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e-ISSN 2544-1620

**Medical Science Pulse** 2020 (14) 3

Original papers

Published online: 29 Sep 2020

DOI: 10.5604/01.3001.0014.4204

# THE ROLE OF SIMULATION-BASED TRAINING IN NEONATAL CARDIOPULMONARY RESUSCITATION COMPLICATED BY MECONIUM ASPIRATION SYNDROME

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**A** – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

**ABSTRACT**

**Background:** The use of simulation-based training is strategic in training medical staff.

**Aim of the study:** The aim of the study was to assess the knowledge and skills of performing neonatal CPR (cardiopulmonary resuscitation) complicated by the presence of meconium in the respiratory tract in two groups of midwives (trained in the traditional tutorial-based model vs simulation-based training) with an interactive neonatal manikin.

**Material and methods:** The knowledge and practical skills assessment was conducted in two groups of midwives. The knowledge of the participants was assessed using both a written test consisting of 25 control questions (5 questions on meconium aspiration syndrome, 20 on neonatal CPR) and practical skills including 12 activities (1-initial, 9-proper, 2-final). The complex “success” indicator was determined based on the effects of patient resuscitation (15 minutes of the scenario), and the reference point for knowledge and skills was to obtain a minimum of 70% correct answers/activities performed, evaluated by three independent experts.

**Results:** In the knowledge test, the respondents scored 17.93 ± 3.11 points out of 25 (71.7%). Practical skills for all respondents were 17.57 ± 2.49 points out of 21 (83.66%), with a tendency to obtain higher points in cleaning of the airways and stimulation of the newborn, and lower for ventilation and the use of an alternative method of intubation. Despite the similar level of practical skills in both groups, only a higher statistical tendency was observed in three out of nine instrumented “proper activities” in the simulation trained midwives.

**Conclusions:** The scenario used by us assessing the knowledge and skills of midwives taught in traditional tutorial-based and simulation-based training, indicates the advantage of acquiring individual competences in a short time using simulation-based training. This increasingly popular scientific model allows the acquisition of “invasive” competencies, but it requires further research.

**KEYWORDS:** newborns, simulation, meconium aspiration syndrome, cardiopulmonary resuscitation, midwives, education

## Background

The use of simulation-based training in developing, improving and maintaining comprehensive clinical competences in healthcare professionals is strategic in the training of medical staff. The simulation-based method is based on training and improving management of rare or incidental clinical events, which are crucial in preventing morbidity and mortality of the patient. In clinical practice they become difficult to assess, due to their occasional incidence [1,2]. Undertaking simulation-based training in this case is aimed at analyzing the performance of the healthcare professional during the patient clinical event (scenario). It aids in the detection of areas of scarcity or excess in practical activities, and direct debriefing initiates improvement in efficiency, translating into better clinical conduct [3,4].

In this case, the relatively rare and unpredictable situation of CPR complicated by the presence of meconium in the amniotic fluid occurs in about 10-20% of viable neonates, and less than 5% will develop meconium aspiration syndrome (MAS) [5,6]. This study aims to assess whether midwife's conduct toward a newborn during a delivery with meconium-stained amniotic fluid and/ or meconium in the airways may influence the baby's health condition in future [1]. In addition, use of medical simulation to analyse a particular case becomes a standard tool used by professionals to learn independently, but also an active tool in the pre- and postgraduate training of nurses and midwives [7–9]. Its main goal is to prepare staff to acquire knowledge and skills, which will ultimately lead to higher quality patient care [4,10–12].

## Aim of the study

The aim of our study was to improve the quality of cardiopulmonary resuscitation in newborns with meconium aspiration syndrome based on the improvement of acquired knowledge and skills through medical modeling.

## Material and methods

### Study design

The study was conducted in two groups of licensed midwives (group I: midwives trained in traditional tutorial-based model, n = 37; group II: midwives trained in medical simulation model, n = 32) in the Center for Medical and Natural Sciences Research and Innovation, University of Rzeszów; all participants provided written consent. The study was carried out on the SimNewB simulator by Laerdal using a neonatal CPR scenario with meconium in the respiratory tract. The study was approved by the Bioethics Committee of the University of Rzeszów.

### Data sources/measurement

Knowledge was assessed by means of a test consisting of 25 control questions (5 questions in MAS, 20 questions in newborn CPR): symptoms, risk factors and management of MAS, vital parameters determining the resumption of CPR and anatomical conditions of the neonatal circulatory and respiratory system, guidelines for resuscitation regarding care and therapeutic measures to protect the newborn from the adverse effects of the actions undertaken (thermoregulation, gas perfusion, pharmacological management). Participants scored 1 point for each correct answer, giving a total maximum score of 25 points.

