Developing a Newborn Resuscitation Telemedicine Program: A Comparison of Two Technologies

Jenna A. Beck, MHA,¹ Julie A. Jensen, PhD,¹ Rochelle F. Putzier,²
Lisa A. Stubert, PMP,² Kathleen D. Stuart,³
Hussain Mohammed, MS,³ Beth L. Kreofsky, MBA,²
Kelly W. Boles,³ Christopher E. Colby, MD,⁴
and Jennifer L. Fang, MD, MS⁴

¹Department of Management Engineering and Internal
Consulting, Mayo Clinic, Rochester, Minnesota.

²Center for Connected Care, Mayo Clinic, Rochester, Minnesota.
Divisions of ³Media Support Services and ⁴Neonatal Medicine,
Mayo Clinic, Rochester, Minnesota.

Abstract

Background: Early work has demonstrated the feasibility and acceptance of newborn resuscitation telemedicine programs (NRTPs). The technology requirements for providing this type of emergency telemedicine service are unclear.

Introduction: We hypothesized that during NRTP consults, a wired telemedicine cart would provide a more reliable and higher-quality user experience than a consumer-grade wireless tablet.

Materials and Methods: In this retrospective observational study, six spoke sites used consumer-grade wireless tablets during preintervention and wired coder/decoder (CODEC)-based telemedicine carts during postintervention. Both technologies used the same videoconferencing software. After the telemedicine consult, providers completed surveys assessing connection reliability, user satisfaction, and audio and video quality using a 1–5 Likert scale.

Results: Preintervention, users completed 99 consults and 95 surveys. Postintervention, users completed 73 consults and 192 surveys. Successful connection on first attempt was significantly improved with the wired cart compared with the wireless tablet (82.7% vs. 69.5%, $p=0.01$), and the percentage of consults complicated by an unplanned disconnection was reduced (6.4% vs. 14.7%, $p=0.02$). User satisfaction and video and audio quality ratings were significantly higher for the wired cart.

Discussion: The wired telemedicine cart increased connection reliability, which is important given the critical nature and long duration of NRTP consults. Audio-video quality was also improved, allowing for better visualization of the neonate and communication with the care team.

Conclusions: Consumer-grade wireless tablets did not meet the program's technical requirements. Wired telemedicine carts improved reliability, user satisfaction, and audio-video quality. Wired carts may not fully meet NRTP requirements because of cart size and limited mobility.

Keywords: pediatrics, technology, telemedicine

Introduction

Pediatric health resources, including subspecialty pediatricians, equipment, and supplies, are often less accessible in rural facilities.^{1,2} Nearly 20% of the pediatric population in the United States reside in a rural location, whereas only 3% of pediatric subspecialists in critical care and emergency medicine practice in rural areas.² Telemedicine provides rural facilities with timely, high-quality emergency services to improve patient care and increase staff support during medical emergencies.³

This rural-urban disparity in access to subspecialty care may affect the health of the newborn population. Approximately 10% of newborns require some level of breathing assistance, and 1 in 1,000 requires extensive resuscitation.^{4,5} When these high-risk deliveries occur in rural hospitals, they may quickly overwhelm the expertise, experience, and resources of the local care team. In a simulated setting, telemedicine for newborn resuscitation was shown to decrease the time to effective ventilation (the most critical step in newborn resuscitation) and improve adherence to the standard of care.⁶ Earlier work has demonstrated the feasibility and acceptance of newborn resuscitation telemedicine programs (NRTPs).⁷ Data also suggest that these programs allow neonatologists to effectively assist local care teams during advanced newborn resuscitation. However, the technical requirements for providing this type of emergency telemedicine service are unclear and may differ from those typically needed for other telemedicine service lines.

