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Imaging the thyroid in children

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Color Doppler Ultrasounds (CDU) and Thyroid Scanning (TS) have much improved in recent years and offer a likely diagnosis of the disorder and its main subtypes. This especially applies when diagnosing permanent or transient causes of congenital hypothyroidism (CH), where dual imaging has proven to be more informative than single scanning. Though both isotopes have acceptable performances, the use of ^{123}I appears more advisable, since it more accurately identifies the various aetiologies of CH and probably has better dosimetric characteristics than ^{99m}Tc. Detailed dual imaging patterns are presented in connection with most of the underlying mechanisms explaining CH, thyroid dysgenesis (75%) and dyshormonogenesis (20%). Imaging of thyroid autoimmunity, of immunogenic thyrotoxicosis and of thyroid autonomy, is helped by CDU but most often requires a quantified ^{123}I-TS (molecular imaging). We finally show the interest of CDU to sort suspicious nodule and present the new TIRADS scoring system.

The aetiology and clinical presentation of thyroid disorders in children differ substantially from those in adults and through time, from birth to adolescence. Both thyroid scanning (TS) and Color Doppler Ultrasounds (CDU) are useful and complementary, and, for many authors, combined imaging appears to be more informative than single scanning.[1] Aside from giving or strongly suggesting a firm diagnosis of the disorder or its subtype,[2] thyroid imaging also helps with genetic counselling and with managing the T4 therapy in congenital hypothyroidism (CH). Transient and permanent thyroid disorders must also be distinguished as soon as possible to avoid useless long term therapy and repeated investigations. Fine-tuned diagnoses of thyroid secretion dysfunctions often depend on the use of new tools such as the quantification of the TS, which demands the use of ^{123}I (^{123}I-TS) and the interpretation

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of the uptake according to the TSH level measurement. The euthyroid nodule is rare before the age of 10 and more frequently corresponds to malignancy in children than in adults.

Technical specificities of paediatric thyroid imaging will be presented first. The aetiological diagnosis of congenital hypothyroidism and thyrotoxicosis according to imaging will be considered next, with a special focus on the influence of the chosen isotope and the use of combined scanning. Image based classification of thyroid autonomy and thyroid auto-immunity will be discussed later. Finally, we will present the new insights in diagnostic imaging of thyroid cancer focusing on the new TIRADS classification system.

Technical specificities and normative data of paediatric thyroid imaging

With both types of imaging, which may be performed in a combined way, it is preferable that the infant be calm during the whole examination, which can often be performed after breast or bottle-feeding in babies. Paediatric thyroid imaging requires a rather extensive amount of experience, especially with ultrasounds which are known to be widely dependent on the practitioner's experience.[3]

Color Doppler Ultrasounds (CDU)

CDU technology has improved greatly with time. Currently, 7.5–15 MHz transducers are used with coupling gel. The gel is often used at room temperature but may be pre-warmed for babies. Small track rectilinear or hockey-stick transducers are best adapted to the newborns' morphology and actual neck size. The children are imaged in supine position with the neck hyperextended. The anterior cervical and midline area must be evaluated from the foramen caecum to the thyroid fossa and above the lower manubrium sternal. The echogenicity of the normal gland is homogeneous, hyperechoic as compared to the muscles of the neck, and slightly to well-vascularised. The volumes are usually calculated according to the ellipsoidal model and for a single lobe as $V = \pi * \text{Length} * \text{Breadth} * \text{Depth}/6$. Some authors recommend using an even lower shape factor of 0.479 since the ellipsoidal model slightly overestimates the actual depth.[4] Hypervascularisation is a common feature in stimulated glands, either by the TSH itself in any functional tissue or of course in immunogenic diseases.

Several normative datas have been published as regards the thyroid volumes in newborns and children. As expected, some discrepancies are reported between studies since the volume assessment varies with the technique, the modelization used to calculate the volume, and the natural influence of other less controlled factors such as the iodine supply of the population, smoking and the alimentary intake of non-specific goitrogens. Reported datas for newborns vary from 0.84 ± 0.38 ml[5] to 1.62 ± 0.41 ml.[6] Increase in thyroid volume is influenced by age and pubertal stage. In subjects aged 8–11 years it is typically 2.8–4.1 ml. In the class 11–14 years, the volume is of about 4.0 ± 0.8 ml (pre-pubertal subjects) to 6.50 ± 2.9 ml (puberty started) to about 7 ± 3 ml at age 14–17. The adult volume is met as of 17 years and is typically of 12 ± 5 ml in countries with normal iodine dietary allowance (>100 μg/d).

Thyroid scan (TS)

The TS has been used for decades to explore thyroid dysfunction and is especially relevant in paediatric indications. It remains the gold standard in imaging congenital hypothyroidism and is very useful in assessing the various subtypes of thyrotoxicosis, whatever the age. TS is performed using either ^{99m}Tc or, less frequently, ^{123}I (Table 1). The ^{123}I uptake parallels the TSH stimulation and reflects both the NIS driven cellular uptake and the organification process. Considering these physiological indicators, it is clear that the ^{123}I-TS is a true molecular imaging option[7] that allows for clinically relevant quantifications of the targeted tissue. The ^{99m}Tc-TS, which is widely available, is nevertheless useful for providing a reproducible inventory of the thyroid tissue or of any NIS positive structure.