Original research article

Effect of maternal heart sounds on physiological parameters in preterm infants during aspiration

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ABSTRACT

Aim: The aim of this study was to evaluate the effect of maternal heart sound given to preterm infants during aspiration on pain and comfort.

Methods: This was a randomized controlled trial. Preterm infants (n = 62) receiving care or treatment at a neonatal intensive care unit (NICU) were eligible for participation in this study. Infants in the intervention group were provided with prerecorded maternal heart sounds before, during, and after aspiration, whereas infants in the control group received routine care.

Results: In both groups, the infants’ physiologic parameters were evaluated during aspiration. In the study, it was determined that while there was an insignificant difference between the experimental group and the control group in terms of respiratory rate and heart rate averages before, during, and after the aspiration, there was a significant difference between them in terms of SO2 averages before, during, and after the aspiration, and this significance arose from the experimental group.

Conclusion: Considering the positive effect of maternal heart sound given to preterm infants during aspiration, we recommend that this method can be used in NICU.

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Introduction

Invasive procedures are common sources of pain in newborns [1, 2]. Suctioning is an invasive procedure often applied by nurses in the care of patients treated with mechanical ventilation [3]. During the stressful process of suctioning, infants are observed to exhibit the same physiologic responses encountered in other painful procedures. Using pacifiers or sucrose solutions or swaddling the baby may be used during the suctioning to help to relieve the pain. In addition, opioids may be administered through continuous intravenous infusion or slow injection [1].

In the NICU, the endotracheal aspiration, which is among the painful interventional procedures applied by nurses, is defined as the mechanical cleaning process of the pulmonary secretions of patients with an artificial airway [4, 5]. A painful procedure such as aspiration adversely affects newborns’ physiological parameters, comfort, sleep, development and the length of hospital stay [6]. There have been many studies on aspiration in recent years [3, 7–14].

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All sense organs in the fetus begin to develop during the prenatal period and generally develop in the following sequence: tactile, vestibular, chemical, auditory, and visual sense organs. Hearing typically starts in the 18th week of pregnancy and matures by approximately the 28th week. Fetal response to sound begins in the 26th–28th week [15]. During the 30th–35th gestational weeks, the fetus can hear the mother’s voice, responds to her sounds, and differentiates her sound from the others [16].

Auditory stimuli such as structured, rhythmic, cardiovascular, and patterned bowel sounds occur in the intrauterine environment and consist of sounds such as the patterning of placental musical sounds [16]. Sounds arising from the mother’s body include sounds from respiration, cardiovascular system, intestinal activities, and body movements. An average noise level of 50 decibels (dB) arises within the uterus. Furthermore, low-frequency sounds from the environment are more audible to the fetus, and the fetus learns about its mother’s voice or the external music played. Both the fetus and the neonate may become accustomed to a sound that they have heard several times [17]. Voice control positively affects communication of infants with their families’ as much as physiological stability, age-appropriate sensory development, and growth [17, 18]. The American Academy of Pediatrics recommends that sound levels in the NICU should not exceed 45 dB [19–21].

It is a great problem for preterm neonates who are separated from the mother’s voice, which is an important source for the development of sound sensation of the fetus, to be exposed to intense sound stimuli in NICU. The fetus is normally familiar with blood flow sound, bowel movements, the mother’s heartbeat sound, the mother’s voice and movements, and synchronized sounds in the uterus [22]. The environment of NICU has very high environmental and human-made sounds. As a result of unwanted noise in NICU; numerous stress behaviors such as fatigue, stress, hyperalertness, fear etc., as well as physiological changes; changes in heart rate, oxygen saturation level, respiratory rhythm, and blood pressure, increase in intracranial pressure, and changes in corticosteroid hormone are observed. However, an effective auditory stimulus occupies the infant, and provides a cognitive effect for pain control, physiological stability and suppressing the pain response [20, 23–26].

