Resuscitation Plus 20 (2024) 100811

Contents lists available at ScienceDirect

Resuscitation Plus

journal homepage: www.elsevier.com/locate/resuscitation-plus

Clinical paper

Impact of video-assisted neonatal resuscitation on newborns and resuscitators: A feasibility study

Hiroki Otsuka [a,b,*], Eiji Hirakawa [a,c], Asataro Yara [a], Daisuke Saito [a], Takuya Tokuhisa [a]

[a] Department of Neonatology, Perinatal Medical Center, Kagoshima City Hospital, Kagoshima, Japan
[b] Department of Pediatrics, Gifu University Graduate School of Medicine, Gifu, Japan
[c] School of Tropical Medicine and Global Health, Nagasaki University, Nagasaki, Japan

ARTICLE INFO

Keywords:
Resuscitation
Infant
Telemedicine
Video-assisted support

ABSTRACT

Aim: High-risk deliveries are still common due to the increased use of assisted reproductive technologies. In Japan, despite centralization of labor, about half of all deliveries are still carried out in obstetric clinics. Telemedicine support is important for neonatal resuscitation involving urgent, life-altering professional judgment in local deliveries. This feasibility study examined the effects of using medical communication software on the quality of neonatal resuscitation, and the physiological parameters of the newborn and stress of the resuscitators.
Methods: This observational study included cesarean births with ≥ 36 weeks gestational age at Kagoshima City Hospital between January 1, 2023 and 2024. A camera on the neonatal resuscitation table allowed a neonatologist to observe the resuscitation through a medical communication software and give instructions to the resuscitators. The midwife performing the resuscitation wore a communication microphone to interact with the neonatologist. Details of the neonatal resuscitation procedures, newborn physical findings, and neonatal intensive care unit (NICU) admission rates were collected from medical records. A midwife questionnaire was also administered. The primary endpoints were resuscitation findings, and the secondary endpoint was resuscitator stress before and after implementing the software.
Results: The intervention had no major adverse effects and no change in NICU admission rates; however, there were increases in post-resuscitation temperature and suctioning frequency. While the intervention caused stress to the resuscitators, it also contributed to an increased sense of security and learning.
Conclusion: Telemedicine support in neonatal resuscitation can be introduced without significant adverse effects.

Introduction

In a society with a declining population, it is crucial to secure medical personnel, maintain expertise, and standardize and enhance healthcare efficiency. High-risk deliveries are still common due to the increased use of assisted reproductive technologies.[1] In Japan, despite centralization of labor, about half of all deliveries are still carried out in obstetric clinics.[2] The number of obstetricians and neonatologists has been declining in recent years, which reduces the capacity for perinatal care; hence, more efficient methods are required to provide the same quality of perinatal care as before.

Telemedicine is an ideal tool to access centralized medical expertise, and benefit neonatal life in urgent cases.[3] Telemedicine also contributes to reducing the stress of frontline medical personnel, and is considered one of the solutions that indirectly sustain community healthcare. One of the life-altering medical procedures in perinatal care is neonatal resuscitation. Around 85 % of term infants begin breathing within 10–30 s after birth and 10 % begin breathing in response to skin drying and stimulation; however, approximately 5 % require positive pressure ventilation.[4–6] Even if the resuscitator is trained in resuscitation techniques, there are difficulties in performing resuscitation procedures successfully. Some neonatal resuscitations require advanced techniques, such as tracheal intubation and drug administration, which requires preparation of supplies, proper use, and prompt contact with a specialist. It is difficult to do all of these things simultaneously in a limited-resource setting as in obstetric clinics. It has been reported that intubation takes longer and is less accurate when performed by the referring team compared to a specialized team trained in resuscitation

Abbreviations: NICU, neonatal intensive care unit; NCPR, neonatal cardiopulmonary resuscitation.

* Corresponding author at: Department of Neonatology, Perinatal Medical Center, Kagoshima City Hospital, 37-1 Uearatacho, Kagoshima 890-8760, Japan.
E-mail address: mawarimiti2@yahoo.co.jp (H. Otsuka).

https://doi.org/10.1016/j.resplu.2024.100811
Received 16 August 2024; Received in revised form 18 October 2024; Accepted 20 October 2024

techniques.[7] The use of telemedicine during neonatal resuscitation enables real-time, high-quality information sharing and rapid neonatal resuscitation with support from skilled specialists, regardless of their location. Telephone assistance previously existed, but video-assistance is now possible. Technical issues, such as connectivity have been improved, leading to enhanced quality of resuscitation, reduced transportations, and shorter hospital stays.[8–10] From the perspective of community medicine, as the number of deliveries decline, experience and proficiency in emergency response related to neonatal resuscitation may become more challenging.[11] Real-time feedback through telemedicine support is expected to maintain the quality of neonatal resuscitation. There are reports indicating that video resuscitation debriefings have resulted in improved resuscitation skills.[12] Although telemedicine should be widely used in primary delivery facilities consisting of obstetricians and midwives, such as those in Japan, there have been no studies on the impact of telemedicine on low-risk deliveries.

