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## *Possibilities of radiography in the diagnosis of pneumonia in newborns*

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*Abstract.*

The features of X-ray semiotics in pneumonia in newborns were evaluated depending on the gestational age at birth. Conducted clinical and radiological examination of newborns with pneumonia. Plain chest radiography was used from radiographic methods. In the group of full-term newborns without signs of intrauterine growth retardation with pneumonia, changes prevailed that were mainly characteristic of the I degree of severity of the respiratory distress syndrome, namely, miliary spotting, limited low-intensity inhomogeneous darkening, blurry nodose-reticular mesh, and a distinguishable «air bronchogram». In full-term newborns with signs of intrauterine growth retardation, changes characteristic of I and II degrees of severity of the respiratory distress syndrome prevailed in equal proportions, that is, a decrease in pneumatization, coarse randomly scattered areas of lung tissue compaction and «air bronchograms». In preterm newborns, depending on the depth of prematurity, and possibly due to a short-term clinically asymptomatic onset, in most cases, II and III degrees of severity of the respiratory distress syndrome were noted at admission: a pronounced decrease in pneumatization ("frosted glass"), smoothing of the pulmonary-diaphragmatic and pulmonary - cardiac border (positive «silhouette» symptom), air bronchograms. The distribution of children according to clinical and radiological signs depends on gestational age, and atelectatic pneumonia is most often recorded in premature babies against the background of morphofunctional immaturity of the lungs. The deeper the prematurity, the more pronounced the influence of immature lung tissue on the occurrence and course of the inflammatory process in the lungs, and the inflammatory process becomes rapid, spreading to a large area of the lungs.

*Keywords:* newborn, pneumonia, radiography, respiratory distress syndrome.

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## *Возможности рентгенографии в диагностике пневмонии у новорожденных*

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*Аннотация.*

Оценены особенности рентгенологической семиотики при пневмонии у новорожденных в зависимости от срока гестации при рождении. Проведено клинико-рентгенологическое обследование новорожденных с пневмонией. Из рентгенологических метожов использована обзорная рентгенография грудной клетки. В группе доношенных без признаков задержки внутриутробного развития новорожденных с пневмонией преобладали изменения, характерные в основном для I степени тяжести синдрома дыхательных расстройств, а именно милиарная пятнистость, ограниченные слабоинтенсивные негомогенные затемнения, расплывчатая нодозно-ретикулярная сетка, различимая «воздушная бронхограмма». У доношенных новорожденных с признаками задержки внутриутробного развития в равных соотношениях преобладали изменения, характерные для I и II степени тяжести синдрома дыхательных расстройств, то есть снижение пневматизации, грубые беспорядочно разбросанные участки уплотнения легочной ткани и «воздушные бронхограммы». У недоношенных новорожденных в зависимости от глубины недоношенности, а возможно и в связи с кратковременным клинически бессимптомным началом при поступлении в большинстве случаев отмечались II и III степени тяжести синдрома дыхательных расстройств: выраженное снижение пневматизации («матовое стекло»), сглаживание легочно-диафрагмальной и легочно-сердечной границы (положительный симптом «силуэта»), воздушные бронхограммы. Распределение детей по клинико-рентгенологическим признакам зависит от гестационного возраста, и наиболее часто у недоношенных детей регистрируется ателектатическая пневмония на фоне морфофункциональной незрелости легких. Чем глубже недоношенность, тем больше выраженность влияния незрелой легочной ткани на возникновение и течение воспалительного процесса в легких, причем воспалительный процесс приобретает стремительный характер, распространяясь на большую площадь легких.

*Ключевые слова:* новорожденные, пневмония, рентгенография, синдром дыхательных расстройств.

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Pneumonia is a fairly common form of respiratory damage in children in all age groups [4,12]. In most neonatal centers, the diagnosis of respiratory distress syndrome (RDS) is based on clinical and radiological findings, although it is certainly important to obtain evidence of surfactant deficiency for a specific diagnosis of RDS. Therefore, sometimes the term «respiratory failure of prematurity» is also used, when mechanical ventilation, additional oxygen is necessary for the treatment of a premature baby, but there are no typical signs of SDR on the chest x-ray, or their nonspecificity is similar to that of pneumonia caused by a certain microflora [1,5,10,11].