The purpose of this experimental study was to determine the effect maternal heart sounds played on preterm infants’ physiologic parameters during the aspiration procedure.

**Materials and methods**

This was a randomized, single-blind experimental study. The study population consisted of preterms, fulfilling the selection criteria, who received treatment and care in the Hospital’s NICU in Turkey, between July 2012 and February 2013. The study was conducted with 62 preterm infants, randomly divided into the experimental ($n = 32$) and the control ($n = 30$) groups. In the power analysis performed to determine the sample size, the calculated sample size was found to be 62 preterms in order to achieve a 0.90 power in the test, at a significance level of 0.05 with a medium level of effect.

**Selection criteria for the study group**

The criteria of the study group were: Infants with gestational age ≥28 weeks and ≤36 weeks; who had no congenital anomalies; required tracheal aspiration; underwent at most three tracheal aspirations after the intubation process; had spontaneous breathing and needed mechanical ventilation support; and had not been given any pharmacological or non-pharmacological pain reliever before the procedure, were included in the study.

**Measuring instruments**

Preterm Infant Introductory Information Form – includes items on the newborn’s age, gender, gestational age, birth weight, length, head circumference, Apgar score, nutritional status (breastfeeding and/or formula feeding) and its diagnostics. Additionally, it is a form developed for the purpose of recording these measurements to evaluate the effect of interventions made before, during and after the aspiration on oxygen saturation, heart rate, and respiratory levels of premature infants.

**Intervention**

Preterms admitted to the NICU were evaluated in accordance with the selection criteria for the study group. The preterm infants supported for mechanical ventilation are not sedated in the studied unit. The aspiration process was performed with aspiration-catheter no. 6 in preterm infants born between 28 and 34 weeks of gestation, and catheter no. 7 was used in 34–38 week-old preterm infants at 100 mmHg pressure. Oxygen at 100% concentration was applied before and after the procedure. The aspiration procedure was carried out in 10 seconds. All of the aspiration procedure was performed by the same nurse working in the day shift. Families of the infants were informed about the research, and the infants were included in the study after obtaining the consent of the families who agreed to participate. It was stated to the families that the data will be confidential and will only be used for this research.

In the study, preterm infants who had spontaneous breathing, but needed respiratory support through application of mechanical ventilation were included in the study during one of the three aspiration needed. In order to record the heart sounds of the mothers, whose babies were included in the experimental group, the maternal heart sounds were recorded using a hand doppler and an MP3 player. Then, these records were played for infants through a speaker set to 45 dB. Maternal heart sounds were played for the babies for 15 min prior to aspiration, during the aspiration and again for 15 min after the aspiration. Heart rate and $SO_2$ were recorded from the monitor and the respiratory rate was counted by the researcher for 1 min.
The preterm infants in control group did not receive any additional interventions during one of the three aspiration requirements in the clinic. Heart rate and SO\textsubscript{2} were recorded from the monitor and the respiratory rate was counted by the researcher for 1 min.

**Data analysis**

Data were analyzed using the SPSS (Statistical Package for Social Sciences) 18.0 and R 2.15.2 statistical analysis software packages. Percentage distribution, mean, standard deviation, chi-square, Kolmogorov–Smirnov Z test, and \( t \)-test comparison between groups were used for the statistical analysis of the data.

**Ethical considerations**

The legal permission of the related institution and ethical consent No 2012.3.1/9 from the Ethics Committee of University, Faculty of Health Sciences in July 24, 2012 was obtained in order to conduct the study. The purpose of the study was explained to the families of the premature infants included in the study, their questions were answered and written consents were obtained. Parents were informed that the information they had given would be confidential and would not be used anywhere else. In the study, the related ethical principles of “Informed Consent Policy”, “Volunteer Policy” and “Privacy Protection Policy” has been fulfilled since the use of human subjects requires the protection of individual rights.

