Evaluation and impact of fetal physiology training on fetal heart rate analysis

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Abstract

Introduction - Evaluation of fetal well-being during labor is based on fetal heart rate (FHR) analysis, which requires physiology expertise. The aim of the present study was to assess medical residents' fetal physiology training in terms of theoretical knowledge, FHR interpretation, and use of second-line examinations.

Methods - This single-center, prospective study of obstetrics and gynecology residents (N=34) at CHU de Lille Hospital (Lille, France) was conducted from November 2017 to November 2018. Evaluation and training were conducted in three stages. First, residents' pre-training knowledge of FHR interpretation and use of fetal scalp blood sampling (FBS) was assessed using clinical cases. Second, a didactic training session on fetal physiology was delivered. Finally, post-training knowledge was evaluated using the same cases presented during pre-training.

Results - Pre-training, 3%, 11.8%, and 14.7% of residents considered their training on fetal physiology, FHR analysis, and second-line examinations, respectively, to be sufficient. Training significantly improved their theoretical knowledge, which was assessed using multiple-choice questions (median [interquartile range]: 1.5 [1.0–2.0] vs. 4.0 [3.0–4.5], $p<0.001$), and reduced the number of FBS requested (36.3% vs. 29.5%, $p=0.002$). Krippendorff's alpha coefficient for the reproducibility of residents' responses improved significantly, reflecting greater homogenization of clinical practice decisions (alpha [95% confidence interval]: 0.60 [0.55–0.65] vs. 0.72 [0.67–0.76]).

Conclusion - Improved fetal physiology knowledge promotes more accurate FHR interpretation, better indications for second-line examinations, and greater homogenization of clinical practice decisions. Future studies should evaluate the impact of fetal physiology training on clinical practice.

Keywords: training, fetal physiology, fetal heart rate, resident, fetal scalp blood sampling

Manuscript

Introduction

Fetal surveillance during labor is primarily based on fetal heart rate (FHR) analysis. The purpose of the interpretation of the FHR is to detect signs of poor fetal tolerance and therefore situations at risk of fetal acidosis. Indeed, this acidosis can be responsible for morbidity and perinatal mortality including motor disability of cerebral origin (1). In these intermediate-risk situations of fetal acidosis, second-line methods exist such as fetal scalp sampling (pH or lactate measurement) or ST segment analysis (2–4).

Interpretation of abnormalities observed on the FHR or second-line exams requires knowledge of fetal physiology during labor (5,6). The recent FIGO recommendations modified in 2015 classify the FHR as normal, suspicious or pathological, leading to a more physiological analysis of the FHR. (7). On the other hand, the place of second-line exams is controversial. In fact, a US randomized study concluded that ST segment analysis was not helpful in preventing fetal acidosis and nor in reducing intervention (cesarean or instrumental extraction) (8). Moreover, the physiopathology and the interest of fetal blood scalp sampling are discussed (9). Therefore, it is proposed to improve the quality of the interpretation of the FHR thanks to a better knowledge of the fetal physiology and of the adaptation of the fetus to the hypoxemia during labor. Thus, the aim of the present study was to assess fetal physiology training in terms of theoretical knowledge, interpretation of FHR and use of second-line examination.

Methods

A single-center prospective study (CHU Lille, France) was conducted among obstetrics and gynecology residents from November 2017 to November 2018 whatever their degree of competence (residency lasts 5 years in France).

The evaluation of the residents was conducted in 3 stages and each resident could only participate once. The first evaluation session was organized before our teaching session called "pre-training period". After this first evaluation session, the residents received one hour and half of teaching on fetal physiology and FHR analysis. The second evaluation session, called "post-training period",

was organized after this teaching and these three sessions were realized at 3 different times during their internship.

Each assessment session (pre- and post-training period) was organized into 2 parts: a theoretical part of multiple-choice questions (MCQs), and a practical part on clinical cases. During the theoretical evaluation, the residents had to answer a series of 7 multiple-choice questions. For each question, five answers were proposed and several answers were possible. They got one point to the question if all the answers were correct, 0.5 point if they made a mistake and no point beyond an error. These questions focused on the fetal response to hypoxemia and thus to fetal physiology during labor (figure 1).