Acute pneumonia in children has clinical and morphological features due to the immaturity of the lung tissue and the reaction of local immunity [1,7,12]. The diagnosis of pneumonia is considered verified only in cases where focal inflammatory lesions of the lungs are confirmed radiographically [2,3,6,8,9].

Purpose of the study: to study the features of X-ray semiotics in pneumonia in newborns, depending on the gestational age at birth.

Material and research methods. A clinical and radiological examination of 71 newborns with pneumonia was carried out. Plain chest radiography was performed in direct and, if necessary, in lateral projections, in a vertical position, at maximum inspiration, or at the height of the crying of the child to improve the contrast of the lung fields with shielding of the gonads. X-ray examination was carried out on the apparatus brand KX050F - «Toshiba» (Japan). When radiography of the chest in children adhered to the following specifications: voltage 50-55 kV, current 100-150 mA, exposure time 0.03-0.1 seconds. In this case, the effective equivalent dose per 1 shot was 0.02-0.04 mSv, in accordance with the Radiation Safety Standards.

Depending on the age and gestational age at birth, the examined children were divided into the following groups:

A1 group - full-term newborns, without signs of intrauterine growth retardation (IUGR) (n=15);

A2 group - full-term newborns with signs of IUGR - hypotrophic variant (n=10);

Group B1 - premature newborns with a gestational age of 35-37 weeks and a birth weight of 2,000 - 2,500 g (n=20);

Group B2 - premature newborns with a gestational age of 32-34 weeks and a birth weight of 1,500 - 2,000 g (n=26).

Research results. According to the goal, in accordance with the well-known rules for the mandatory availability of x-ray evidence for the diagnosis of pneumonia in children, an x-ray examination was performed in patients with pneumonia.

Considering that X-ray examination reveals pathological immaturity of the lungs, our attention was focused on the features of the development of pneumonia in preterm infants against the background of SDR, namely, the main triad of radiological symptoms in the first days of SDR development, as diffuse symmetrical foci of reduced transparency ("ground glass" symptom without or with signs of «mesh lungs»), «air bronchogram», reduced pneumatization of peripheral lung fields, taking into account the opinion that the radiographic signs of SDR are sometimes nonspecific, but chest x-ray is still necessary, as it allows to exclude other conditions that sometimes require surgical intervention.

Analyzing the radiographic manifestations of pneumonia in the examined newborns and generalizing the results obtained, the radiological symptoms were systematized. When assessing the airiness of the lung fields in most of the examined full-term newborns with normal birth weight (group A1), lung ventilation had satisfactory parameters (80%). A pronounced decrease in the transparency of both lungs was noted only in minor observations (20%). Darkening of the type of «white lungs» and «frosted glass» was not observed in any of the observations.

The infiltration zones determined in pneumonia, that is, the radiographic symptom of darkening, were noted in limited areas (73%) with a heterogeneous structure (60%), which is most likely due to the presence of normally functioning and swollen lobules and acini in the affected segments, as well as functional bronchiectasis that has arisen in the small bronchi in acute respiratory failure. In isolated cases (13%), limited shadows with a homogeneous structure were visualized. Along with this, emphysematous bullae of various sizes were often visualized (53%).

Localized occlusion foci were more common in the right upper lobe (60%), followed by the lower left lobe (46%), the lower right lobe (33%), and less frequently in the upper left lobe (27%). Parallel to them, in the medial zones of the lung fields, singly scattered small-focal shadows (73%) were visualized, tending to merge (67%) and also having fuzzy contours (93%). Diffusely distributed multiple focal shadows in both lungs were interpreted in isolated cases (20%).

In the prevailing percentage of observations, blackouts had a low intensity (80%) and fuzzy contours (93%), which is typical for an acute inflammatory process, and were combined with areas of limited swelling (100%).

When assessing the state of the lung pattern in this group of newborns, a more frequent manifestation of an increase in the vascular pattern (67%) was noted throughout both lung fields and, especially in the affected lobe, both due to hyperemia and due to increasing perivascular edema of the lung tissue. The shadows of the vascular branches became wider, their contours were indistinct and blurred. Impoverishment of the vascular pattern, cellularity of the lung pattern, and the symptom of «air bronchogram» in full-term infants with normal birth weight were not specific (20%).

