



Fetal physiology cardiotocography training, a regional evaluation

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Title: Fetal physiology cardiotocography training, a regional evaluation.

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Introduction:

Cardiotocography (CTG) has its limits in detecting fetal acidosis and intrapartum asphyxia. Our aim was to evaluate a CTG training programme based on fetal physiology in the Mediterranean perinatal network.

Methods:

Professionals from 41 maternity units of the Mediterranean network were invited to participate in a CTG masterclass based on fetal physiology in March 2019 and October 2019. They were asked to react to three practical cases by a physiological approach before the training course (T0), one month after (T1) and six to seven months after (T2). The mean scores were compared by using a mixed model including lapse of time to evaluation, profession of participants and level of the maternity unit as fixed effects.

Results:

A total of 248 professionals from 32 maternity units finally participated in the organizational audit. By using a mixed model, we found a significant improvement of the mean score at T1=6.44/10 compared to T0=4.97/10 ($p<0.0001$), and a significant improvement of the mean score obtained at T2=6.17/10 compared to T0 ($p<0.0001$). T2 scores were not significantly different from T1 scores ($p=0.143$).

Discussion:

A CTG training programme based on fetal physiology showed a significant improvement in the professionals' interpretation of CTG at short term and stable results at long term. Continuing medical education could help maintain and improve knowledge to ensure neonatal safety.

Key words : Cardiotocography, fetal physiology, training

1. Introduction:

Continuous monitoring of the fetal heart rate (FHR) by cardiotocography (CTG) is the established reference method for fetal monitoring during labour. This tool has limits regarding screening for fetal acidosis and intrapartum asphyxia [1]. The main differences in performance were found in the interpretation of decelerations [2], the evaluation of variability [3] and in the classification of intermediate tracings [4]. The subjectivity of this analysis was also observed when the observer was aware or not of adverse neonatal outcome [5–7]. According to the 2017 Cochrane review [8], in comparison with intermittent auscultation (IA), CTG was associated with a 63% increase in the rate of cesarean deliveries and with 15% more instrumental extraction but was not associated with a reduced incidence of cerebral palsy [9].

In France, use of the Collège National des Gynécologues Obstétriciens Français (CNGOF) classification simplified by Carbone et al in 2013 or the Fédération Internationale de Gynécologie et Obstétrique (FIGO) classification revised in 2015 are recommended for CTG analysis. These “3 or 5 tier” classifications are not used by all healthcare professionals and their interpretation can vary. A CTG tracing that accounts for fetal physiology may reduce this variability and respect fetal health conditions while reducing indications for emergency fetal extraction [10,11].

Several physiologists defend the view that intrapartum foetal surveillance should be approached from a physiological standpoint which also consists of accurately identifying fetuses at risk of intrapartum compromise, rather than just focusing on the morphological appearances of the FHR tracings [12–16]. These considerations however, have yet to be validated to replace or at least be complementary to the CNGOF classification.

It is necessary to consider CTG interpretation as an essential skill in intrapartum health care [17]. A literary review has already shown the importance of training in CTG analysis and its positive impact in clinical practice [18], however there is no initial standardized and generalized training on a regional, nor even an international level. On-site training has been proposed since 2015 in the Auvergne-Rhône-Alpes perinatal network and its evaluation has shown an improvement in healthcare professionals’ knowledge of CTG [19]. Likewise, in the Aquitaine area there are FHR monitoring workshops with a “training network” accreditation

that enables to expand them to the majority of public or private maternity units in that area [20].

With the aim of harmonizing this practice, we decided to evaluate a CTG teaching programme within the Provence-Alpes-Côte d'Azur, Corsica and Monaco perinatal network. Based on literature and the examples above, we hypothesized that knowledge would be improved after a CTG teaching course including fetal physiology, even some time later. The primary objective of our study was to evaluate this training by comparing the knowledge of healthcare professionals before (T0) and a short (T1) or long (T2) term after the course. Secondary objectives were to review the current practices concerning fetal monitoring in the 41 maternity units belonging to the Mediterranean Network (Réseau Méditerranée). We also wanted to assess the participants' satisfaction with regards to the course.

