AN EVALUATION OF THE ELECTRONIC FETAL MONITOR AS A FEEDBACK DEVICE DURING LABOR

WILLIAM S. BRASTED AND EDWARD J. CALLAHAN

WEST VIRGINIA UNIVERSITY

We describe new methodology for the evaluation of the labor experience and preliminary findings using these methods. The effects of feedback from an Electronic Fetal Monitor on report of contraction onset were evaluated during the labors of eight primiparous women, four of whom had attended childbirth preparation classes. Using a within-subject reversal design, data were gathered across four phases for each woman: no feedback (monitor turned away from mother and coach), feedback, no feedback, and feedback again. The women were observed in early labor without medication. Six women were able to note the onset of contractions earlier with the availability of feedback; two women (who had not attended childbirth preparation classes) were more variable in their response. Threshold for recognition of pain onset did not change reliably. Seven of the eight women chose to continue monitoring when offered the chance to discontinue it. These results suggest that the technological advance of fetal monitoring can be used in cooperation with prepared childbirth techniques to facilitate earlier recognition of contraction onset, allowing increased preparation for contractions. Further experimental evaluations during labor are suggested.

DESCRIPTORS: applied research, feedback, behavioral medicine, pain

The Electronic Fetal Monitor (EFM) provides immediate and continuous feedback of fetal heart rate and maternal uterine contraction during labor. Graphic juxtaposition of contraction activity and fetal heart rate allows early detection of fetal distress and the necessary steps to preserve the health of the fetus and mother (e.g., change maternal position, use or discontinuation of labor-facilitating drugs, caesarean section). Electronic fetal monitoring has evolved rapidly from experimental use to almost routine use during labor and delivery (e.g., Hughey, LaPata, McElin, & Lussy, 1979).

Routine usage of EFM is still controversial among parents and professionals. Many contend that EFM increases maternal anxiety by turning the labor room into an intensive care setting (e.g., Haverkamp, Thompson, McFee, & Cetrulo, 1976; Hurst & Summey, 1979). Others claim that EFM does not interfere with the psychological process

and may enhance the labor and delivery experience (e.g., Starkman, 1977). Only in the past few years have researchers attempted to evaluate maternal responses to EFM. Starkman (1976), Shields (1978), and Tatano (1978) found that approximately 40% of mothers expressed negative or mixed attitudes towards monitoring. Brasted and Callahan (1980) questioned 65 mothers and found that 73% reported that graphic presentation was helpful in preparing for contractions, and 95% reported that it was a comforting stimulus. Electronic fetal monitoring may elicit positive responses, but it is not clear what mechanisms account for this effect. One potential explanation is that EFM signals the onset of contractions prior to maternal awareness that a contraction is occurring. If so, EFM may provide an interesting in vivo paradigm for evaluating the effects of signaled vs. unsignaled aversive stimuli.

Whether humans prefer to be warned about painful events has been a controversial issue. Infrahuman organisms select situations in which aversive stimuli are signaled over those in which no warning is provided (e.g., Badia, Culbertson, & Harsh, 1973). Evidence on humans is less conclusive. Research with humans suggests that when

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the aversive stimulus presentations are of high probability and intensity, and occur with no external distractors, predictive stimuli are preferred and stress reducing (e.g., Averill & Rosenn, 1972; Miller, 1979). Unpredictability appears preferred and stress reducing when the aversive stimulus condition is noninvasive, nonintrusive, and supportive of distraction (e.g., Bloom, Houston, Holmes, & Burish, 1977). In labor, the aversive stimuli (i.e., contractions) are both high probability and high intensity: A predictive stimulus might be expected to be both preferred and stress reducing.

This study was conducted to determine whether EFM feedback serves as a warning stimulus for contraction onset, and whether its presence changes the latency to report of pain. In addition, preference for continuing EFM monitoring after the study was determined.

