MCN in Advance

OB HUB: Remote Electronic Fetal Monitoring Surveillance

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Abstract

Objective: The purpose of this project was to implement a remote fetal surveillance unit with increased vigilance and timelier responses to electronic fetal monitor tracings to improve neonatal outcomes and increase safety.

Methods: A pilot project, OB HUB, facilitated implementation of a centralized remote fetal surveillance unit including artificial intelligence software and nurse experts dedicated to fetal monitoring interpretation. A telemetry room was established. Notification parameters were created to promote consistent communication between OB HUB nurses and bedside nurses. Outcomes for term neonates included body cooling, arterial cord pH less than 7.0, Apgar scores less than 7 at 5 minutes, emergency cesarean births, and cesarean births. Surveys were used to evaluate team perceptions of fetal safety.

Results: There were 2,407 births 6 months pre OB HUB implementation and 2,582 births during the 6-month trial, for a total sample of 4,989 births included in the analysis. Six births (0.25%) resulted in cooling prior to implementation and 2 (0.08%) cooling events occurred during the trial; these differences were not significant ($p = .1$). There were no significant differences between groups for neonatal outcomes. Average level of safety perceived by nurses and providers remained relatively unchanged when comparing pre- and postimplementation survey results; however, of those responding, 78.8% of nurses indicated the OB HUB improved safety.

Clinical Implications: There were few adverse events in either group, thus it was a challenge to demonstrate statistically significant improvement in neonatal outcomes even with a sample of nearly 5,000 births. A larger sample is needed to support clinical utility. The OB HUB was perceived favorably by most of the L&D nurses.

Key words: Cardiotocography; Fetal; Fetal monitoring; Fetal status; Heart rate; Labor and birth; Newborn infant; Remote consultation; Telemetry.

Background

In the United States, electronic fetal monitoring (EFM) is routinely used in inpatient labor and delivery (L&D) settings as a tool to assess fetal heart rate (FHR) responses to the stressors of labor. Systematic reviews of EFM trials have shown that this technology has not resulted in improvement in neonatal morbidity or mortality and is associated with increased cesarean births (Alfirevic et al., 2017; Devane et al., 2017). Yet it remains a common screening tool for fetal well-being with the goal of preventing injury from impaired fetal oxygenation. Following the publication of the National Institute of Child Health and Development (NICHD) terminology for EFM (Macones et al., 2008), clinicians have a common language for interpretation, communication, and collaboration in management of EFM tracings. There has also been consensus on the validity of the negative predictive value for fetal metabolic acidemia in the presence of normal or category I FHR tracings (American College of Obstetricians and Gynecologists [ACOG], 2009), FHR accelerations (ACOG & American Academy of Pediatrics [AAP], 2014; Macones et al., 2008), or moderate FHR variability (Parer et al., 2006; Williams & Galerneau, 2003). Assuring competence and consistency in interpretation and management of EFM tracings are ongoing priorities for health care teams (Lyndon & Wisner, 2021).

Clinician skills in EFM tracing interpretation are developed over time with wide exposure to subtle variations. Even with the NICHD terminology, interpretation can remain subjective among members of the health care team due to intra- and interobserver variability in EFM interpretation (Agency for Healthcare Research and Quality [AHRQ], 2017). Electronic fetal monitoring tracing interpretation and management is a common allegation in litigation involving adverse outcomes in term pregnancies. According to the most recent (ACOG, 2015) liability survey, 73.6% of obstetricians-gynecologists responding reported at least one

professional liability claim during their career. Based on data from one medical professional liability insurer, 40% of obstetric claims allege mismanagement of labor, including failure to respond appropriately to FHR tracings (Hanscom et al., 2018). Because failure to intervene and perform a timely cesarean birth is a leading cause of preventable hypoxic ischemic encephalopathy injuries (AHRQ, 2017), a fetal telemetry unit can potentially support the care team with timely interventions and delivery when indicated.

During the COVID-19 pandemic, some L&D units experienced dramatic changes in nurse staffing. Increased turnover of experienced nurses resulted in more novice nurses and use of travel nurses, as well as an overall shortage of staff nurses. In one study, nurses reported higher nurse–patient ratios, less-experienced nurses at the bedside, and fewer resource nurses available during the pandemic (George et al., 2021). According to a 2021 survey of over 1,000 obstetric hospitalists, the current nurse staffing crisis was a top safety concern, and the nursing shortage was noted to be a significant safety risk by 58.4% of respondents (OB Hospitalist Group, 2021).