Both wired and wireless technology solutions have been used in the emergency telemedicine clinical setting. Consumer-grade wireless devices, such as tablets, may be attractive options for end users because the technology is mobile, readily available,

and familiar to many users. However, audio and video quality deteriorates when mobilizing wireless solutions from one location to another.⁸ Although wired solutions may improve audio and video quality, they restrict mobility and may require considerable clinical service redesign.⁹

In addition to the technical requirements shared with other emergency telemedicine services (e.g., telestroke, tele-emergency medicine), NRTPs have distinct characteristics that must be considered when selecting telemedicine technology. These include the highly emergent nature of the consult (i.e., assessments and interventions occur at 30- to 60-s intervals during newborn resuscitation), the need for high-quality video and audio to provide remote guided care for a small patient (birth weight can be as light as 0.5 kg), and often a small workspace surrounded by a large local care team.

The purpose of this retrospective study was to compare the effectiveness of two telemedicine technologies for providing newborn resuscitation telemedicine consults. We hypothesized that a wired telemedicine cart would be more reliable and provide a higher level of user satisfaction than a consumer-grade wireless tablet.

Materials and Methods

In 2013, the Mayo Clinic Division of Neonatal Medicine began offering telemedicine consults to six community hospitals located in our health system. The purpose of the NRTP was

to provide remote guided care during neonatal resuscitations by using a hub-and-spoke model. Telemedicine consults were provided by board-certified neonatologists at the regional, level IV neonatal intensive care unit at Mayo Clinic Hospital in Rochester, Minnesota (the *hub*). The six community hospitals that received telemedicine service (the *spokes*) were located 40–120 miles from Mayo Clinic. Community hospital staffing models differed by site, ranging from hospitals with a level II nursery and in-house pediatric hospitalists, to hospitals with a level I nursery staffed by family medicine physicians who take on-call service from home.

The standard process map for our NRTP is shown in *Figure 1*. When emergency consultation from a neonatologist is needed, a local care provider activates the service by calling the institutional admission and transfer call center. The call center nurse pages the on-call neonatologist to alert the neonatologist to the telemedicine request. The neonatologist establishes a real-time video connection with the community hospital to provide the consult. On completion of the consult, the neonatologist and the referring provider determine the appropriate patient disposition (i.e., whether the baby can remain at the local hospital or needs to be transferred to a higher level of care).

PREINTERVENTION TECHNOLOGY

In the pilot and early stages of the NRTP from March 2013 to December 2015, telemedicine consults were provided to

Fig. 1. Newborn resuscitation technology program consult process. This swim lane diagram outlines the process steps completed by the local care team, the admission and transfer call center, and the remote neonatologist during a newborn resuscitation telemedicine consult.

the local sites through consumer-grade wireless tablets running the enterprise standard Health Insurance Portability and Accountability Act (HIPAA)-compliant videoconferencing software (Vidyo, Inc.). This tablet endpoint was selected because of its size, portability, familiarity to users, and ease of deployment. During the telemedicine consult, the wireless tablet was either attached to a stand near the resuscitation bed or held by a care team member. Pre-existing on premise Vidyo infrastructure provided the foundational videoconferencing capabilities. It was chosen because of its use of scalable video coding algorithms. The highly tolerant Vidyo platform continuously monitors the video connection. It adjusts the audio and video bandwidth and resolution as needed on the basis of network conditions, to maintain the highest-quality video session. The Vidyo platform was fully vetted and had been in production supporting other telemedicine use cases since 2013. Hub-and-spoke care teams relied on the local wireless networks at their sites and the wired enterprise network to carry the video traffic.

During the first 18 months of clinical service, care teams had difficulties with connectivity and poor audio-video quality. In addition, having a local care team member hold the wireless tablet during the resuscitation further reduced the number of skilled hands caring for the newborn. These issues led to low user satisfaction with the technology and ultimately made delivery of clinical service more difficult. In February 2015, we performed a comprehensive assessment of the current system, which included testing of the end-point technology, videoconferencing software, and the video service network infrastructure.