METHOD

Patients and Setting

Eight primiparous females (that is, women experiencing their first birth), ranging from 16 to 28 years of age ($M = 21.6$ years), participated in the study. Four had attended childbirth preparation classes during the third trimester of pregnancy whereas the other four had not received any childbirth training. The training series consisted of: (a) six weekly, 2-hour sessions on preparation for labor and delivery with breathing and progressive deep muscle relaxation techniques (Beals, 1977) and body toning exercises, (b) discussions of anatomy of pregnancy, physiology of labor and delivery, medications, anesthetics, fetal monitoring, and newborn care, and (c) a tour of the hospital facilities. Patients were accompanied by husbands who coached during the classes and assisted during labor. Two women who did not attend training classes were accompanied by husbands, and two were accompanied by mothers.

Three women received epidural anesthesia and were delivered by caesarean section (none had attended classes). The fourth woman who did not attend childbirth training received a sedative (Vis-

taril), but did deliver vaginally. None received medication prior to or during the experimental period. Mean cervical dilation at the beginning of experimental observations was 3.8 cm with a range of 2 to 6 cm.

Labor nurses asked potential participants if they would agree to the experimenter entering the labor room and discussing the study. Those who agreed then signed a consent form. Of 10 women approached, eight agreed to participate. The experiments were conducted in private labor rooms of the West Virginia University Medical Center.

Equipment

Electronic fetal monitoring was done with the Corometrics Fetal Monitor Model 112 which uses ultrasound and a tocotransducer to monitor uterine contractions and fetal heart rate. The two monitors can be attached by one or two belts; the single belt monitor was used in this study.

Design and Procedure

Each mother participated in a single-subject reversal design. The monitor was turned away from the mother and coach for three contractions, toward the mother and coach for three contractions, away for three further contractions and, finally, toward the mother and coach for the final three contractions. Three dependent measures were obtained. To test the predictive value of EFM feedback, the latency from contraction onset to patients' awareness of contraction onset was obtained. To measure this, the laboring woman was asked to press an event button when she felt the start of a contraction. Second, pain perception was evaluated by recording contraction intensity in mmHg at the time patients indicated onset of pain by a second press of the event button. Finally, patients were asked at the termination of the recordings if they wished to continue the monitoring.

The experimental period occurred during the first stage of labor while cervical dilation ranged from 2 to 6 cm. Baseline began at the moment a contraction terminated, continued through three contractions, and ended at the termination of the third contraction. The first feedback phase then

continued through three contractions. At the termination of the third contraction the second baseline condition began. This procedure was maintained throughout the four phases of the ABAB design.

The feedback conditions consisted of the presentation of uterine contraction and fetal heart rate feedback by turning the EFM toward the mother. Feedback consisted of graphic presentation of uterine activity and fetal heart rate presented on a paper printout. Mother and coach were able to watch a continuous presentation of uterine contraction activity and fetal heart rate for three consecutive contractions in each intervention phase.

Following collection of data, the mother was thanked for her cooperation. Before the experimenter left, he asked, "Would you like me to take the monitor off now or would you prefer to continue using it?"

Recording and Reliability

Reliability for the latency of contraction onset recognition was determined by having two judges (an experimenter and an obstetrical nurse practitioner) review the EFM printouts. Each judge independently determined the points of actual contraction onset: the point at which the slope of uterine activity began a consistent positive acceleration. Each judge then measured the distances between the point of actual contraction onset to the mark made when the mother activated the event marker. The known speed of the printout was then used to convert the distances on the recordings to time. Each judge rated all 12 contractions in each of the eight women. Agreement between observers was noted if the two independent measures for each contraction agreed within 2 seconds. Reliability was determined by the formula dividing the number of agreements by the number of agreements plus disagreements. This resulted in a reliability coefficient of 93.75% for the latency of contraction recognition variable prior to any recalculations.

The pain variable, defined as the contraction intensity (i.e., mmHg) at the point at which the mother signaled subjective onset of pain, was de-

termined in the same way. A reliability coefficient of 94.7% was found for agreement at the point of subjective pain onset.

RESULTS

Latency measures are presented in Figure 1 for all. Six of the eight women demonstrated decreases in latency for recognition of contraction onset when the monitor feedback of uterine activity was provided. Two of the eight women failed to demonstrate consistent decreases in response latency when the uterine activity feedback was provided.