**Results**

In the study, no statistically significant difference was found between the preterm infants in the control and experimental groups in terms of gender, gestational age, birth weight, birth height, birth head circumference, diet, the Apgar score at the 5th minute and diagnosis averages \((p > 0.05, \text{Table 1, 2})\). A statistically significant difference was only found in the 1st minute Apgar score variable between the infants in the experimental and control group. These results indicate that the experimental and control groups were similar in terms of control variables except the 1st minute Apgar score \((p < 0.05, \text{Table 1, 2})\).

**Table 1 – Comparison of descriptive characteristics of the experimental and control groups \((n = 62)\)**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Experimental ((n = 32))</th>
<th>Control ((n = 30))</th>
<th>Test/(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girl</td>
<td>9</td>
<td>13</td>
<td>(\chi^2 = 1.56) (p &gt; 0.05)</td>
</tr>
<tr>
<td>Boy</td>
<td>23</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Birth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spontaneous</td>
<td>1</td>
<td>3</td>
<td>(\chi^2 = 1.213) (p &gt; 0.05)</td>
</tr>
<tr>
<td>Section</td>
<td>31</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Diet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPN\textsuperscript{a}</td>
<td>1</td>
<td>4</td>
<td>(\chi^2 = 2.17) (p &gt; 0.05)</td>
</tr>
<tr>
<td>IV Infusion</td>
<td>31</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDS\textsuperscript{b}</td>
<td>31</td>
<td>28</td>
<td>(\chi^2 = 0.42) (p &gt; 0.05)</td>
</tr>
<tr>
<td>RDS + IUGR\textsuperscript{c}</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

\(\textsuperscript{a}\) Total parenteral nutrition.

\(\textsuperscript{b}\) Respiratory distress syndrome.

\(\textsuperscript{c}\) Intra uterine growth retardation.

**Table 2 – Comparison of descriptive characteristics of the experimental and control groups \((n = 62)\)**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Experimental ((n = 32))</th>
<th>Control ((n = 30))</th>
<th>Test/(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational age</td>
<td>33.63 ± 3.32</td>
<td>32.23 ± 1.17</td>
<td>(t = 1.68) (p &gt; 0.05)</td>
</tr>
<tr>
<td>Birth weight (gr)</td>
<td>2265.65 ± 780.74</td>
<td>1886.83 ± 803.57</td>
<td>(t = 1.86) (p &gt; 0.05)</td>
</tr>
<tr>
<td>Birth head circumference (cm)</td>
<td>32.90 ± 5.22</td>
<td>30.78 ± 3.36</td>
<td>(t = 1.89) (p &gt; 0.05)</td>
</tr>
<tr>
<td>Birth height (cm)</td>
<td>45.28 ± 5.27</td>
<td>43.13 ± 5.12</td>
<td>(t = 1.58) (p &gt; 0.05)</td>
</tr>
<tr>
<td></td>
<td>M ± IQR</td>
<td>M ± IQR</td>
<td></td>
</tr>
<tr>
<td>Apgar score 1 min</td>
<td>7.00 ± 3.75</td>
<td>4.00 ± 3.25</td>
<td>KS(z = 1.55) (p &gt; 0.05)</td>
</tr>
<tr>
<td>Apgar score 5 min</td>
<td>8.00 ± 3.00</td>
<td>6.50 ± 2.00</td>
<td>KS(z = 1.03) (p &gt; 0.05)</td>
</tr>
</tbody>
</table>
It was found that while heart rate averages were 136.41 ± 18.67 before the procedure, 147.00 ± 18.64 during the procedure, and 145.97 ± 17.03 after the procedure in the experimental group; they were 141.53 ± 12.49 before the procedure, 155.47 ± 16.16 during the procedure, and 154.60 ± 18.13 after the procedure in the control group and the difference between the groups was statistically insignificant \((p > 0.05, \text{Table 1, 2})\). There was a statistically significant difference between the experimental and control groups in terms of heart rate averages before, during, and after the procedure \((p < 0.05, \text{Table 3})\).

