Research on the clinical value of ultrasound diagnosis of neonatal respiratory distress syndrome

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Research Article

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Abstract

Background To explore the diagnostic value of ultrasound in neonatal respiratory distress syndrome.

Method The clinical data of 96 neonatal respiratory distress syndrome cases treated in our hospital from July 2015 to October 2017 were retrospectively analysed. According to the results of chest X-ray examinations, the patients were divided into the mild group (55 cases) and severe group (41 cases). All children were required to undergo ultrasound examination before treatment, 12 hours after treatment and 24 hours after treatment. The ultrasound findings and ultrasound scores were compared between the two groups.

Result The ultrasound score in the mild group was lower than in the severe group ($P < 0.05$). There was no significant difference in the ultrasound score between the pulmonary surfactant (PS) treatment group and the non-PS treatment group before treatment ($P > 0.05$). The ultrasound score of the non-PS treatment group was higher than the PS treatment at each time after treatment ($P < 0.05$).

Conclusion Ultrasound can effectively evaluate the severity of neonatal respiratory distress syndrome. In addition, ultrasound scores can be used as an important index for evaluating and quantifying the severity of neonatal respiratory distress syndrome.

Introduction

Respiratory distress syndrome is a common and critical condition in neonates, mostly caused by immature lung development, lack of pulmonary surfactant (PS) and low synthesis of alveolar type II epithelial cells, which is one of the critical factors leading to high neonatal mortality [1–3]. For a long time, the clinical diagnosis of this disease has been based on the typical clinical manifestations of the child and chest X-ray examination, the former of which has a high rate of misdiagnosis, while the latter is susceptible to the limitation of factors, such as the child's position and environment and the difficulty to perform at the bedside within a short period [4]. Therefore, it is vital to find an effective diagnostic tool for this disease. In this paper, the diagnostic value of ultrasound in neonates with respiratory distress syndrome was further investigated, which is reported as follows.

Data And Methods

1.1 General Information

The clinical data of 96 cases of neonatal respiratory distress syndrome treated in our hospital from July 2015 to October 2017 were retrospectively analysed, and the children were divided into the mild (55 cases) and severe (41 cases) groups based on chest X-ray findings, in which X-ray grades I–II belonged to mild respiratory distress syndrome and X-ray grades III–IV belonged to severe respiratory distress syndrome. In the mild group, there were 35 males and 20 females; among them, there were 26 preterm infants with gestational ages ranging from 25 to 36 ± 5 weeks and 29 full-term infants with gestational

ages ranging from 37 + 1 to 41 + 5 weeks. For the mode of delivery, 24 cases were delivered spontaneously, and 31 cases were delivered by caesarean section. In the severe group, there were 26 males and 15 females; among them, there were 30 preterm babies with gestational ages ranging from 21 to 33 ± 5 weeks, and 11 full-term babies with gestational ages ranging from 38 to 40 + 5 weeks. For the mode of delivery, there were 15 cases of natural delivery and 26 cases of caesarean delivery. Statistical comparison of the general data of both groups (gender, gestational age, delivery method) showed no statistically significant differences ($P > 0.05$), which were comparable.

Inclusion criteria: (1) the presence of characteristic changes of respiratory distress signs on chest X-ray, such as ground glass-like changes, reduced translucency of both lungs, and bronchial inflation signs; (2) the presence of symptoms, such as progressive dyspnoea, nasal agitation and pale skin; (3) arterial blood gas analysis suggesting hypercapnia and/or hypoxemia. Exclusion criteria: (1) combined with infectious diseases such as infectious pneumonia; (2) those with severe congenital heart disease; (3) those who have received prophylactic use of PS; (4) those with severe organic lesions.