Skills of the participants were assessed with the neonatal CPR scenario complicated by the presence of meconium in the amniotic fluid and the airways, focusing on the knowledge and skills required to take action during the occurrence of this event.

For the purpose of the study, a database of scenarios was created covering numerous variants of newborn CPR, depending on the actions undertaken by the participants during the scenario. The assessments have been designed by ourselves to involve teams of three working together. Therefore, three months prior to the study, an introduction to the specifics of medical simulation was organized for the participants. They were familiarized with the environment and equipment, and weekly two-hour training sessions in three-person teams were organized. All participants were introduced in simulation debriefing based on similar scenarios. Each scenario was developed with specialist knowledge in the areas of: preparatory, proper, and final activities. The scenario prepared for the purpose of the study consisted of three parts:

1. Preparatory actions: diagnosis of the clinical situation; checking the equipment; gathering the team for resuscitation; preparation of equipment for intubation and aspiration of meconium from respiratory tracts; applying aseptic rules.
2. Proper actions: clamping the umbilical cord, cleaning the airways; maintaining thermoregulation; stimulation of breaths; assessment of vital signs; ventilation; alternative intubation; heart massage; pharmacotherapy.
3. Final actions: monitoring of the newborn's condition.

For each properly performed specific action, the participants could score 2 points, 1 point for each preparatory and final action, up to a maximum total score of 21 points.

### Statistical methods

Statistical analysis was carried out using Statistica 10.0 software by StatSoft, while the database and charts were created in Microsoft Excel. Parametric and nonparametric tests were used for the analysis of variables: the Shapiro-Wilk W test for compliance of distributions of the tested variables with normal distribution; Student's t-test to assess differences in the mean level of a numerical feature in two populations for independent variables or, alternatively, the Mann-Whitney U test. The assessment of qualitative data was based on the Pearson chi-square test, and the correlation of numerical variables that did not meet the normality criterion based on the Spearman rank correlation coefficient. The statistical significance was assumed at $p < 0.05$.

## Results

In the test of knowledge, the respondents scored on average 17.93 ± 3.11 points out of 25 (71.7%). The least was 8 points, the most 24 points. From group I, the subjects scored an average 17.7 ± 3.04 points out of 25 (70.8%), while in group II the average score was 18.19 ± 3.11 points out of 25 (72.8%), differentiating the respondents groups among themselves (Table 1).

Table 1. Assessment of the participants' knowledge (minimum 70% of positive answers)

| The results of the test on knowledge | | | | |
|---|---|---|---|---|
| **Descriptive statistics** | **Total** | **Group I** | **Group II** | ***p*** |
| n<br>mean±SD | 69<br>(17.93±3.11) | 37<br>(17.70±3.04) | 32<br>(18.19±3.22) | 0.018* |
| min. – max. | 8.00-24.00 | 8.00-22.00 | 10.00-24.00 | |
| Total: n (%) | 69 (100) | 37 (100) | 32 (100) | |

n – number of observations; S – -standard deviation; p – level of probability for the Mann-Whitney U test.

For assessment of participants' skills during newborn CPR with MAS, each correct proper action was awarded 2 points, with preparatory and final actions scoring 1 point each. Activities with the highest score (2 points) included efficient upper airway cleaning and stimulation of the newborn, with the lowest being ventilation and alternative airway intubation. The different scoring between the two groups was not found to be statistically significant ($p > 0.05$) (Table 2).

The number of points from the practical task obtained by the participants was transformed into a grade with a total of 21 points possible to obtain. Participants of the experiment acquiring knowledge in traditional tutorial-based training (Group I) obtained an average of 17.81 ± 1.63 points, with the group learning using the simulation-based method (Group II) scoring 17.28 ± 3.22 points, ranking the participants of the experiment at a good level (Group I: 35.1%, Group II: 43.8%). Pooling all participants of the experiment, the average score was 17.57 ± 2.49 points, with a range of 10-21 points (Group I: 15-20 points, Group II: 10-21 points). Despite similar levels of practical skills in both groups, there was a trend in favor of medical simulation-based training in three instrumented actions (Group I>Group II: umbilical cord clamping Group I 1.41±0.86 vs. Group II 1.66±0.65, thermoregulation Group I 1.54±0.56 vs. Group II 1.56±0.56, alternative intubation Group I 1.35±0.79 vs. Group II 1.47±0.76). This preliminary study did not reveal the existence of a clear relationship between the traditional tutorial-based training and the medical simulation-based training of the participants in our experiment (Group I vs. Group II). The general assessment of skills also did not differentiate between the groups ($p > 0.05$) (Table 3).

