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Clinical paper

The impact of telemedicine on the quality of newborn resuscitation: A retrospective study☆

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ABSTRACT

Objective: We hypothesized that telemedicine consults provided by neonatologists to local care teams (termed teleneonatology) would improve the quality of high-risk newborn resuscitations that occur in community hospitals.

Methods: This retrospective cohort study compared 47 newborns who received a teleneonatology consult during their resuscitation at a community hospital to 45 controls who did not. Controls were matched on gestational age, sex, admission diagnosis, and level of newborn care. A two-person expert panel blinded to the intervention reviewed demographic and resuscitation data for each patient and assigned a resuscitation quality rating using a 1–10 descriptive rating scale. Paired comparisons between groups were evaluated using the Wilcoxon signed rank test for continuous measures and the McNemar's test for dichotomous measures.

Results: The median resuscitation quality rating was 7 for the teleneonatology group and 4 for the control group, with a median difference of 1 between matched pairs (P = .002). Neonates who received a teleneonatology consult were more likely to undergo measurement of temperature, glucose, and blood gases. When analyzing the 35 matched pairs that had a consult within one hour of birth, the positive impact of teleneonatology was greater (median rating 8 vs 4, median difference 2, P = .003). Subgroup analysis demonstrated teleneonatology significantly improved the resuscitation of preterm neonates (median rating 8 vs 4, median difference 1.5, P = .004)

Conclusion: Teleneonatology improves the quality of high-risk newborn resuscitations that occur in community hospitals and increases adherence to process metrics. Earlier teleneonatology consults appear to have greater positive impact.

Introduction

Approximately 10% of newborns will require some breathing assistance after birth, and 1 in 1000 newborns will require extensive resuscitation after delivery [1]. Infants who require advanced resuscitation, especially very low-birth-weight infants, have poorer outcomes when delivered at hospitals with lower levels of neonatal care [2–4]. This outcome disparity may be related to knowledge and procedural skill decay experienced by providers due to the infrequency of high-risk deliveries at community hospitals [5,6]. In addition, the ability to deliver risk-appropriate care in the U.S. may be limited by geographic challenges and discordance in access to higher level perinatal care [7].

Institutions are beginning to use telemedicine to address disparities in access to subspecialty perinatal care and inequalities in newborn outcomes [8–10]. During simulated newborn resuscitations performed by general pediatric providers, video telemedicine consultation with a neonatologist significantly improved the time to effective ventilation and adherence with the Neonatal Resuscitation Program (NRP) guidelines [11]. When neonatologists located in a regional referral center were able to provide synchronous video telemedicine consults to community providers, 93% of local staff agreed that the telemedicine consult improved patient safety and/or the quality of care [12].

The objective of our retrospective study was to assess the impact of synchronous video telemedicine consults provided by neonatologists

Abbreviations: NRP, neonatal resuscitation program; NICU, neonatal intensive care unit; EMR, electronic health record; MCH, Mayo Clinic Hospital; MCHS, Mayo Clinic Health System

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(teleneonatology) on the quality of high-risk newborn resuscitations that occur in community hospitals. We hypothesized that the overall resuscitation quality rating would be higher for neonates who received a teleneonatology consult during their resuscitation when compared to matched controls who were managed by the local care team. We also sought to evaluate the impact of teleneonatology on individual resuscitation quality metrics (e.g. ventilation, thermoregulation, and glucose homeostasis) and subsequent neonatal morbidities and mortality experienced in the neonatal intensive care unit (NICU).

Methods

Study design

In March 2013, neonatologists at Mayo Clinic Hospital, Rochester, MN, began offering teleneonatology to six community-based hospitals within the Mayo Clinic Health System (MCHS) as previously described [12]. The neonatologists established a synchronous, audio-video telemedicine connection to assess the newborn and guide the local care team using the two technology solutions described by Beck et al. [13]. For this retrospective study approved by the Mayo Clinic Institutional Review Board, inclusion criteria for newborns in the intervention group were 1) a teleneonatology consult performed during the initial resuscitation and stabilization period at the birth hospital between March 21, 2013 and July 30, 2016, 2) subsequent admission to the NICU at Mayo Clinic Hospital (MCH), and 3) authorized access to medical records based on either the neonate's general Minnesota research authorization status or written parental consent specifically for this study.

A matched control group was selected from outborn neonates who 1) were born between January 1, 2010 and July 30, 2016, 2) were admitted to the NICU at MCH within 12 h of delivery but did not receive a teleneonatology consult, and 3) had authorized access to their medical records for research purposes. Any communication between the neonatologist and local provider was done via telephone. For each neonate in the teleneonatology group, we randomly identified one neonate from the pool of potential controls matched on gestational age (within one week for subjects < 36 weeks; within 2 weeks for subjects ≥36 weeks), level of newborn care at the referring hospital, primary admission diagnosis, and sex. Exclusion criterion for both groups was the presence of the neonatal transport team at time of delivery. For study purposes, the resuscitation period was defined as the time of birth until time of arrival of the neonatal transport team.

