RESEARCH ARTICLE

MULTIMODAL APPROACH TO DIAGNOSTIC RADIOLOGY OF PULMONARY COMPLICATIONS OF PNEUMONIA IN CHILDREN

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ABSTRACT

Introduction. Pneumonia and its complications are one of the leading causes of death in children worldwide. According to the WHO in 2017, 808,694 children under the age of 5 died of pneumonia, accounting for 15% of all deaths of children under the age of 5 worldwide. Materials and methods. The object of the study was 154 children with pulmonary and pleural complications of pneumonia in the age aspect from 3 months to 18 years, who were examined and treated at the clinic of the Tashkent Pediatric Medical Institute for the period from 2014 to 2019. A comprehensive examination of children was carried out at the TashPMI clinic. Digital radiography was the main and primary radiation method of investigation for suspected pulmonary complications of pneumonia in children. In case of destructive pneumonia, the zones of infiltration of the lung tissue ("darkening") with a decrease in its airiness were determined on X-ray images. It was obligatory to perform radiographs in two projections - direct and lateral. Results and Discussion. We have identified radiation signs of pulmonary complications in children. Pulmonary complications accounted for 92 children, of whom 75 (57.0%) were diagnosed with pulmonary destruction and 17 (43.0%) with lung abscess. Destructive changes in lung tissue were found in young children, mainly up to 3 years of age. Conclusion. Thus, the results of our study showed that the use of high-tech methods of radiation examination significantly increases the accuracy of diagnosing lung lesions with complications of pneumonia at different stages of examination and treatment of patients.

KEYWORDS

radiology, pediatrics, pneumonia, X-ray

1. INTRODUCTION

Pneumonia and its complications are one of the leading causes of death in children worldwide. According to the WHO in 2017, 808,694 children under the age of 5 died of pneumonia, accounting for 15% of all deaths of children under the age of 5 worldwide (Belova et al., 2013).

In the Republic of Uzbekistan, the incidence of pneumonia and their complications continues to remain at high rates and does not have a tendency to decrease, in the structure of the overall incidence and in the republic it was 5.5 (Yusupaliyeva et al., 2020).

A timely multimodal approach to radiological diagnosis of complicated pneumonia in children occupies a leading position and is one of the promising directions in pediatrics and pediatric surgery.

Scientists and specialists of Uzbekistan and foreign countries have performed a number of works on radiation diagnosis of pneumonia and their complications (Olkhova et al., 2005a; Olkhova et al., 2005b; Shchitinin et al., 2004; Yusupalieva et al., 2016a), but not work was carried out to assess the significance of multimodal radiology diagnostics in complicated pneumonia in children.

At the same time, the achievements of recent years in the diagnosis, treatment and monitoring of complicated pneumonia have been achieved due to the possibility of multimodal studies, because Each of the visualization methods, along with advantages, has certain disadvantages,

so they complement each other well. The study of the aspects of multimodal radiology diagnostics of complicated pneumonia in children is still ongoing (Yusupalieva et al., 2016b; Biederer et al., 2012; Leone et al., 2018).

However, this direction requires further development and clarification of data on the modern possibilities of radiation methods in the diagnosis of pulmonary and pleural complications of pneumonia in children.

The aim of the study is to optimize the diagnosis of pulmonary and pleural complications of pneumonia in children by using modern methods of radiation diagnostics in the system of comprehensive examination of patients.

2. MATERIALS AND METHODS

The object of the study was 154 children with pulmonary and pleural complications of pneumonia in the age aspect from 3 months to 18 years, who were examined and treated at the clinic of the Tashkent Pediatric Medical Institute for the period from 2014 to 2019.

A comprehensive examination of children was carried out at the TashPMI clinic. Digital radiography was the main and primary radiation method of investigation for suspected pulmonary complications of pneumonia in children. In case of destructive pneumonia, the zones of infiltration of the lung tissue ("darkening") with a decrease in its airiness were determined on X-ray images. It was obligatory to perform radiographs in two

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projections - direct and lateral. A side view was taken from the side of the lesion. According to the division of the lungs into lobes and segments, it was possible to accurately determine the localization of the inflammatory process by X-ray. Radiography was performed on a Shimadzu X-ray machine in standing, sitting and lying positions. When analyzing radiographs, the position of the child, the correct placement and compliance with the technical shooting conditions, the airiness of the pulmonary fields, the presence of swelling or decrease in the volume of the chest, changes in the pulmonary pattern (its strengthening, impoverishment, enrichment or deformation), the presence, nature and topography of darkening, size, the shape and position of the mediastinum, the location and symmetry of the domes of the diaphragm, the transparency of the sinuses, the state of the soft tissues and bone structures of the chest.

