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Rachel Coffey
Maine Medical Center

Et al.

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Telemedicine Consultation to Assess Neonatal Encephalopathy in Rural Community Hospitals and Tertiary Care Centers

Authors

Rachel Coffey, Misty Melendi, Anya K. Cutler, and Alexa K. Craig

INNOVATION HIGHLIGHT

Telemedicine Consultation to Assess Neonatal Encephalopathy in Rural Community Hospitals and Tertiary Care Centers

Rachel Coffey, DO,¹ Misty Melendi, MD,^{1,2} Anya K Cutler, MS, MPH,³ Alexa K Craig, MD, MS^{1,4}

¹Maine Medical Center, Department of Pediatrics, Barbara Bush Children's Hospital, Portland, ME, ²Maine Medical Center, Division of Neonatology, Barbara Bush Children's Hospital, Portland, ME, ³Maine Medical Center, Center for Outcomes Research, Portland, ME, ⁴Maine Medical Center, Division of Pediatric Neurology, Barbara Bush Children's Hospital, Portland, ME

Introduction: Teleconsultation is used in tertiary care hospitals to evaluate neonatal encephalopathy. Neonates born in community hospitals, however, often experience delayed evaluation due to transport to the tertiary care center. We studied teleconsultations in community hospitals to decrease this disparity.

Methods: Prospective observational study in 9 community hospitals and 1 neonatal intensive care unit. Inclusion criteria: gestational age greater than or equal to 35 weeks and one of the following: umbilical cord pH less than or equal to 7.2, 5-minute Apgar less than 7, prolonged respiratory support, perinatal event, or abnormal neurological exam. We performed synchronized, unscheduled telemedicine consults with the main outcome of time to teleconsultation.

Results: From April 2018 to September 2020, we performed 53 teleconsultations: 34 (64%) in community hospitals and 19 (36%) in the tertiary care center. Teleconsultations occurred at a median of 98 minutes (IQR, 76-127) in community hospitals versus 68 minutes (IQR, 43-91) in the tertiary care center ($P = .004$). Nine (26%) neonates born in a community hospital remained with their parents and were not transferred to the tertiary care center for further assessment.

Discussion: Neonates born in rural community hospitals have slightly later teleconsultations than neonates born in the tertiary care center. Telemedicine use reduced this disparity from nearly 5 hours in our prior study to 98 minutes in this study by permitting evaluation of neonates in community hospitals without transporting them to the tertiary care center.

Conclusions: Teleconsultations to evaluate neonatal encephalopathy are a feasible, accessible, and reliable way to bring expert-level care into rural community hospitals.

Keywords: neonatal encephalopathy, therapeutic hypothermia, telemedicine, health care disparity, rural hospitals

Neonatal encephalopathy (NE) is a clinical syndrome of abnormal neurological function in a neonate at greater than 35 weeks gestation.¹ Symptoms of NE can include abnormalities in any of the following: level of consciousness, spontaneous movement, muscle tone, posture, primitive reflexes (e.g., Moro and suck), and autonomic functions (e.g., heart rate, respiration, pupil function).^{2,3} Neonates with

moderate to severe NE, acidotic umbilical cord pH, and low Apgar scores are eligible for therapeutic hypothermia (TH),⁴ a neuroprotective therapy that must be started in the first 6 hours of life for maximal effect.⁵ NE can fluctuate within the first several hours of life,⁶ highlighting the importance of experienced provider assessments (e.g., pediatric neurologist, neonatologist) and access to serial examinations.⁷

Correspondence: Alexa K. Craig, MD
Maine Medical Partners Pediatric Neurology
92 Campus Drive, Scarborough, Maine, 04074
craiga@mmc.org

Newborns who are delivered in small community hospitals and may be eligible for TH need to be transferred to tertiary care centers for evaluation.

This transfer can complicate the timeliness of assessment and initiation of therapy.⁸ Telemedicine use is rapidly expanding for multiple indications in the neonatal intensive care unit,^{9,10} especially for neurological indications given the high reproducibility of neonatal neurological exams performed by telemedicine consults.¹¹ NE assessment by telemedicine within the tertiary care facility is feasible. Unfortunately, for neonates born in community hospitals, the time required for transfer to a tertiary care center can delay this evaluation by hours.¹²

To assess feasibility of telemedicine use in the non-tertiary care setting, we implemented synchronous, unscheduled telemedicine consults for neonates with suspected symptoms of NE in the community hospital. Our primary outcome measure was the time to teleconsultation, measured in hours from birth.

METHODS

Study design

Prospectively recruited neonates who received telemedicine consults from April 2018 to September 2020. The MaineHealth Institutional Review Board approved this study (#1173919).

Inclusion/Exclusion criteria

Neonates were included if their gestational age was greater than or equal to 35 weeks and they showed one of the following signs of a difficult delivery: cord pH less than or equal to 7.2, 5-minute Apgar less than 7, prolonged respiratory support, perinatal event (e.g., dystocia, cord prolapse, placental abruption, uterine rupture), or abnormal neurological exam. Infants more than 6 hours old at the time of telemedicine consultation were excluded.