2. Material and Methods:

2.1 Teaching course on CTG analysis and evaluation of knowledge prior to the course (T0):

The Mediterranean Network proposed a teaching course on CTG interpretation including fetal physiology. It took place in Marseille and Nice with two sessions in March 2019 and two others in October 2019. The course was in the form of a masterclass led by a midwife specialized in CTG and trained in fetal physiology [21,22].

A satisfaction questionnaire was handed out to all of the participants in order to evaluate Kirkpatrick Level 1 [23].

The following subjects were treated:

- Physiology of FHR regulation during labour
- Singularity of the mother-fetus duo
- Sleep/wake cycles and variability
- Interpretation of decelerations
- Presentation of types of hypoxia (acute, sub-acute, chronic, evolving)

For the primary objective, participants were asked to fill in a computerized organizational questionnaire on CTG before the course and respond to clinical cases on a computerized multi-choice questionnaire:

- prior to the course (T0)

- short term (T1: in the month following the course)
- long term (T2: 6-7 months after the course)

2.2 Computerized Collected data:

2.2.1 Organizational CTG audit:

The organizational audit provided us with the healthcare professional's profile (age, gender, profession: trainee or registered midwife, junior doctor, public or private practitioner), amount of time spent in the delivery room, classification used in practice to interpret CTG, training in the subject, under what form and how regularly, and if they knew anything about fetal physiology. The questionnaire gave the type of institution, whether public or private, shifts on site or on call, access to which second-line tests, whether there was obstetric staff and at what frequency.

2.2.2 Clinical cases:

Actual clinical cases were transformed into progressive files with about ten questions per file. The first case illustrated chronic hypoxia on a vascular background; the second, sub-acute hypoxia due to inappropriate use of oxytocin, the same as in the third case illustrating evolving hypoxia finally leading to bradycardia in a low-risk patient. They were reviewed and validated by the course instructor. Participants had access to information concerning the patient's medical history, parity, gestational age, pregnancy, data from the last ultrasound scan and the onset of labour. All of the CTG data, from the entrance exam to the expulsion tracing, were available as well as information concerning the progress of labour, amniotic fluid characteristics and monitor readings.

The participants had to give their answers in a computerized multi-choice questionnaire during labour progress where they were asked to propose or criticize an intervention (no intervention, corrective action, second-line tests, imminent birth) and to answer questions on fetal physiology.

Neonatal outcome was hidden from the participants so as not to influence their answers.

The last questions on the cases asked for a prediction of pH at birth and in some cases the APGAR score.

Participants were given a detailed correction with the neonatal outcome after T2.

2.3 Data collection:

In order to study the participants' knowledge in a reproducible way, the same clinical cases were studied at T0, T1 and T2. To preserve anonymity while respecting the study times, participants gave the first three letters of their first and last names. To reduce the numbers of people lost to follow-up, reminder emails were sent every week, after one month for the short-term evaluation, and after 6-7 months for the long-term evaluation. Clinical cases were sent at 7 months for the October training course due to the COVID-19 pandemic. Each participant was given a score out of 42 (/12 for the first case, /15 for the second and last cases). Some questions were weighted (x2) when treating an essential point of the course and others gave negative points (-1) when the action or the non-action undertaken by the professional was particularly at risk for the fetus. Scores were then given out of 10 for legibility.

2.4 Statistical analysis:

Statistical analysis was performed using SPSS v20 software and SAS software for the mixed model.

Concerning the organizational part, descriptive analysis was performed on all of the collected variables in order to describe the profile of the participants, the maternity units and professional practices. Quantitative variables were expressed as average and standard deviation, median, minimum and maximum. Categorical variables were expressed as numbers or percentages. Correlation between different variables was tested with Chi-square tests. Results were compared according to the level of maternity unit. Threshold for significance was set at 5% for all tests.

Concerning the clinical case part, an average score out of 10 was given for each of the 3 clinical cases, as well as an average total score (out of 10). The 95% Confidence Interval was calculated for each of these scores.

Mixed effects models were performed to analyze repeated measures and to manage unbalanced design or incomplete data.