Assessing the state of the roots of the lungs on radiographs, the narrowing of the roots was noted only in one sick newborn. An additional shadow in the root zone due to the involvement of the interstitial tissue in the process very often created a picture of the expansion of the root zone (93%). In addition, the root structure changed dramatically (93%) if focal shadows were located in segments whose projection coincided with the root and root zone. Structural roots were noted only in 7%. In part, the roots on x-rays looked compacted (40%), having fuzzy outer contours (93%), and only in 7% - relatively clear outer contours.

In the dynamics of the disease in many of our studies, we saw an expansion of the mediastinal shadow (60%), noted mainly due to the expanded lower arches and smoothness of the waist of the heart, which is interpreted as a mitral configuration.

Assessing the position of the domes of the diaphragm, its usual position at the level of the fifth pair of ribs was visualized in 20% of cases, high standing - only in a small number of patients (7%). We observed the descent of the diaphragm in the majority of the examined newborns (73%).

Intrauterine growth retardation (IUGR), as a frequent sign of intrauterine pathology, is also accompanied by disorders of morphogenesis, a decrease in the supply of energy substrates to the fetus. In the full-term newborns with IUGR observed by us, the hypotrophic variant prevailed. In our observations, the radiographic picture of pneumonia, combined with respiratory failure and against the background of signs of immaturity, was characterized by the following manifestations.

In newborns with IUGR (group A2), satisfactory radiological parameters of ventilation were not observed. Hypoventilation of the lungs predominated (80%) (Fig. 2), while in some of the examined patients it manifested itself in the form of «ground glass» (20%), combined with the «silhouette» symptom (20%) (smoothing of the pulmonary-diaphragmatic and pulmonary-cardiac border). The "silhouette" symptom is when a part of the lung loses its airiness, the border of the structure, normally outlined by the area of the lung, becomes fuzzy or resembles a silhouette.

Darkening of the «white lungs» type was not observed in any of the cases. Hypoventilation of the lungs of varying severity was combined with areas of limited swelling (70%), more often visualized in the lateral zones, and especially in the supradiaphragmatic areas. Reliable radiographic manifestation of pneumonia - darkening, was found mainly in the form of areas of limited apneumatosis, having a heterogeneous structure (60%), due to the presence of normally functioning and swollen lobules and acini in the affected segments. Along with these, there were single emphysematous bullae of various sizes (40%). Homogeneous darkening occurred only in 20% of newborns with IUGR. The syndrome of total darkening of the pulmonary field with the shift of the shadow of the mediastinal organs to the healthy side, visualized in 1 patient, was combined with the veiling of the sinuses, which is characteristic of exudative pleurisy.

Localized foci of opacities were more common in the right upper lobe (60%), followed by the lower right lobe (50%), the upper left lobe (40%), and least often in the lower left lobe (20%). Parallel to them, in the medial zones of the lung fields, singly scattered small-focal shadows with fuzzy contours (100%), also tending to merge (50%), were visualized. Diffusely distributed multiple focal shadows were not typical in this group of newborns, and were detected only in 20%.

In the prevailing percentage of observations, blackouts had a low intensity (90%) and fuzzy contours (100%), which is very typical for an acute inflammatory process.

When assessing the state of the lung pattern, such a characteristic radiological symptom of an acute inflammatory process in the lungs as an increase in the vascular pattern throughout both lung fields was noted in minor observations (10%). In most cases, in this group

of newborns with signs of IUGR, the vascular pattern was depleted (70%). Partly in the affected areas, the lung pattern had a peculiar cellular appearance (60%). The X-ray picture also reflected another very important symptom of an "air bronchogram" (40%) for this condition, when the lumen of the bronchus begins to differentiate among the infiltration surrounding it.

There is also a reaction from the roots of the lungs: they are wide, have a fuzzy structure and fuzzy outer contours (70%) due to infiltrative-edematous changes, sometimes visualized as a seal (30%). In the same number of observations, the roots were not differentiated.

When assessing the position of the domes of the diaphragm, its usual position for this age group at the level of the 5th ribs was noted in 40%, while in most children the diaphragm had some lowered position (60%). In many of our studies, we have seen an expansion of the mediastinal shadow (60%), noted mainly due to the expansion of the lower arches and the flattening of the waist of the heart.

