A Clinical Study of the N-Terminal pro-Brain Natriuretic Peptide in Myocardial Injury after Neonatal Asphyxia

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Background: We aimed to study the changes of serum N-terminal pro-brain natriuretic peptide (NT-proBNP) levels after asphyxia-induced myocardial injury in children and explore the relationship between serum NT-proBNP levels and neonatal asphyxia.

Methods: One hundred and six cases of neonatal asphyxia were randomly selected for the study, including 46 severe cases with myocardial injury and 60 mild cases with no cardiac injury. Sixty-three healthy newborns were selected as the control group. The serum NT-proBNP level was detected using electrochemiluminescence. Creatine kinase MB (CK-MB) and serum sodium and calcium were measured simultaneously.

Results: The serum NT-proBNP level in the myocardial injury group was significantly higher than that of the noncardiac injury and control groups (p < 0.01). Asphyxia serum NT-proBNP and cardiac enzymes were significantly correlated. The median value of neonatal NT-proBNP was 1491 pg/mL at postnatal Day 3 (P3) and 1077 pg/mL at postnatal Day 14 (P14). The cutoff value for children with myocardial injury was 3612.5 pg/mL; the area under the receiver operating characteristic curve was 0.80 (p < 0.001), with a sensitivity of 83.3%, a specificity of 80.5%, a positive predictive value of 82.8%, and a negative predictive value of 79.4%. After treatment, the serum NT-proBNP level in children with myocardial damage showed a significant decrease.

Conclusion: The serum NT-proBNP level can reflect myocardial injury in neonates with asphyxia and can guide its diagnosis.

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Neonatal asphyxia is a common pediatric disease with an incidence of 5–10% in China. Asphyxia causes hypoxia and leads to multiple organ damage, of which heart damage is the most common. Reports show that the occurrence of myocardial damage in neonatal asphyxia was 28–65% or even up to 73%. However, the diagnosis of hypoxic-ischemic myocardial damage has been difficult because of the lack of sensitive laboratory tests for early diagnosis and the absence of standard diagnostic criteria.

Creatine kinase MB (CK-MB), which exists mainly in the cytoplasm of myocardial cells, is currently accepted as an indicator and has high sensitivity and specificity for the diagnosis of myocardial injury. The serum CK-MB level was found to be closely related to the time after myocardial injury; a normal CK-MB level in the first detection does not completely eliminate the possibility of myocardial injury. CK-MB is also present in the bones and brain in small amounts. As a result, we aimed to search for an additional laboratory marker for an early diagnosis of myocardial injury.

Brain natriuretic peptide, or B-type natriuretic peptide (BNP), is a heart peptide hormone. When the tension of a blood vessel increases or its volume is overloaded, preproBNP mRNA is rapidly transcribed in the myocardial cells of the ventricles. PreproBNP is then synthesized and processed to produce a signaling peptide and proBNP. The proBNP is then catalyzed to generate N-terminal (NT-proBNP) and BNP, which are released into the blood.

NT-proBNP has attracted clinical attention as a marker of cardiac function. In recent years, studies in adults have demonstrated that BNP/NT-proBNP is an indicator of left ventricular dysfunction. In heart failure, plasma BNP/NT-proBNP levels increase dramatically according to heart failure severity. In addition, the BNP/NT-proBNP levels are the strongest independent prognostic indicator for death or cardiovascular incidents in patients with heart failure after discharge. In the study of myocardial infarction, an increase in the BNP/NT-proBNP level appears to be correlated with the timing and extent of myocardial infarction. Therefore, the BNP/NT-proBNP level is useful for the detection of chronic ventricular dysfunction in adults and congestive heart failure in patients with breathing difficulty; the BNP/NT-proBNP level is useful for the diagnosis of subclinical asymptomatic patients with left ventricular abnormalities.

However, there are relatively few studies regarding BNP/NT-proBNP in the newborn. NT-proBNP does not pass the blood-placenta barrier; thus, any changes in the baby’s body are autonomous. Myocardial ischemia and energy metabolism dysfunction lead to irreversible damage and even necrosis. Furthermore, during recovery, blood reperfusion can cause further damage to myocardial cells.

