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Study on the Value of Bedside Brain Ultrasound Examination in Early Diagnosis of Brain Tissue Injury in Neonates with Intrauterine Distress

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Abstract: *Objective*: To analyze the value of bedside cranial ultrasonography in the early diagnosis of neonatal brain tissue injury in intrauterine distress. *Methods*: 128 neonates with suspected intrauterine distress admitted to the Yichang Central People's Hospital from January 2023 to December 2024 were selected as study subjects based on the inclusion and exclusion criteria, and all subjects underwent bedside craniocerebral ultrasonography and MRI, and the results of MRI were used as the gold standard to divide the infants into the brain-injury group (n = 31) and the no-brain-injury The children were divided into brain injury group (n = 31) and no brain injury group (n = 97), and the value of bedside cranial ultrasonography for early diagnosis of brain tissue injury in neonates with intrauterine distress was analyzed. *Results*: (1) Among the 128 cases of intrauterine distress neonates, 31 cases were examined for abnormal signs, including 22 cases (70.97%) examined by bedside craniocerebral ultrasonography and 28 cases (90.32%) examined by MRI. (2) Bedside cranial ultrasound detected hypoxic-ischemic encephalopathy in 6 cases, accounting for 4.69%, ventricular widening in 2 cases, accounting for 1.56%, intracranial hemorrhage in 8 cases, accounting for 6.25%, periventricular softening of white matter in 5 cases, accounting for 3.91%, and cerebral edema in 1 case, accounting for 0.78%, while MRI detected hypoxic-ischemic encephalopathy in 9 cases, accounting for 7.03%. 3 cases of ventricular widening, accounting for 2.34%, 4 cases of intracranial hemorrhage, accounting for 3.13%, 9 cases of periventricular-intraventricular white matter softening, accounting for 7.03%, and 3 cases of cerebral edema, accounting for 2.34% were examined. Among them, the detection rate of periventricular-intraventricular hemorrhage by bedside cranial ultrasound was significantly higher than that of MRI ($P < 0.05$). *Conclusion*: The diagnostic value of bedside cranial ultrasound in periventricular-intraventricular hemorrhage is high, but the diagnostic value is not as good as that of MRI in other brain tissue injuries, and clinically appropriate examination protocols can be selected according to the specific types of craniocerebral injuries.

Keywords: Bedside cranial ultrasound; Diagnosis of intrauterine distress; Neonate; Brain tissue injury

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1. Introduction

The neonate is the early stage of a child's life and the life stage with the highest child mortality rate. With the development of intensive care and therapeutic techniques, the survival rate of critically ill neonates and very preterm infants has increased significantly, but at the same time the incidence of neurologic injury in the neonatal population is on the rise. Neonatal brain injury refers to non-progressive brain injury, including congenital brain underdevelopment and central nervous system dysfunction left by trauma, which can be manifested as behavioral neurodevelopmental abnormalities, central movement disorders, mental retardation, etc., and brain injury in preterm infants is most commonly seen in the clinic [1]. When neonates suffer from brain injury, they may have serious clinical symptoms, such as frequent spitting up, poor sleep, abnormal crying, and even convulsions, which may affect their intellectual and physical development in severe cases, which not only seriously affects the quality of life of the affected children, but also brings a heavy burden to the families and the society, therefore, early identification and timely intervention are crucial for the poor prognosis of neonatal brain injury [2]. There are many causes of neonatal brain injury, including birth injury, intracranial infection, and gestational hypertension, among which intrauterine distress is one of the more common causes. Intrauterine distress triggers neonatal brain tissue injury, mainly from fetal hypoxia and ischemia in utero. In utero, conditions such as abnormal placental function, umbilical cord prolapse, and tightening of the umbilical cord around the neck can impede the delivery of oxygen and nutrients from the mother to the fetus [3]. When the fetal blood oxygen supply is insufficient, it will prioritize the blood supply to vital organs such as the heart and brain to maintain basic life activities. However, prolonged and severe hypoxia will break this compensatory mechanism and lead to insufficient cerebral blood perfusion [4]. At the same time, hypoxia will lead to enhanced anaerobic fermentation and lactic acid accumulation, causing metabolic acidosis and further aggravating brain tissue injury. In addition, the reperfusion phase after hypoxia-ischemia will produce a large number of oxygen free radicals, which attack cell membranes, proteins, and nucleic acids, triggering oxidative stress and damaging the blood-brain barrier, leading to serious pathological changes such as cerebral edema and intracranial hemorrhage, and ultimately resulting in irreversible damage to the neonatal brain tissues and affecting neurological development [5]. Therefore, timely bedside cranial ultrasound examination of neonates with intrauterine distress is crucial.

