RADIOLOGY FOR PRACTITIONERS

ORIGINALITY OF NEW IMAGING TECHNIQUES IN PEDIATRIC RADIOLOGY

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ABSTRACT : Pediatric radiology is a specialty that combines the performances of imaging and radioprotection. It also has to deal with absence of cooperation and motion of the child which have limited for a long time many radiological applications. Technical advances with shorter acquisition time in CT and MRI, higher frequencies in ultrasound, and digitalization in conventional radiology have widened the indications especially with the new modalities. We present in this article the originalities and the benefits of current pediatric radiology and perform a historic review outlining its evolution.

INTRODUCTION

Maturation and growth observed during childhood account for the originality of pediatric radiology, a sub-specialty that combines performances of imaging and radioprotection of the child. One of the major concerns of radioprodaiticians is the good choice of the imaging procedure that one should perform in a given situation, and to avoid repetitive and not adapted exam. From this point of view, pediatric radiology has reached a prominent place.

Conventional radiology gives us very good information with minimal risks because of very selective indications and optimization of techniques (adjustment of parameters and diaphragms, digitalization, and limitation of views). Ultrasound, a non irradiating technique, is the first choice exam whenever it can be contributive. MRI should have a predominant place for the same reasons. Technical easiness offered by the multichannel scanner constitutes a considerable progress.

New indications appear thus continuously in pediatric radiology that we must pursue to be able to give the best management for the child.

DISCUSSION

History

At the time of discovery of X-rays by Roentgen in 1896, applications to child pathology were very limited because of the length of the exposition time. Years after, technology made it possible to lessen the exposition time rendering indications wider. The first organ that benefited from this kind of exam was the bone, followed by the lungs. But the main handicap for pediatric radiologists was that they were dealing with children, very often uncooperative, that resulted in bad quality images, blurred and very difficult to interpret [1].

In the 40’s, a new breakthrough happened. Advances in surgery pushed surgeons to be more innovative and asking for more sensitive exams that were possible with the new technologies, thus increasing the applications [1].

By the end of the 60’s, the advent of ultrasound took place. Its continuous technical improvement made pediatric radiologists more and more interested in its use [1].

From the 70’s began the scanner era, and that of MRI by the 80’s. Here too technology was rapidly progressing in both spatial resolution and reduction in the length of acquisition time [1].

Radioprotection / Sedation

During this chronological evolution, and precisely from the 60’s, pediatric radiology became a sub-specialty gathering numerous practitioners. Pediatric radiology societies began to grow. Irradiation was their main topic [2]. Recommendations started to be applied by selecting the indications, reducing the acquisition doses and limiting control exams: an irradiating exam should not be performed unless it is of absolute necessity; whenever we have to chose between two exams giving the same information, the one that is less invasive and less irradiating should be chosen; between an image of high resolution and another of lesser resolution and irradiation but giving the information needed, one should choose the second alternative [3]. In 1997, in Europe, a new directive relative to the population protection against medical irradiation (Euratom 97-43) was elaborated and imposed to all EU states. It claims for exams justification and techniques optimization [4].

Immobilization plays a key role in the radioprotection of the child. It reduces the number of repetitive radiographs. One must always be looking for patient cooperation, whenever the age permits. For newborns under six months of age, nursing the child before or during the exam remains a good solution for putting the child to sleep. Another way is to give medication for babies

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between six months and four years of age. If unsuccessful, general anesthesia should be the last resort [3].

**PRACTICAL APPLICATIONS**

**Conventional Radiology**

Conventional radiology is essential. It is often performed at first, especially in all malformations to study the morphology of the skeleton. In metabolic diseases, it highlights the abnormal bone densities and the associated findings. Its contribution is fundamental in traumatology. Conventional radiology has benefited from digitalization that made exams easier and less irradiating [3]. The introduction of flat panels has increased digital performance.

**Ultrasound**

With ultrasound (US) progress, and development of high frequency probes together with improvement of image resolution, indications of sonography are increasing taking into account its easy use and the child morphology [5]. Its role, first recognized in the investigation of solid organs of the abdomen, became essential in investigating the digestive tract.

Ultrasound has become the most important examination method for the diagnosis of intestinal intussusception (Fig. 1) and the detection of edema at the ileocecal valve after reduction of the intussusception [6]. Opacification with water-soluble contrast is only used for therapeutic reasons (Fig. 1). Its usefulness is recognized in appendicitis [7] and other bowel diseases (Fig. 2 & 3) [8]. Ultrasound helps in the diagnosis and the follow-up of neonatal portal thrombosis and its ischemic effects in the liver.

Transfontanellar ultrasound has replaced, during the neonatal period, the irradiating scanner used for ventricular dilatation, for subventricular hemorrhage and the malformations of the medial line [9]. A new ultrasound window in neonates, the mastoid window, has been recently described [10]. It offers a panoramic view of the

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**FIGURE 1**

Intussusception in a 4-month-old boy.

a. Transverse ultrasound shows the layered bowel walls of the outer and inner loop (arrow), the intussuscipiens, and the intussusceptum.

b. Note the convex-shaped filling defect of the intussusceptum (double arrows), which is reduced to the level of the cecum on a contrast enema.

