Original Article
The development and application of electronic information system for safety administration of newborns in the rooming-in care

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Abstract: Objective: To independently research and develop an electronic information system for safety administration of newborns in the rooming-in care, and to investigate the effects of its clinical application. Methods: By VS 2010 SQL SERVER 2005 database and adopting Microsoft visual programming tool, an interactive mobile information system was established, with integrating data, information and knowledge with using information structures, information processes and information technology. From July 2011 to July 2012, totally 210 newborns from the rooming-in care of the Obstetrics Department of the Second Affiliated Hospital of Nantong University were chosen and randomly divided into two groups: the information system monitoring group (110 cases) and the regular monitoring group (100 cases). Incidence of abnormal events and degree of satisfaction were recorded and calculated. Results: ① The wireless electronic information system has four main functions including risk scaling display, identity recognition display, nursing round notes board and health education board; ② statistically significant differences were found between the two groups both on the active or passive discovery rate of abnormal events occurred in the newborns (P<0.05) and the satisfaction degree of the mothers and their families (P<0.05); ③ the system was sensitive and reliable, and the wireless transmission of information was correct and safety. Conclusions: The system is with high practicability in the clinic and can ensure the safety for the newborns with improved satisfactions.

Keywords: Information, safety care, rooming-in care, clinic application

Introduction

Rooming-in care has its standardized management requirements [1-3], which can effectively promote the intelligence and mental development of the newborns [4]. It is a primary task for healthcare managers to take protective nursing measures for newborns in the rooming-in care so as to reduce or eliminate potential safety hazards and to maintain life safety for babies, guaranteeing no physical harms under hospital environment. Currently, both general hospitals and specialized hospitals attach great importance to the safety administration of newborns in the rooming-in care and multi-channels of safety precautions have been built [5-7]. However, understaffed clinical nurses in certain hospitals [8], nurses of younger age, and poor sense of risk management can result in various hazardous events. Therefore, we developed a wireless electronic information system for safety administration of newborns, and implemented in our hospital’s rooming-in care of the Obstetrics Department with favorable results of clinic application.

Materials and methods

Overall design

The wireless electronic information system for safety administration of newborns is composed of three parts: central monitor system, wireless network system and electronic card in the hospital ward (see Figure 1 for functional block diagram). By VS 2010 SQL SERVER 2005 database and adopting Microsoft visual programming tool, an interactive mobile information
Electronic information system for safety administration

A system was established, with integrating data, information and knowledge with using information structures, information processes and information technology.

**Design of the electronic card in the hospital ward**

The electronic card in the ward has four interfaces, including risk scaling display, identity recognition display, nursing round notes board and health education board. The displayer (an electronic screen with size of 20×12 cm) of the electronic card was installed securely in the area of the access control at every door of the wards (see Figures 2 and 3 for screenshots). General information of the newborns was inputted into the central monitor system at the Nurse Station. The Delphi method was employed to work out the early warning indicators, which were used to generate two risk assessment

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**Figure 1.** Functional block diagram for the wireless electronic information system.

**Figure 2.** Information form of the electronic card in the ward.
Electronic information system for safety administration

The second affiliated hospital of nantong university

The newborn information list

16
BD 2012-4-8
Amniotic fluid properties II°
17
BD 2012-4-8
Apgar scoring 8 points
18
BD 2012-4-8
Amniotic fluid properties 1°
19
BD 2012-4-6
20
BD 2012-4-11

21
BD 2012-4-5
22
BD 2012-4-4
23
BD 2012-4-5
24
BD 2012-4-4
25
BD 2012-4-8
Umbilical bleeding

Figure 3. Secondary interface of the electronic card for detailed information on the newborns.