This feasibility study was conducted at the Kagoshima City Hospital, a tertiary care hospital to provide telemedicine support for low-risk cesarean section deliveries. We aimed to examine the effects of using medical communication software on the quality of neonatal resuscitation, and the physiological parameters of the newborns and stress levels of the resuscitators.

Methods

This was an observational study approved by the Institutional Review Board of Kagoshima City Hospital (Approval date: July 6, 2023, Approval number: 2023–14). This study adheres to the Declaration of Helsinki. Informed consent was obtained in the form of an opt-out method on the website for the pre-intervention group. Prior to the intervention, ward staff explained the study to the parents or carers, from whom informed consent was directly obtained. This consent was subsequently documented in the patient's medical chart. Patients who did not consent were excluded from the study. Consent was also obtained from all midwives receiving telemedicine support to have a survey. The study included cesarean births of ≥36 weeks gestational age at the Kagoshima City Hospital between January 1, 2023 and January 1, 2024. The hospital has 587 beds, with 36 beds in the NICU. The NICU is a tertiary center in Kagoshima prefecture, where the population is 1.6 million. The annual number of admissions to NICU is approximately 600. The neonatal resuscitation table was equipped with a camera, and the resuscitator wore a microphone for communication. A neonatologist in the neonatal intensive care unit (NICU) observed the resuscitation through a tablet and provided necessary support via JOIN software (Allm Inc., Tokyo, Japan), a medical communication application. The medical communication software enabled higher quality neonatal resuscitation than the standard methods through visual information provided by real-time video. When more advanced resuscitation procedures were necessary, the neonatologist went to the operating room to directly provide therapeutic intervention.

Data were collected from the medical records, which included the number of weeks of gestation, weight, name of the disease, details of neonatal resuscitation procedures, oxygen administration, invasive or non-invasive respiratory management, NICU admission, and the temperature data of the newborn. The Brief Job Stress Questionnaire was administered to the midwives who were responsible for resuscitation to assess their stress levels, and was supplemented by an open-ended questionnaire.[13] To increase the collection rate, only a 5-point scale of 17 items (maximum total score of 68) was used. The rationale for using only 17 items is that they represent key aspects of work, such as workload, control, interpersonal relationships, and job compatibility. These factors are directly related to the nature of the work itself. In contrast, other indices assess daily conditions, which we deemed less suitable for evaluating the impact of video interventions. By concentrating on work-related stressors, we aimed to ensure that the assessment accurately reflects the specific context of the intervention. Participants were asked to freely write about the advantages and disadvantages of the descriptive questionnaires before and after the study. Open-ended responses were grouped into four categories. We conducted a quantitative evaluation using content analysis, determining the frequency and percentage of occurrence for each key element.

The primary and secondary endpoints were compared before and after the introduction of the medical communication software. The primary endpoints were the Apgar score, frequency of continuous positive airway pressure and oxygen use, rate of NICU admission, and temperature at admission to the obstetric ward or NICU. The secondary endpoint was the change in the stress levels of midwives due to the introduction of remote support.

R (version 4.3.2) was used for statistical analysis. The Mann–Whitney *U* test was used for the birth weight, number of weeks in gestation, Apgar score, and body temperature. Fisher's exact probability test was used for hospitalization and various procedures. Paired *t*-test was used to compare stress values. Statistical significance was set at $p < 0.05$. Additionally, sensitivity analysis was conducted using Monte Carlo simulations, with 10,000 iterations per variable to evaluate the impact of sample size discrepancies. Given the imbalance between the Pre (9 months) and Post (3 months) periods, subsampling with bootstrapping was applied to align sample sizes. Statistical significance was then assessed through sensitivity analysis.