Ultrasound examinations were performed on Sonoscape 5000, Sonoscape S 22 and Aplio 500 devices polypositionally, in vertical (standing and sitting in older children) and horizontal (lying on the back, right and left side, on the stomach) patient positions. The study of the chest was carried out from two approaches: transthoracic (through the intercostal spaces) and transabdominal (through the abdominal wall, liver and spleen).

MRI studies were carried out on a Super Star MRI device from Neusoft 0.35T and on a high-field MRI device Brivo 355w 1.5T. X-ray studies were carried out using Shimadzu devices and a 64-slice MSC tomograph Siemens SOMATOM Perspective.

3. RESULTS

We have identified radiation signs of pulmonary complications in children. Pulmonary complications accounted for 92 children, of whom 75 (57.0%) were diagnosed with pulmonary destruction and 17 (43.0%) with lung abscess. Destructive changes in lung tissue were found in young children, mainly up to 3 years of age.

Pulmonary destruction X-ray had the appearance of an irregular darkening corresponding to the affected segment of the lung. With severe inflammatory infiltration, the vascular pattern in the affected area was not traced, and the structure of the lung root at the site of the affected area did not differentiate.

With complex echography, small foci of destruction (mainly subpleural localization) that had no communication with the bronchial tree were observed in 30 (40.0%), which were visualized by X-ray in 11 cases (14.6%) of all patients with destructive changes. Subpleurally located destructive areas, echographically determined in the form of an irregular form of increased echogenicity, located more often in the peripheral part of the airless fragment of the lung. In the central part of the hyperechoic area, an irregularly shaped zone / zones of decreased echogenicity, regarded as a destructive focus / foci, were determined. When analyzing the results of echography, radiography, MSCT and MRI, the main forms of lung tissue damage identified in sick children with pulmonary destruction were multiple air cavities, most of which were detected against the background of zones of compaction and infiltration of lung tissue with the symptom of "air bronchogram".

The area of inflammatory infiltration of the lung tissue during echography was determined as a fragment of an airless pulmonary parenchyma with uneven contours separating this area from the unaffected parts of the lung. Against the background of an airless fragment of the lung, fragments of the air-containing bronchi were determined with a linear or "branched" shape - the phenomenon of an "air bronchogram". In the Doppler study in color mode, the vascular pattern in the affected fragment of the lung tissue in children with destructive changes in the parenchyma was traced in all cases.

In the dynamics of the disease, as the inflammatory process resolved, the infiltrate decreased in size, and smaller bronchi began to fill with air, which was echographically manifested by a greater severity of the air bronchogram phenomenon.

An infrequent echographic symptom was the presence of small, multiple, anechoic areas in the parenchyma of the lung tissue, regarded as fluid-filled acini. A characteristic evidence of the absence of bronchial conduction in the affected part of the lung was a negative phonation test in these patients. With the preserved "air bronchogram", the child's phonation was accompanied by a pronounced flickering artifact. More than half of the children of this group had multiple small areas of destruction - in 45 (60.0%) cases. The vascular pattern and the phenomenon of air bronchogram in the indicated areas were not determined. During phonation of the child, no flickering artifact was

observed in the zones of destruction and infiltration of the pulmonary parenchyma. The course of the inflammatory process was favorable, the foci of destruction of the pulmonary parenchyma themselves did not require surgical intervention, the repair process took place against the background of massive infusion and polyantibiotic therapy. However, the majority of children in this group (46 out of 92) also had pleural complications that required sanitation.

The zone of compaction of the lung tissue during echography visualized small areas of slightly increased echogenicity, in the center of which anechoic inclusions with an indistinct contour then appeared, which were surrounded by an echo-positive rim. Such areas were often multiple and were also developing foci of destruction.