X-ray changes in the premature newborns we observed, regardless of the degree of prematurity, depended on the state of immaturity of the organism, in particular, the respiratory organs, and the orientation was based on the 4 X-ray stages of bronchopulmonary dysplasia (BPD) proposed by W. Northway and co-authors, in the pathogenesis of which The immaturity of the lung tissue, insufficient activity of the antiprotease protection of the lungs, which contribute to the destructive processes in the lungs in combination with other provoking factors, are of decisive importance.

During X-ray examination of premature newborns with pneumonia, the prevalence of manifestations of signs characteristic of SDR was observed. In all observations in the groups of premature newborns (B1 and B2), a decrease in pneumatization of the lung fields was characteristic of varying degrees of severity (Fig. 3). In no case were satisfactory air parameters observed. Studying x-rays and comparing them with clinical manifestations, the following pattern was noted: the deeper the prematurity, the more pronounced the manifestations of hypoventilation. So if in group B1 the symptom of «ground glass» was detected in 30% of cases, then in preterm infants of group B2 - in 35% of cases, and in 4% - «white lungs» occurred.

Ground glass opacity has always been associated with a silhouette symptom (blurring of mediastinal and diaphragm contours). It should be noted that although with «frosted glass» there is a general darkening, it is most compact in the paramediastinal and paracardiac zones. With a careful study of x-rays, in the inferolateral zones in most children (B1-90% and B2-85%), areas of limited swelling were visualized. Violation of the structure is also due to single bullous swellings detected (65% and 35%).

In addition to signs of impaired ventilation, radiographs showed shadows from miliary spotting of the reticulogranular pattern with a gradual general uniform veiling to large or conglomerate lobular shadows and general diffuse hypopneumatosis or apneumatosis of all lobes.

The dynamics of these changes in our observations corresponded to the severity of the child's condition. In contrast to full-term newborns, in groups B1 and B2, diffusely widespread multiple focal opacities (50% and 42%) are more typical, very often tending to merge (80% and 76%) and combined with multifocal swellings (80% and 73 %). And again, these changes are well expressed mainly in the medial sections. Focal shadows differed not only in size, but also in intensity, which indicates their occurrence at different times and unequal depths. So, shadows of low intensity were more often observed (85% and 76%), and shadows of medium intensity only in a part of patients (60% and 40%). Spotting of the lung fields during the development of SDR is caused not only by primary atelectasis, which mostly have relatively clear contours (10% and 12%), but also by bronchopneumonia, and, as a result, the contours of focal shadows are mostly fuzzy (90% and 84%).

In the total mass of nest-scattered focal pneumonias observed by us in premature newborns, I would like to highlight dystelectatic pneumonias (30% and 35%). This type of pneumonia is characterized by their paravertebral location. As you know, the basis of this form of pneumonia is a violation of the ventilation of certain areas of the lungs. According to our observations, ¾ of paravertebral pneumonias are bilateral and only in ¼ of cases there is unilateral pneumonia, more often on the right side. Distelectatic pneumonia in the x-ray image has the appearance of a more or less wide band of blackout and strands located in the paravertebral region: it is characteristic for it to spread not to the side, but vertically.

Analysis of the X-ray picture of the pulmonary pattern revealed in premature babies, due to their immaturity, depletion of the vascular pattern (30% and 42%). The symptom of increased pulmonary pattern, characteristic of the inflammatory process, did not have its pronounced manifestation in the groups of premature infants examined by us. However, its enrichment in the type of nodose-reticular mesh was very clear, due to expanded interlobular septa and manifested by gentle polygonal shadows, having a different length and detected in most cases (65% and 57%).

Against the background of an airless lung parenchyma, linear and branched fragments of normally invisible air-containing bronchial branches, the so-called "air bronchogram" phenomenon, were determined. The frequency of registration of «air bronchogram» in the pictures directly correlated with the aggravation of the condition and immaturity of the newborn. So, if this symptom in premature babies from group B1 was observed in 45%, then in premature babies from group B2 it was observed in 54%.

