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Ultrasonography for the diagnosis of craniosynostosis

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ABSTRACT

Objectives: The aim of this study was to report our experience with ultrasonography in our routine practice for the diagnosis of cranial deformity in infants.
Methods: We conducted a single-institution retrospective study of infants referred to our department because of skull deformity. We only included in this study infants having undergone both US and 3D-CT to ensure accurate comparisons. Each cranial suture was described as normal or closed (partial or complete closure). Sonography examination results were correlated with 3D-CT findings as a gold-standard.
Results: Forty infants were included with a mean age of 5.2 ± 4.9 months. Thirty had a craniosynostosis and 10 children had a postural deformity with normal sutures. Correlation between US and 3D-CT for the diagnosis of normal or closed suture had a specificity and a sensitivity of 100%. US examination for the diagnosis of complete or incomplete synostosis had a sensitivity of 100%.
Conclusions: Cranial US is an effective technique to make a positive or negative diagnosis of prematurely closed suture. US examination of sutures is a fast and non-radiating technique, which may serve as a first-choice imaging modality in infants with skull deformity.

1. Introduction

Cranial deformity is common in children. The 2 main causes remain positional plagiocephaly and craniosynostosis. Positional plagiocephaly is becoming more and more frequent since recommendations to place infants on their backs for sleeping in order to prevent sudden infant death syndrome. On the contrary, craniosynostosis caused by the premature closure of one or more sutures of the cranial bones is a much more uncommon condition occurring in only 3–6 infants per 10,000 live births [1]. Consequences of these 2 deformities may be very different as craniosynostosis may lead to severe chronic intracranial hypertension and thus need surgical correction. Differential diagnosis between these 2 malformations sometimes remains challenging. Although physical examination is sufficient to differentiate craniosynostosis and deformational plagiocephaly in most cases, cranial imaging is still regularly needed to confirm the diagnosis especially for non-specialized practitioners [1]. Conventional cranial X-ray has traditionally been the first imaging modality but its interpretation is particularly demanding and it is a source of radiation. Three-dimensional computed tomography (3D-CT) has high diagnosis accuracy, and is considered as the gold standard [2] but acquisition may need sedation and it is also a source of radiation. Very recently, ultrasonography (US) has been proposed to assist practitioners in the diagnosis of craniosynostosis with excellent efficiency [3,4]. However, although US has multiple advantages such as low cost and non-ionising technique few studies have as yet been conducted [5–10]. To date US is not yet considered as a screening tool for craniosynostosis.

The aim of this study was to report our experience with US in our routine practice for the diagnosis of cranial deformity in infants and to demonstrate its high accuracy in the diagnosis of craniosynostosis.

2. Materials and methods

2.1. Study group

We conducted a single-institution retrospective study between 2004 and 2014 in our paediatric radiology department. During

Abbreviations: 3D-CT, three dimensional computed tomography; US, Ultrasound.

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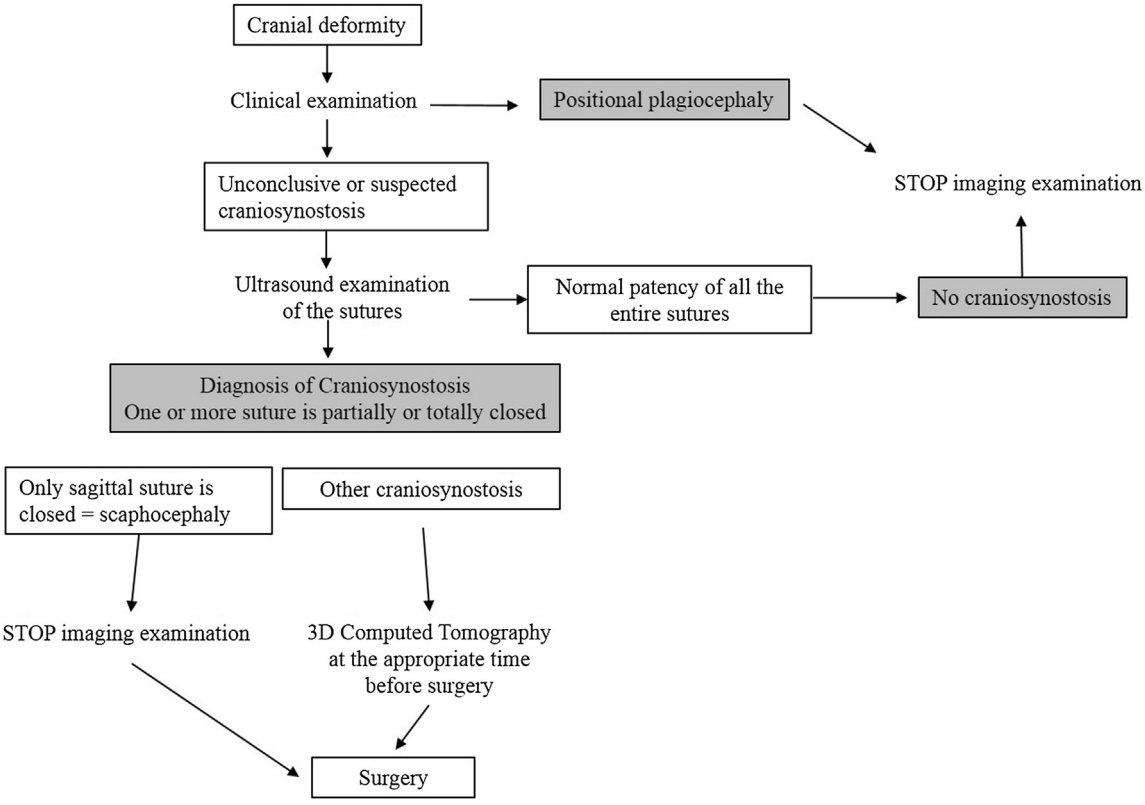