In this analysis, we identified vulnerabilities in the Wi-Fi networks. Our original wireless network was not designed with the enhanced engineering techniques needed to support emergency video telemedicine services such as the NRTP. The Wi-Fi network was initially deployed as a means of convenience for accessing data services (e.g., files, printers). In addition, our institution has >100 integrated or affiliated healthcare venues whose initial information technology infrastructure was deployed in an autonomous manner over several decades. The resulting local area network architectures varied widely across the enterprise, and wireless network infrastructure was deployed inconsistently.

The number of advertised service set identifiers (SSIDs), traversal between wireless access points, channel assignments, and the so-called hidden node phenomena can all potentially introduce instabilities into real-time audio-video communications. *Figure 2* shows an analytical visual captured in a hospital during the NRTP pilot. It depicts the advertising of 24 SSIDs and channel overlap. The Wi-Fi radiofrequency power levels were noted to fluctuate markedly in response to environmental changes—such as human movement, elevators, and carts—because all can potentially reflect or absorb Wi-Fi radiofrequency signals. Subsequent to this study, information technology infrastructure cohesion was achieved under an enterprise networking shared services model.

The tablet end point was also found to be problematic. Consumer devices such as tablets differ in their ability to gracefully traverse across multiple wireless access points. Some devices seek the best signal quality, whereas others attempt to maintain connectivity with a wireless access point even as signal conditions deteriorate. Consumer-grade tablets can also be prone to unscheduled and unexpected software updates. They require careful attention to the audio (microphone or speaker) and video settings. As an example, one tablet was inadvertently set to half-duplex mode, which meant it was not possible to speak and listen simultaneously.

POSTINTERVENTION TECHNOLOGY

On the basis of these test results, the technical teams recommended stabilizing the clinical service with a wired telemedicine cart equipped with a high-definition (720 p) Vidyo coder/decoder (CODEC) running enterprise-standard,

Fig. 2. Wireless network analyzer that demonstrates 24 service set identifiers (SSIDs), channel overlap, and fluctuating radiofrequency power levels.

HIPAA-compliant videoconferencing software (Fig. 3A). The telemedicine cart also included a pan-tilt-zoom camera that could be controlled by the remote neonatologist, a noise canceling, full duplex microphone-speaker set, and battery backup capabilities. Prepositioned network jacks were activated in all rooms where an NRTP consult was likely to occur. Network bandwidth >3 MBs per second with low latency (<50 ms) was generally available from the wired infrastructure, and the configuration performed reliably during the term of the program. These wired telemedicine carts were implemented at the community hospitals between December 2015 and March 2016 (Fig. 3B). A multidisciplinary team tested the new technology at each health system site, trained the local care teams, and performed a series of mock consults in various clinical settings (i.e., labor and delivery room, newborn nursery, and operating room) before implementation.

PRE- AND POSTINTERVENTION DATA COLLECTION

The clinical team collected data on the reliability and quality of the wireless tablet technology after each telemedicine consult. Electronic surveys were sent to the consulting neo-

natologist and local team leader after each telemedicine interaction. The survey assessed connection reliability (i.e., ability to connect on the first attempt and the lost or dropped connection), overall satisfaction with the technology, and video and audio quality on a 5-point Likert scale (1, very poor; 5, excellent). The survey also allowed for qualitative data collection with comment sections where users could provide additional information about their experience.

Before implementing the new wired telemedicine cart, the clinical and operational teams scheduled two or three simulated calls at each spoke site to assess the new technology. After each simulation, the remote neonatologist and local care team members completed a paper survey. Similar to the electronic survey used for clinical consults, this survey measured reliability of connection, video and audio quality, and user satisfaction on the same 5-point Likert scale. In addition, the paper survey assessed usability of the cart (i.e., ease of retrieval and setup, usability during call, and mobility and ease to position the cart in the room), given concerns about its size and use of an Ethernet cable to establish the wired connection. After cart implementation, the electronic surveys

continued to be sent to the neonatologist and local care team leader after each clinical consult.