Fixed effects were as follows: time of evaluation (T0, T1, T2), type of profession (midwife, obstetrician-gynaecologist), type of institute (level I, II, III), time of evaluation-by-type of profession interaction, time of evaluation-by-type of institute interaction, and the random

effect was the subject. Mixed models were used with the restricted maximum likelihood estimate method and Satterthwaite degrees of freedom approximation. Least square means were compared between levels using Tukey-Kramer method. The level of significance was set at a P value of 0.05. Statistical analysis was performed using SAS Version 9.4 (SAS Institute, Cary, NC).

3. Results:

3.1 Organizational audit:

Among the 260 healthcare professionals originally signed up for the training course, the audit finally concerned 248 professionals including 198 midwives and 50 obstetrician-gynaecologists. These professionals came from 32 maternity units (13 level I, 16 level II and 3 level III maternity units). There were 22 public facilities and 10 private clinics. Nine maternity units were not represented, giving a response rate of 78%. All of the centres combined, 85 professionals attended the March course and 163 professionals attended the October course.

Items are detailed in Table 1. The majority of participants was confronted with CTG analysis one or several times per week on shift. The classification the most often used was that of the CNGOF modified by Carbonne in 2013 [24] followed by the FIGO classification[22]. Approximately one third of participants used an approach including fetal physiology. Among the 133 professionals out of 248 who declared to have had training, this was mainly occasional and took place less than once a year in 58% of cases. Among the 115 professionals who declared to have had no training, 98% considered the course useful. Intermittent auscultation was reported in slightly over half of the centres, all levels combined.

Table 1 – Overview of the organizational audit results

	Total (n=242)	Level I (n=66)	Level II (n=123)	Level III (n=53)	p
Professionals with shifts systematically on site					
Obstetrician-Gynaecologist	187 (78%)	36 (54%)	99 (81%)	53 (100%)	<0.05
Junior Doctor	81 (34%)	1 (1%)	28 (23%)	53 (100%)	<0.05
Intermittent auscultation	125 (52%)	42 (64%)	58 (47%)	25 (48%)	NS
Classification for CTG interpretation	219 (90%)	56 (85%)	113 (92%)	50 (94%)	NS
FIGO 2015 [4]	86 (39%)	29 (52%)	33 (29%)	24 (48%)	<0.05
ACOG 2009 [25]	20 (9%)	3 (5%)	14 (12%)	3 (6%)	NS
CNGOF 2007	26 (12%)	8 (14%)	12 (11%)	6 (12%)	NS
CNGOF Carbonne 2013 [24]	129 (59%)	25 (45%)	74 (65%)	30 (56%)	<0.05
Murphy Criteria [26]	26 (12%)	8 (14%)	14 (12%)	4 (8%)	NS
Rosen 2004 (STAN) [27]	23 (10%)	4 (7%)	16 (14%)	3 (6%)	NS
Thoulon [28]	9 (4%)	1 (2%)	6 (5%)	2 (4%)	NS
FHR Coletta 2012 [29]	1	0	1	0	NS
2nd line tests	180 (75%)	32 (48%)	96 (78%)	53 (100%)	P<0.05
Fetal scalp pH	88 (36%)	11 (17%)	28 (23%)	49 (92%)	
Fetal scalp lactates	127 (52%)	23 (35%)	72 (59%)	32 (60%)	
STAN	20 (8%)	2 (3%)	15 (11%)	3 (6%)	
Digital fetal scalp stimulation	19 (8%)	3 (4%)	7 (6%)	9 (17%)	
Doppler ultrasound	26 (11%)	5 (8%)	10 (8%)	11 (21%)	
Pathophysiological approach	62 (26%)	17 (26%)	28 (23%)	17 (32%)	NS
CTG training	133 (55%)	28 (42%)	70 (57%)	35 (66%)	P<0.05
Service meeting	62 (26%)	8 (12%)	33 (27%)	21 (40%)	
Continuous personal development	41 (17%)	9 (14%)	23 (19%)	41 (77%)	
Masterclass	18 (7%)	5 (8%)	8 (6%)	5 (9%)	
Other	24 (10%)	7 (11%)	14 (12%)	3 (6%)	
Obstetric staff presence	192 (80%)	40 (61%)	100 (82%)	53 (100%)	P<0.05
Weekly	72 (37%)	24 (60%)	45 (45%)	3 (6%)	
Daily	81 (42%)	5 (12%)	27 (27%)	49 (92%)	
Several times per week	9 (5%)	1 (2%)	8 (8%)	0	
Monthly	15 (8%)	4 (6%)	11 (11%)	0	
Mortality and morbidity reviews	5 (3%)	2 (5%)	3 (3%)	0	