As a practical medical diagnostic technology, bedside cranial ultrasound diagnosis of neonatal brain tissue injury has obvious advantages, it is easy to operate, without the need to transfer the child to a special examination room, can be carried out at the bedside, especially for the critical condition of neonates in intensive care wards, not suitable for moving, and can obtain the diagnostic information in a timely manner [6]. Moreover, cranial ultrasound takes the unclosed fontanel of newborns and infants as the acoustic window, and applies ultrasound imaging technology to scan intracranial structures, which is able to obtain diagnostic information on cranial and cerebral anatomy and pathology, as well as blood flow, and clearly display common injuries such as intraventricular hemorrhage, ventricular dilatation, and parenchymal lesions, which can help to intervene in a timely manner, and gain valuable time for clinical diagnosis and treatment, and play an irreplaceable role in the early screening, diagnosis, and subsequent monitoring of neonatal brain tissue injuries. It plays an irreplaceable and important role in the early screening, diagnosis, and follow-up monitoring of neonatal brain tissue injury [7].

In view of this, this study selected 128 cases of neonates with suspected intrauterine distress admitted to the Yichang Central People's Hospital from January 2023 to December 2024 as the study subjects, aiming to analyze the value of bedside cranial ultrasonography for the early diagnosis of intrauterine distress neonatal brain tissue injury.

2. Data and methods

2.1. Clinical data

According to the inclusion and exclusion criteria, 128 cases of neonates with suspected intrauterine distress admitted to the Yichang Central People's Hospital from January 2023 to December 2024 were selected as the study subjects. According to the diagnostic results, they were divided into brain injury group (n=31) and no brain injury group (n=97), and there was no significant correlation between the baseline data of the two groups of children ($P > 0.05$), as shown in **Table 1**. The study was approved by the Ethics Committee of the hospital.

Table 1. Comparison of baseline data of children in two groups

Group	Number of cases	Male/female	Mean gestational age (weeks)	Average birth weight (kg)
Brain injury group	31	14/17	37.78 inju	3.048 inj
No brain damage group	97	45/52	38.12ain d	3.422ain
X^2/t value		0.014	0.406	1.878
P-value		0.905	0.686	0.065

2.2. Inclusion and exclusion criteria

2.2.1. Inclusion criteria

(1) Meeting the diagnostic criteria of intrauterine distress in Obstetrics and Gynecology [8].
(2) Perfect clinical data of the child.
(3) Single fetus.
(4) Gestational age of 37–42 weeks.
(5) Informed consent of the family of the child.

2.2.2. Exclusion criteria

(1) Combined congenital disabilities.
(2) The presence of genetic diseases in the mother.
(3) Brain damage caused by trauma.
(4) The child can not cooperate with the completion of MRI examination.
(5) The presence of congenital neurological malformations.

2.3. Examination methods

All newborns underwent bedside cranial ultrasonography and MRI examination. Bedside cranial ultrasonography: In the supine position under the quiet or sleep state, the doctor used a high-frequency ultrasonic probe to scan the cranium and brain through the fontanels of the anterior fontanel, posterior fontanel and lateral fontanel of the newborns, including the sagittal, coronal and transverse planes, to observe the brain parenchyma, the brain ventricular system, the brain midline structure and so on, and to detect the existence of brain tissue injuries.

