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REDUCING RADIATION EXPOSURE IN NEWBORNS WITH BIRTH HEAD TRAUMA

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Background. Birth head trauma causing intracranial injury is one of the most common causes of neonatal mortality and morbidity. In case of suspected cranial fractures and intracranial hematomas, diagnostic methods involving radiation, such as x-ray radiography and computed tomography, are recommended. Recently, an increasing number of studies have highlighted the risk of cancer complications associated with computed tomography in infants. Therefore, diagnostic methods that reduce radiation exposure in neonates are important. One such method is ultrasonography (US).

Aim. We evaluated US as a non-ionizing radiation method for diagnosis of cranial bone fractures and epidural hematomas in newborns with cephalohematomas or other birth head traumas.

Material and methods. The study group included 449 newborns with the most common variant of birth head trauma: cephalohematomas. All newborns underwent transcranial-transfontanelle US for detection of intracranial changes and cranial US for visualization of bone structure in the cephalohematoma region. Children with ultrasonic signs of cranial fractures and epidural hematomas were further examined at a children's hospital by x-ray radiography and/or computed tomography.

Results and discussion. We found that cranial US for diagnosis of cranial fractures and transcranial-transfontanelle US for diagnosis of epidural hematomas in newborns were highly effective. In newborns with parietal cephalohematomas (444 children), 17 (3.8%) had US signs of linear fracture of the parietal bone, and 5 (1.1%) had signs of ipsilateral epidural hematoma. Epidural hematomas were visualized only when US was performed through the temporal bone and not by using the transfontanelle approach. Sixteen cases of linear fractures and all epidural hematomas were confirmed by computed tomography.

Conclusion. The use of US diagnostic methods reduced radiation exposure in newborns with birth head trauma. US methods (transcranial-transfontanelle and cranial) can be used in screening for diagnosis and personalized monitoring of changes in birth head trauma as well as to reduce radiation exposure.

Keywords: newborns; birth injury; radiation exposure; cephalohematoma; linear skull fracture; epidural hematoma; transcranial-transfontanelle ultrasonography.

К ВОПРОСУ О СНИЖЕНИИ ЛУЧЕВОЙ НАГРУЗКИ ПРИ РОДОВОЙ ТРАВМЕ ГОЛОВЫ

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Актуальность. Внутричерепные повреждения у новорожденных в результате родовой травмы головы являются одной из главных причин неонатальной смертности и детской инвалидности. При подозрении на перелом свода черепа или внутричерепную гематому у новорожденных рекомендуется применять лучевые методы

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диагностики — рентгенографию черепа и компьютерную томографию (КТ). В последние годы появляется все больше работ о риске онкологических осложнений, связанных с применением компьютерной томографии у младенцев. Поэтому большое значение имеют методы диагностики, позволяющие уменьшить лучевую нагрузку в неонатологии. Один из таких методов — ультрасонография (УС).
Цель — оценить возможности ультрасонографии в диагностике переломов костей свода черепа и эпидуральных гематом у новорожденных с кефалогематомами и обеспечить снижение лучевой нагрузки при родовой травме головы.
Материал и методы. В обследуемую группу включены 449 новорожденных с самым распространенным вариантом родовой травмы головы — кефалогематомами. Всем новорожденным проводили транскраниально-чрезродничковую ультрасонографию для выявления внутричерепных изменений и ультрасонографию черепа для визуализации состояния кости в области кефалогематомы. Дети с ультразвуковыми признаками переломов костей свода черепа и эпидуральными гематомами были дообследованы в детской больнице с помощью рентгенографии черепа и/или компьютерной томографии.
Результаты и обсуждения. На примере новорожденных с кефалогематомами показана высокая эффективность ультрасонографии черепа в диагностике переломов костей свода черепа и транскраниально-чрезродничковой ультрасонографии в диагностике оболочечных гематом. У 17 (3,8 %) новорожденных с теменными кефалогематомами из 444 выявлены УС-признаки линейного перелома теменной кости, у 5 (1,1 %) — с эпидуральной гематомой на стороне перелома. Эпидуральные гематомы визуализировались только при сканировании через височную кость, при чрезродничковом исследовании они видны не были. 16 случаев линейных переломов и все эпидуральные гематомы были подтверждены КТ.
Заключение. В статье обоснована необходимость и представлена возможность снижения лучевой нагрузки при родовой травме головы у новорожденных. Описанные методики ультразвукового исследования (транскраниально-чрезродничковая ультрасонография и ультрасонография черепа) позволяют, с одной стороны, обеспечить скрининг-диагностику и персонализировать мониторинг изменений при родовой травме головы, а с другой — существенно снизить лучевую нагрузку.