1.2 Inspection Method

The test instrument was a LOGIQ E9 colour ultrasound diagnostic instrument (GE Medical Systems Trade & Development (Shanghai) Co., Ltd.), and the probes were selected from high-frequency micro-convex probes and high-frequency linear array probes. Pulmonary ultrasound examinations were performed before, 12 h after and 24 h after treatment. The child was placed in the dorsal and prone positions in a calm state. If the lung ultrasound images were unclear, the child would be placed in the lateral position. The lung areas in the anterior (between the sternum and anterior axillary line), lateral (between the anterior and posterior axillary lines) and posterior (between the posterior axillary line and the spine) caudal-cranial directions were examined. Each lung was divided into six regions (upper and lower regions of the anterior, posterior and lateral sections), for a total of 12 regions. A transverse sweep was performed using the probe, first along the child's intercostal space, starting from the second intercostal space, in a top-to-bottom and left-to-right principle, followed by a longitudinal sweep by rotating the probe perpendicular to the intercostal space. During this procedure, detailed documentation and preservation of the ultrasound signs viewed in each region were required. The lung ultrasound was also scored; for each lung region, a score of 0–3 was given (total score ranges from 0–36). A-lines were part of the normal lung sign and were repetitive artifacts parallel to the pleural line. The spacing between a-lines was equal to the distance from the skin to the pleural line. The presence of a-lines without a lung sliding sign suggested the presence of a pneumothorax. B-lines were vertical echogenic comet-tail artifacts that indicated fluid-filled interstitium and alveolar spaces, and they were often associated with a loss of lung ventilation and an increase in lung water. Type A (defined by the presence of only a-lines or the presence of a-lines <3 b-lines) was scored as 0, type B (defined by the presence of ≥3 well-spaced b-lines) was scored as 1, severe type B (defined by dense and combined b-lines, with or without consolidation, confined to the subpleural space [alveolar interstitial syndrome]) was scored as 2, type C (some pulmonary consolidation, do not have air bronchograms, and are punctate and look like beaches, some pulmonary consolidation present as bronchial inflation signs, pleural effusion and pulmonary pulsation:

a sign of complete pulmonary atelectasis, a manifestation of the heart transmitting vibrations through the resting lungs) was scored as 3 [5,6].

1.3 Statistical Methods

SPSS 18.0 software was used for data processing, and the measurement data were expressed as $\bar{x} \pm s$, and the t-test was used. $P < 0.05$ was considered statistically significant.

Results

2.1 Ultrasound Findings

In the mild group of 55 children, the X-ray showed a mild reduction in the transmittance of both lungs, with some children having a clear heart shadow and some having a slightly blurred heart shadow (Figure 1a). Those with clearer heart shadows were classified as grade I RDS changes, and those with slightly blurred heart shadows were classified as grade II RDS changes (Figure 1a). The children in the mild group showed small subpleural focal pulmonary consolidation with alveolar interstitial syndrome and strong bronchial inflation signs on ultrasound. Their a-lines disappeared, and pleural lines were more blurred (Figure 1b). No lung sliding sign was observed by real-time ultrasound, but a lung pulsation sign was visible. During the recovery process of 42 children in this group after PS treatment, their ultrasound showed the disappearance of small subpleural focal pulmonary solids, the pulmonary edema and bronchial inflation signs had disappeared, and the a-line and the pleural line had gradually returned to normal form, in which normal lung tissue could be seen (Figure 1c). In the severe group of 41 children, X-ray showed significantly reduced transmittance of both lungs. Some children had blurred heart shadow, but the outline could be distinguished, and some children had indistinct heart shadow outline (Figure 1d). Those with distinguishable heart shadows were classified as grade III RDS changes, and those with indistinct heart shadows were classified as grade IV RDS changes (Figure 1d). All children in the severe group showed a large consolidation shadow in the lung field, with severe alveolar interstitial syndrome and obvious bronchial inflation signs. A small amount of pleural fluid was seen in some children, and the a-line and pleural lines were completely absent in all children (Figure 1e). On real-time ultrasound, no lung sliding sign was seen, and a lung inflation sign was visible. During the recovery process of the 30 children in this group after PS treatment, the ultrasound showed a gradual reduction of the pulmonary consolidation, disappearance of the effusion in the children with pleural effusion, relief of the bronchial inflation sign and reduction of pulmonary edema. In some children, the alveolar interstitial syndrome was still visible in some areas of examination, the a-line was visible in the intercostal space in some areas, and the pleural line appeared and showed blurring and thickening (Figures 1f,g).

2.2 Ultrasound Scoring

The pre-treatment lung ultrasound score was 18.26 ± 5.39 in the mild group, which was lower than 27.66 ± 4.17 in the severe group, with a statistically significant difference ($t = 9.282$, $P = 0.000$).

2.3 Judgment of the Effect of PS Treatment by Ultrasound

Among the 96 children, a total of 72 children received PS treatment, including 42 cases in the mild group and 30 cases in the severe group. Before treatment, there was no statistically significant difference between the ultrasound scores of PS-treated and non-PS-treated children in each group ($P > 0.05$). After treatment, the ultrasound scores of non-PS-treated children in each group were higher than those of PS-treated children at all times, and the difference was statistically significant ($P < 0.05$), as shown in Table 1.