2.3.1. MRI examination

(1) Before the examination, make sure that the newborn is free of metal implants.
(2) During the examination, lie supine in the supine position.
(3) Use the Philips 1.5T MRI scanner to perform various sequences of scanning, such as T1WI, T2WI, etc.,

and observe the transverse axial T_1WI, transverse axial T_2WI, sagittal T_1WI, transverse axial FLAIR from different perspectives and levels.

2.4. Observation indexes

(1) Diagnostic results of brain tissue injury in neonates with intrauterine distress by different examination methods.

(2) Specific types of brain tissue injury diagnosed by different examination methods.

2.5. Statistical analysis

Data were analyzed using SPSS26.0 software, and for count data, they were expressed in the form of %, and the correlation between groups was explored with the help of the X^2 test or *Fisher's* exact probability method; for the metrological data that conformed to the normal distribution, this study presented them in the form of ($\bar{x} \pm s$), and the significance of the differences was assessed by t-tests, and the threshold value of $P < 0.05$ as a criterion for determination, indicating that significant differences are meaningful in statistical tests.

3. Results

3.1. Comparison of the diagnostic results of different examination methods for brain tissue damage in neonates with intrauterine distress

The results showed that among 128 cases of intrauterine distress neonates, 31 cases were examined with abnormal signs, among which 22 cases were examined with abnormal signs by bedside cranial ultrasound, accounting for 70.97%, and 28 cases were examined with abnormal signs by MRI, accounting for 90.32%, as shown in **Table 2**.

Table 2. Comparison of the diagnostic results of different examination methods for brain tissue injury in neonates with intrauterine distress

Inspection methods	Examination of abnormalities [n (%)]
Bedside cranial ultrasound	22 (70.97)
MRI	28 (90.32)

3.2. Specific types of brain tissue injury diagnosed by different examination methods

The results showed that bedside cranial ultrasound detected hypoxic-ischemic encephalopathy in 6 cases, accounting for 4.69%, ventricular widening in 2 cases, accounting for 1.56%, intracranial hemorrhage in 8 cases, accounting for 6.25%, periventricular white matter softness in 5 cases, accounting for 3.91%, and cerebral edema in 1 case, accounting for 0.78%; MRI detected hypoxic-ischemic encephalopathy in 9 cases, accounting for 7.03%, and ventricular widening in 3 cases, accounting for 2.34%. In MRI, 3 cases of ventricular widening were detected, accounting for 2.34%, 4 cases of intracranial hemorrhage were detected, accounting for 3.13%, 9 cases of periventricular-intraventricular white matter softening were detected, accounting for 7.03%, and 3 cases of cerebral edema were detected, accounting for 2.34%. Among them, the detection rate of periventricular-intraventricular hemorrhage by bedside cranial ultrasound was significantly higher than that of MRI ($P < 0.05$), as shown in **Table 3**.

Table 3. Specific types of brain tissue injury diagnosed by different examination methods

Examination methods	Hypoxic-ischemic encephalopathy	Ventricular widening	Periventricular-intraventricular hemorrhage	Periventricular white matter softening	Cerebral edema
Bedside cranial ultrasound (n = 128)	6 (4.69)	2 (1.56)	8 (6.25)	5 (3.91)	1 (0.78)
MRI (n = 128)	9 (7.03)	3 (2.34)	4 (3.13)	9 (7.03)	3 (2.34)
X^2Value	2.306	0.706	13.000	1.132	0.001
P-value	0.129	0.401	0.000	0.287	0.970