Table 2. Checklist of skills of participants: newborn CPR complicated by the presence of meconium in the respiratory tract

| Checklist of skills | | Descriptive statistics ($\bar{x}$ ± SD) | | | |
|---|---|---|---|---|---|
| | | **Total** | **Group I** | **Group II** | ***p*** |
| Preparatory actions | preparation of equipment for intubation and aspiration of meconium from respiratory tracts, gathering the team for CPR | 0.99±0.12 | 1.00±0.00 | 0.97±0.18 | 0.295 |
| | applying aseptic rules | 1.00±0.00 | 1.00±0.00 | 1.00±0.00 | 1.000 |
| Proper actions | clamping the umbilical cord | 1.52±0.87 | 1.41±0.86 | 1.66±0.65 | 0.259 |
| | cleaning the airways | 1.91±0.28 | 1.95±0.23 | 1.88±0.34 | 0.306 |
| | thermoregulation | 1.55±0.56 | 1.54±0.56 | 1.56±0.56 | 0.851 |
| | Stimulation | 1.78±0.57 | 1.86±0.42 | 1.69±0.69 | 0.311 |
| | assessment of vital signs | 1.71±0.52 | 1.81±0.46 | 1.59±0.56 | 0.054 |
| | Ventilation | 1.45±0.58 | 1.54±0.56 | 1.34±0.60 | 0.167 |
| | intubation = laryngeal mask | 1.41±0.77 | 1.35±0.79 | 1.47±0.76 | 0.506 |
| | heart massage | 1.71±0.46 | 1.73±0.45 | 1.69±0.47 | 0.708 |
| | Pharmacotherapy | 1.58±0.72 | 1.65±0.68 | 1.50±0.76 | 0.369 |
| Final actions | monitoring of the newborn's general condition | 0.96±0.21 | 0.97±0.16 | 0.94±0.25 | 0.485 |

$\bar{x}$ – arithmetic mean; SD – standard deviation; $p$ – level of probability for the Mann-Whitney U test

Table 3. Skill checklist transformed into assessment: the neonate CPR complicated by the presence of meconium in the respiratory tract (minimum 70% of positive responses).

| Assessement of skills | Total n=69 | Group I n=37 | Group II n=32 | *p* |
|---|---|---|---|---|
| A, n (%) | 1 (1.5) | 0 (0) | 1 (3.1) | 0.574 |
| B, n (%) | 13 (18.8) | 7 (18.9) | 6 (18.8) | 0.996 |
| C, n (%) | 27 (39.1) | 13 (35.1) | 14 (43.8) | 0.644 |
| D, n (%) | 11 (15.9) | 9 (24.3) | 2 (6.3) | 0.572 |
| E, n (%) | 11 (15.9) | 8 (21.6) | 3 (9.4) | 0.641 |
| F, n (%) | 6 (8.7) | 0 (0) | 6 (18.8) | 0.201 |

n – number of observations; %-percent; *p* – level of probability; * statistically significant result at the level of $p < 0.05$.

Assessment of skills: A – very good (5.0); B – good plus (4.5); C – good (4.0); D – sufficient plus (3.5); E – sufficient (3.0); F – insufficient (2.0).

## Discussion

### Key results

Meconium-stained amniotic fluid (MSAF) is a complication in approximately 10-20% of viable neonate deliveries, of whom 5% will develop meconium aspiration syndrome, and half of them will require replacement ventilation [5]. The scenario created by us shows a great need for practical training of such clinical situations, because for decades, the presence of meconium in the amniotic fluid and occurring airway obstruction was considered a serious consequence of MAS, resulting in suction of the newborn's airway [13]. The scenario also indicates the strengths and weaknesses of preparation of the participants to react in the event of identifying possible symptoms of MSAF (dyspnea, pulmonary hypertension) in the newborn [1]. It compares the undertaken activities, strategies for prevention, diagnosis, treatment and monitoring of the patient's condition, on the basis of the benefit/harm balance in midwives trained in the traditional tutorial-based model and simulation-based model [10,13].

In the case constructed by us, the opening and clearing of the oral cavity was of fundamental importance for the course of the scenario. Any delay in starting activities and making decisions could lead to loss of health or even the life of a newborn, an example of which is the analysis of the actions of the participants in our experiment. The highest assessment was for activities of airway clearing and newborn stimulation, the lowest was for using the laryngeal mask and ventilation with bag valve mask.