**FIGURE 2**

Pyloric stenosis in a newborn

a. The pylorus is viewed in longitudinal plane (arrow). The sonographic hallmark is the thickened pyloric muscle.

b. On the upper gastrointestinal series note the collection of barium in the dilated prepyloric antrum and the presence of two thin tracks of barium compressed between thickened pyloric mucosa and muscle.
anatomical structures that can be identified in each US slice. However, MRI is the reference for neurological explorations.

Its indications in osteoarticular imaging are increasing; it includes congenital dysplasia of the hip (Fig. 4), detection of articular effusion, and traumatic lesions of

![Figure 3](image3.png)

**Figure 3**

Intestinal malrotation in a 2-year-old girl

- **a.** Note that the superior mesenteric vein (arrow) lies to the left side of the artery in contrary to the normal position on this transverse US image.
- **b.** Note the “whirl sign” representing the superior mesenteric vein twisting toward the artery.
- **c.** In this upper gastrointestinal series, the duodenum (double arrows) does not cross the midline to the left side, and the small bowel is present only in the right side of the abdomen.

![Figure 4](image4.png)

**Figure 4**

Developmental dysplasia of the hip

- **a (neutral position).** The hip is viewed in a coronal plane showing the maximum depth of the acetabulum. Note the lack of the amount of the bony (arrow) and cartilaginous (double arrows) cover of the femoral head by the acetabulum.
- **b (dynamic examination).** Gentle but firm pressure placed on the hip in a posterior and/or lateral direction reveals to a better advantage the dysplasia of the hip.
- **c (normal hip).** Note good acetabular coverage of at least one half of the femoral head.
Some pediatric radiologists advocate the use of color Doppler to characterize inflammatory diseases (Fig. 5). One must not forget its role in differed emergencies; it can detect occult fractures unrevealed by conventional radiography, either by showing cortical irregularities (Fig. 6), or by revealing a juxtaphyseal hematoma (Fig. 7) [11], but this requires much expertise that only few radiologists have nowadays.

CT Scan

The tremendous technical advances in scanner and MRI with the introduction of multichannel CT scanners and faster MRI sequences have multiplied the indications of these two techniques.

CT scan allows rapid and detailed evaluation of lesions. Its increasing resolution and its multiplanar capacity allows an excellent 3D evaluation of the bone in traumatology [12], congenital and developmental lesions (Fig. 8). In infectious and tumoral pathologies, even though MRI is superior for the evaluation of medullar...
bone, scanner still has the superiority in the detection of cortical lesions, periosteal reactions, calcifications and sequestrations [13].

Cardiovascular exploration by the scanner constitutes the ultimate achievement in this field [6]. These exams require on one hand to master technical control of sequences, acquisition modes and data processing, and on the other hand diagnostic skills. Cardiac gating has broken the obstacle to this application caused by cardiac beat artifacts. Coronary arteries can thus be explored as in the adult. Scanner is also being helpful to study pulmonary arteries and congenital lesions where it is superior to angiography [14]. Abnormalities like pulmonary sequestration (Fig. 9) can be easily revealed. Its sensitivity to

**Figure 9.** Intralobar pulmonary sequestration in a 13-year-old boy. The feeding artery is originating from the descending thoracic aorta. The venous drainage is via pulmonary vein. Note that the hemiazygos vein is not enlarged.
make the diagnosis of aortic coarctation has been already demonstrated (Fig. 10). The evaluation of collateral circulation in relation with the stenosis is readily achievable.

MRI
MRI is considered now as the exploration modality of reference in neuroradiology (Fig. 11). The apparition of new sequences has increased indications of this technique. Sequences of diffusion and tractography are well developed and used in the diagnosis of certain pathologies (e.g. ischemic diseases), as well as in their therapeutic follow-up [15-16].

Functional MRI is feasible in the fetus, and contributes to localize the origin of the convulsive seizures in the case of cortical heterotopy [6].

The application of spectroscopic imaging is represented by the exploration of cerebral tumors and their preoperative workup [6]. The most discriminative elements in favor of a high grade lesion for example, are the elevation of choline and lactate.

However, taking into account the constraints related to the use of MRI, the usage of this kind of exploration could not be regular and transfonantar ultrasound remains the first explorative technique for the diagnosis of neonatal intracranial hemorrhages and for ischemia [17].

In osteoarticular pathology, it permits recognition of articular lesions that were ignored by other techniques [18]. As with the scanner, it can screen traumatic spinal lesions that used to be ignored on simple X-rays, or inversely redress over-diagnosis of fracture. It is superior to scanner in the evaluation of tumoral or infectious pathologies of the medullary bone.

MR study of the digestive tract is promising. This technique is evaluated as a futuristic alternative to conventional radiology, with a good correlation compared to the colonscopic data. It is also presented as a reliable tool in the therapeutic follow-up of Crohn’s disease [6].

The whole body MRI realized in coronal STIR sequence is of interest in cancerology for detection of metastases. This technique can also be applied for evaluation of other diseases such as histiocytosis. In these instances, one can skip radiography and thus avoid irradiation for the child [19-20].

CONCLUSION
Technical progress will always continue and the actual concerns that we have just exposed will always be present. Conventional radiology will not disappear soon and it is at the present time facilitated by digitalization that
reduces the irradiating doses. The performances of the ultrasound will continue to grow. The multislice scanner, which already has very short acquisition time and great quality images, will certainly continue to advance medical applications. This is also true for MRI with shorter time of acquisition. Functional MRI will have surely a promising future. Concomitantly, one must evolve by adapting the new techniques to the needs of the child.

REFERENCES