### Table 3 – Comparison of the average HR score between the experimental and control groups

<table>
<thead>
<tr>
<th>Heart rate (HR) (a)</th>
<th>Groups</th>
<th>Test/p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental ((n = 32))</td>
<td>Control ((n = 30))</td>
</tr>
<tr>
<td>HR before aspiration</td>
<td>136.41 ± 18.67</td>
<td>141.53 ± 12.49</td>
</tr>
<tr>
<td>HR during aspiration</td>
<td>147.00 ± 18.64</td>
<td>155.47 ± 16.16</td>
</tr>
<tr>
<td>HR after aspiration</td>
<td>145.97 ± 17.03</td>
<td>154.60 ± 18.13</td>
</tr>
</tbody>
</table>

\(a\) The number in a minute.

It was determined that while respiratory rate averages were 45.25 ± 9.51 before the procedure, 32.63 ± 8.89 during the procedure, and 42.41 ± 7.41 after the procedure in the experimental group, in the control group were 45.10 ± 11.56 before the procedure, 32.80 ± 9.89 during the procedure, and 41.80 ± 10.11 after the procedure, and the difference between the groups was statistically insignificant \((p > 0.05, \text{Table 4})\).

### Table 4 – Comparison of the average respiration score between the experimental and control groups

<table>
<thead>
<tr>
<th>Respiratory rate (a)</th>
<th>Groups</th>
<th>Test/p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental ((n = 32))</td>
<td>Control ((n = 30))</td>
</tr>
<tr>
<td>RR before aspiration</td>
<td>45.25 ± 9.51</td>
<td>45.10 ± 11.56</td>
</tr>
<tr>
<td>RR during aspiration</td>
<td>32.63 ± 8.89</td>
<td>32.80 ± 9.89</td>
</tr>
<tr>
<td>RR after aspiration</td>
<td>42.41 ± 7.41</td>
<td>41.80 ± 10.11</td>
</tr>
</tbody>
</table>

\(a\) Breaths per minute.

It was determined that \(\text{SO}_2\) averages were 96.59 ± 3.08 before the procedure, 93.19 ± 4.58 during the procedure, and 95.66 ± 3.42 after the procedure in the experimental group; whereas, they were 96.20 ± 3.95 before the procedure, 87.50 ± 6.56 during the procedure, and 91.17 ± 6.08 after the procedure in the control group, and the difference between the groups in terms of \(\text{SO}_2\) averages was statistically significant during and after the procedure \((p > 0.05, \text{Table 5})\). It was found that the significant difference arising between the experimental group and the control group in terms of \(\text{SO}_2\) averages was caused by the experimental group (according to Post hoc advanced analysis results). \(\text{SO}_2\) before the procedure was lower than the saturation during the procedure at a statistically significant level and \(\text{SO}_2\) after the procedure was lower than the saturation during the procedure at a statistically significant level. \(\text{SO}_2\) average was the lowest during the procedure.

### Table 5 – Comparison of the average \(\text{SO}_2\) level score between the experimental and control groups

<table>
<thead>
<tr>
<th>(\text{SO}_2)</th>
<th>Groups</th>
<th>Test/p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental ((n = 32))</td>
<td>Control ((n = 30))</td>
</tr>
<tr>
<td>(\text{SO}_2) before aspiration</td>
<td>96.59 ± 3.08</td>
<td>96.20 ± 3.95</td>
</tr>
<tr>
<td>(\text{SO}_2) during aspiration</td>
<td>93.19 ± 4.58</td>
<td>87.50 ± 6.56</td>
</tr>
<tr>
<td>(\text{SO}_2) after aspiration</td>
<td>95.66 ± 3.42</td>
<td>91.17 ± 6.08</td>
</tr>
</tbody>
</table>
Discussion