STATISTICAL ANALYSIS

Continuous variables were summarized by using mean (SD) or median (range) as appropriate. Categorical variables were summarized by using frequency counts and percentages. Comparison of technology metrics was conducted by using χ^2 test, *t* test, and Spearman rank correlation coefficients as appropriate. $p < 0.05$ was considered significant. Statistical analysis was performed by using JMP software version 10.0.0 (SAS Institute, Inc.) and Excel 2010 (Microsoft Corp.).

Results

During the preintervention period, 99 consults were performed (84 clinical and 15 simulated), and users at the hub and spoke sites completed 95 surveys. During

Fig. 3. Newborn resuscitation technology program technology. (A) Wired telemedicine cart equipped with a hardware CODEC, high-definition pan-tilt-zoom camera, and a microphone-speaker set. (B) Wired telemedicine cart positioned in the delivery room during a simulated newborn resuscitation. CODEC, coder/decoder. Published with the permission of the participants; used with permission of the Mayo Clinic.

Table 1. Comparison of Overall Satisfaction, Video Quality, and Audio Quality Based on the Technology Used for Newborn Resuscitation Telemedicine Program Consults

TECHNOLOGY	NO. OF COMPLETED SURVEYS	RATING, ^a MEAN (SD)	P-VALUE
Overall satisfaction			<0.001
Wireless tablet	95	3.27 (1.11)	
Wired telemedicine cart	187	4.44 (0.66)	
Video quality			<0.001
Wireless tablet	95	3.34 (1.10)	
Wired telemedicine cart	191	4.61 (0.64)	
Audio quality			<0.001
Wireless tablet	95	3.19 (1.13)	
Wired telemedicine cart	191	4.32 (0.93)	

^aRatings are based on a 5-point Likert scale (1, very poor; 5, excellent).
SD, standard deviation.

postintervention, 73 consults were performed (31 clinical and 42 simulated), and users completed 192 surveys. Connection reliability was assessed on the basis of ability to establish a connection on first attempt and whether the connection was dropped during the consult. Using the consumer-grade wireless tablet, providers were able to connect on first attempt during 69.5% of consults (66/95). This was significantly improved—to 82.7% of consults (153/185)—when the wired telemedicine cart was used ($p=0.01$). During the pre-intervention period, 14.7% of consults (14/95) were interrupted by an unintended disconnection. This outcome was reduced to 6.4% of consults (12/187) after implementation of the wired telemedicine cart ($p=0.02$).

Table 1 shows a comparison of overall satisfaction, video quality, and audio quality for the wireless tablet and the wired telemedicine cart. Mean (SD) overall satisfaction rating for the cart was 4.44 (0.66), which was significantly higher than for the tablet (3.27 [1.11], $p<0.001$). In addition, the mean (SD) video quality was rated significantly higher for the cart than the tablet (4.61 [0.64] vs. 3.34 [1.10], $p<0.001$).

Further, mean (SD) audio quality was significantly higher for the cart (4.32 [0.93]) than the tablet (3.19 [1.13], $p<0.001$).

Additional metrics were collected during the postintervention period to ensure specific video and audio problems were resolved with the new technology (Fig. 4). Additional video and audio metrics included video sharpness (4.61 [0.68]), video quality motion (4.48 [0.89]), video color (4.59 [0.68]), and audio clarity (4.46 [0.92]). Similarly, given a priori concerns about the telemedicine cart size in the neonatal care setting, cart usability metrics were gathered during postintervention. These metrics included ease of (1) retrieval, (2) setup, (3) use during the call, and (4) cart positioning in the care setting (Fig. 4). The care team rated the ease of retrieval and setup for the wired telemedicine cart as excellent during 66.4% of consults. Ease of use during the call was rated as excellent during 77.3% of consults; ease of cart positioning within the care setting was excellent for 63.6%. The average patient room size ranged from 203 to 417 square feet, depending on the hospital. Overall satisfaction with the telemedicine cart did not significantly correlate with patient room size (Spearman $\rho=-0.43$, $p=0.36$).