When interpreted in a timely manner by experienced personnel, EFM tracings can warn of changes in fetal status that may require urgent intervention. Common safety issues related to use of EFM have been well documented and include the following (AHRQ, 2017):

- Perinatal team members with inadequate experience to correctly interpret EFM tracings
- Intra- and interobserver variability in EFM interpretation
- Failure to observe the EFM tracing frequently enough
- Disabling the EFM system alerts
- Poor communication among team members related to EFM interpretation
- Suboptimal L&D nurse staffing
- Fear of conflict, intimidation, and failure to function as a team.

These issues may result in delayed recognition and response to EFM patterns.

Problem Description and Context

Recent events at two sister facilities in Denver, Colorado, with a combined total of over 6,000 annual births, identified gaps in interpretation and management of concerning EFM tracings. One hospital is an urban teaching facility and the other is a community hospital. Both facilities have variability in nurses' tenure; approximately 20% of night-shift nurses have less than 2 years of L&D experience. Previously, measures taken to achieve EFM competence included biannual EFM education from the Association of Women's Health, Obstetric, and Neonatal Nurses (2022) for all L&D nurses and multidisciplinary debriefing conducted after all adverse outcomes. We have implemented proven communication techniques such as CUS (Concerned, Uncomfortable, Safety), and SBAR (Situation, Background, Assessment, Recommendation) for escalating concerns and flattening the hierarchy (AHRQ, 2019). Safety practices recommended by AHRQ (2019) have also been implemented. These include regular multidisciplinary simulation drills, L&D board rounds, EFM tracing rounds every 4 hours, *Code EFM* for emergency evaluation of a concerning tracing by the entire team, AHRQ TeamSTEPPS training (AHRQ, 2019), and mandatory online provider EFM education. Despite this, both sites experienced an adverse outcome considered to be due to lack of appropriate interpretation and management of unfavorable EFM tracings. It was clear that additional safety measures were needed.

The perinatal leadership team discussed creation of a centralized environment for rapid and consistent identification of Category II and III EFM patterns to expedite evaluation and appropriate intervention. An offsite, centralized monitoring room, with continuous observation of all active EFM tracings by experienced L&D nurses with no other clinical duties, could provide another layer of support for bedside caregivers, free from distractions related to bedside L&D care. Responsibilities of the fetal surveillance nurses include continuous evaluation of all live EFM tracings, assistance with recognition of concerning patterns, timely communication with the bedside team, discussion of the plan of care, and support for documentation of the features of the FHR tracing and team response.

Available Knowledge

Studies on the value of a remote centralized monitoring system are sparse. A recent study using such a model for five hospitals suggested that unanticipated term neonatal intensive care unit (NICU) admissions, cesarean births, and operative vaginal birth rates could be decreased (Martin et al., 2021). With over 19,000 live births in their pre- and postimplementation analysis, they found no significant differences between groups on unexpected admission to the NICU after multivariate regression analysis (Martin et al., 2021). In further analysis of each hospital individually, their highest volume teaching hospital noted a decrease in cesarean births, operative vaginal birth rates, and 5-minute Apgar scores of <7, suggesting that in some settings, remote EFM may be associated with lower cesarean and operative vaginal birth rates (Martin et al., 2021). In another study, L&D nurses acting in the role of remote EFM monitor nurses participated in a survey to assess their perceptions of the benefits of the role. The nurses felt there were overall benefits but expressed concerns that moving a nurse from the bedside was not sustainable at times of high census and acuity (Griggs & Woodard, 2019). There were no differences in their perceptions of unit safety pre- and postimplementation of the remote EFM monitor nurse role (Griggs & Woodard, 2019). Despite conflicting data, we hypoth-

esized that a remote centralized fetal monitoring system with increased vigilance and response to EFM tracings would improve outcomes and culture of safety in the context of current staffing challenges.

Methods

PeriGen recently released technology PeriWatch Vigilance® (PeriGen, 2021). This validated software uses artificial intelligence and computerized algorithms to alert clinicians about fetal tracings that exhibit 30 minutes of Category II or Category III characteristics. The team hypothesized that neonatal outcomes could be improved with a centralized fetal surveillance unit that included a combination of EFM artificial intelligence software along with nurse experts dedicated to EFM interpretation. Using the PeriWatch Vigilance® system would allow EFM telemetry nurses to monitor and respond to multiple EFM tracings at one time. This system uses color to highlight tracings where specific criteria are exceeded, thereby cueing the EFM telemetry nurses. Criteria that trigger alerts are FHR patterns that persist for 30 minutes and are combinations of changes in variability, recurrent decelerations, and/or tachysystole. This technology allows clinicians to quickly identify patterns with concerning trends.