Myocardial injury often occurs simultaneously with elevated ventricular tension and a compensatory increase in cardiac output. Particularly, in the event of heart failure, the ventricle is stretched by atrial and ventricular dilatation. At the same time, pulmonary vasodilation stimulates pulmonary and cardiac nerve receptors, regulating the release of BNP. The increase in the vascular BNP/NT-proBNP concentration leads to an increase of the ventricular volume. The elevated blood vessel pressure further induces the synthesis and secretion of BNP. Goetze et al showed that myocardial hypoxia affects ventricular BNP gene expression and increases the plasma BNP/NT-proBNP concentration, suggesting that the elevated plasma BNP/NT-proBNP levels in the acute phase of myocardial injury in children are correlated with acute phase-localized myocardial ischemic injury.

2. Methods

2.1. General information

According to the visit order, every other case was selected from patients who were admitted to our hospital from December 2012 to December 2013 in accordance with the hospital’s neonatal asphyxia standards. A total of 106 cases of neonates <3 days old were selected. We obtained informed consent from the parents or legal guardians of the patients, and this study was approved by the Zhongnan Hospital of Wuhan University Ethics Committee.

According to the Apgar scoring method, we performed 1-minute and 5-minute scores for neonatal asphyxia. When the 5-minute score was <7, we scored the patient every 5 minutes until 20 minutes had passed. Patients with a 1-minute Apgar score of 0–3 were categorized as having severe asphyxia, and patients with a score of 4–7 were categorized as having mild asphyxia according to the clinical presentations of myocardial damage in neonatal asphyxia: (1) history of asphyxia and perinatal hypoxia; (2) clinical manifestations: low, blunt heart sound and tachycardia; ii) poor circulation, demonstrated by a pale complexion, finger cyanosis, or capillary refill time over 3 seconds; iii) heart failure; iv) severe arrhythmias; and v) cardiac arrest; (3) electrocardiogram (ECG) ST-T changes that last for ≥2–3 days; and (4) an increase in serum CK-MB or troponin T. The diagnosis of myocardial injury must satisfy the following: (1) history of asphyxia; (2) low, blunt heart sound and poor circulation; (3) ECG abnormalities; and (4) enzyme abnormalities, as listed above in detail.

In the 106 asphyxia cases, 46 met the diagnostic criteria of myocardial injury. The control group of neonates was admitted in the same period; these neonates did not have asphyxia or neonatal cardiovascular disease. Instead, they had a mild upper respiratory tract infection, omphalitis, or mild diarrhea. Neonates with water and electrolyte balance disorders and kidney dysfunction were excluded from the control group. Gestational age, birth weight, sex, or mode of delivery was not significantly different among the three groups. See Table 1 for the demographic data of all of the cases selected in our study and Table 2 for the clinical manifestations of the patients.

2.2. Methods

We first established a neonatal datasheet that included age, sex, admission time, mode of delivery, birth weight, gestational age, history of fetal distress, and Apgar score. Then, routine ECG and chest X-ray examinations were
performed. A 2 mL blood sample was drawn from the femoral vein of children within 2 hours of admission to the hospital and again on Day 14. The blood sample was mixed with ethylene diamine tetra-acetic acid and centrifuged for 15 minutes at 2500 rpm/min at room temperature. The serum was collected for the detection of CK-MB, serum sodium and calcium, and was stored at \(-70^\circ\)C. The serum NT-proBNP level was measured with an electrochemiluminescence kit (Roche, Shanghai, China), using the Elecsys 2010 instrument. The detection sensitivity was 50 pg/mL and the detection range was 5–35,000 pg/mL.

2.3. Statistics

SPSS version 17 software (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Because the NT-proBNP test results were not normally distributed, we performed a logarithmic transformation and then compared the groups using the Student t test. Multiple groups were analyzed with analysis of variance and were expressed as the mean ± standard deviation. Plasma NT-proBNP and a variety of factors were examined by rank correlation analysis and multiple linear regression. The receiver operating characteristic (ROC) curve was determined by plotting the cutoff value to further clinical diagnosis.

3. Results

We first determined the NT-proBNP level of neonatal children of varying asphyxia degrees at different time points compared with the control group. Within 3 days after birth, compared with the control group, the serum NT-proBNP levels of both severe and mild asphyxia groups were significantly higher than the control group, and the serum NT-proBNP level of the severe asphyxia group was also significantly higher than the mild asphyxia group. However, in the second week after birth, the NT-proBNP level of the severe asphyxia group was not significantly different from the mild asphyxia or control groups (Table 3).