Contraction intensity at the subjective onset of pain, as shown in Table 1, was highly inconsistent both across and within patients. Data for the eight women revealed no systematic effect of providing uterine activity feedback. There is so much overlap between data in the feedback and no feedback conditions for individuals that no conclusion can be drawn.

Only one of the eight women asked that the EFM be turned off at the conclusion of data gathering. All others preferred that uterine activity feedback be available, stating the reasons for their preference as the information was useful in preparing for contractions ($n = 5$), or the information was rewarding because it let them see that the contraction had peaked and was nearly over ($n = 6$). The woman who chose to discontinue the monitoring later requested that it be started again.

DISCUSSION

The latency data were consistent with self-report data collected in the preliminary study by Brasted and Callahan (1980). In the study reported here, six of eight women recognized the onset of contractions more quickly when EFM feedback was available. In the self-report measure used earlier, approximately 75% of the mothers reported that the EFM provided a forewarning of contractions. The two women who were less able to attend to the task and use the information in predicting contraction onset had not gone through childbirth preparation.

Figure 1. Latency to report of contraction onset. Women 1-4 had taken childbirth preparation classes, Women 5-8 had not.

Data derived from contraction intensity when the mother signaled subjective onset of pain were highly inconsistent. For some women, a trend toward earlier report of pain onset appeared to occur

in the presence of EFM feedback. This trend was neither reliable nor strong. Earlier awareness of contraction onset may speed the button press response used to measure pain with or without

Table 1
MmHg Pressure at Signaled Pain Onset

Con- trac- tions		EFM feedback			No feedback			EFM feedback			No feedback		
		1,	2,	3,	4,	5,	6,	7,	8,	9,	10,	11,	12
Woman	1	22,	39,	25	24,	35,	44	32,	52,	21	22,	19,	21
	2	32,	59,	24	23,	44,	14	63,	67,	61	57,	37,	24
	3	27,	6,	10	15,	5,	8	17,	6,	8	16,	7,	44
	4	50,	86,	33	31,	47,	30	40,	38,	35	47,	34,	28
	5	51,	29,	39	14,	52,	25	25,	45,	24	34,	23,	25
	6	32,	48,	42	40,	38,	32	26,	30,	45	47,	52,	34
	7	25,	40,	42	23,	44,	NR*	15,	18,	20	23,	NR,	32
	8	23,	18,	22	25,	22,	16	6,	27,	9	23,	25,	18

* NR = no response.

changing the experience of pain. There may be other sources of pain which were not evaluated that could have had an effect. Aboulsh (1977) discussed both direct and indirect sources of pain during labor. The actual contractions of the uterus and stretching the cervix, for example, provide direct sources of pain stimuli during the first stage of labor. Additional sources of referred pain not directly related to the labor mechanisms exist. These include the abdominal wall, lower back, and pelvic muscles. The precise reason that these areas are sources of experienced pain is not well established, but Aboulsh indicated that tension in these muscle groups can exaggerate and even initiate pain during labor. Regardless of the effect on pain perception, it is interesting to note that mothers indicated a preference for the monitoring. Thus, as would be forecast by Averill and Rosenn (1972), a predictive signal of contractions is preferred in the labor situation in which the aversive stimuli are of high intensity and probability.

The presentation of EFM feedback appeared to have some unintended effects. When feedback was presented, coaches appeared to increase their interactions with the mother by providing feedback from the monitors. EFM may have provided them with specific tasks (e.g., providing feedback, comforting responses such as massaging) in a somewhat alien environment and consequently may have increased their interactions. If this is the case, perhaps mothers chose monitoring because it was cor-

related with increased positive social interaction. This question is currently being evaluated empirically.

This study indicates the potential for further evaluations of the labor process in vivo. To date, most studies evaluating labor have largely used analogue situations. For example, Stone, Demchik-Stone, and Horan (1977) provided a component analysis of prepared childbirth techniques using a coldpressor task, which is typically used as an analogue to childbirth (e.g., Stevens & Heide, 1977; Worthington & Martin, 1980). Other researchers have attempted to simulate labor by instructing the mothers to try to keep their hands in the ice water for intermittent periods of time over a number of trials, to mimic the variability of contractions. Another type of research involves investigating labor records and comparing the anesthesia and other pain medications given, and length of labor (Gregg, 1978). Unfortunately, controlled prospective outcome studies are rare.