A 6-month trial using Perigen Vigilance®, centralized surveillance, and experienced L&D nurses was implemented and entirely funded by hospital system in early 2021. The project, OB HUB, had an estimated budget of $385,000 that included purchase of computer hardware, software, and nursing salaries. Perinatal leaders established a project management team under the direction of the shared nursing director. Stakeholders included obstetricians, nurse managers, clinical nurse specialists, bedside nurses, and clinical informaticists. Initial project steps included a quality improvement project proposal which was approved by the Institutional Review Board.

Location and Equipment

An observation room adjacent to the L&D unit at the community hospital was converted into a designated space. Six large monitors were mounted on the wall. A table holds three desktop computers with six monitors. See Figure 1.

Software

Clinical Informatics professionals reprogrammed computers to allow access of patient data and EFM tracings from both hospitals. PeriWatch Vigilance® software was loaded on the desktop computer and configured to include labor and antepartum patients from both hospitals.

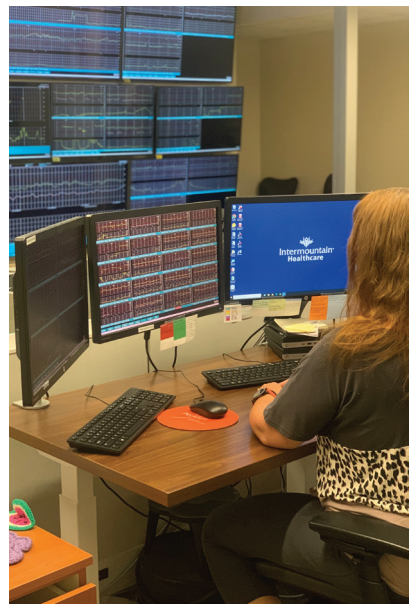
Process Development

The planning team gathered resources for OB HUB nurse reference (EFM policies, chain of command, Vigilance cues, and NICHD definitions), created communication scripting, team notification processes, and standardized documentation (development of Epic note template). The OB HUB nurses used standardized assessments and responses to support appropriate notification with bedside clinicians. They investigated each alert to determine its accuracy. Based on their clinical judgment, if an FHR tracing warranted potential intervention, the nurse initiated these steps:

- Electronic medical record review to determine if the team recognized the FHR and were performing interventions.
- If no team documentation noted within 30 minutes, or additional interventions were warranted, the nurse at the bedside was notified by the EFM telemetry nurse to discuss the tracing and plan of care.
- Additional actions that may have been initiated if appropriate included notification of the charge nurse, initiation of the chain of command, or activation of a *Code EFM*.

OB HUB nurses participated via phone in fetal tracing rounds held every 4 hours at the larger teaching hospital, led by OB resident physicians in training where the team discusses all tracings and the plan of care.

Figure 1.



Inclusion Criteria

All patients at 37 weeks gestation or greater who gave birth during the trial from both participating hospitals were included in the data.

OB HUB Nurse Recruitment

The L&D managers identified nurses who had a minimum of 2 years of experience in L&D, were comfortable with change, and had professional communication skills based on annual review. The nurses ultimately selected to staff the OB HUB during the trial had an average of 19 years of L&D experience. They dedicated a minimum of one shift per pay period to the OB HUB. Nurses were scheduled for 6-hour blocks, with a goal of staffing with one nurse from each hospital at all times. To minimize fatigue, they were provided with standing desks and exercise equipment. Breaks were staggered.