Teleconsultation

In the tertiary care center, we used medical grade, wheeled telemedicine carts with a 32-inch screen and a high-resolution, zoom-capable camera with Cisco Jabber video conferencing software for a two-way interface between the pediatric neurologist and neonatologist. In the community hospital, we used Vidyo® software, which was capable of a three-way interface between the pediatric neurologist, the neonatologist, and the community hospital pediatrician. Both software platforms were

encrypted and compliant with the Health Insurance Portability and Accountability Act. The telemedicine carts were plugged into the Ethernet to ensure high-quality audio/video feeds.

Neonatal encephalopathy exam

We examined neonates using a modified version of the Sarnat staging exam.^{2,4} This exam involves categorizing the level of consciousness, spontaneous movements, muscle tone, distal flexion, quality of the suck reflex, Moro reflex, and autonomic features, including heart rate, respiratory rate, and pupillary function (Supplement 1). We assigned scores of 1 for mildly abnormal features, 2 for moderately abnormal features, and 3 for severely abnormal features. Individual scores were added for a total score. The neurologist assigned the NE score by observing the neonate through the telemedicine consult. Scores ranged from 1 to 6 for mild NE, 7 to 18 for moderate NE, and 19 to 27 for severe NE. As NE can be a waxing and waning clinical condition, we repeated telemedicine exams for neonates who did not meet inclusion criteria for treatment with TH as long as the exam could be started within the 6-hour window.

Statistical analysis

Patients were grouped by birth location (community hospital vs tertiary care center), and statistical differences were determined for several clinical characteristics. Student's *t* tests were used for normally distributed continuous variables, and Wilcoxon rank-sum tests were used for non-normally distributed variables. Normality was determined by visualizing histograms and Shapiro tests. Chi-squared tests were used for categorical variables, unless expected cell counts were less than 5, in which case Fisher's exact tests were used. All analyses were performed in R 3.6.2.

RESULTS

From April 4, 2018, to September 24, 2020, there were 57 neonates who received telemedicine consults to evaluate for NE. Four neonates were excluded: 1 who was born at the tertiary care center at a gestational age less than 35 weeks, and 3 who were born at community hospitals and the teleconsultation was requested after the neonate was transferred to the tertiary care center for other reasons (e.g., respiratory distress). Nineteen (36%) neonates were born in the tertiary care center, and the remaining 34 (64%) were born in community

hospitals. Neonates from the tertiary care center were born at significantly younger gestational ages, had smaller birth weights, and were delivered via cesarean section at a higher rate than neonates born in community hospitals (Table 1). At the tertiary care center, patients' umbilical cord gases had lower pH and higher base deficits than patients at community hospitals. Twenty-four (45%) neonates were treated with TH. Of these, 7 (37%) were born in the tertiary care center and 17 (50%) were born in community hospitals.

The first teleconsultation occurred at a median of 98 minutes (IQR, 76-127) in community hospitals compared to 66 minutes (IQR, 43-91) in tertiary care centers ($P = .004$) (Table 2). More neonates at the tertiary care center ($n = 14$, 74%) had second telemedicine consults than neonates born at community hospitals ($n = 12$, 35%). For the neonates who received second and third consults, the interval time between those assessments was not different between cohorts. After teleconsultation, 9 (26%) neonates born at community hospitals were not transferred to the tertiary care center for

Table 1: Table 1. Maternal and Neonatal Characteristics

Characteristic	Tertiary Care Center, N = 19 ¹	Community Hospitals, N = 34 ¹	p-value ²
Maternal Age	30 (6)	30 (5)	0.789
Unknown	0	4	
Gestational Diabetes	4 (21%)	4 (12%)	0.436
GBS Positive	5 (26%)	6 (18%)	0.496
Preeclampsia/Eclampsia	2 (11%)	2 (5.9%)	0.612
Prolonged Rupture of Membranes	2 (11%)	9 (26%)	0.290
C-Section	13 (68%)	10 (29%)	0.006
Gestational Age 35-36 wks	4 (21%)	1 (2.9%)	0.050
Male Sex	11 (58%)	24 (71%)	0.349
Birth Weight (kg)	3.17 (0.53)	3.64 (0.52)	0.004
Unknown	0	3	
APGAR at 1 Minute	3 (2)	2 (2)	0.595
APGAR at 5 Minutes	7 (2)	5 (2)	0.016
APGAR at 10 Minutes	7 (1)	6 (2)	0.436
Unknown	11	7	
Umbilical Cord ABG/VBG Obtained	18 (95%)	26 (76%)	0.133
Arterial Cord pH	7.07 (0.16)	7.15 (0.14)	0.108
Unknown	2	10	
Arterial Base Deficit	-13.6 (7.4)	-10.0 (4.9)	0.085
Unknown	2	12	
Venous Cord pH	7.14 (0.14)	7.20 (0.11)	0.151
Unknown	2	11	
Venous Base Deficit	-10.9 (5.9)	-8.6 (4.5)	0.280
Unknown	2	12	
Infant ABG or VBG or capillary blood gas within First Hour of Life	10 (53%)	16 (48%)	0.773
Unknown	0	1	
pH	7.25 (0.09)	7.17 (0.16)	0.139
Unknown	9	18	
Base Deficit	-11.5 (5.3)	-10.8 (5.9)	0.763
Unknown	9	20	
Received Therapeutic Hypothermia	7 (37%)	17 (50%)	0.356