Ключевые слова: новорожденные; родовая травма; лучевая нагрузка; ассоциированная кефалогематома; линейный перелом черепа; эпидуральная гематома; транскраниально-чрезродничковая ультрасонография.

Introduction

Reduction of radiation load in children with birth injuries of the head has recently become increasingly practical [1–4]. This is mainly attributable to two factors. First, modern medical care standards for children with head traumas recommend extensive use of skull radiography and computed tomography [5–7]. Lesions of the skull bones or intracranial hematomas are indications of repeated use of radiation diagnostic methods. Second, in newborns and young children, the use of these methods is associated with a high risk of radiation-related complications [8–12]. According to J.D. Mathews et al., a delayed risk of developing cancer in patients exposed to ionizing radiation during childhood is 25% greater than that in the general population [13]. Therefore, non-radial technologies for visualizing skull bones and intracranial spaces are particularly relevant [1, 4]. Most often, this need arises with cephalhematomas (CHs), the frequency of which varies between 0.1% and 10%, according to literature. A majority of these spontaneously resolve without consequences. However, in 3%–20% cases, CHs are combined with linear cranial vault bone fractures and in 2%–5% cases, they are accompanied by epidural hematomas (EH) [14–17]. An early diagnosis of CH is crucial. The reliability of neurological status interpretations is low in newborns. Fractures of the cranial vault bones and EH are often accompanied by satisfactory clinical status of newborns [18]. The most effective methods of neuroimaging are characterized by minimal invasiveness, wide accessibility, and possibility of conducting an examination without taking a newborn from an incubator couveuse. One such method is ultrasonography (US) [1, 4, 17, 19, 20].

Aim. This study aimed at assessing the possibility of using US for diagnosing fractures of the skull vault bones and epidural hematomas in newborns with CH and ensuring a reduction in the radiation load in children with birth injuries of the head.

Materials and methods

The study was performed in maternity hospital No 10 and the city children's hospital No 1 of Saint Petersburg from September 2014 to February 2017. Totally, 449 newborns with CH were examined in the maternity hospital: 396 (88.2%) newborns had unilateral parietal CHs, 42 (9.4%) had bilateral parietal CHs, 6 (1.3%) had bilateral parietal CHs combined with occipital ones, and 5 (1.1%) had

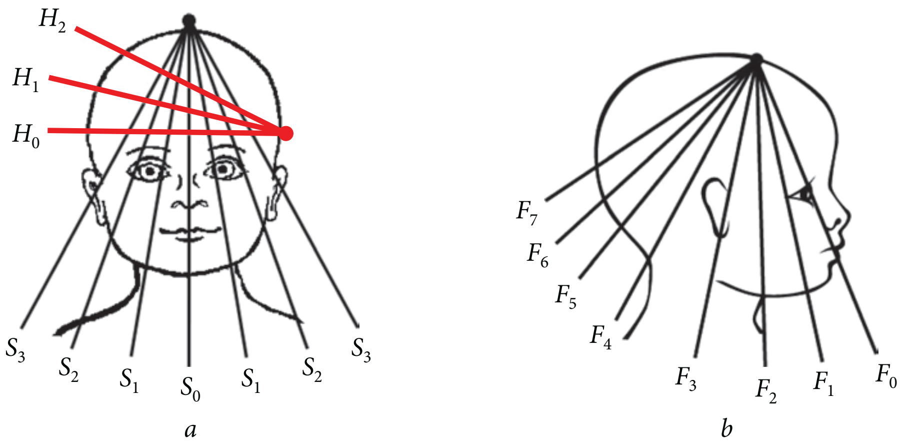

Fig. 1. Scheme of orientation and designation of the scanning planes for transcranial and transfontanellar ultrasonography: *a* — sagittal and horizontal planes; *b* — frontal planes