Education

Education of L&D nurses, certified nurse midwives, resident physicians in training, and attending physicians was accomplished through formal

Table 1. Neonatal Outcome Comparison for Pre and Post OB HUB Implementation

Neonatal Outcomes	Pre		Post		*p*-value
	N	%	*N*	%	
pH <7	4	0.17%	3	0.12%	0.64
pH 7.0 to 7.09	29	1.20%	45	1.74%	0.12
Apgar Score <3	33	1.36%	28	1.08%	0.36
Apgar Score <7	31	1.28%	27	1.04%	0.43
Emergency Cesarean Births	37	1.54%	37	1.54%	0.76
Urgent Cesarean Births	115	4.78%	132	5.11%	0.59
Emergency + Urgent Cesarean Births	152	6.31%	169	6.54%	0.74
Cooling Protocol	6	0.25%	2	0.08%	0.13
Operative Vaginal Births	83	0.35%	97	0.36%	0.56
Total Cesarean Births	671	27.89%	752	29.16%	0.33

presentations, email, newsletters, shift huddles, and at monthly meetings. Education for OB HUB nurses included instruction on the Vigilance System as well as standardized response and documentation processes. This 4-hour session included remote computer training with Perigen, communication scripting, the documentation template, resources, and a tour of the telemetry room.

Metrics

Prior to the trial, L&D nurses, certified nurse midwives, resident physicians in training, and attending physicians were surveyed about their perceptions of fetal safety through an electronic survey developed by the implementation team. Surveys were repeated halfway through and after the trial.

Neonatal outcomes included arterial cord pH less than 7.0, Apgar scores less than 7 at 5 minutes, body cooling in term neonates, emergency cesarean births, and overall cesarean births. The neonatal outcomes selected are assessments and interventions associated with those at risk for neonatal encephalopathy (ACOG & AAP, 2019).

Analysis

Descriptive statistics were calculated for pre- and postimplementation of the OB HUB, including frequency and percent for categorical indicators, and mean and standard deviation for continuous indicators. These statistical analyses were conducted on neonatal outcomes and team member surveys. Six months of neonatal data pre and prior to implementation were included in the analysis. To determine difference in these indicators pre- and postimplementation, chi-square tests for categorical indicators and student's *t*-tests for continuous indicators were performed. The significance threshold for comparative tests was set at 0.05.

Results

There were 2,407 births in the 6 months pre OB HUB implementation and 2,582 births in the 6-month OB HUB trial for a total sample of 4,989 births included in the analysis. During the trial, the goal was to staff the OB HUB with one or two nurses; however, due to nurse staffing challenges during the COVID pandemic, approximately 10% of shifts did not have a nurse in the OB HUB. Babies birthed during closed HUB shifts were included in the results.

The primary neonatal outcome evaluated was body cooling in term neonates, a routine intervention for those at risk for neonatal encephalopathy (ACOG & AAP, 2019). Six births (0.25%) resulted in cooling prior to OB HUB implementation and 2 (0.08%) cooling events occurred during the 6 months of the trial ($p = .1$). This difference was not significant. See Table 1. There was no difference between groups in babies with a pH of 7.00 to 7.09 post OB HUB implementation (1.74%) and babies with a pH of 7.00 to 7.09 pre OB HUB implementation (1.20%, $p = .1$). There was no difference between groups on the neonatal outcomes of pH <7.0; 1-minute Apgar score <3; 5-minute Apgar score <7; emergency and urgent cesarean births, and operative vaginal births.

Survey results are indicated in Table 2 and Table 3. Of 100 L&D staff nurses, 33 nurses responded to the survey pre OB HUB implementation, 59 to the survey midway through the project,

Table 2. Average Score (0–100) on Survey Question: *How safe do you perceive the Labor and Delivery Unit?*

Survey	RN Survey Responses				Midwife, Resident Physician in Training, Attending Physician Survey Responses			
	Respondents	Mean	Standard Deviation	*p*-value	Respondents	Mean	Standard Deviation	*p*-value
Pre	33	82.5	9.2		66	88.8	8.8	
Mid	59	80.0	14.4	0.32	46	86.4	12.8	0.34
Post	66	82.9	14.9	0.86	49	82.6	22.3	0.07

Table 3. Responses to Survey Question: *I believe the OB Tele HUB has improved safety on the unit.*