Other 11 (4%) 4 (6%) 7 (6%) 0

Data are presented as n(%)

3.2 Clinical case results:

236 professionals participated at T0, 107 participated at T1 and 73 participated at T2. (Table 2)

There was a significant increase in the average score obtained at T1 compared to that of T0 for the different cases and for the total scores, with an average T1 score of 6.44/10 versus an average T0 score of 4.97/10 ($p<0.001$).

There was also a significant increase in T2 scores compared to T0 scores, with an average T2 score of 6.17/10 ($p<0.001$).

T2 scores were not significantly different from T1 scores ($p=0.143$). (Figure 1)

Type of maternity unit effect and type of profession effect were not significant for all scores, except a tendency for case 3 where obstetrician-gynaecologists scores were higher than those of midwives 7.2/10 [6.9 ; 7.5] vs 6.8/10 [6.7 ; 7.0] respectively ($p=0.064$).

Table 2 - Mean scores by time of evaluation – Mixed model

	T0 (n=236)	T1 (n=107)	T2 (n=73)	p-values Time of evaluation effect
Case 1	2.93	5.00	4.53	T0 < T1 ($p<0.001$)
Chronic hypoxia	[2.67 ; 3.18]	[4.57 ; 5.43]	[3.96 ; 5.11]	T0 < T2 ($p<0.001$) T1 > T2 ($p=0.284$)
Case 2	5.37	6.96	6.59	T0 < T1 ($p<0.0001$)
Subacute hypoxia	[5.20 ; 5.55]	[6.71 ; 7.21]	[6.26 ; 6.91]	T0 < T2 ($p<0.0001$) T1 > T2 ($p=0.038$)
Case 3	6.56	7.23	7.40	T0 < T1 ($p=0.001$)
Evolving and acute hypoxia	[6.39 ; 6.73]	[6.97 ; 7.49]	[7.07 ; 7.74]	T0 < T2 ($p<0.001$) T1 > T2 ($p=0.660$)
Total	4.97	6.44	6.17	T0 < T1 ($p<0.001$)
Score	[4.85 ; 5.10]	[6.25 ; 6.63]	[5.88 ; 6.41]	T0 < T2 ($p<0.001$) T1 > T2 ($p=0.143$)

Data are mean scores and 95% confidence interval. P-value adjusted from mixed model included fixed effects: “time of evaluation”, “type of institute”, “type of profession”, and their interactions with time of evaluation.