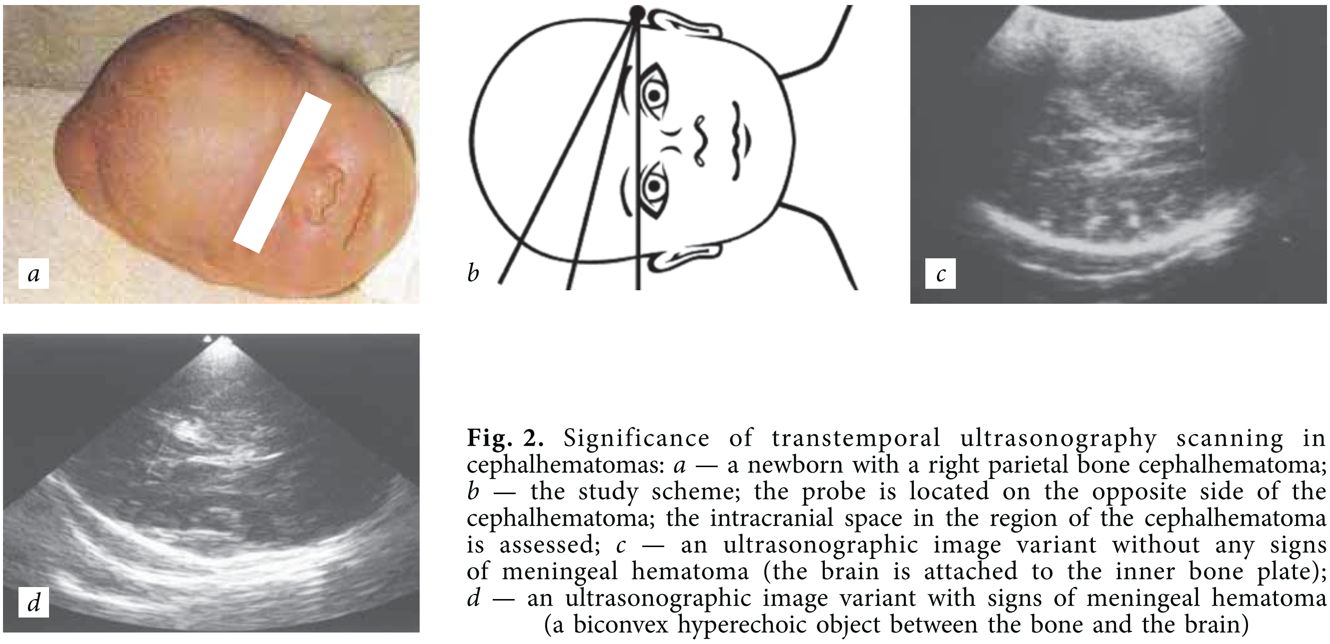

Fig. 2. Significance of transtemporal ultrasonography scanning in cephalhematomas: *a* — a newborn with a right parietal bone cephalhematoma; *b* — the study scheme; the probe is located on the opposite side of the cephalhematoma; the intracranial space in the region of the cephalhematoma is assessed; *c* — an ultrasonographic image variant without any signs of meningeal hematoma (the brain is attached to the inner bone plate); *d* — an ultrasonographic image variant with signs of meningeal hematoma (a biconvex hyperechoic object between the bone and the brain)

isolated occipital CHs. All patients with CHs underwent transcranial and transfontanellar US (TTUS) to detect intracranial changes and skull US to assess the CH region bone condition (according to the methods of A.S. Iov [1996]).

When examining newborns with a scalp birth trauma (e.g., CH), evaluating the intracranial condition directly in the zone of external damage was particularly important. A widely used transfontanellar US is incapable of solving this problem; the main disadvantages of this method are as follows: 1) inability to assess the intracranial state in areas directly located under the cranial vault bones (in zones where the meningeal hematomas are most often localized); 2) insufficiency of visualization of the midbrain (lack of reliable US-criteria of dislocations and cerebral edema); 3) dependence on the anterior fontanel size; and 4) inability to perform differential diagnosis of pathological conditions in the convective-parasagittal region (subdural clusters/external hydrocephalus) when scanning with only one probe (sector/microconvex).