The practical part was based on 6 clinical cases resulting from real clinical situations chosen by 2 investigators of the study. These were cases of singleton pregnancy in labor (spontaneous or induced) at term and with presence of abnormalities of the FHR for which the medical team had been solicited. Among the 6 files selected, 5 had been the subject of one or more FBS for a total of 10 fetal pH measurements actually achieved. For each of these clinical cases, 3 to 5 periods (27 in total) were chosen during the labor and at each period the residents had to analyze the FHR according to the CNGOF classification (10) divided into 5 categories: normal, low risk of acidosis, intermediate risk of acidosis, significant risk of acidosis, major risk. They were then asked if they achieved FBS or not, and the estimate of the result of this pH measurement if achevied: below 7.20, between 7.20 and 7.25 or above 7.25 (3). The obstetrical context and the progress of labour were explained but the participants were blinded to the FBS result. The second evaluation session (after teaching) was based on the same clinical cases, the neonatal outcome was not given at the end of the first session so as not to influence the answers (11).

The teaching session consisted of a 1.5 hour course and performed both times by the same teacher. During this session the basics of fetal physiology and FHR analysis were recalled. This class was based on the literature on this topic (12,13) and carried out in a team working in experimental development of a new fetal monitoring tool based on the analysis of the autonomic nervous system (14,15). The first evaluation was carried out at the beginning of the semester followed by the course.

shortly after and the second evaluation took place at the end of the semester (similar time between sessions).

Statistical analyzes

Qualitative variables were described in terms of frequency and percentage. The note of theoretical radiographic knowledge of the residents has been described in terms of median and interquartile range.

The comparison of the radiographic theoretical knowledge scores of the residents between the two sessions was evaluated using a rank test signed of Wilcoxon.

The distribution of FHR evaluation grades was compared between the 2 sessions using a mixed ordinal regression model including the session as a fixed effect and an internal random effect to take into account the correlation between the different assessments by resident (27 scenarios, 2 sessions). To evaluate the impact of the training on the analyze of the FHR by the residents, the reproducibility of the responses between the 34 residents on the FHR graduation was evaluated using the Krippendorff's alpha coefficient with its confidence interval of 95% [95% CI].

The FBS requested rate and the rate of correct estimation of the pH (if requested) were compared between the 2 sessions using a mixed logistic model including the session as a fixed effect and an effect internal random.

The p-values were calculated with a significance level of 5%. Statistical analyzes

were performed using the SAS software (SAS Institute version 9.4).

Results

A total of 34 residents participated in the 3 sessions, with seniority ranging from the 1st to the 5th year (Table 1). Only 11.8% of the residents surveyed felt that they had sufficient training on FHR analysis and 2.9% on fetal physiology during labor. Of these, 14.7% felt that they had sufficient training in the indication of second-line surveillance examinations. They were 81.8% have received specific training on FHR during their residency, mainly during a planned course in their university studies. Yet 90.9% believed that their training was insufficient on the use of the FIGO and CNGOF

classifications. As for FBS, 66.7% had already laid an indication and 48.4% had never achieved a FBS.

The median MCQ score before teaching was 1.5 [1.0 to 2.0] with scores ranging from 0.0 to 4.5. After our training, the median was 4.0 [3.0 to 4.5] with scores ranging from 1.0 to 6.5 ($p < 0.0001$). Of all the FHR analyzed during the defined periods, 49.2% of the rhythms were considered normal or low risk before our training against 54.7% after (Table 2). The distribution of FHR grades found a less pejorative evaluation after training ($p<0.001$). In fact, 17.4% of the FHR analyzed by the residents were considered to be at significant risk of acidosis and 2.7% at major risk in pre-training, compared with respectively 11.2% and 0.1%. The reproducibility of residents' responses to FHR evaluation was improved after training with Krippendorff's alpha index pre-training of 0.60 [IC95, 0.55 to 0.65] and post training of 0.72 [IC 9, 0.67 to 0.76]. Before our formation, 327 FBS were requested on all clinical cases against 269 after our training, a decrease of 6.9% ($p=0.002$). The evaluation of the pH estimate relative to the actual value (110 estimations concerned) was significantly different between the two sessions ($p = 0.020$) with a higher good estimate rate after training (47.2% vs 40.0%) although not significant with $p = 0.28$, a lower underestimation rate after training (26.4% vs. 38.2%) and a higher overestimate rate after training (26.4% vs. 21.8%). The rate of underestimation and overestimation was identical after training