Figure 4. Screenshot of the central monitor system at the Nurse Station, BD: Birth date.

tables for the newborns, one for the admission to the rooming-in care at the Nurse Station and the other for daily assessment at bedside. All admissions to the rooming-in care followed doctor’s advices with expert’s consultation. The risk assessment for the admission was scaled by three warning signs: no risk (blue), moderate risk (yellow) and high risk (red), while daily assessment by two warning signs: no risk (blue) and high risk (red). In the central monitor system at the Nurse Station, a drop-down box was used to display explicitly the risk factors where red and yellow signs showed. The information would be automatically synchronized with the electronic card in the ward with dynamic changing of signs accordingly (see Figure 4 for the screenshot of the central monitor system at the Nurse Station).

Design of the function of newborns automatic identification

The automatic identification of the newborns used RF electronic label technology. Electronic label, aka Smart Label, is an extremely flat configured transponder under a conventional print-coded label, which includes chip, antenna and bonding wires as a so-called inlay. As a data carrier, the electronic label has functions as identifying, tracing and information acquisition.
When nurses inputted information on the newborns into the computer, the reader-writer would write the data onto the ankle strap, and at the same time, high fidelity Wi-Fi will transmit the data to the electronic screen in the ward, ensuring the accuracy and security of the information.

**Design of the assessment tables**

The risk early warning, assessing table for admission (Table 1) and the nursing round notes for daily risk assessment (Table 2) were made ourselves. Contents of the later referred to the key points of the first visit on the newborns [9]. Click to open the nursing round notes board after every assessing, and the general information would be automatically generated based on earlier entries. The system was set to show texts of different colors for different results of the assessment, blue for normal and red for abnormal, which would be transmitted to the central monitor system at the Nurse Station.

**Subjects**

From July 2011 to July 2012, a total of 210 newborns from the rooming-in care of the Obstetrics Department of our hospital were chosen and randomly divided into two groups: the information system monitoring group (110 cases) and the regular monitoring group (100 cases). This study was approved by the Ethics Committee of the Second Affiliated Hospital of Nantong University and all the mothers had signed an informed consent.

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### Table 1. Early warning and assessing table for admission

<table>
<thead>
<tr>
<th>Risk indicators</th>
<th>Red</th>
<th>Yellow</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apgar score (1 min)</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Amniotic fluid [II° or III°]</td>
<td>I°</td>
<td>Clear</td>
<td></td>
</tr>
<tr>
<td>Pregnancy complication (diabetes, hypertension, ICP)</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Gestational weeks [Full term or overdue]</td>
<td>Normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery mode (ventouse, forceps, assisted breech delivery)</td>
<td>Assisted vaginal delivery</td>
<td>Vaginal delivery, cesarean delivery</td>
<td></td>
</tr>
</tbody>
</table>

Note: ICP, intrahepatic cholestasis of pregnancy.

### Table 2. Nursing round notes for daily risk assessment (style sheet)

<table>
<thead>
<tr>
<th>Project</th>
<th>Date</th>
<th>Name</th>
<th>Bed No</th>
<th>Date of Birth</th>
<th>Year</th>
<th>Month</th>
<th>Day</th>
<th>Admission No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexion</td>
<td>Red</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Purple</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiration</td>
<td>Gentle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tachypnea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omphalorrhagia</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cry</td>
<td>Loudly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Groaning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sucking</td>
<td>Strong</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weak</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stool\Urine</td>
<td>Normal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abnormal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vomiting</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscular tension</td>
<td>Normal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weak</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When nurses inputted information on the newborns into the computer, the reader-writer would write the data onto the ankle strap, and at the same time, high fidelity Wi-Fi will transmit the data to the electronic screen in the ward, ensuring the accuracy and security of the information.
Methods

Application of the central monitor system

We connected the central monitor system with the electronic card in the ward and conducted a pilot run of the monitor system. After inputting information into the central monitor system and transmitting the data via Wi-Fi to the display of the electronic card in the ward, how the electronic card serviced was observed upon the following two aspects: ① system, including service behavior of the monitor system, correctness of data transmitting and timeliness of early warning; ② monitoring, on general condition of the newborns and dynamic display of their weight with our self-made early warning and assessing table for admission and nursing round notes for daily risk assessment.