	RN Survey Responses					Midwife, Resident Physician in Training, Attending Physician Survey Responses				
	Mid		Post		*p*-value	Mid		Post		*p*-value
	N	%	N	%		N	%	N	%	
Did Not Improve	4	6.8	5	7.6	0.86	16	34.8	14	28.6	0.51
No Change	13	22.0	9	13.6	0.22	16	34.8	20	40.8	0.54
Some Improved Safety Noted with Tele-room	30	50.8	30	45.5	0.55	13	28.3	14	28.6	0.97
Absolutely Improved Safety	12	20.3	22	33.3	0.10	1	2.2	1	2.0	0.96

and 66 nurses to the postimplementation survey. There were no differences on the average level of safety perceived by L&D nurses on a scale of 0 to 100%; 82.5% preimplementation and 82.9% postimplementation (p = .86). In response to the postimplementation prompt, *I believe the OB Tele HUB has improved safety on the unit*, 78.8% of nurse participants responded *some* (50.8%) or *absolutely* (20.3%). For the survey of certified nurse midwives, resident physicians in training, and attending physicians, of 110 potential participants, there were 66 participants pre OB HUB implementation, 46 midway through the project and 49 postimplementation. There were no differences in the average overall perceived safety on a scale of 0 to 100%; 88.8% pre OB HUB, and 82.6% post OB HUB trial (p = .07). In contrast to their nurse colleagues, 69.4% of nurse midwives, resident physicians, and attending physicians who responded to the survey did not perceive the OB HUB improved patient safety (*did not improve* 28.6%, *no change* 40.8%).

Clinical Implications

Our pilot study was not adequately powered to find a significant difference in neonatal outcomes given the small numbers of adverse events pre- and postimplementation. However, the data indicate favorable clinical trends in the number of term infants requiring cooling. It will require a larger trial to thoroughly evaluate clinical effectiveness.

Although neonatal outcomes and cesarean incidence are quantitative, perception of safety across a team affects culture and collaboration. At the end of the trial, in survey responses about perceptions of improved safety, over two-thirds of responding nurses indicated improved unit safety, whereas only approximately one-third of midwives, resident physicians in training, and attending physicians noted an improvement. Although they did not perceive an improvement in safety, over 80% who responded to the survey perceived their units as safe both before and after OB HUB implementation.

Trial implementation proceeded smoothly due to a carefully planned initial roll-out. Collaborative discussions between the remote team and bedside clinicians were intended to confirm recognition of concerns and explore interventions to improve a fetal tracing, not to direct care. Robust communication and education to all stakeholders was critical to successful implementation.

Limitations

A major limitation of this project was that adverse neonatal outcomes are rare, and higher patient numbers may be needed to demonstrate a significant effect of OB HUB implementation. We did not have enough statistical power to find possible differences in these rare outcomes. Potential confounding variables included turnover of the resident physician classes during the project period, as well as a high turnover of nurses during the COVID pandemic. Another limitation was the difference in cultures of the two participating hospitals. Survey responses may have been influenced by regular fetal tracing rounds that occur at the teaching hospital. Responses may have also been affected by the presence of the OB HUB adjacent to L&D at the community hospital. Survey results perhaps would have been different if we had matched pre- and postresponses.

One controversial decision was use of skilled L&D nurses in the OB HUB rather than at the bedside. This issue is similar to the findings of Griggs and Woodard (2019) where L&D nurses felt staffing the unit should be a higher priority than staffing the remote EFM surveillance room. In our project, the management team needed to balance staffing the OB HUB as well as their L&D units, thus approximately 10% of the shifts involved returning to OB HUB nurse to L&D to ensure safe staffing leaving the OB HUB uncovered. This was a key limitation of our project.

Conclusion

The primary intentions of implementing the OB HUB were to maximize safety and improve outcomes for newborns and to provide additional clinical support to nurses and physicians in a time of stretched resources and unstable staffing. Although we didn't demonstrate significant improvement in neonatal outcomes in our project, there was a perceived increased in safety felt by the L&D nurses based on postsurvey responses. Based on the results of this quality improvement project, approval was obtained to expand the OB HUB to

Clinical Implications

- A remote fetal telemetry unit allows experienced nurses to assess EFM tracings without other distractions.
- Novice L&D and antepartum nurses can use expertise of fetal telemetry nurses for additional support while caring for patients being monitored via EFM.
- Nurses perceive improved unit safety following implementation of a remote fetal telemetry unit.
- Artificial intelligence software alerts fetal telemetry nurses of concerning trends in the FHR pattern. No increase in cesarean birth rate was noted following implementation of a remote fetal telemetry unit.
- More data are needed on this approach to promote perinatal safety before it can be recommended for routine use.

six more hospitals in our health care division, providing additional fetal surveillance to approximately 12,000 laboring patients a year. The added volume of patients will add clarity and statistical power for analysis of the clinical impact of this software technology combined with expert nurse surveillance. ✣

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The authors declare no conflicts of interest.

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