Fig. 1. Diagnostic approach of craniosynostosis in Rennes University Hospital for children under 8 months old.

this period, infants that were referred to our department by a general practitioner or a paediatrician for skull deformity and suspicion of craniosynostosis underwent both a cranial US and a plain radiography or 3D-CT according to the practitioner's prescription. Ultrasonography was performed in all cases by one of the paediatric radiologist from our department (CT, BB, KC with respectively 30, 15 and 10 years of experience). Given the US experience acquired during the first 7 years, we changed our practice after 2011 in agreement with the paediatric neurosurgeon (LR). After this date, US was performed as a first-line radiological examination in cases of suspicion of craniosynostosis and considered as an alternative to classic plain radiography or 3D-CT for the diagnosis of craniosysnostosis (Fig. 1).

For this retrospective study, we only included infants having undergone both US and 3D-CT in order to compare the sutures in the most reliable manner. We considered that comparison of all the sutures was not possible with plain radiography. Each child was examined first by US and then by 3D-CT.

The study was approved by the local ethics committee and did not require informed consent from the relatives.

2.2. Ultrasonography procedure

All US examinations were performed on a Philips HDI 5000 Sonoct from 2004 to 2008, then a Philips IU 22 machine from 2008 onwards (Philips Medical System, The Netherlands) using a high frequency linear transducer (12,5 and/or 17,5 MHz transducer). The probe was positioned perpendicular to the expected linear course of the suture. Coronal, sagittal, lambdoïd and metopic sutures were systematically analysed. During US examination, the cranial sutures were followed along their whole length.

A cranial suture was considered as normal (patent suture) if a hypoechoic gap was identified between two hyperechoic bony plates, with end-to-end appearance or bevelled or overlapped appearance [3]. A suture was considered closed (synostosed suture) if there was a loss of hypoechoic fibrous gap between bony plates [4]. Paediatric radiologists paid particular attention to partial or complete closure of sutures. Image and video recordings were systematically performed during examination and reviewed for comparison with 3D-CT findings.

2.3. CT acquisition

All CT examinations were performed using the same 16-slice multidetector CT (Philips Brilliance, Cleveland, Ohio, USA) with a stereotyped protocol. The imaging parameters used were as follows: tube voltage 120 kV, tube current 100 mAs, collimation 16×0.75, pitch 0.688, rotation time 0.5 s, slice thickness 0.8 mm, increment 0.4 mm. 3D-CT volume rendering reconstruction were systematically performed.

2.4. Data analysis

Sonography examination was correlated with 3D-CT findings as a gold-standard. The sensitivity, specificity, positive and negative predictive values of ultrasound for the diagnosis of craniosynostosis was calculated.

3. Results

3.1. Study group description

A total of 40 infants were finally included. There were 7 girls and 33 boys. Thirty children had a craniosynostosis including 20 scaphocephaly, 4 trigonocephaly, 3 plagiocephaly, 2 brachycephaly, and 1 atypical craniosynostosis. The case of atypical craniosynostosis was one case with both sagittal and left coronal suture synostosis. Ten children had a postural deformity with