Evaluation on the results

Trained and qualified nurses, who have worked for no more than one year, from the designated research team were chosen to collect data by direct observation. Unlike the Special Care Baby Unit, condition of the newborns in the rooming-in care changes any time and calls for close observation. In our study, abnormal events occurred with the newborns that were observed by the nurses were defined as active discovery while that by the mothers or their families as passive discovery. Rates of the two were compared. Satisfaction Degree Evaluation Form for Obstetrical Department was created out of the Inpatient Satisfaction Degree Evaluation Form of our hospital with certain modifications. Safety administration on the newborns, safety facilities management, proficiency and manner of the nurse, implementation and timeliness of the nursing round, instructions on breast feeding, and health education on daily-care of the newborns were evaluated in the form of questionnaires.

Statistical analysis

SPSS 17.0 was used for statistical analysis. All numerical data were analyzed by chi-square test, and the results were considered significant when \( P < 0.05 \).

Results

Comparison of active and passive discovery of abnormal events occurred in the newborns between the information system monitoring group and the regular monitoring group

Because the room of mother and infant was not special nursing wards, newborn’s milk vomiting, abnormal respiration and omphalorrhagia and these changes of illness couldn’t be found at any time when in lack of human resources, which led to the occurrence of the nursing adverse events. Neonatal abnormalities observed by nurses could be defined as active findings by studying team and abnormalities found by parturients and families could be defined as passive findings, then abnormalities in active, passive detection rate comparison could be conducted. \( \chi^2 \) test could be used to test and \( P = 0.033 \), with statistical significance. The electronic card neonatal intensive care group and routine care group of active, passive detection rate of abnormal conditions were recorded (Table 3).

Comparison of high risk abnormal events between the two groups

Newborn’s common milk vomiting, abnormal respiration (neonatal respiration below 40 beats per minute, more than 44 beats per minute can be rated as abnormal respiration) and omphalorrhagia (shed ligature haemorrhage...
Electronic information system for safety administration

and umbilical blood oozing could be defined as omphalorrhagia) and these three kinds high risk symptoms data could be selected to analyze. \(X^2\) test could be used to test and \(P=0.097\), without statistical importance. Comparison of high-risk neonatal events was shown (Table 4).

Comparison of satisfaction degree of the mothers and their families in 210 cases

Inpatient satisfaction evaluation table used in our hospital could be modified to form obstetric specialty satisfaction scale. Neonatal safety management, safety facilities management, the nurses' technique and attitude, nursing rounds in place, breastfeeding guide, the daily care of neonatal health guidance and these six indexes were rated by means of the questionnaire survey and satisfaction, dissatisfaction were evaluation index. \(X^2\) test could be used to test and \(P=0.034\), with statistical significance. Satisfactory in 210 cases of pregnant women and families were shown (Table 5).

Discussion

At ordinary times, the home screen of the electronic card in the ward would display basic information on the mothers, with the changing color indicating the risk scaling of the newborns (Figure 2). Health education board could be opened by clicking the bed number of each mother. Detailed information on the newborns and nursing round notes board can only be accessed by nursing personnel with access password, mothers and their families not permitted to access.

Displaying of risk scaling of the newborns improves safety

In the Obstetrical Department, fast turnover of beds and intensive workload may result in inadequate observation and nursing of the newborns, leading to delayed discovery of potential risk factors, which usually cause nursing errors and accidents. It is important for clinical nurses to get aware and make decision of which newborns need special care in the ward easily and fast during nursing rounds and shift handovers. The electronic information system designed by us can display signs of different colors (red, yellow and blue) according to admission risk assessment and daily risk assessment, and the central monitor system switches color signs simultaneously. Blue sign, for low risk, means the newborns are in normal condition; yellow sign, for moderate risk, calls for intensive care and close observation; and red sign, for high risk, tells that the newborns need special care and immediate attention, which will also be reported to superior nurses and informed to the next shift. Comparison of active and passive discovery of abnormal events occurred with the newborns between the two groups (Table 3) showed that in the information system monitoring group significant improvements had been made for nurses to observe and realize high risk situations of the newborns. If the condition of the newborns changes and is discovered by the mothers and their families, disputes may happen for blaming the hospital for negligence. Now with nurses being able to observe and monitor the newborns more intensively, especially on their life-threatening symptoms like emesis, abnormal respiration and omphalorrhagia, such disputes can be avoided. Although no statistical significance was found in Table 4, which might be the result of our sample size and the random grouping, the incidence of abnormal events occurred with the newborns slightly dropped. We believed it was connected with better nursing round, prompt treatment and strengthened health education. When the possibility of high risk situation recurrence was narrowed down, the safety of the newborns would be improved. The application of the information system for the newborns also provided reliable references for physicians when making ward rounds. At the same time, it worked as an information provider for the mothers and families concerning their babies. All of the above improved the safety administration on the newborns in hospital and reduced the incidence of medical disputes.