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Discussion

Main Findings

The cardiotocograph was developed in the 1960s to improve fetal surveillance. But its generalization has led to an increase in the rate of cesarean section and extractions for FHR abnormalities and without significant reduction in neonatal risk (16,17). A recent Cochrane review also found no differences in cerebral palsy, infant mortality, or other standard measures of neonatal well-being between intermittent or continuous FHR auscultation (17). The only difference found is the reduction of neonatal convulsion rates during continuous auscultation. These findings, including the

increase in caesarean section rate, are related to the high sensitivity of the FHR and its low specificity, but not only. Misinterpretations or erroneous decisions are involved with a failure to take into account a pathological pattern in 20% of cases in newborns with metabolic acidosis (18). It therefore appears essential to improve our analysis of FHR and we wanted to evaluate the interest of training on fetal physiology in obstetric gynecology residents regardless of their initial level. We find a better global knowledge in fetal physiology with a reduction of "extreme" classification during the analysis of FHR, resulting in a decrease in the number of FBS, a better estimation of these and a homogenization of practices in clinical cases performed. Indeed, the increase in Krippendorff's alpha coefficient was significant with no overlapping of confidence interval.

The FHR interpretation training starts at the residency but the training time is variable and generally limited. The training is not systematic in France and varies according to the enrollments in workshops during congresses and the courses planned in the university. Conversely, in other countries such as England, the regulation has imposed the need for continuing education on the interpretation of the FHR every 6 months for midwives (19). Residents can also be trained personally through scientific articles or by their senior in the delivery room or during everyday staff. But this training is extremely variable and involves personnel already sensitized to the more physiological analysis of FHR. Therefore, the formation of residents on the FHR and fetal physiology is insufficient in France and all of our residents interviewed were applicants for such training.

The FHR analysis makes it possible to detect situations at risk of fetal acidosis when its interpretation is correctly performed and thus to provide indications of second-line examinations or fetal extraction. Metabolic acidosis and associated neonatal morbidity could potentially be prevented in 40-50% of cases (18). Indeed, the most found errors are a misinterpretation of the RCF, an imprudent use of oxytocin and a failure to recognize at-risk pregnancies (20–22). Training development could reduce the consequences of inadequate monitoring. Indeed, Draycott and al conducted a retrospective study evaluating the value of training in obstetric emergencies. They were interested in the Apgar scores at 5 minutes of all the liveborn singletons with va ginal deliveries at term, between 1998 and 2003. They also identified hypoxic and ischemic encephalopathies. All the

155 medical staff (midwife, gynecologist, anesthesiologist ...) benefited from a training day during the year
156 2000. Draycott and al did not analyze the year 2000 and compared two periods: a pre-training period
157 (from 1998 to 1999) and a post-training period (from 2001 to 2003). They found a significant
158 reduction in low Apgar scores (<6) and in the incidence of hypoxic and ischemic encephalopathy (23).
159 Thellesen and al, for their part, found a 14% decrease in fetal extraction, without increased risk of fetal
160 hypoxia, after a training program for midwives and gynecologists from a Danish maternity hospital
161 (24). Their training consisted of e-learning sessions and a day of theoretical courses.

162 The interpretation of the FHR is subject to intra- and inter-observer variability well studied
163 now (25–27). This variability persists despite the existence of classification and this is more important
164 when it comes to FHR classified as intermediate or pathological according to the FIGO classification
165 (28). Regular training on FHR could reduce this inter-observer variability. Pehrson and al interviewed
166 the Medline database to study and evaluate FHR training programs (29). Of the 409 citations they
167 found, 20 studies included and analyzed. They report a better inter-observer agreement after training
168 on the physiology and interpretation of FHR. We had the same findings by studying the
169 reproducibility of the responses and therefore the inter-observer variability via the Krippendorff's
170 alpha index (0.60 before training vs. 0.72 after). Therefore, training in fetal physiology promotes the
171 homogenization of answers. Thus, an education in the interpretation of the FHR would allow a
172 reduction of its variability inter and intra observer and therefore standardize our practices.

173 Finally, we wanted to evaluate the impact on the use of a second-line examination. Indeed,
174 when the FHR analysis is considered non-reassuring, there are different second-line exams to better
175 characterize the fetal state such as the FBS with pH measurement to study the acidobasic state of the
176 fetus (3,4,30). The interest of FBS is currently debated. It may not be representative of fetal acid-base
177 status as it is derived from peripheral tissue or because of the compression of the fetal scalp during
178 labor for example. This could lead to unnecessary interventions in fetuses that are not really hypoxic,
179 which means that the debate on this subject persists (9,31). The purpose of this study was not to
180 discuss the interest of FBS but to evaluate the decision to perform this second-line exam in our
181 residents. We note a decrease in the number of FBS requested so second-line examination, currently

being discussed, through a better interpretation. However, the rate of underestimation and overestimation was identical after training with an increase in overestimation with consequently a risk of not indicating sampling or missing a hypoxemic situation.