We then examined the serum NT-proBNP level of children with or without cardiac injury at different time points compared with the control group. Three days after birth, the NT-proBNP level of children with cardiac injury was significantly higher than suffocated children without cardiac injury and the control group. Suffocated children without cardiac injury also had higher NT-proBNP levels than the control group. After treatment at 2 weeks, the serum NT-proBNP levels of all three groups were not significantly different from each other (Table 4). Furthermore, the NT-proBNP level in the cardiac injury group was significantly lower than before treatment ($p < 0.05$), but the nonmyocardial injury group and the control group showed no significant difference ($p > 0.05$).

### Table 1: Demographic data of patients and controls.

<table>
<thead>
<tr>
<th></th>
<th>Severe asphyxia group ($n = 44$)</th>
<th>Mild asphyxia group ($n = 62$)</th>
<th>Control group ($n = 63$)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male 22</td>
<td>38</td>
<td>39</td>
<td>0.405</td>
</tr>
<tr>
<td></td>
<td>Female 22</td>
<td>24</td>
<td>24</td>
<td>0.405</td>
</tr>
<tr>
<td>Gestational age (wk)</td>
<td>32–35 16</td>
<td>26</td>
<td>14</td>
<td>0.059</td>
</tr>
<tr>
<td></td>
<td>~37 18</td>
<td>17</td>
<td>27</td>
<td>0.160</td>
</tr>
<tr>
<td></td>
<td>~40 9</td>
<td>17</td>
<td>20</td>
<td>0.434</td>
</tr>
<tr>
<td></td>
<td>~40 1</td>
<td>2</td>
<td>2</td>
<td>0.952</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>1000–1500 11</td>
<td>18</td>
<td>10</td>
<td>0.205</td>
</tr>
<tr>
<td></td>
<td>1501–2500 21</td>
<td>31</td>
<td>28</td>
<td>0.823</td>
</tr>
<tr>
<td></td>
<td>2501–4000 10</td>
<td>10</td>
<td>20</td>
<td>0.120</td>
</tr>
<tr>
<td></td>
<td>~4000 2</td>
<td>3</td>
<td>5</td>
<td>0.691</td>
</tr>
<tr>
<td>Mode of delivery</td>
<td>Natural birth 20</td>
<td>18</td>
<td>17</td>
<td>0.101</td>
</tr>
<tr>
<td></td>
<td>Cesarean section 24</td>
<td>44</td>
<td>46</td>
<td>0.101</td>
</tr>
<tr>
<td>Clinical manifestation</td>
<td>NRDS 52</td>
<td>30</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HIE 13</td>
<td>1</td>
<td>Omphalitis 11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NEC 14</td>
<td>2</td>
<td>Mild diarrhea 17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anemia 38</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Myocardial injury 42</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jaundice 32</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HIE = hypoxic-ischemic encephalopathy; NEC = Necrotizing enterocolitis; NRDS = Neonatal respiratory distress syndrome; URI = Urinary tract infection.

### Table 2: Clinical presentation of patients with cardiac injury.

<table>
<thead>
<tr>
<th>Diagnostic criteria of cardiac injury</th>
<th>No. of cases</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of asphyxia and hypoxia</td>
<td>46</td>
<td>100.00</td>
</tr>
<tr>
<td>Clinical manifestation</td>
<td>46</td>
<td>100.00</td>
</tr>
<tr>
<td>Low, blunt heart sound</td>
<td>46</td>
<td>100.00</td>
</tr>
<tr>
<td>Poor circulation</td>
<td>46</td>
<td>100.00</td>
</tr>
<tr>
<td>Heart failure</td>
<td>13</td>
<td>28.26</td>
</tr>
<tr>
<td>Severe arrhythmia</td>
<td>12</td>
<td>26.09</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>2</td>
<td>4.35</td>
</tr>
<tr>
<td>ECG abnormalities</td>
<td>46</td>
<td>100.00</td>
</tr>
<tr>
<td>Enzyme abnormalities</td>
<td>46</td>
<td>100.00</td>
</tr>
</tbody>
</table>

ECG = electrocardiogram.
In the myocardial injury group, the NT-proBNP levels of children with mild asphyxia and severe asphyxia were significantly different ($T = 2.578$, $p = 0.032$) ($T$: ratio of the difference between the mean of the severe asphyxia group and the mean of the mild asphyxia group over the standard error of the mild asphyxia group). However, the NT-proBNP levels of children with a 5 minute Apgar score $>7$ and $\leq 7$ did not differ significantly ($T = 1.516$, $p = 0.138$).