More timely and scientific nursing rounds

Graded nursing system was issued by the Ministry of Health to standardize and make

<table>
<thead>
<tr>
<th>Table 5. Satisfaction degree comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Regular monitoring</td>
</tr>
<tr>
<td>System monitoring</td>
</tr>
<tr>
<td>Note: (\chi^2=4.507, P=0.034).</td>
</tr>
</tbody>
</table>

requirements for hospital nursing. Appropriate nursing are required towards patients of different conditions. Currently in China, grade 1 nursing asks for one round per hour, same for the newborns. However, one to three days after the birth of the newborns is a critical period and accidents are easy to happen once there is any inadequate observation or improper nursing round, especially during the night shifts when there are fewer nurses on duty but large quantity of nursing [10] (Table 4). The electronic round notes board can notify the nurses that which newborns are of high risk and needs more attention, and extra rounds can be made accordingly, for example, newborns with red sign need one round every 30 min. Times of rounds can be adjusted flexibly when necessary. Alarms will set off automatically when it is time for a nursing round, a visual alarm of flashing light on the bed number on the home screen of the central monitor system five minutes before the round and an audible and visual alarm two minutes prior, reminding the nurses on duty to work the round on time and make sure the safety of the newborns. The audible and visual alarm can only be dismissed by the nurses at the bedside of the patient after responding to it. The nursing round notes board, with functions of printing and data storage, is a good instruction for nurses to check for all the observation targets one by one, avoiding unrecognizable signatures on the notes, skipping points and filling missed points afterwards. In the 110 cases of newborns of the information system monitoring group, 22 cases of emesis, two of asphyxia and five of abnormal respiration were treated promptly because of timely nursing round and observation. No serious adverse consequences were observed.

Identity recognition and matching

The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has a well-compiled practice guideline for preventing in-hospital newborns stealing and ensuring safety [11]. Relevant measures have been taken in safety management for newborns in hospitals all over the world [12-14]. The wireless electronic information system can identify newborns automatically by an electronic label strapped to the ankle of the newborn. When the newborn goes through the access control at the ward door, the warning sign will be changing from blue to red with audible and visual alarm and the signal will be transmitted immediately to the Nurse Station. Nurses can type in passwords to dismiss the alarm after confirmation of the newborns’ safety, lowering risks of newborns being switched or stolen [15]. It is proved in clinic application to be sensitive and reliable.

High efficiency for health education

As an important educator for health education, the educating ability of the nurses directly affects the educational outcomes [16]. Nowadays, most hospitals conduct health education by means of pamphlets and posters, but these traditional ways can present drawbacks like contents hard to memorize and easy to forget. The electronic card designed by us can provide personalized and specialized educating contents with texts, illustrates and audio clips. The courses are arranged according to the length of hospital stay of the mother and the newborns. The friendly interface and interaction won recognition and praise from the patients with every signing in and improved their health knowledge and nursing skills for newborns [16]. Also, as a measure of details management [17], the Satisfaction Degree Evaluation Form for Obstetrical Department showed that the satisfaction degree of the mother and their families improved (Table 5) among the 110 cases.

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Disclosure of conflict of interest

None.

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