In minor observations on x-rays, pleural thickening of the horizontal interlobar fissure was noted (5% and 12%). In a single case in group B1, radiological changes were observed, characteristic of lobar pneumonia, and in the same number of observations, a picture of pneumothorax was noted, manifested by a syndrome of extensive enlightenment in the lateral zone of the corresponding lung field.

Assessing the state of the roots of the lungs in pneumonia in the examined preterm infants, sometimes (25% and 19%) it was not possible to identify their pattern due to the increased shadow of the mediastinal organs, and also because of the additional shadow in the root zone due to the involvement of interstitial tissue in the process, which was interpreted as an extension of the root zone (65% and 77%). In addition, the root structure changed dramatically (75% and 81%) if the focal shadows were located in segments whose projection coincided with the root and root zone. Narrowing of the roots was noted only in one sick newborn from group B2. Partly, the roots on x-rays looked compacted (30% and 15%), having fuzzy external contours (75% and 81%).

In the dynamics of the disease, an increase in the mediastinal shadow (70% and 62%) was noted, due to the expansion of the lower arches and smoothness of the waist of the heart, and is interpreted as a mitral configuration. The loss of clarity of the contours of the heart (30% and 42%), visualized in a certain part of the patients, is obviously associated not only with the fusion of small atelectatic areas of the lungs located near the shadow of the heart and blood vessels, but also with the development of changes in the myocardium.

Assessing the position of the domes of the diaphragm, its usual position at the level of the fifth pair of ribs was visualized in almost half of the examined premature newborns (50% and 54%). High standing of the diaphragm was seen in a small number of patients (5% and 8%). We observed

the descent of the diaphragm in 45% of studies in preterm infants from group B1 and 38% of cases in preterm infants from group B2.

Based on our own observations on the basis of a combination of radiographic symptoms, in comparison with the well-known radiological classifications of the stages of SDR, we singled out our own version of radiological verification of changes in the severity of the inflammatory process against the background of immaturity of the lung tissue.

## THE DISCUSSION OF THE RESULTS

In the group of full-term newborns without signs of IUGR with pneumonia (group A1), the changes characteristic mainly for the I degree of SDR severity, namely, miliary spotting, limited low-intensity inhomogeneous darkening, blurry nodose-reticular grid, distinguishable «air bronchogram» prevailed. It should be remembered that even in completely healthy preterm infants without clinical respiratory disorders, the presence of scattered atelectatic areas can be detected radiographically. In the genesis of disseminated atelectasis, not only the relative deficiency of surfactant is important, but also the absence or weak expansion of the arterioles of the lungs.

In full-term newborns with signs of IUGR (group A2), changes characteristic of I and II degrees of SDR severity prevailed in equal proportions, i.e. decreased pneumatization, coarse randomly scattered areas of lung tissue compaction and «air bronchograms». In dynamics, there was a tendency to transition to the I degree of severity of SDR.

In our observations, in premature newborns, depending on the depth of prematurity, and possibly due to a short-term clinically asymptomatic onset, at admission, in most cases, II and III severity of SDR were noted: a pronounced decrease in pneumatization («ground glass»), smoothing of the pulmonary-diaphragmatic and pulmonary-cardiac border (positive «silhouette» symptom), air bronchograms. It should be noted that in group B2, relative to group B1, manifestations of the III degree of severity of SDR somewhat prevailed.

When comparing the airiness of the lung fields in the majority of those examined with normal birth weight (group A1), ventilation of the lungs had relatively satisfactory parameters, which was not typical for the other groups of examined newborns, who had especially clear symptoms of impaired ventilation of varying severity depending on the degree of immaturity. Ground-glass opacification in combination with a positive silhouette symptom was mainly expressed in immature children (groups A2, B1 and B2) and was not observed in full-term infants with normal birth weight. And «white lungs» were visualized only in group B2.

With regard to the assessment of the prevalence of blackouts, areas of limited blackouts on radiographs were more often detected in groups A1 and A2. Our X-ray observations noted the selective localization of the inflammatory process in separate lung segments lagging behind in their development. These, according to our observations, are segments 1,2,7,9,10 of the right lung and segments 1,2,4,5,9,10 of the left lung. X-ray analysis showed that diffusely widespread small-focal shadows, as one of the manifestations of SDR, were relatively more often observed in newborns from groups B1 and B2.

