Chapter 1

The normal child: growth and development of the infant and child; frequent and important normal variants

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General remarks on the development of the human body

The body proportions and the size of the organs vary greatly in different age groups from birth to adolescence. In early life, 0–1 years of age, the head is very large, the neck extremely short and the trunk is long with a relatively short chest in relation to the abdomen (Figure 1.1). On the other hand, the arms and legs are relatively short in the first years. During the growth spurt, which starts at about eight years, the long bones of the extremities lengthen considerably, the neck becomes longer and the head smaller. The technician and the radiologist have to consider these extreme differences of body proportions for patients of different age groups. For example, if the radiographer does not collimate the exposure field for a chest radiograph closely in small premature babies, a cumulative high eye lens dose can result as a deterministic radiation effect. Of course, correct coning is also important at the lower field edge of a chest X-ray, because a great number of abdominal organs are exposed to radiation. Figure 1.2 shows the increase of optimally coned field size in radiographs of the chest and abdomen. A similar problem exists in multidetector CT of the chest in young children. This effect is called over ranging and must be kept as low as possible in small patients.

Concurrently with the changes of the body proportions there is a shift of the red bone marrow from the head and the long bones in infants to the axial skeleton (spine, pelvic bones, ribs and sternum) in older children. This process is nearly completed at about 15 years of age (Figure 1.3). Of note, Cristy *et al.* described bone marrow conversion, but did not mention the extramedullary hematopoiesis within the liver, spleen and the kidneys in the first three months. The distribution of red and yellow bone marrow is readily apparent on magnetic resonance (MR) images. The most significant changes occur in the long bones. In newborns the long bones of the arms and the legs are entirely filled with red marrow. After infancy the yellow marrow begins to extend from the center of the bone to the metaphyseal ends. The conversion of fatty marrow occurs earlier in the epiphyses and diaphyses than in the metaphyses. The partly converted normal marrow in children aged 10 years or older appears isointense or hyperintense to skeletal muscle on plain T1-weighted MR images, while focal neoplasms appear hypointense. In adults, only small areas of hematopoietic bone marrow persist in the vertebrae as well as proximal metaphyses of the femur and humerus.

Skull

Ossification of the skull (calvaria and skull base) starts prenatally at the 12th week. The ossification at the skull base is of the enchondral type, in the cranial vault of the desmal type. The synchrondroses at the base of the skull are widely open at birth. This growing cartilage of the synchrondroses at the skull base is relatively soft and can accidentally be passed by tubes and catheters. The cranial vault grows along the sutures depending on the intracranial pressure. The infant's head has six physiological gaps, so-called fontanels, which diminish in size gradually during the first 12 months. The great (anterior) fontanel between the frontal and parietal bones is the largest. It closes normally between 8 and 24 months. The posterior fontanel is very small and lies between the parietal bones and occipital bone. In most term neonates it is closed. The lateral fontanels are anterior and posterior to the squamous bones. All fontanels allow access to perform ultrasound of the brain and to perform Doppler examinations of intracranial vessels.

In infants there is great variation in the head shape: one example is a long skull with a large anterior–posterior (ap) diameter; and the opposite, a short head with large bitemporal diameter. The neurocranium in the first two years is considerably larger than the viscerocranium. In term infants the ratio is 4 to 1 and will reduce to a value of 2.5 at five years. The cranial sutures begin to close at the age of about seven years. Complete closure is noted in adulthood, between 30 and 40 years.

Wormian bones represent normal variants in skull growth, and are apparent as small bones located in and between normal sutures, frequently in the Lambda and Mendoza sutures. If abundant, Wormian bones may indicate an

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