In the study, it was determined that HR and respiratory rates of infants in the experimental group and the control group showed a distribution within normal limits before, during, and after aspiration; HR was 136–147 and respiratory rate was 32–45/min. for the experimental group, and HR was 141–155 and respiratory rate was 32–45/min. in the control group, but the difference between the groups was not statistically significant (p > 0.05, Tables 3, 4). Additionally, HR increased and respiratory rate decreased during the procedure in both groups. In the literature [27] it is stated, that for a premature neonate it is required to have a HR between 100–180/min and a respiratory rate between 30–60/min. In preterm infants, the respiratory rate is more unstable compared to term newborns and a tendency toward apnea is observed [28]. In the study, SO2 rates of infants in the experimental group showed a distribution between 93 and 96, and SO2 rates of infants in the control group showed a distribution between 85 and 98. It was determined that there was a statistically significant difference between SO2 averages of the infants in the experimental and control groups during and after the aspiration (p < 0.05, Table 5). In the literature [27] it is stated, that the confidence interval of SO2 values of premature neonate needs to be between 95 and 100. These results supported the hypothesis that “physiological parameters of preterm infants who listened to the mother’s heartbeat sound before, during, and after the aspiration are within normal limits” in respect of SO2.

It is a known fact that the infant is affected by the mother’s heartbeat in the mother’s womb, and after the birth, hearing this familiar sound and rhythm again enables a soothing effect. In the experiments, newborn infants who stayed in the room with the taped sound of the uterus fell asleep earlier than those in the room without the mentioned sound [24, 29].

In the study conducted by Segall [30], who investigated the effect of auditory stimulus on the cardiovascular system, it was determined that in terms of HR, there was a significant difference between the infants who listened to the mother’s voice and the group listening to another woman’s voice and the group listening to no voice. Similarly, in the study conducted by Türker [31] it was found, that there was a significant difference between respiratory rate averages of newborns, who listened to white noise and those of control group before and after invasive intervention. In the present study, there was no significant difference between the groups in terms of HR and respiratory rate. The results of the study show no similarity with these results.

In the study conducted by Colins and Khuck [32] it was found, that during the aspiration procedure made on intubated preterm infants, the SO2 levels of infants who listened to the sound of the intrauterine environment were higher compared to the control group. In other studies [7, 33] examining the effect of musical therapy during endotracheal aspiration on SO2 among preterm infants who were administered with endotracheal intubation, the SO2 values of infants in the group listening to the music returned to normal values faster compared to those who did not listen to music. In the study of Schwartz [34], the preterm newborns listened to soothing music similar to a mother’s voice and uterus’s voice in intervals. It was observed that listening to music positively affected the vital signs of preterm infants by providing a decrease in stress indications. The results of the study show similarity with these results.

In the literature, there are studies that investigate the effect of listening to mother’s heartbeat sound on stress behaviors. In the study conducted by Kurihara et al. [35] stress behaviors of newborns were examined and it was observed that there was a significant decrease in stress behavior scores of the group listening to mother’s heartbeat compared to the group who listened to Japanese drum sounds and the group who did not listen to anything. Again in the study conducted by Doheny et al. [36], who evaluated the therapeutic effect of listening to a mother’s heartbeat sound and mother’s voice on cardiorespiratory system in preterm infants, it was determined that the group who listened to the mother’s heartbeat sound had lower apnea and bradycardia.

In the study conducted by Johnston et al. [37], it was reported that SO2 values of preterm infants who listened to mother’s voice during the heel lance were higher at a significant level compared to the control group, however it had no significant effect on the pain. The results of the study show similarity with these results.

Conclusion

The summary of results obtained in this experimental study determine that there was an insignificant difference between the respiratory rate and HR averages before, during, and after the aspiration, and there was a significant difference between them in terms of SO2 averages during and after the procedure, and this significance was associated with the experimental group. Considering the positive effect of maternal heart sound given to preterm infants during aspiration, we recommend that this method be used in NICU.

Conflict of interests

The authors declare that they are not aware of any conflicts of interest regarding this article.

Acknowledgements

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