In our case, difficulties in carrying out a replacement respiration with the bag valve mask may result from differences in the initial length of inspiration (5-20 seconds), maximum inspiratory pressure (20-30cm $H_2O$) and the interface devices used (endotracheal tube, face mask, nasopharyngeal cannulas) that provide optimal volume and the necessary strength to expand the lungs of the newborn, with minimal risk of iatrogenic complications [14]. Visual determination of the volume and strength necessary to start replacement ventilation, in addition to the participants' knowledge of the CPR algorithm, requires consideration of the emotional and physical state of the resuscitator [15]; then, this type of training will contribute to the high performance of participants [1,16]. Our scenario included endotracheal intubation of the newborn, since we required specialist skills [17] on the use of the laryngeal mask from the participants. It was associated with the success and rapidity of the use of resuscitation equipment, guaranteeing the achievement of effective positive pressure ventilation (PPV) and better tightness hemodynamically. In addition, it could be effectively implemented in clinical practice after a short training of all participants, being an alternative to endotracheal intubation among people who do not have sufficient skills to perform this procedure, or due to the smaller number of such interventions [17]. Our actions in the description of the scenario and associated endotracheal intubation of the newborn were preceded by studies of other authors indicating the legitimacy of the use of neonatal ventilation with the laryngeal mask [18–21].

### Interpretation

Classes conducted by simulation are one of the more promising methods of education of medical staff [16,22], as manikins for simulation activities offer high fidelity anatomical features and clinical functionality, including realistic airways and breathing patterns, tactile impulses, and realistic response to actions [4,23]. Despite causing stress in the trainees, they promote the acquisition of proficiency in performing medical procedures and making decisions, constituting an indicator of effective action [4,7,8,24]. Worldwide, medical simulation has become an instrumental, experimental science, using well-established principles of andragogy in adult learning. In Poland, it has only recently become a part of nurse training programs, setting trends in practical education [2,23].

As this study shows, in this population of midwives, simulation-based training appears to confer greater effectiveness in instrumented tasks, compared to traditional tutorial-based training. The results of our research present the superiority of pragmatism of simulation training over the traditional clinical education model, due to the safety of the environment, repeatability, standardization of content, and ease of simulation of critical events [10]. Attention needs to be drawn to continuous evaluation of simulation-based training - to implement, refine and adapt the scenarios to realistic conditions, so that they accurately resemble the real picture of the medical event, [4,10,23,25], increase the participants' ability to respond to strategic moments of practice [11,12], giving them a sense of greater competence and self-confidence [24,26].

Although our clinical case is not specifically practiced, alternative ventilation and cardiac massage may be used in clinical practice in other patients [27]. Scenarios based on real cases emphasize the value of simulation exercises and automatic memorizing of the „nuances" of rare cases perpetuated during debriefing. They are based on improving practical skills, gaining knowledge, and working in a team [1,2,12,28,29], to increase the learning and memory of each participant in the simulation session [8,9,30].

### Limitations of the study

Our study involved three-person teams of midwives, instead of an interdisciplinary team, as would be the case in a real clinical situation; in this particular case, our assessment model can teach making strategic decisions until the doctor arrives. This program combines reality with active involvement of all team members [4,11], and creates a sense of security without the mental burden and embarrassment of other team members with the possibility of repeating the task, reflection and evaluation of its performance [30]. However, in order for such an educational program to bring tangible benefits, it must be focused on maintaining acquired competences through the 5 step strategy "Learn-See-Exercise-Proof-Perform-Improve", enhanced by participation in training and courses of medical simulation, due to the progress of effectiveness observed three months after the end of the training [2,3,27,31,32]. Undoubtedly, the prepared and maintained vocational education program for midwives will be conducive to effective cooperation in the team, building trust, and acquiring competence in the care of the newborn [12,33,34].

## Conclusions

Medical simulation on high fidelity manikins is an opportunity to improve acquired knowledge and skills in midwives trained in the traditional tutorial-based model of education, and those trained with the newer method of medical simulation. This increasingly popular science model allows acquisition of "instrumental" competences over a short period of time, and in conditions not threatening to the health of the baby. Despite the benefit/risk balance indicated by us on the example of participants of our experiment, it will require further analysis to develop proven methods of effectiveness, evaluation, and demonstration of improvement in clinical results.

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Word count: 2572 • Tables: 3 • Figures: – • References: 34

**Sources of funding:**
The research was funded by the authors.

**Conflicts of interests:**
The authors report that there were no conflicts of interest.

**Cite this article as:**
Zych B, Błaż W, Muster M, Kraśnianin E, Wróbel R, Kremska A, Błajda J, Raba G.
The role of simulation-based training in neonatal cardiopulmonary resuscitation complicated by meconium aspiration syndrome.
Med Sci Pulse 2020; 14, 3: 25–30. Published online: 29 Sep 2020.



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Received: 6.08.2020
Reviewed: 1.09.2020
Accepted: 21.09.2020