, these areas can be problematic for a large percentage of pediatric patients with scoliosis and hip dysplasia such as those with cerebral palsy and myelomeningocele. Furthermore, DEXA is unable to account for the significant changes in body and skeletal size that occur during growth, limiting its use for evaluation of response to therapy in children. In addition, the study is somewhat lengthy and may require sedation in the young or uncooperative patient.

The second technique for assessing fracture risk is quantitative ultrasound (QUS) to evaluate the transmission of sound across the calcaneus. This technique uses no ionizing radiation, making it attractive for children; however, it has primarily been used as a screening tool in adults to predict fracture risk independent of bone mass determinations for patients with osteoporosis. The QUS technique does not actually generate a bone density value and cannot be used to assess response to treatment. Furthermore, QUS can measure bone quality only at a single peripheral site. The ultrasound values are dependent on many structural properties of the trabecular bone of the calcaneus which are not yet fully understood. The calcaneus may not be completely ossified in prepubertal children. The literature indicates that the information from QUS may not be meaningful in children.

The most precise and accurate technique for determining trabecular bone density is quantitative computerized tomography (QCT). QCT assesses both the volume and density of bone in the axial and appendicular skeletons without the inaccuracy from assumption of the bone position or overall skeletal size. The significant advantage of QCT is that it produces bone density values based on the actual bone scanned rather than an assumption of the 3D anatomy. In addition, a variety of bones can be accurately assessed based on the patient's needs. For instance, trabecular bone density measurement is usually performed in the upper lumbar spine to minimize the radiation dose to the pelvis. Patients with spinal rods, however, can still be evaluated by measuring trabecular bone density at the femoral neck. Clinical research is also being performed at Dayton Children's in conjunction with Wright State University to measure normal pediatric bone density in the radius versus the tibia. This will be helpful in evaluating patients who are wheelchair bound, as bone density in the lower extremities is less than in the upper extremities in this population. The radiation dose from QCT is low, though not as low as DEXA. Additionally, the scan time for QCT is short and sedation is not required. Children as young as 2 years of age can be referred for bone density QCT.

The quantitative bone density CT study is performed with the patient supine on a gel pad with the intended body part (spine or hip) positioned over a calibration phantom. A volumetric helical scan is performed through the body part. The patient is generally on the CT table for less than five minutes. There is no special preparation for the examination and no contrast is given. The patient should not have had recent enteric contrast as this may interfere with the study. The post processing is performed for the lumbar spine by placing an oval region of interest in each of the volumes representing the

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mid body of L1 and L2 without including cortical bone or the region of the vascular pedicle. The volumetric scan is useful for accurate placement of the region of interest in the mid vertebral body regardless of scoliosis. The trabecular bone density is calculated in milligrams per cubic centimeter.

The results are compared to normative data for age and gender matched controls. A z-score is given which reports the patient's mean trabecular bone density as the number of standard deviations from the mean. For instance, a bone density at two standard deviations below the mean would be reported as a z-score of -2.0. A t-score is also reported which compares the patient's bone mineral density to the average peak bone mineral density for a 20-year-old gender matched control.

Pediatric patients who may benefit from quantitative CT bone density measurement include those with significant exposure to corticosteroids, significant periods of immobilization or inability to ambulate, history of multiple fractures with concern for osteopenia, whole body irradiation, chronic renal disease, malabsorption or other causes of metabolic bone disease. The results of the quantitative bone density measurement are used to help guide therapeutic decisions and patient management. The patient's response to treatment can be assessed with a follow up scan in six to 12 months.

FEATURED SPECIALIST

ELIZABETH EY, MD, is medical director of medical imaging at The Children's Medical Center of Dayton. Dr. Ey completed a fellowship in pediatric radiology at Cincinnati Children's Hospital Medical Center. She is board certified in diagnostic radiology and has a certificate of added qualification in pediatric radiology. She performs angiography and interventional studies such as drainages, biopsies and intraoperative image guidance. Dr. Ey has special interest in neuroradiology, interventional radiology, cross-sectional imaging and 3D reconstructions available in CT and MRI.

MEDICAL IMAGING AT DAYTON CHILDREN'S

The department of medical imaging at Dayton Children's provides a full spectrum of diagnostic imaging for infants, children and teens. It has been recognized for providing the lowest amount of radiation to keep children safer during diagnostic tests. Board-certified pediatric radiologists are available 24 hours a day, seven days a week and staff are specially trained to provide care for children of all sizes. Dayton Children's also has five convenient off-site locations with medical imaging services. For more information, call 937-641-3811 or visit childrensdayton.org.

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