Results

All low-risk cesarean section deliveries were consented. A total of 245 patients were included in the study, with 203 subjects before the introduction of telemedicine support and 42 after. After the introduction of telemedicine support, 52 eligible cases were resuscitated, with telemedicine support provided to 42 of them. The remaining 10 cases were excluded due to various reasons: no support at night without notification from the midwife (2 cases), tablet or communication signal malfunction (3 cases), and conditions of the mother or newborn that precluded coverage (5 cases). No patients were excluded due to opting out, and there were no missing data for any variables of interest. The resuscitation results before and after the introduction of telemedicine support are detailed in Table 1. From 9 months prior to the introduction of telemedicine support, there were six NICU admissions (2.9 %), and the treatment that was most administered was suctioning (129 cases, 63.5 %). There were no cases of laryngeal mask use, surfactant administration, chest compressions, or adrenaline administration. For the 3 months after introduction, there was one NICU admission, and the treatment that was most administered was suctioning (38 cases, 90.5 %). There were no cases of laryngeal mask use, intubation, surfactant administration, chest compressions, or adrenaline administration.

Significant differences were found in the post-resuscitation temperature and in the frequency of suctioning performed. Temperature increased from 36.9 °C (36.6–37.2) before introduction to 37.0 °C (36.8–37.3) after introduction ($p = 0.012$). Suction increased from 129 (63.5 %) before introduction to 38 (90.5 %) after introduction ($p = 0.0004$). The Monte Carlo simulations demonstrated statistically significant differences between the Pre and Post periods for suction rate and temperature after resuscitation. Suction rate increased significantly from 63.4 % to 90.5 % ($p < 0.0001$), and temperature after resuscitation was also higher in the Post period (Pre: 36.9 °C, Post: 37.0 °C, $p < 0.0001$), indicating improved thermal regulation.

The results of the Brief Job Stress Questionnaire are shown in Table 2. The response rate was 100 % (34/34) for pre-survey midwives and 91 % (30/33) for post-survey midwives. The results of the open-ended questionnaire are shown in Table 3. Prior to the introduction of the system, there were expectations for more secure resuscitation, rapid coordination, and advanced procedures. The system was also expected to be needed in remote and isolated areas. On the other hand, there was a concern about the quality of performance despite the instructions, and that the support provided might be stressful. Other concerns included

Table 1
Neonatal resuscitation data before and after the introduction of video telemedicine support.

	Pre (n = 203)	Post (n = 42)	p-value
Birth weight (g)	2,756 (2,480–3,057)	2,860 (2,595–3,132)	0.31
Gestational age (weeks)	38 (37–38)	38 (37–38)	0.96
Apgar score (5 min)	9 (9–9)	9 (9–9)	0.28
Temperature after resuscitation	36.9 (36.6–37.2)	37.0 (36.8–37.3)	0.01
Admission to NICU	6/203 (2.9 %)	1/42 (2.3 %)	1
Resuscitators	n = 34	n = 33	
Suction	129 (63.5 %)	38 (90.5 %)	<0.001
CPAP	25 (12.3 %)	5 (11.9 %)	1
Non-invasive ventilation	5 (2.5 %)	1 (2.4 %)	1
Laryngeal mask	0	0	
Any additional oxygen	11 (5.4 %)	3 (7.1 %)	0.71
Intubation + invasive ventilation	1 (0.5 %)	0	1
Surfactant via ETT	0	0	
Less-invasive surfactant administration	0	0	
Chest Compression	0	0	
Peripheral intravenous access	0	0	
Umbilical venous access	0	0	
Intraosseous access	0	0	
Epinephrine	0	0	
Caffeine	0	0	

The median and the values in parentheses represent the interquartile range (IQR).The Mann–Whitney *U* test was used for birth weight, number of weeks in gestation, Apgar score, and body temperature. The Fisher's exact probability test was used for hospitalization and other procedures.
NICU, neonatal intensive care unit; CPAP, continuous positive airway pressure; ETT, endotracheal tube.

Table 2
Stress scores of the midwives before and after the introduction of video telemedicine support.

	Pre	Post	p-value
Midwifery Experience (years)			
0–5	48 (45.0 – 49.8)	48 (45.8 – 49.3)	0.12
5–10	47 (44.0 – 52.5)	47 (43.8 – 49.5)	0.74
>10	46 (45.0 – 47.0)	46 (44.0 – 49.0)	0.81
Overall	47 (45.0 – 49.8)	47 (44.0 – 49.0)	0.12

The median and the values in parentheses represent the interquartile range (IQR). Paired *t*-test was used to compare stress values.

how to set up the system, glitches, delays in emergency preparedness, security and privacy, and the risk of communication errors due to the gap shifting from audio-only to combined audio–video that were previously non-existent. After the introduction of the system, the positive aspects included a sense of security in performing resuscitation and the opinion that information sharing was quick and easy due to the video. The disadvantages noted were nervousness or stress when interrupted during critical tasks. Other comments included the increased resuscitation preparation and time consumption, and that some images were not conveyed well due to quality issues.