Because CK-MB is accepted as an indicator for the diagnosis of myocardial injury, we examined its relationship with NT-proBNP. The NT-proBNP level is positively correlated with CK-MB in children with myocardial injury (Spearman correlation, $r = 0.405$, $p = 0.007$). However, the NT-proBNP level was negatively correlated with the serum sodium level (Spearman correlation, $r = -0.342$, $p = 0.025$), but was not correlated with the serum calcium level ($p > 0.05$).

We also determined the NT-proBNP levels in normal neonates of the control group. The serum level of NT-proBNP gradually declines during the first 2 weeks after birth (Table 5).

At present, there is no uniform standard for the normal NT-proBNP range. We used an ROC curve to determine the optimal cutoff value and analyzed the sensitivity, specificity, and positive and negative predictive values. In our study, the NT-proBNP level is very high at birth and then rapidly declines. We set the NT-proBNP cutoff value for neonatal myocardial injury at 3612.5 pg/mL. The area under the ROC curve is 0.80 ($p < 0.001$), the sensitivity is 83.3%, the specificity is 80.5%, the positive predictive value is 82.8%, and the negative predictive value is 79.4% (Figure 1).

### Table 3 NT-proBNP level of neonatal children with varying degrees of asphyxia.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Severe asphyxia group ($n = 44$)</th>
<th>Mild asphyxia group ($n = 62$)</th>
<th>Control group ($n = 63$)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>logNT-proBNP (pg/mL) 3 d</td>
<td>$3.916 \pm 0.194^{*\dagger}$</td>
<td>$3.173 \pm 0.309$</td>
<td>$2.778 \pm 0.495$</td>
<td>85.648</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>2 wk</td>
<td>$2.987 \pm 0.286$</td>
<td>$2.854 \pm 0.309$</td>
<td>3.226</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

* Compared with the mild asphyxia group, $p < 0.05$.
\dagger Compared with the control, $p < 0.05$.

### Table 4 N-terminal pro-brain natriuretic peptide (NT-proBNP) and creatine kinase MB (CK-MB) levels of suffocated children with and without myocardial injury.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Myocardial damage group ($n = 46$)</th>
<th>Noncardiac damage group ($n = 60$)</th>
<th>Control group ($n = 63$)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>logNT-proBNP (pg/mL) 3 d</td>
<td>$3.86 \pm 0.262^{\dagger\ddagger}$</td>
<td>$3.30 \pm 0.317$</td>
<td>$2.78 \pm 0.495$</td>
<td>72.52</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>2 wk</td>
<td>$2.98 \pm 0.305$</td>
<td>$2.89 \pm 0.349$</td>
<td>3.120</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>CK-MB (units/L) 3 d</td>
<td>$175.87 \pm 109.520^{\dagger\ddagger}$</td>
<td>$47.60 \pm 8.500$</td>
<td>$57.38 \pm 29.91$</td>
<td>26.522</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>2 wk</td>
<td>$54.00 \pm 27.524$</td>
<td>$49.26 \pm 0.895$</td>
<td>0.799</td>
<td>0.454</td>
</tr>
</tbody>
</table>

* Compared with the noncardiac damage group, $p < 0.05$.
\dagger Compared with the control, $p < 0.05$.
\ddagger Compared with the control, $p < 0.05$.