Using standard TTUS, scanning is performed through the fontanel and squamosa of the temporal bones with the obligatory application of two probes (sector/microconvex and linear). For transfontanellar scanning, multifrequency probes (7–12 MHz, microconvex and linear), and for transtemporal scanning, multifrequency sector probes (2–4 MHz) were used. Figure 1 shows the schematic orientation of the scan planes at TTUS. It is demonstrated that the blind zone visualization, characteristic for transfontanellar US, is provided by the transtemporal horizontal planes H_0, H_1, and H_2.

When performing TTUS in children with parietal CH, the intracranial space in the CH region is the area of interest, as visualized during scanning through the opposite temporal bone (Figure 2).

When conducting skull US, a linear multi-frequency probe (5–10 MHz) was mounted on the CH region and longitudinal and transverse scanning was performed over the entire CH area. As shown in Figure 3, the hyperechoic line nearest to the probe represents the image of the skin, the line following it represents the image of the bone, and the hypoechoic soft tissue lies between the two (subcutaneous fatty tissue, aponeurosis) (Figure 3).

In cases of linear skull fractures, interruption of the hyperechoic bone pattern was noted; the “hyperechoic mark” was located under the fracture region (Figure 4). It is noteworthy that with US, a linear fracture looks identical to a normal skull suture. In case of suspected fractures, one should ensure that the probe is not located above the cranial suture.

Children who showed signs of cranial vault bone fractures and EH on US in the maternity hospital were transferred to the Children’s hospital No 1 (17 patients), where they underwent skull X-ray examination and/or CT of the head. All patient representatives agreed for the examination, participation, and processing of personal data for this study.

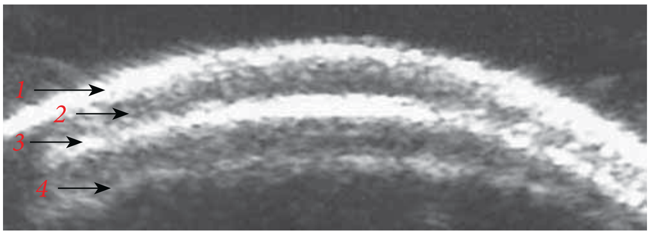

Fig. 3. Scalp and skull ultrasonography under normal conditions: *1* — skin, *2* — subcutaneous tissue, *3* — bone, and *4* — reverberation artifacts

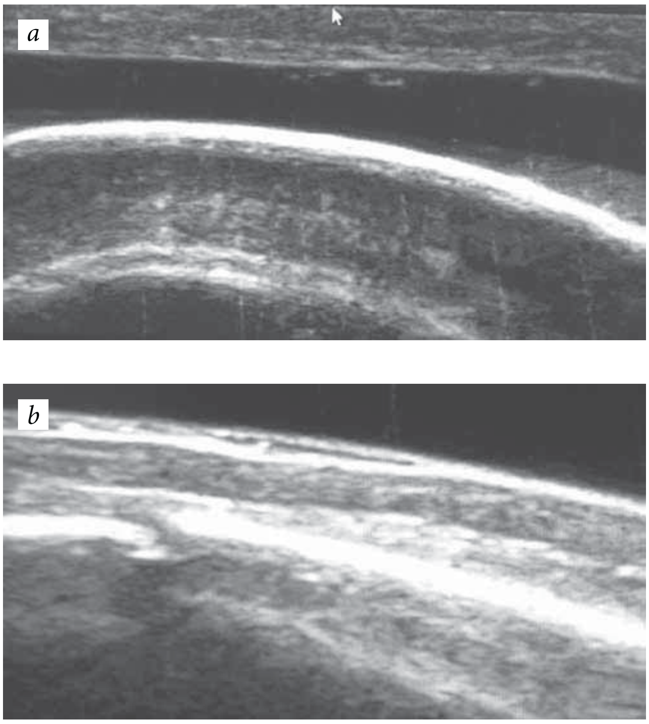

Fig. 4. Ultrasonographic craniography in the cephalhematoma region: *a* — the norm, no fracture signs (bone continuity is not violated); *b* — signs of parietal bone linear fracture (bone continuity is violated, the “hyperechoic mark” phenomenon is immediately revealed under the fracture)

Results and discussion

In the parietal region CT of the patients ($n = 444$), 17 (3.8%) had US signs of parietal bone linear fracture on the CH side. Five (1.1%) patients had EH on the fracture side. EHs were visible only through the transtemporal access, reconfirming the low efficiency of the transfontanellar US in diagnosing meningeal convexital hematomas. The presence of a fracture and EH did not depend on the CH size. In cases of occipital CHs (11 patients), occipital fractures and intracranial hematomas were not detected. EHs were confirmed using CT in all cases; linear fractures were confirmed in 16 (94%) cases (Figures 5 and 6).