Discussion

This feasibility study was conducted to introduce video telemedicine support for in-hospital low-risk cesarean sections, with the aim of expanding telemedicine support to local deliveries. The study found that NICU admission rates did not increase, and telemedicine support was introduced without compromising resuscitation outcomes. Significant differences were observed in the post-resuscitation temperature and

Table 3
Descriptive comments by midwives on expectations, concerns, and the actual benefits and disadvantages before and after the introduction of video telemedicine support.

Pre	%	Post	%
Expectations		***Benefits***	
Psychological		**Psychological**	
a. Reduced anxiety about potential adverse conditions.	24	a. Security from professional support.	40
b. Increased confidence in performing advanced techniques.	15	b. Opportunity for review and improvement.	27
Procedural/Technical		**Procedural/Technical**	
a. Consistent on the job training regardless of experience level.	9	a. Clearer communication through video.	13
b. Smooth communication during emergencies.	44	b. Faster decision-making with expert support.	33
		c. Increased precision procedures.	33
Social		**Social**	
a. Necessary for remote or isolated areas.	21	a. Essential for remote and emergency situations.	20
Concerns		***Disadvantages***	
Psychological		**Psychological**	
a. Feeling stressed or intimidated by being observed and evaluated.	32	a. Increased nervousness from external support.	60
		b. Stress from interruptions during critical tasks.	17
Technical		**Technical**	
a. Difficulty with device setup.	15	a. App setup issues and potential delays.	20
b. Potential delays during emergencies or malfunctions.	12	b. Resolution and colour issues in detail.	3
c. Security and privacy.	3		
d. Risk of communication errors via video.	6		

The frequency of responses for key elements was shown as a percentage in open ended question.

frequency of suctioning. The results of the questionnaire indicated no change in stress levels before and after implementing telemedicine support. While the descriptive survey provided reassurance and technical feedback, some respondents expressed increased stress because of the support. Overall, neonatal resuscitation support via video telemedicine is feasible and can be implemented, although some limitations need to be addressed.

Telemedicine support has potential for integration into community deliveries without compromising neonatal resuscitation outcomes. The Japan Obstetric Compensation System for Cerebral Palsy has established a system for managing high-risk deliveries in comprehensive and regional perinatal centers. However, prenatal prediction of all high-risk infants is not possible, and sudden issues to extrauterine life can occur even after a successful pregnancy and delivery. Appropriate neonatal resuscitation procedures rely on the ability to predict and respond to the condition of the newborn based on the pregnancy and delivery process.[14] In cases where cerebral palsy was caused by hypoxia/acidemia during labor, only 70 % of cases could be predicted using a readable fetal heart rate contraction diagram. Severe neonatal asphyxia during community deliveries remains a possibility; however, 90.8 % of severe neonatal asphyxia cases requiring post-analysis involved healthcare professionals who had completed the Neonatal Cardiopulmonary Resuscitation (NCPR) training, suggesting that standard resuscitation techniques are already widely disseminated. The next step for advancing resuscitation in community deliveries should be the widespread use of telemedicine support. This approach can enhance the quality of neonatal resuscitation by providing real-time guidance and support from skilled specialists, thereby improving outcomes even in unexpected high-risk situations.

Neonatal hypothermia is defined as a deep body temperature below 36.5 °C.[15] A previous report showed that for every 1 °C drop in the admission temperature of low-birth-weight infants, there is a 28 %

increase in mortality and an 11 % increase in morbidity-related to sepsis.[16] Another report found neonatal hypothermia in approximately 20 % of the study population.[17] Hypothermia was less frequent among neonates resuscitated by trained neonatal resuscitation team members compared to those resuscitated at the referral source.[7] Reports suggest that telemedicine leads to more frequent monitoring of temperature, blood glucose, and gas levels, indicating an increased tendency to rely on objective indicators and provide appropriate interventions.[10] Although this study did not encounter cases of hypothermia, the results suggest that telemedicine support may contribute to better resuscitation outcomes. The enhanced monitoring and rapid response facilitated by telemedicine could potentially reduce the incidence of neonatal hypothermia and improve overall neonatal health outcomes.