Diffusely distributed small focal opacities tended to coalesce and were associated with multifocal swellings. Focal shadows differed not only in size, but also in intensity, which indicates their occurrence at different times and unequal depths. There was a combination of inflammatory foci with high-intensity focal-like shadows of blood vessels and atelectatic lobules. Therefore, both shadows of low and medium intensity were simultaneously visualized on the radiographs.

The severity of radiological signs of SDR in pneumonia in newborns, depending on the signs of immaturity and their distribution by degrees

| Severity of SDR | Radiological manifestations | Group A1 | Group A2 | Group B1 | Group B2 |
|---|---|---|---|---|---|
| I | Moderate reduction of pneumatization<br>Miliary spotting<br>Limited low-intensity shadows<br>Nodose-reticular mesh (blurry)<br>«Air bronchogram» is distinguishable | 66,7% | 40% | 25% | 15,4% |
| II | Reduced pneumatization<br>Rough, randomly scattered areas of lung tissue seals<br>Nodose-reticular mesh<br>Air bronchograms | 26,7% | 40% | 35% | 34,6% |
| III | Pronounced decrease in pneumatization (“frosted glass”)<br>Smoothing of the pulmonary-diaphragmatic and pulmonary-cardiac border (symptom of «silhouette»)<br>Air bronchograms | 6,6% | 20% | 40% | 42% |
| IV | «White lungs» | - | | | 8% |

Analysis of the X-ray picture of the pulmonary pattern revealed that the depletion of the vascular pattern, due to its immaturity, prevailed in newborns from groups A2, B1 and B2. The symptom of increased vascular pattern, characteristic of the inflammatory process, did not manifest itself in the groups of premature infants examined by us, but prevailed in mature newborns. In premature babies, its enrichment in the form of a nodose-reticular mesh, which has a different length and is detected in most cases, was very evident.

The frequency of registration of an air bronchogram in the images directly correlated with the aggravation of the condition of the newborn, which is closely related to the immaturity of the lungs.

Taking into account the rapid dynamics of pathological processes in the lungs in premature infants, as well as the great similarity of clinical and radiological changes in SDR and congenital pneumonia in premature infants in the first 24 hours of life, the final differential diagnosis between these pathological conditions should be made on the basis of repeated radiological examination in dynamics. treatment. The appearance of small-dotted shadows against the background of a delicate reticulation of the lung pattern, thin or non-differentiating roots, a pronounced or undetectable air bronchogram, indicates the presence of SDR. Congenital pneumonia is indicated by the appearance of large and small focal shadows against the background of coarse reticulation, thickening of the lung pattern in the root zones, and a moderate increase in the airiness of the bronchogram. The fuzziness of the lung pattern with thickening in the basal zones, the formation of wide, non-structural roots, the appearance of small and medium focal shadows indicates the development of pneumonia. A comparative analysis of the causes of respiratory disorders depending on gestational age revealed that the distribution of children according to clinical and radiological signs depends on gestational age, and atelectatic pneumonia is most often recorded in premature babies against the background of morphofunctional immaturity of the lungs.

Comparing X-ray parameters for pneumonia in different groups of newborns, we noted the options for the development of a bronchopneumonic process with symptoms of lung immaturity, i.e. X-ray studies indicate a close relationship between pneumonia of prematurity and pathological immaturity of the lung tissue, which aggravates the inflammatory process. The deeper the prematurity, the more pronounced the influence of immature lung tissue on the onset and course of the inflammatory process in the lungs, and the inflammatory process becomes rapid, spreading to a large area of the lungs.

In X-ray analysis of combinations of various forms of pulmonary pathology, it must be borne in mind that each component, interacting with others, changes its pathomorphological and pathophysiological appearance, which ultimately contributes to the formation of appropriate degrees of severity of radiological signs of SDR in newborns, depending on the signs of immaturity.

The inclusion of mandatory X-ray confirmation of pneumonia in the «gold standard» of diagnosis allows, by verifying the pathological process in the early stages of development, to prescribe targeted etiopathogenetic therapy in a timely manner, which significantly improves the prognosis of the disease. It is X-ray examination that is the main radiation method of investigation for suspected pneumonia in children.

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