### Table 5 Changes in N-terminal pro-brain natriuretic peptide (NT-proBNP) level after normal birth (pg/mL).

<table>
<thead>
<tr>
<th>n</th>
<th>Median</th>
<th>Interquartile</th>
<th>5th Percentile</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0-3</td>
<td>63</td>
<td>1491</td>
<td>2373</td>
<td>499.5</td>
</tr>
<tr>
<td>P1</td>
<td>63</td>
<td>1077</td>
<td>2039</td>
<td>423.04</td>
</tr>
</tbody>
</table>

Figure 1 Receiver operating characteristic (ROC) curve of serum N-terminal pro-brain natriuretic peptide (NT-proBNP). Creatine kinase MB (CK-MB) is divided into two groups at 70 units. Then, the ROC curve is plotted with the N-terminal pro-brain natriuretic peptide as a test variable and the CK-MB groups as the state variable. The abscissa is specificity, and the ordinate axis is the sensitivity.
To determine the relationship of serum NT-proBNP and various factors in children with myocardial injury after neonatal asphyxia, we analyzed perinatal factors, including the mother’s age, gender of the children, gestation length, placental function, mode of delivery, fetal distress, birth weight, Apgar score, and length of hospitalization. After stepwise regression screening, two factors were eventually selected in the model, namely, the Apgar score ($p < 0.001$) and gestational age ($p = 0.042$). Both are negatively correlated with the serum NT-proBNP level (Table 6). When the Apgar score is controlled, regression shows that the serum NT-proBNP level is negatively correlated with gestational age ($B = -0.239, p = 0.019$) ($B$ is the slope of the regression line), while the other factors did not show any correlation. When gestational age is controlled, the NT-proBNP level shows a negative correlation with the Apgar score ($B = -0.74, p < 0.001$), whereas the other factors are not correlated with the NT-proBNP level.

### 4. Discussion

In this study, we examined the serum NT-proBNP levels in children with neonatal asphyxia. Compared with normal newborns, the level of NT-proBNP increased significantly in suffocated children, with an even stronger effect in the severe asphyxia group. Furthermore, we found that suffocated children with myocardial injury had significantly higher serum NT-proBNP levels than the noncardiac injury and control groups. Serum NT-proBNP levels were positively correlated with cardiac enzymes, suggesting that the elevated plasma BNP/NT-proBNP levels in the acute phase of myocardial injury in children were associated with acute phase-localized myocardial ischemic injury. In the event of hypoxia, myocardial cells are damaged, allowing myocardial enzymes to escape, leading to elevated serum enzyme activity. Gu$^{23}$ suggested that the diagnosis sensitivity was $\sim 50$% and specificity was $\sim 75$% when the diagnosis is based on experience. However, when the diagnosis is combined with serum NT-proBNP detection, the diagnosis sensitivity can be increased to $90$% and the specificity to $87$%. In our study, we found that when the NT-proBNP cutoff value for neonates with myocardial injury was set at 3612.5 pg/mL, the diagnosis sensitivity was 83.3%, the specificity was 80.5%, the positive predictive value was 82.8%, and the negative predictive value was 79.4%.

The serum NT-proBNP level in neonates with myocardial injury is associated with various factors. The serum NT-proBNP level is negatively correlated with gestational age. In addition, it is negatively correlated with Apgar scores, indicating that more severe asphyxia leads to higher serum NT-proBNP levels and more severe myocardial damage. Surprisingly, the NT-proBNP levels of children with a 5 minute Apgar score $>7$ and $\leq 7$ did not differ significantly ($F = 1.516, p = 0.138$) (The $F$ ratio is the ratio of two mean square values), suggesting that the serum NT-proBNP level is independent of the duration of suffocation, which might be a result of the limited number of cases in our study. The serum NT-proBNP level has a negative correlation with serum sodium, suggesting that hyponatremia may occur with increasing NT-proBNP levels. NT-proBNP can promote the excretion of sodium and water, resulting in hypovolemic hyponatremia$^{25,26}$ and decreased myocardial blood flow, which aggravates ischemic injury after suffocation and creates a vicious feedback loop. Therefore, the simultaneous detection of serum sodium in suffocated children and timely correction of hyponatremia should help in the treatment and prevention of myocardial injury. In addition, fetal distress can cause hypoxia and further lead to fetal myocardial injury. In general, a more severe injury requires longer hospitalization. Nuntnarumit et al$^{27}$ found that the NT-proBNP level is closely correlated with fetus weight at birth and that the NT-proBNP level on neonatal Day 1 has a weak negative correlation with gestational age. However, we found that the NT-proBNP level was not correlated with age of the mother at pregnancy, gender of the child, serum calcium, placental function, mode of delivery, fetal distress, birth weight, or length of hospitalization. Interestingly, although fetal distress is closely related to the Apgar score, we were unable to find a negative correlation between fetal distress and the NT-proBNP level. This might be because of the limited number of cases with fetal distress in our study.