The method used for assessing pain perception may yield data that are too variable to enable adequate evaluations. However, if phases are continued over a greater number of contractions, a more consistent effect might be observed. Additionally, training sessions prior to labor in an analogue situation may enhance mothers' skill in performing the required task. With further refinement, the methodology used in this study may facilitate other evaluations of maternal experiences in labor.

REFERENCES

- Aboulsh, E. (1977). Psychological methods of analgesia: Prepared childbirth, hypnosis, and acupuncture. In E. Aboulsh (Ed.), *Pain control in obstetrics* (pp. 365-371). Philadelphia: Lippincott.
- Averill, J. R., & Rosenn, M. (1972). Vigilant and non-vigilant coping strategies and psychophysiological stress reactions during the anticipation of an electric shock. *Journal of Personality and Social Psychology*, 23, 128-141.
- Badia, P., Culbertson, S. A., & Harsh, J. (1973). The relative aversiveness of signalled vs. unsignalled avoidance. *Journal of the Experimental Analysis of Behavior*, 19, 23-32.
- Beals, P. (Ed.). (1977). *Parents' guide to the childbearing year*. Rochester: The International Childbirth Education Association.
- Bloom, L. J., Houston, B. K., Holmes, D. S., & Burish, T. G. (1977). The effectiveness of attentional diversion and situation redefinition for reducing stress due to a nonambiguous threat. *Journal of Research in Personality*, 11, 83-94.
- Brasted, W. S., & Callahan, E. J. (1980). An evaluation of electronic fetal monitoring. Paper presented to 8th Meeting of the West Virginia College of Obstetricians and Gynecologists. Morgantown, West Virginia.
- Gregg, R. H. (1978). Biofeedback relaxation training effects in childbirth. *Behavioral Engineering*, 4, 57-66.
- Haverkamp, A. D., Thompson, H. E., McFee, J. G., & Cetrulo, C. (1976). The evaluation of continuous fetal heart rate monitoring in high risk pregnancy. *American Journal of Obstetrics and Gynecology*, 125, 310-320.
- Hughey, M. J., LaPata, R. E., McElin, T. W., & Lussky, R. (1979). The effect of fetal monitoring on the incidence of caesarean section. *Obstetrics and Gynecology*, 49, 515-517.
- Hurst, M., & Summey, P. (1979). Electronic fetal monitoring. *Health Policy Advisory Center Bulletin*, 83, 20-24.
- Miller, S. M. (1979). Coping with impending stress: Psycho-physiological and cognitive correlates of choice. *Psychophysiology*, 16, 572-581.
- Shields, D. (1978). Maternal reactions to fetal monitoring. *Nursing*, 79, 2110.
- Starkman, M. N. (1976). Psychological responses to the use of the fetal monitor during labor. *Psychosomatic Medicine*, 38, 269-277.
- Starkman, M. N. (1977). Psychological consequences and management recommendations. *Obstetrics and Gynecology*, 10, 500-504.
- Stevens, R. S., & Heide, R. (1977). Analgesic characteristics of prepared childbirth techniques: Attention focusing and systematic relaxation. *Journal of Psychosomatic Research*, 21, 423-438.
- Stone, C. I., Demchik-Stone, D. A., & Horan, J. J. (1977). Coping with pain: A component analysis of Lamaze and cognitive-behavioral procedures. *Journal of Psychosomatic Research*, 21, 451-456.
- Tatano, C. L. (1978). Patients' cognitive and emotional responses to fetal monitoring. Unpublished master's thesis, Yale University, School of Nursing.
- Worthington, E. L., Jr., & Martin, G. A. (1980). A laboratory analysis of response to pain after training in three Lamaze techniques. *Journal of Psychosomatic Research*, 24, 109-116.

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