Qualitative comments from the surveys were analyzed to gain deeper understanding of the favorable characteristics and limitations of the telemedicine technologies. Themes and exemplar quotes are summarized in Table 2. The information gathered from the qualitative section proved

Fig. 4. Additional audio and video quality metrics and cart usability metrics measured in the postintervention period. Error bars represent one standard deviation from the mean.

Table 2. Summary of Advantages and Limitations of the Wireless Tablet and Wired Telemedicine Cart

TECHNOLOGY	THEME	QUOTE
Wireless tablet		
Advantages	Connection time	"We are truly fortunate to have this link with Rochester; it is reassuring to have a neonatologist you connect with instantly." (local MD)
	Ability to connect with a neonatologist	"The neonatologist guided us through a very difficult situation and stayed online until the transport team arrived and took over. Please convey my thanks to him for his excellent work." (local MD) "We have been very impressed with the neonatologists when using [telemedicine]. They have all been very clear, concise, and communicate well to the team. It is very helpful to have someone 'at the code' that is more comfortable with premature deliveries and fetal anomalies." (local MD)
	Ability to debrief with family	"One added benefit was the ability to have face-to-face conversation with the father of this infant, who was by his daughter's side in the resuscitation room. I was able to tell him 'next steps' of his daughter's medical care, which made our delivery of medical care seem more personal. I later met the dad here in Rochester at the bedside and he recognized me immediately. His first comment was how impressed he was with our video technology to help his daughter." (remote neonatologist)
Limitations	Dropped audio/calls	"Besides the 1 dropped phone call, it went very well" (MD)
		"The audio occasionally dropped" (MD)
	Quality of video and audio	"The poor quality of the connection was unacceptable" (MD)
		"When trying to zoom in on the scalp defect, the image quality was still a bit pixelated" (remote neonatologist)
	Degraded functionality in care team environment	"Bright lighting made it challenging [to see the infant]" (remote neonatologist)
Wired telemedicine cart		
Advantages	Reliable connection	"Easy connection/reliable" (MD)
		"Stability of connection" (RN)
	Camera controlled by remote neonatologist	"Ability for Rochester consultant to control zoom" (MD)
		"Will be helpful to be hands free" (RN)
	Quality of video and audio	"Video quality excellent, much better than [wireless tablet]" (MD)
		"Picture quality is great" (RN)
Limitations	Large size	"Bulkiness" (RN)
		"I did not like working around the cart" (RN)
	Challenging to maneuver	"Very difficult to retrieve for use in a patient room" (RN)
		"I did not like having to retrieve the cart to the area of need" (RN)
	Inability to maintain connection when patient changes locations	"Concerns with reconnecting as we move patient locations" (RN)

MD, physician; RN, registered nurse.

valuable in understanding the effect of the service. Although quantitative data for the wireless tablet showed low scores in reliability and audio-video quality, qualitative data demonstrated that most community providers greatly appreciated the ability to connect with neonatologists through video telemedicine (compared with a telephone consult). The importance of preserving the value gained from video

telemedicine consults while improving on technical limitations was a theme of the qualitative comments for the wireless tablet.

Most care team members liked that the tablet was mobile and easy to position around the resuscitation bed. However, concerns were frequent about difficulties establishing and maintaining video connection, poor audio quality and low

volume, and challenges positioning the tablet so the remote neonatologist had the necessary view of the newborn. Most users believed that the wired telemedicine cart provided a reliable and stable video connection. The camera allowed the remote neonatologist to find the best view of the neonate throughout the resuscitation. Some local care team members mentioned that when the cart was deployed, it also provided a steady, hands-free platform for the local care team. Audio was improved, but some delays and fragmentation still occurred. Some users identified disadvantages of the cart, which included its large size in a small space and concerns that the Ethernet cable could present a trip hazard in the busy clinical environment.