<table>
<thead>
<tr>
<th>Strain</th>
<th>Independent variable</th>
<th>Partial regression coefficient (B)</th>
<th>Standardized partial regression coefficient (B)</th>
<th>Standard error ($S$)</th>
<th>$p$</th>
<th>$t$</th>
<th>95.0% Confidence interval for B</th>
</tr>
</thead>
<tbody>
<tr>
<td>NT-proBNP</td>
<td>(Constant)</td>
<td>12176.367</td>
<td>6818.488</td>
<td>0.077</td>
<td>1.786</td>
<td>-1341.949</td>
<td>2569.657</td>
</tr>
<tr>
<td></td>
<td>Apgar score</td>
<td>-1681.041</td>
<td>152.947</td>
<td>0.000</td>
<td>-10.991</td>
<td>-1984.275</td>
<td>-1377.808</td>
</tr>
<tr>
<td></td>
<td>Gestational age</td>
<td>-1311.323</td>
<td>167.093</td>
<td>0.042</td>
<td>2.078</td>
<td>13.153</td>
<td>681.400</td>
</tr>
<tr>
<td></td>
<td>Gender</td>
<td>-244.656</td>
<td>633.008</td>
<td>0.700</td>
<td>-0.386</td>
<td>-1499.655</td>
<td>1010.000</td>
</tr>
<tr>
<td></td>
<td>Mode of delivery</td>
<td>50.893</td>
<td>199.665</td>
<td>0.799</td>
<td>0.255</td>
<td>-344.962</td>
<td>446.748</td>
</tr>
<tr>
<td></td>
<td>Birth weight</td>
<td>0.530</td>
<td>0.650</td>
<td>0.417</td>
<td>0.102</td>
<td>0.027</td>
<td>0.799</td>
</tr>
<tr>
<td></td>
<td>Length of hospitalization</td>
<td>-39.224</td>
<td>32.397</td>
<td>0.229</td>
<td>-1.211</td>
<td>-103.454</td>
<td>25.000</td>
</tr>
<tr>
<td></td>
<td>Fetal distress</td>
<td>-287.147</td>
<td>658.807</td>
<td>0.664</td>
<td>-0.436</td>
<td>-1593.296</td>
<td>1019.000</td>
</tr>
<tr>
<td></td>
<td>Mother’s age</td>
<td>-353.120</td>
<td>225.169</td>
<td>0.120</td>
<td>-1.568</td>
<td>-799.538</td>
<td>93.299</td>
</tr>
</tbody>
</table>
In general, mild asphyxia does not lead to myocardial injury. Nevertheless, there are two exceptions in our study. In one case, the patient’s heart structure was normal. However, both parents of the patient had many years of drug abuse and did not stop drug use during pregnancy, which may have caused chronic hypoxia for the fetus and, as a result, myocardial injury could have occurred under mild asphyxia. In the other case, the patient had a ventricular septal defect. Therefore, with increased resistance in pulmonary circulation, even mild asphyxia can cause myocardial damage.

After treatment, the serum NT-proBNP level of children with myocardial injury decreased significantly at 2 weeks, approaching the levels observed in the control group. However, the nonmyocardial injury and control groups showed no significant difference. These results indicate that serum NT-proBNP is a marker for heart function improvement.

It has been reported that the NT-proBNP level reaches a maximum in the first 3 days after birth, gradually decreases, and then stabilizes at a certain level. Our study examined the NT-proBNP level at 3 days and 2 weeks after birth and confirmed that it maintains a high level right after birth and gradually declines. Early clinical manifestations of neonatal myocardial injury after asphyxia are not obvious and often rely on laboratory tests for its diagnosis. Our study demonstrated that the serum NT-proBNP level is a useful marker for neonatal myocardial injury after asphyxia and can be used to determine the severity of the injury and guide treatment. However, the normal range for the neonatal NT-proBNP level remains to be determined. In addition, some of the asphyxia patients in our study were preterm babies with low birth weights. Complications, such as Patent Ductus Arteriosus (PDA) and respiratory distress syndrome (RDS), may increase the cardiac load. These limitations require further examination with an expanded sample size.

Conflicts of interest

The authors declare no conflict of interest.

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References