On the MRI apparatus, 1.5T were visualized as an irregularly shaped area with uneven, indistinct contours, and an inhomogeneous structure. The intensity of the destructive area was weakly hypointense in the T1 and T2 modes (which corresponded to the zone of parenchymal compaction), weakly iso-hyperintense in the STIR mode. Large foci of destruction of lung tissue also did not have a clear X-ray picture until transbronchial drainage occurred and a typical level of fluid in the abscess cavity appeared.

In the case of a lung abscess, echographic imaging was possible in 100% of cases.

Infiltrative changes were characterized by pronounced darkening of the pulmonary field in the projection of the abscess and "sagging" of its lower contour. At the same time, during ultrasound, undrained abscesses were clearly visualized in the form of irregularly rounded foci with hypoanechoic structureless avascular contents. More often destructive changes were observed in the 6th segment.

With the help of ultrasound, we visually traced the echographic dynamics of the lung abscess and identified the echographic stages of the formation of the lung abscess.

At the first stage of abscess formation, destruction of the pulmonary parenchyma was observed, it was characterized by a rounded or irregular shape of the focus, the absence of its clear boundaries and capsule, and an inhomogeneous structure, which was associated with the process of the incipient melting of the lung tissue. Such lesions were multiple, small, ranging in size from 2 to 10 mm in 8 (47.0%) children in diameter. In 3 (17.6%) cases, the destruction focus was anechoic; dynamic ultrasound showed its increase in size, the appearance of a capsule along the periphery and suspension in the lumen.

The second stage of formation (non-draining lung abscess) was echographically visualized as an anechoic formation of a rounded shape with clear even contours with a hyperechoic suspension in the lumen (pus). The capsule along the periphery of the abscess had clear boundaries, hyperechoic structure, 1.0-1.5 mm thick in 16 (94.1%) children.

Ultrasound visualization of abscesses draining in the bronchi (the third stage of formation) became significantly difficult due to the appearance of air in it, which has a shielding effect in 5 (29.4%) children ($p < 0.005$), but a hypoechoic rim 7 was determined (41, 1%) around the abscessed area.

The stage of abscess resolution was characterized by complete release of the focus from pus and obliteration of the cavity, followed by resorption. During dynamic ultrasound examination in the abscess cavity, the amount of fluid gradually decreased, the volume of hyperechoic masses (fibrin) along the inner surface of the capsule increased, this stage was recorded in 6 (36.3%) children ($p < 0.005$).

Pulmonary abscesses appeared on digital radiography in the form of cavities that could arise in areas of consolidation or were isolated.

When analyzing the results of X-ray and MSCT studies with the main forms of lung tissue damage, a decrease in density in the center of the infiltrate, a drained cavity with a horizontal fluid level, an air cavity with unevenly thickened walls were revealed.

In the initial phase of the process of AL formation in children, massive compaction of lung tissue was observed in 10 (58.8%) children with X-ray and 15 (88.2%) children with MSCT; MRI did not reveal statistically significant differences ($p = 0.002$). In most cases, the infiltrate was located in the peripheral parts of the lung tissue and was adjacent to the costal pleura. In 8 children, the process was of a polysegmental nature, this phenomenon was determined by digital radiography in 5 (62.5%>), by MSCT and MRI in 6 patients (75.0%).

On radiography, a rounded form of infiltrate, with the presence of an increase in density in its center, was observed in 6 (35.2%>) patients on radiographs, in 8 (47.0%) children with complex echography, in and with MSCT in 8 (47, 0%>) patients, respectively ($p = 0.105$).

In the subsequent phase of the development of a lung abscess, a decrease in density in the center of the infiltrate was observed in 1 (5.8%) patients with radiography, in 3 (17.6%) children with complex echography, in 9 (52.9%) children with MRI and 4 (23.5%>) with MSCT. Further, due to the melting of the infiltrate tissue, a decrease in density in its center to liquid was determined. The liquid occupied almost the entire volume of the abscess, which was visualized by X-ray examination in 2 (11.5%) children, in 16 (94.1%) children with complex echography, in 14 (82.3%) children with MRI and MSCT in 14 patients (82.3%>). In 4 (23.5%>) patients with MSCT and MRI, a symptom of sagging of the interlobar pleura was noted, which was not found on radiographs and echotomograms.