Discussion

In this study, we found that use of a wired telemedicine cart increased the connection reliability and audio-video quality compared with a wireless tablet. A highly reliable telemedicine technology is especially important for NRTPs given the emergent, critical nature of the consults. In addition, the ability to sustain the connection is an important consideration because these consults can last up to 4 h (median, 45 min) for neonates delivered extremely preterm.⁷ When telemedicine technology is not reliable, local care teams may choose not to activate the service and instead to rely on local resources or previous models of support, such as telephone consult. In this study, we demonstrated that the telemedicine carts were more reliable than the tablets. A successful connection was established on first attempt in a greater percentage of consults when the cart was used, and the percentage of video consults that had a dropped call was significantly reduced. Although reliability was significantly improved with use of the wired cart, ~17% of consults still required more than one attempt to connect and ~6% had an unintentional disconnection. These metrics fall short of what is needed to establish a highly reliable NRTP.

User satisfaction is a crucial characteristic for the success of an NRTP, and overall satisfaction with the technology was significantly greater for the wired telemedicine cart. Users rated the video quality for the wired cart significantly higher than the wireless tablet. With the remote neonatologist controlling the camera on the cart, the care team was able to attend to patient-related tasks during the resuscitation. The neonatologist also was able to secure the necessary view throughout the procedure, ranging from a wide view of the local team to maintain situational awareness, to a focused view of the newborn to evaluate for millimeters of chest rise during assisted ventilation. Video resolution for technologies used in NRTPs must be sufficient to allow remote guided care, in-

cluding performance of procedures such as umbilical catheter placement into an artery with an internal lumen of 1–2 mm. Color fidelity must be high to monitor central and peripheral perfusion.

We found that the wired telemedicine cart provided significantly improved audio quality compared with the wireless tablet. Seamless audio quality is important during newborn resuscitation telemedicine consults to facilitate communication between the remote neonatologist and local care team. To provide high-quality care during neonatal resuscitations, the team needs to share information, manage the workload, and communicate intentions and plan of care.¹⁰ If audio quality provided by the telemedicine technology is insufficient, it could negatively affect the consult effectiveness. Although audio quality was significantly improved by the wired cart, users still commented on issues with audio delay and fragmentation that were disruptive to the consult.

We identified several limitations of the wired telemedicine cart. The most frequent concern was device size because the cart had a large footprint in a constricted care environment. Because it is wired in a single location, the telemedicine cart also lacks mobility. The care team must shut down the cart, move the device to another location, and restart the device to reconnect with the neonatologist. This interrupts the telemedicine consult for critically ill babies who must be moved from the birth location (e.g., labor room, operating room) to the resuscitation or stabilization location (e.g., newborn nursery). In addition, depending on the Ethernet port location, the cable may create a trip hazard that needs to be monitored and mitigated. Although care teams were concerned about the cart size, study data demonstrated that care teams were willing to work through these difficulties to gain the benefits of improved reliability and video and audio quality.

Transition of our NRTP technology from a wireless tablet to a wired cart significantly improved reliability, user satisfaction, and audio-video quality. Some of this improvement may be attributable to a learning effect because users had more experience with the NRTP when the carts were implemented. In addition, the simulated consults performed before clinical implementation of the cart may have contributed to this effect. Nevertheless, certain deficiencies remain that need to be addressed to achieve our programmatic goals. These include (1) achievement of 99% reliability in rapidly establishing and maintaining a connection, (2) a more responsive remotely controlled camera, (3) seamless high-fidelity audio, (4) a form factor that fits well into the typical neonatal work space, and (5) mobile technology that moves easily between care spaces (e.g., between the labor and delivery room, nursery, and operating room).

LIMITATIONS

Study limitations include those associated with retrospective observational study design—namely, recall and information bias. During the pre- and postintervention periods, electronic surveys sent to users could be completed between 1 and 14 days after the consultation. This 2-week interval could affect the accuracy of user recall when completing the survey. In addition, a greater percentage of consults were simulated by using the wired telemedicine cart. These simulated consults may not provide an accurate representation of technology performance during clinical consults.