Abbreviations: ABG, arterial blood gases; GBS, group B strep; SD standard deviation; VBG venous blood gases

¹Mean (SD); n (%)

²Wilcoxon rank sum test; Fisher's exact test; Pearson's Chi-squared test; Welch Two Sample t-test

Table 2. Encephalopathy Scores and Timing of Scores

Characteristic	Tertiary care center (n = 19)	Community hospitals (n = 34)	P value ¹
First encephalopathy score			
No.	19	34	0.422
Median (IQR)	4 (2, 6)	6 (1, 9)	
Time from birth to first consult (min)	66 (43, 91)	98 (76, 127)	0.004
Second encephalopathy score			
No.	14	12	0.513
Median (IQR)	2 (0, 4)	4 (0, 8)	
Time from first to second consult (min)	106 (94, 132)	151 (103, 194)	0.292
Third encephalopathy score			
No.	4	2	0.100
Median (IQR)	0 (0, 2)	9 (8, 10)	
Time from second to third consult (min)	130 (116, 146)	108 (99, 116)	0.533

Abbreviations: IQR, interquartile range. ¹Wilcoxon rank sum test

further medical assessment or management. Of the 25 neonates who were born at community hospitals and transferred, 8 (33%) were ultimately not treated with TH despite being transferred.

DISCUSSION

This study demonstrates that teleconsultations for evaluating NE are a feasible, accessible, and reliable way to bring expert-level care into rural community hospitals to evaluate neonates who may be eligible for TH. Although neonates born in community hospitals still have later teleconsultations than those born in the tertiary care center, the disparity decreased from nearly 5 hours (when the teleconsultation occurred after transfer to the tertiary care center¹²) to approximately 1.5 hours (when teleconsultation occurred at the rural community hospital). We show that the high-resolution, zoom capable camera controlled by the neurologist from a remote location was an interface that worked successfully to assess neonates born in community hospitals. The telemedicine cart was set up with a hard-wired device (plugged into an Ethernet socket) to avoid complications with video and audio quality related to low bandwidth from wireless connections that previously compromised user satisfaction.¹⁰

Telemedicine evaluation for genetic and neurological examination accurately and reliably identifies exam abnormalities when compared to the gold standard,

a bedside examiner.¹¹ Our prior work showed that telemedicine assessments could be performed within the tertiary care center to specifically evaluate NE.¹² This study highlights how telemedicine can improve access to repeated neurological exams for neonates born in either the tertiary care center or a community hospital. Almost 75% of neonates born in the tertiary care center and 35% of those born in a community hospital had access to a second neurological assessment in the first 3 hours of life. With the increasing complexity of decision-making surrounding the use of TH for symptoms of mild NE,¹³ serial neurological examinations⁷ of neonates by telemedicine may, at minimum, offer clinicians more information on which to base their clinical decisions within the critical 6- hour timeframe.

Our study also shows that using telemedicine consults in rural community hospitals prevented the transfer of approximately one quarter of the neonates assessed. In this project, the research funds were used to develop the infrastructure of the camera system in multiple community hospitals. Thus, we were unable to obtain brain imaging or neurodevelopmental outcome data on patients who were excluded from TH to be certain the correct clinical decision was made. We are careful to only claim that the telemedicine consultation may have helped to avoid unnecessary transfer, not that the clinical decision-making was correct. Avoiding unnecessary neonatal transports is desirable to

prevent unnecessary separation of families¹⁴ and excessive cost of transport and admission to the neonatal intensive care unit. In rural states with limited resources, transport team arrival could be largely influenced by retrieval destination and availability of transport resources (e.g., staffing, proper equipment, ambulance). Other investigators have reported on the successful use of telemedicine consults to decrease neonatal transport.^{15,16}

A strength of this study is that the telemedicine technology was applied in a relatively large network of 9 community hospitals in the most rural state in the United States.¹⁷

The main limitations of this study include the lack of outcome data for neonates that were not treated with TH, the absence of data assessing how the teleconsultation affects transfer times, and an acknowledgment that these results reflect the experience of 1 telemedicine network and may not be generalizable to other health care systems. Future research will study short-term outcomes of electroencephalogram and magnetic resonance imaging on neonates excluded from TH and long-term neurodevelopmental outcomes to further verify the clinical decisions made by teleconsultation.

CONCLUSIONS

In summary, our study shows that teleconsultations are a feasible, accessible, and reliable approach to evaluating NE and triaging neonates in community hospitals. Our study also highlights how telemedicine can improve access to repeated neurological exams for neonates born in tertiary care centers or community hospitals. These findings support efforts that may lead to more efficient care for neonates in a resource-scarce environment.

Conflicts of interest None

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