After emptying the abscess in the bronchus, an air cavity was determined, as a rule, of an irregular shape, with unevenly thickened walls.

The contours of the cavity in most cases were not clear due to perifocal inflammatory infiltration of the lung tissue. These signs were observed in 13 (76.8%) patients with X-ray, in 5 (29.4%) with complex echography, in 16 (94.1%) children with MRI and 15 (88.2%) with MSCT- research. The walls of the cavity were uneven in thickness, with a "bay-like" inner outline. The draining bronchus was visualized. After the rejection of necrotic masses and the formation of an abscess capsule, the cavity assumed a more or less regular rounded shape, uniform wall thickness and smooth, clear internal contours. The sizes of the decay cavities varied from 8 mm to 40 mm.

Cavities communicating with each other were visualized on X-ray in 2 (11.7%) children, on MRI and MSCT studies in 4 (23.5%) children, with complex ultrasound it was not possible to detect this symptom. In the lung tissue adjacent to the abscess capsule, as a rule, infiltrative changes were visualized.

The outcome of a lung abscess in 3 (17.6%) children was the formation of cicatricial changes and in 4 (23.5%) children the formation of a residual air cavity-cyst, in 10 (58.9%) children complete recovery of lung tissue was determined during the period of reconvalescence ...

In our study, MRI revealed significantly more lung abscess cavities in the infiltration phase than digital radiography. This indicated that digital radiography could reveal larger cavities and abscesses, but minor changes could be missed. These results are consistent with previous studies and provide additional evidence that MRI is superior to digital radiography in detecting lung abscess and necrosis.

The severity of morphological findings was more efficiently assessed on MRI at baseline and at follow-up, which was underestimated on X-ray. Intra- and interpleural tissues were also better visualized on MRI, indicating a higher diagnostic confidence.

When using additional ultrasound, the detection of abscess increased to 85.6%. However, the visualization of the abscess was higher on MRI, although the difference was no longer significant. The reason for this was that in order to identify a pathological focus by ultrasound, the consolidation site had to be located subpleurally and be found in the intercostal space. With a multimodal combination of digital radiography and ultrasound, it has a high sensitivity to peripheral abscesses within consolidations, whereas central parts of the lung and abscesses without large consolidations can be difficult to assess. On MRI, the abscess wall usually appeared hypointense compared to fluid, had an isointense abscess center, and was clearly identified on T2-weighted images.

In the clinical context, the diagnosis of lung abscess formation is important because it appears to be associated with a higher ICU admission rate and also carries the risk of bronchopleural fistulas, which usually require surgery. In addition to detection, it is also important to reliably assess the response to treatment with conservative therapy.

However, the sensitivity of MRI to an abscess decreased from 83.3% to 66.7% with a decrease in its size, while it did not change with CR, which means that CR assessment becomes more difficult with a decrease in the size of an abscess. With the formation of large-focal destruction, i.e. abscess in the phase of compaction (consolidation) of lung tissue, MRI and MSCT had the best informational content. With the prevalence of induration in the pulmonary field, there was no significant difference between MRI and CR, while the severity of consolidation was assessed higher on MRI. On follow-up, the prevalence of induration was unchanged on MRI, with CR it decreased by -25%, scores for consolidation were significantly reduced on MRI and opacification on radiography.

Thus, MRI did not show significant benefits in assessing consolidation, so there is no real benefit from MRI compared to CR for consolidation.

With the help of ultrasound, it was possible to visually trace the echographic dynamics of a lung abscess and determine the echographic stages of the formation of a lung abscess, mainly parietally located, but with deeply located peri-root formations, the sensitivity of the ultrasound method decreased compared to radiography, MRI and MSCT.

4. CONCLUSIONS

Thus, the results of our study showed that the use of high-tech methods of radiation examination significantly increases the accuracy of diagnosing lung lesions with complications of pneumonia at different stages of examination and treatment of patients. The multimodal application of radiation methods in the diagnosis of pulmonary complications of pneumonia makes it possible to expand the possibilities of detecting and assessing the prevalence of the process in the lung parenchyma. Combined data analysis makes it possible to increase the sensitivity and specificity of each of these methods and make an accurate diagnosis.

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