The success of an NRTP is highly (but not exclusively) dependent on the reliability and quality of the underlying technological infrastructure and devices. This before-and-after observational study demonstrated that consumer-grade wireless devices did not meet the technical requirements for newborn resuscitation telemedicine consults. These devices were not designed for the healthcare setting and did not provide the required reliability or audio-video quality needed for such a service. Wired telemedicine carts improved reliability, user satisfaction, and audio-video quality. However, this technology may not fully meet NRTP requirements because of its size and limited mobility. Institutions should consider reliability of connection, ease of use, and audio-video quality when selecting a technology for their NRTP.

Acknowledgments

The authors thank the Mayo Clinic Department of Pediatric and Adolescent Medicine and the Center for Connected Care for their dedication to developing a reliable teleneonatology program. They appreciate the invaluable partnership and feedback provided by the neonatal care teams in the Mayo Clinic Health System. The authors acknowledge the Management Engineering and Internal Consulting Department for its help with the study and, in particular, Shwetha Devanagondi, MS, Yu Li Huang, PhD, and Adam J. VanDeusen, MPH.

This publication was supported by Grant Number UL1 TR000135 from the National Center for Advancing Translational Sciences (NCATS). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the National Institutes of Health.

Disclosure Statement

No competing financial interests exist.

REFERENCES

1. Yang NH, Dharmar M, Kuppermann N, Romano PS, Nesbitt TS, Hojman NM, et al. Appropriateness of disposition following telemedicine consultations in rural emergency departments. *Pediatr Crit Care Med* 2015;16:e59–e64.
2. Dharmar M, Romano PS, Kuppermann N, Nesbitt TS, Cole SL, Andrada ER, et al. Impact of critical care telemedicine consultations on children in rural emergency departments. *Crit Care Med* 2013;41:2388–2395.
3. Mueller KJ, Potter AJ, MacKinney AC, Ward MM. Lessons from tele-emergency: Improving care quality and health outcomes by expanding support for rural care systems. *Health Aff (Millwood)* 2014;33:228–234.
4. Kattwinkel J. *Textbook of neonatal resuscitation*, 6th ed. Elk Grove Village, IL: American Academy of Pediatrics and American Heart Association, 2011:328.
5. Perlman JM, Risser R. Cardiopulmonary resuscitation in the delivery room. Associated clinical events. *Arch Pediatr Adolesc Med* 1995;149:20–25.
6. Fang JL, Carey WA, Lang TR, Lohse CM, Colby CE. Real-time video communication improves provider performance in a simulated neonatal resuscitation. *Resuscitation* 2014;85:1518–1522.
7. Fang JL, Collura CA, Johnson RV, Asay GF, Carey WA, Derleth DP, et al. Emergency video telemedicine consultation for newborn resuscitations: The Mayo Clinic experience. *Mayo Clin Proc* 2016;91:1735–1743.
8. Tachakra S, Banitsas KA, Tachakra F. Performance of a wireless telemedicine system in a hospital accident and emergency department. *J Telemed Telecare* 2006;12:298–302.
9. Herrington G, Zardins Y, Hamilton A. A pilot trial of emergency telemedicine in regional Western Australia. *J Telemed Telecare* 2013;19:430–433.
10. Thomas EJ, Sexton JB, Lasky RE, Helmreich RL, Crandell DS, Tyson J. Teamwork and quality during neonatal care in the delivery room. *J Perinatol* 2006;26:163–169.

Address correspondence to:

Jennifer L. Fang, MD, MS
Division of Neonatal Medicine
Mayo Clinic
200 First Street SW
Rochester, MN 55905

E-mail: fang.jennifer@mayo.edu

Received: May 5, 2017

Revised: August 17, 2017

Accepted: August 21, 2017

Online Publication Date: December 12, 2017