Data collection

All demographic, perinatal and neonatal data were abstracted from the electronic medical record (EMR) and recorded in an institutional password-protected database. When data collection was complete, two neonatologists with over 30 years of combined experience in newborn resuscitation (CEC and WAC) separately reviewed the patient characteristics and newborn resuscitation quality metrics for each patient. Each reviewer, blinded to the intervention, independently assigned an overall "resuscitation quality rating" to each patient using a 1–10 descriptive rating scale (Table 1). Because there is no validated tool to assess the overall quality of newborn resuscitation, the authors developed a rating scale based on clinically relevant, objective data with defined "normals" that were likely to be documented in the EMR. If the ratings from the two experts disagreed, the experts reviewed the patient's record together and reached a consensus rating.

The resuscitation quality rating served as the primary outcome for the study. The rating was analyzed as both a continuous measure and as a dichotomous measure using categories of 1–4 versus 5–10 (a rating of ≥5 was assigned if abnormal parameters normalized during the resuscitation). Secondary study outcomes included the individual resuscitation metrics as well as complications experienced during the NICU stay. We documented the following neonatal outcomes: death prior to discharge, pneumothorax, duration of mechanical ventilation, length of stay, and other morbidities associated with prematurity including bronchopulmonary dysplasia [14], necrotizing enterocolitis (Bell's Stage 2 or greater), severe retinopathy of prematurity (worst ROP stage between 3 and 5), any grade and severe intracranial hemorrhage (severe defined as periventricular-intraventricular hemorrhage grade 3 or 4), and cystic periventricular leukomalacia.

Statistical analysis

The initial power calculation was based on assuming 55 neonates in the intervention group would meet study criteria and a standard deviation (SD) of 2 for the resuscitation quality rating. Based on a two-sided *t*-test with 55 per group, the study would have 80% power to detect a difference in group means of 0.54 SD or 1.1 units. Although the statistical power would be slightly less when analyzed using a non-parametric test, the power would be maintained upon taking matching into account in the analysis.

Patient characteristics were summarized using standard descriptive statistics for all unique patients in the intervention and control groups. Unpaired comparisons of the baseline characteristics were made using the two-sample *t*-test or Wilcoxon rank sum test for continuous measures and the chi-square test or Fisher's exact test for dichotomous measures. Paired comparisons between the matched pairs were conducted for the resuscitation quality rating, individual resuscitation metrics, and mortality and morbidities using the Wilcoxon signed rank test for continuous measures and the McNemar's test for dichotomous measures. A planned subgroup analysis stratified by gestational age (< 37 versus ≥37 weeks) was performed for each of the outcome measures. A sensitivity analysis of the primary outcome restricted to the matched pairs in which the newborn in the teleneonatology group had their consult initiated within one hour of birth was also conducted. All calculated *p*-values were two-sided and *p*-values less than .05 were considered statistically significant. Analyses were performed using SAS version 9.4 software (SAS Institute, Inc.; Cary, NC).

Results

During the study period, 47 neonates met inclusion criteria (Fig. 1). Forty-four were matched to unique controls, while three born at 24 weeks were matched to the same control, for a total of 45 unique controls. Suitable controls for these three neonates could not be identified even if the time period were extended by another five years due to the infrequency of extremely preterm deliveries in our community hospitals. Among the 47 matched pairs, 38 (81%) were exactly matched on all 4 characteristics, 8 (17%) were matched on 3 characteristics, and 1 (2%) was matched on 2 characteristics.

Patient characteristics are summarized in Table 2. The mean gestational age was 34–35 weeks, with 17% (n = 16) of the patients born < 29 weeks gestation. The mean birth weight was approximately 2500 g, with the smallest neonates weighing around 500 g. Rates of antenatal steroid use in this population were low. Thirty-five percent of newborns in the study were delivered by emergency C-section. The median duration of the initial resuscitation and stabilization period at the birth hospital (time from birth until arrival of the transport team) was 103 min ([IQR] 61, 143). While the two groups were generally similar, there was a higher rate of placental abruption and lesser exposure to antenatal steroids for neonates in the teleneonatology group.

Comparison of the resuscitation quality rating and individual resuscitation metrics between the 47 matched pairs is shown in Table 3. In analyzing the primary study outcome, we found the median resuscitation quality rating was 7 for the teleneonatology group and 4 for the control group, with a median difference (teleneonatology – matched control) of 1 between matched pairs (P = .002). When evaluating a rating cutoff of 4, 55% (26/47) of patients in the teleneonatology group had a rating of 5–10 compared to 30% (14/47) of the matched controls