Discussion

Neonatal respiratory distress syndrome is a common type of pulmonary disease during childhood growth. The typical physiological changes of this disease are an imbalance of pulmonary ventilation/blood flow ratio, pulmonary atelectasis and poor alveolar inflation [7]. Numerous studies have confirmed that PS replacement therapy is an effective treatment for children with this disease, and it is effective in reducing the incidence of complications as well as the morbidity and mortality rate [8]. Therefore, early detection and diagnosis of this disease, timely administration of PS therapy and dynamic evaluation of the effects of PS therapy are particularly important.

Chest radiography has high diagnostic sensitivity and reliability in children with neonatal respiratory distress syndrome. The chest radiographic changes can be classified into four grades according to the progression and severity of the disease [9,10]. Relevant literature has indicated that there is a close correlation between PS and the grading of the child's chest X-ray; that is, the more deficient the PS, the more severe the child's chest radiograph findings [11,12]. Therefore, this examination method is an important method for clinical evaluation of the efficacy of exogenous PS in the treatment of neonatal respiratory distress syndrome, but its use is limited by its drawbacks, such as radiological damage. At this stage, scholars at home and abroad have studied the application of pulmonary ultrasound in various aspects and gradually applied it in clinical practice, and satisfactory results have been achieved in predicting bronchopulmonary dysplasia, diagnosing pulmonary atelectasis, diagnosing pulmonary edema and evaluating acute respiratory distress syndrome [13–15]. In addition, an increasing number of studies have confirmed that ultrasound can make reasonable and accurate judgments of a variety of pulmonary diseases in neonates, such as neonatal wet lung, pneumothorax, pulmonary atelectasis and infectious pneumonia. The results of our study showed that the lung ultrasound scores in the mild group were lower than those in the severe group, and the lung ultrasound scores in all groups of non-PS-treated children were higher than those in PS-treated children at all times after treatment, suggesting that ultrasound is an essential tool for diagnosing neonatal respiratory distress syndrome, and the higher the ultrasound score, the more severe the respiratory distress in the child. Consistent with the pathological changes of the children, when their pulmonary ventilation in the body was reduced, ultrasound showed massive fusion of b-lines, that is, alveolar interstitial syndrome. When the lungs became variable, ultrasound showed parenchymal changes in the liver, and when the children inhaled, dot-like

hyperechogenicity was observed, that is, bronchial inflation sign. The severity of the disease, as evidenced by the different degrees of pulmonary edema and the extent of pulmonary consolidation, varies with the lack of PS in the alveoli of children with this disease, resulting in various degrees of pulmonary atelectasis. After PS treatment, the lung tissue air content and alveolar recruitment would be significantly improved in children, and with the improvement of the condition, bronchial inflation sign, lung parenchyma and pulmonary edema could be gradually reduced or cleared by ultrasound. In addition, ultrasound has the advantages of being repeatable, safe, non-invasive, and there is no radiation and no need to move the child and it is not restricted by the environment and space, making it more acceptable to the child.

Conclusion

In conclusion, ultrasound is an effective tool for the diagnosis of neonatal respiratory distress syndrome, which facilitates dynamic observation of the effect of PS treatment, and can be used as an alternative to chest X-ray.

Abbreviations

PS
pulmonary surfactant

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the declaration of Helsinki.This study was conducted with approval from the Ethics Committee of Xuzhou Central Hospital (No.: XZY-LJ-20150510-104).Written informed consent was obtained from all parents/local guardians.

Competing Interest

The authors declare that they have no competing interests.

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Author Contributions

H L have made substantial contributions to conception and design, H L acquisition of data, analysis and interpretation of data; H L have been involved in drafting the manuscript and revising it critically for important intellectual content; H L have given final approval of the version to be published.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Consent for publication

Written informed consent was obtained from the patient for publication of this case report and accompanying images

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Tables

Table 1 Comparison of ultrasound scores (*±s*, points)

Group		Before treatment	12h after treatment	24h after treatment
Mild group (n=55)	PS treatment (n=42)	18.32±3.11	11.51±3.32[a]	7.42±1.93[a]
	Non-PS treatment (n=13)	18.19±3.57	16.43±3.71	14.84±3.62[a]
	t	0.127	4.543	9.667
	P	0.899	0.000	0.000
severe group (n=41)	PS treatment (n=30)	27.63±4.13	21.34±3.34[a]	13.53±2.71[a]
	Non-PS treatment (n=11)	27.31±3.82	25.21±3.14	21.56±3.44[a]
	t	0.224	3.337	7.816
	P	0.824	0.002	0.000