The increased frequency of suctioning was largely due to the inability of telemedicine support to directly assess auscultation findings. Identifying secretory retention is challenging when relying only on video information, inaudible breath sounds picked up by the microphone, and the auscultatory evaluation of the resuscitator. A report indicated that active resuscitation support led to a higher frequency of suctioning procedures compared to passive support, suggesting that suctioning is often performed at the prompting of others.[18] Although the current Consensus on Science with Treatment Recommendations do not recommend routine suctioning,[19] it remains one of the easiest procedures to perform, which may explain its increased frequency. These findings highlight the need for careful consideration of telemedicine support for neonatal resuscitation. Understanding its limitations and ensuring appropriate training and protocols are essential to optimize resuscitation outcomes.

The total stress levels were not significantly different between pre- and post-introduction of telemedicine support, regardless of the years of experience. The Brief Job Stress Questionnaire helps prevent mental health problems by identifying high-stress individuals through their total score; however, delivery is inherently a stressful task, which contributed to the high stress levels observed prior to the introduction of telemedicine support.[20] In the open-ended questionnaire, midwives expressed both a sense of relief and pressure from being observed. A comparison of remote assistance versus field instructions in resuscitation simulations showed higher workloads for remote assistance.[21] However, the quality of neonatal resuscitation has been reported to be better with video assistance than without assistance.[22] These findings suggest that telemedicine support for neonatal resuscitation generated a mix of relief and nervousness among midwives, resulting in no significant overall change in stress levels. While telemedicine provided reassurance through continuous observation, it also introduced new pressures, indicating the need for balanced support and comprehensive training to optimize its benefits.

The open-ended questionnaire raised concerns related to the devices used and the advantages and disadvantages of telemedicine support and video. Some instances of malfunction and lack of preparation affected the functionality of the support, but minor issues decreased over time, suggesting that these can be resolved with increased familiarity (no data). Participants expressed concerns about stress caused by interruptions during critical tasks; hence, standardization and improvement of support methods were deemed necessary to address these issues. Passive support has been reported to be more stressful than active support.[18] Building a good relationship requires a calm and supportive attitude, tailored to the capabilities and pace of the facility being supported.[23]

Limitations

This study is a single-center feasibility study and does not comprehensively discuss the usefulness of video telemedicine support. A key limitation of this study is the unequal sample sizes, which may introduce bias. The disparity between the 3-month and 9-month datasets could affect model sensitivity. Although the Monte Carlo simulations was demonstrated as standardization, data heterogeneity and potential outliers in the smaller dataset may have influenced the results. Regarding stress assessment, not all of the original survey items were used, limiting the ability to determine a high-stress state. The questionnaire was open-ended, preventing the quantification of the advantages and disadvantages of telemedicine support. Some respondents noted that the presence and content of telemedicine support were stressful, which might have been due to the lack of understanding or competence assessment of the resuscitator. Actual implementation should consider familiarity with receiving assistance, standardization of assistance methods, and evaluation of resuscitation capabilities.

Conclusions

Telemedicine support in neonatal resuscitation is feasible without significant issues in low-risk deliveries. However, the study did not show notable improvements in the quality or timeliness of postnatal stabilization. While telemedicine can enhance resuscitator confidence and offer opportunities for professional growth, it is important to ensure that it does not increase stress for medical staff.

Institutional approval

This was a observational study approved by the Institutional Review Board of Kagoshima City Hospital (Approval date: July 6, 2023, Approval number: 2023-14). This study adheres to the Declaration of Helsinki.

Consent statement

Informed consent was obtained in the form of an opt-out method on the website. Patients who did not consent were excluded from the study.

Funding

This study was funded by a joint research grant from Allm Inc.

CRediT authorship contribution statement

Hiroki Otsuka: Writing – review & editing, Writing – original draft, Project administration, Formal analysis. **Eiji Hirakawa:** Writing – review & editing, Project administration, Methodology, Funding acquisition, Conceptualization. **Asataro Yara:** Writing – review & editing, Project administration. **Daisuke Saito:** Writing – review & editing, Project administration. **Takuya Tokuhisa:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank Shino Kihara and Ayumi Kamiya for supporting this study; Takeshi Ikeda and Teppei Sakano for providing the application from Allm Inc. We also thank Editage editing service for the help with our manuscript.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100811.

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