4. Discussion

Fetal intrauterine distress refers to acute or chronic hypoxia of the fetus in the uterus due to various factors, and symptoms that jeopardize the health or even the life of the fetus. It is also divided into acute fetal distress and chronic fetal distress. Acute fetal distress mainly occurs during labor and delivery, and once the signs of acute fetal distress are found, measures should be taken decisively to improve fetal hypoxia. Chronic fetal distress mainly occurs in the late stage of gestation, and is mostly attributed to hypertensive disorders of pregnancy, chronic nephritis, and diabetes mellitus, etc. [9]

The pathophysiology of intrauterine fetal distress is based on a series of changes caused by ischemia and hypoxia. In the initial stage of ischemia and hypoxia, due to the accumulation of carbon dioxide in the fetal body, respiratory acidosis occurs, sympathetic nerve excitation, increased secretion of adrenal catecholamines and cortisol, resulting in increased blood pressure, increased heart rate, and redistribution of blood in the fetal body [10]. At this time, the heart, brain, and adrenal gland vasodilatation, blood flow increases, and other organs vasoconstriction, blood flow decreases. When hypoxia is aggravated, myocardial inhibition is obvious, and cardiac function is not compensated, leading to brain cell damage, which in turn causes brain tissue damage, mental retardation, and many other neonatal complications. Therefore, how to detect and correctly diagnose fetal distress at an early stage is an important topic in perinatal medicine and an eternal topic in obstetrics.

Bedside cranial ultrasound uses the unclosed fontanel of newborns and infants as an acoustic window, and applies ultrasound imaging technology to scan intracranial structures, obtaining diagnostic information on cranio-cerebral anatomy and pathoanatomy, as well as blood flow [11]. Its ability to suggest the location, type, and extent of intracranial lesions has made it the modality of choice for neonatal brain tissue injury. At present, regarding the diagnosis of neonatal brain tissue injury, or internal and external has been carried out in a number of hospitals bedside craniocerebral ultrasound examination, its examination mode and operation practice has become a recognized standard of judgment. The value of bedside cranial ultrasonography in the diagnosis of neonatal brain tissue injury in intrauterine distress in this study is summarized below.

This study found that the detection rate of MRI for the diagnosis of hypoxic-ischemic encephalopathy, ventricular widening, periventricular white matter softening, and cerebral edema was higher than that of bedside cranial ultrasound; and the detection rate of bedside cranial ultrasound for periventricular-intraventricular hemorrhage was significantly higher than that of MRI ($P < 0.05$). The reason may be that ultrasound has higher sensitivity to hyperechoic hemorrhagic lesions. The acute phase of hemorrhage in PIVH manifests as a strong echogenic mass within the ventricles, and ultrasound can directly observe the location, extent, and echogenic features of the hemorrhage through the fontanelle transillumination window, which is especially advantageous for identifying small hemorrhages of grade I-II [12, 13]. In contrast, MRI is not sensitive to the display of small amount of bleeding in the acute stage (bleeding ular widening, periventricular white matter softening, and cerebral edema was higher than that of bedside cranial ultrasound; and the detection rate examined in real time at the bedside, which is especially suitable for emergency evaluation of critically ill neonates, and can detect the lesion in time at the early stage of hemorrhage. Whereas MRI examination requires the transfer of the child and is often delayed in neonates due to sedation and life support, which may miss the optimal observation window in the acute stage of hemorrhage [14]. In addition, high-frequency ultrasound probe has higher resolution for small intracerebral hematomas and blood clots, while MRI is more advantageous in displaying ferritin deposits in the late stage of hemorrhage or chronic phase changes, but is not as good as ultrasound in detecting small amounts of hemorrhage in the acute phase, especially in preterm infants with unclosed fontanelles, and it is easier to detect subtle hemorrhagic foci with the real-time dynamic scanning of ultrasound [15].

5. Conclusion

In conclusion, bedside cranial ultrasound has a high diagnostic value in periventricular-intraventricular hemorrhage, but its diagnostic value in other brain tissue injuries is not as good as that of MRI, and clinically appropriate examination protocols can be selected according to the specific type of cranial brain injury.

Disclosure statement

The authors declare no conflict of interest.

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