Note: Compared with pre-treatment, *aP* < 0.01

Figures

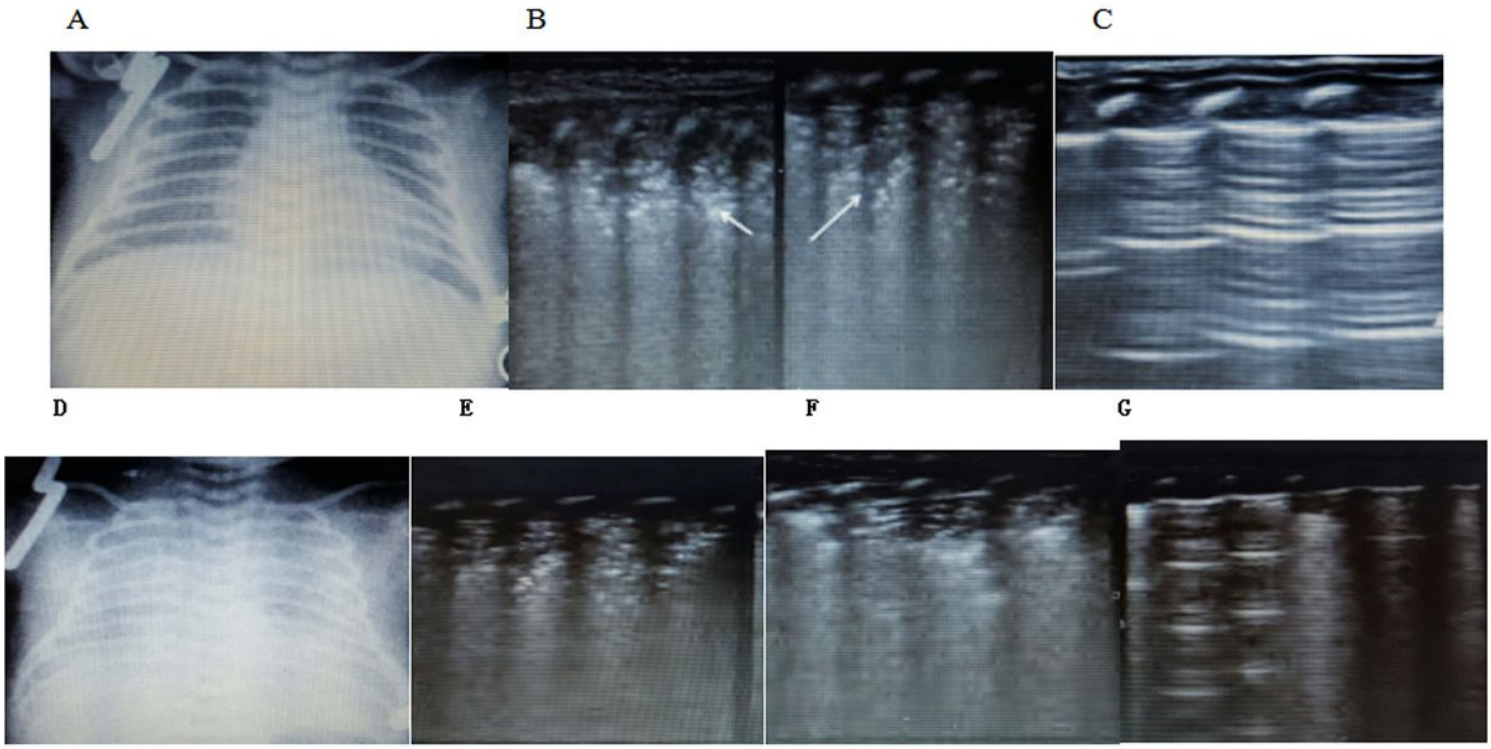

Figure 1

a. X-ray chest film showing grade II RDS changes; b. Ultrasound performance before PS treatment; c. Ultrasound performance 24 hours after PS treatment; d. X-ray chest radiograph showing grade IV RDS changes; e. Ultrasound performance before PS treatment; f. Ultrasound performance at 12h after PS treatment; g. Ultrasound performance at 24h after PS treatment