Strengths and Limitations

Our study was conducted directly with our residents and the clinical cases were derived from real situations in order to get as close as possible to a current clinical practice. However neonatal outcome was not communicated at the end of the first session so as not to influence the responses of the residents, the knowledge of an unfavorable neonatal outcome leading to a more pessimistic evaluation of the FHR (11,32).

This study has limitations, however. Only 6 cases were selected reflecting only part of FHR abnormalities and obstetric context. In addition, during the second session, the same clinical cases were evaluated. Finally, these positive results are based on theoretical cases and it will be interesting to evaluate their impact in current practice with study of obstetrical decisions. It would indeed be interesting to assess the impact on indications of birth and neonatal status.

Interpretation

In this study, we showed that it is necessary to improve our knowledge of fetal physiology for a better interpretation of FHR with better indications of FBS and more generally, more similar practices between practitioners.

Conclusion

Improved knowledge in fetal physiology allows for better interpretation of FHR with better second-line examination indications and homogenization of practices. It will be interesting to evaluate the impact of training of all professionals in current practice.

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The authors report no conflict of interest.

Details of Ethics Approval

None

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Characteristics of residents and their education	**N = 34**
Women	26 (76.5)
Year of the residency 1 2 3 4 5	 12 (35.3) 5 (14.7) 8 (23.5) 6 (17.7) 3 (8.8)
Do you feel you have sufficient training on FHR analysis ?	Yes : 4 (11.8)
Do you feel that you have sufficient training in fetal physiology during labor ?	Yes : 1 (2.9)
Do you feel you have sufficient training on the indication of second-line exams ?	Yes : 5 (14.7)
Have you ever attended specific training on fetal heart rate ?	Yes : 27 (81.8)
If yes, this training took place within the framework: University Congress Hospital internship Other	 11 (33.3) 10 (30.0) 7 (21.2) 6 (18.2)
Will you be applying for such training during your residency ?	Yes : 34 (100)
When you are asked for the interpretation of FHR, what classification do you use ? FIGO CNGOF None	 2 (6.3) 22 (68.8) 8 (25)
Do you consider your training sufficient on the use of classifications ?	Yes : 3 (9.1)
Have you ever asked the realization of a FBS ?	Yes: 22 (66.7)
How much FBS did you achieve ? None 1 to 5 6 to 10 > 10	 15 (48.4) 12 (38.2) 3 (9.7) 1 (3.2)

Table 1 : Characteristics of residents and their education. Results presented in number (percentage)
FIGO = International Federation of Gynecology and Obstetric; CNGOF = National College of Gynecologists and Obstetricians ; FBS = Fetal Blood Sampling

	Pre-training period	Post-training period	p
Theoretical part (7 MCQs)			
Score	1.5 [1.0 to 2.0]	4.0 [3.0 to 4.5]	<0.001
Distribution of FHR evaluation grades according to the CNGOF classification	**N= 905**	**N=912**	
Normal FHR	193 (21.3)	262 (28.7)	< 0.001
FHR at low risk of acidosis	252 (27.8)	237 (26.0)	
FHR at intermediate risk of acidosis	279 (30.8)	310 (34.0)	
FHR at high risk of acidosis	157 (17.4)	102 (11.2)	
FHR at major risk of acidosis	24 (2.7)	1 (0.1)	
FBS requested	**N= 900**	**N=913**	
Request of pH	327 (36.3)	269 (29.5)	0.002
Evaluation of the estimated pH compared to the actual value realized pH. *	**N= 110**	**N=110**	
Overestimation of pH	24 (21.8)	29 (26.4)	0.02
Good estimate of pH	44 (40)	52 (47.2)	
Underestimation of pH	42 (38.2)	29 (26.4)	
Reproducibility of answers			
Krippendorff's alpha index	0.60 [0.55 ; 0.65]	0.72 [0.68 ; 0.76]	NA

Table 2 : Results presented in number (percentage) and median [interquartile range]. FHR = fetal heart rate.
** Among all the clinical situations, 110 pH estimated by the interns were actually achieved and therefore their results could be compared.*