The present results showed a high efficiency of skull US in diagnosing cranial vault bone fractures and that of TTUS in diagnosing meningeal hematomas in newborns with CHs.

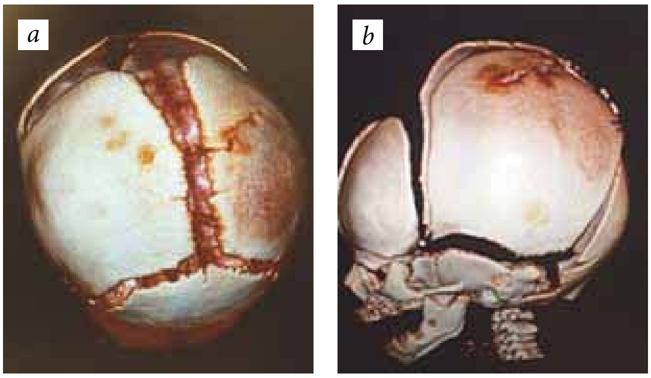

Fig. 5. Spiral computed tomogram of the skull. Linear fracture with lacunar craniopathy. *a* — top view; *b* — side view

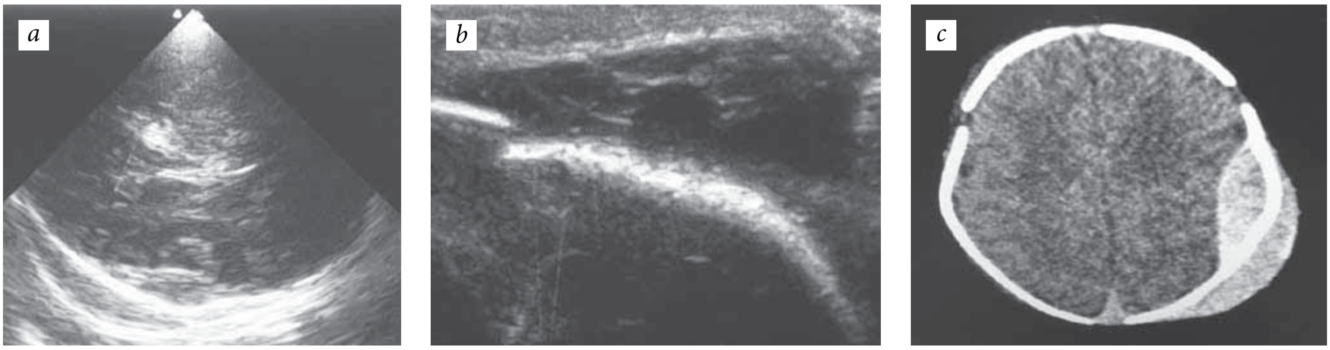

Fig. 6. Cephalhematoma associated with epidural hematoma and linear parietal bone fracture, 5-day-old newborn, *a* — transcranial and transfontanellar ultrasonography, transtemporal scanning, and visualized subperiosteal and epidural hematomas; *b* — skull ultrasonography (right parietal bone linear fracture); *c* — computed tomogram of the head, confirming ultrasonography data

In 69% patients (11 newborns), the fractures were combined with US and/or CT parietal bone lacunar craniopathy (LC) signs. LC is a single or multiple rounded defect of the cranial vault bones (often parietal) that is ossified during the first few months of life. Isolated LC does not require special treatment. Clinical signs of LC are softness and thinning of the parietal bones (symptom of a "felt hat"); less commonly, they are palpable rounded bone defects. US signs of LC include local bone thinning areas without interruption to its hyperechoic pattern. The data obtained suggest that parietal bone LC increases the risk of linear fractures even during physiological labor.

Conclusion

Skull, transcranial, and transfontanellar ultrasonography enabled the accomplishment of a crucial practical task for modern medicine, that is, the significant increase in the availability of visualization of fractures of the skull bones and meningeal hematomas in newborns, while reducing the use of methods involving radiation.

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