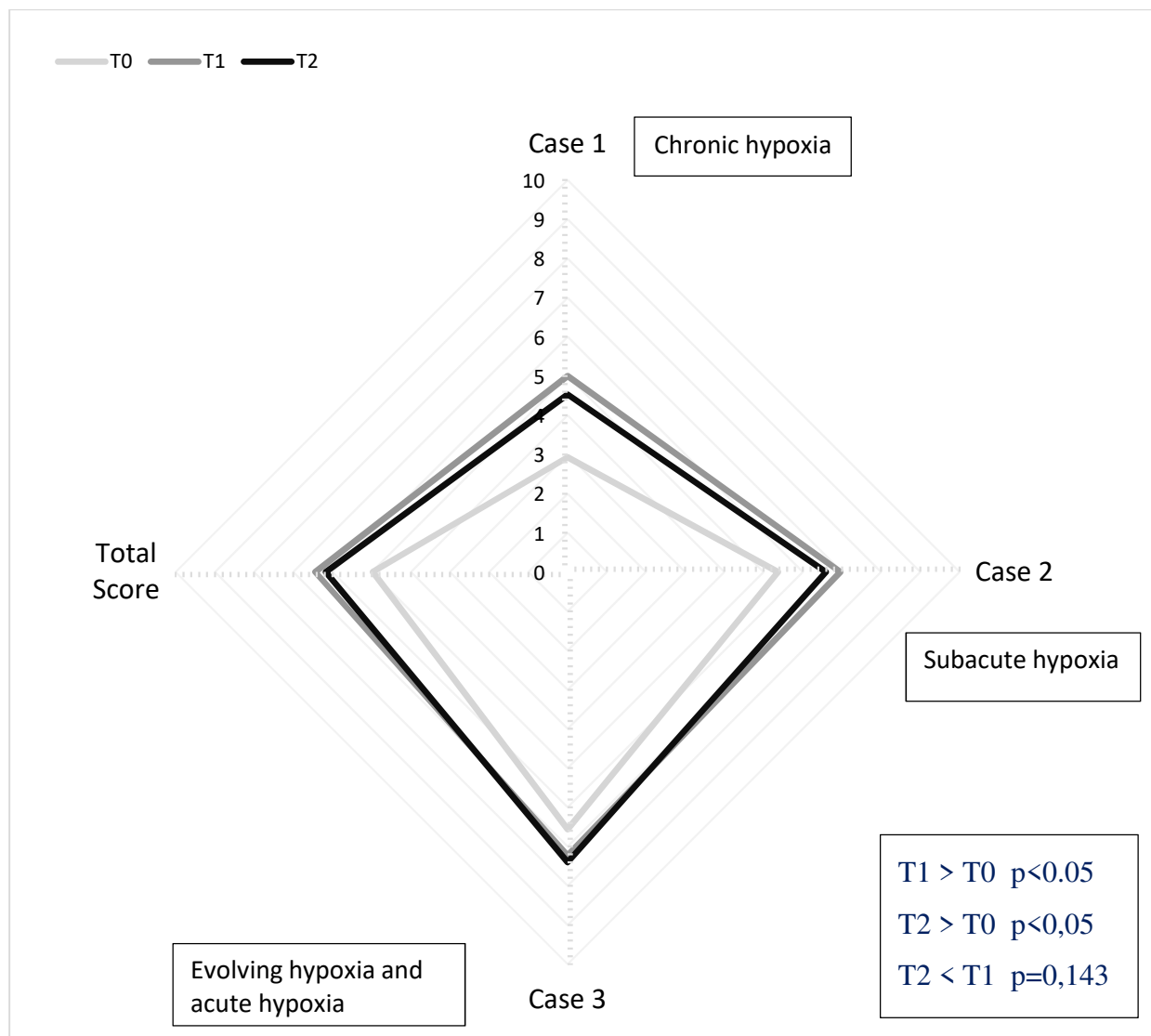


Figure 1: Variation of mean scores for the clinical case results at different times T0, T1 and T2 for each case and total score

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247 ***3.3 Satisfaction questionnaire:***

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249 The satisfaction questionnaire was handed out immediately after the teaching course to the

250 260 people signed up. In March the course was given a grade of 9.8/10 for usefulness, and in

251 October it got 9.8/10 for usefulness and 9.8/10 for the teaching method.

252

253

254 **4. Discussion:**

255

256 Our study found a significant increase in the average score obtained after the teaching course
257 compared to pre-teaching scores. This concerned short-term post-teaching scores and applied
258 to all of the different cases as well as to total scores. Long-term scores were not significantly
259 higher than short-term scores but the results were stable, indicating the necessity to
260 consolidate knowledge.

261

262 These results confirm those already published. One of the originalities of our study was that
263 we chose progressive clinical cases to evaluate performance, because real-life situations
264 seemed to be better than single choice questions about the teaching course. This evaluation
265 was inspired by the e.RCF website from Lille University, that was proved to be useful in the
266 study by Demailly et al [29]. Our study was also original because the training programme
267 used a physiological approach.

268 In a literary review, Pehrson et al [18] found that theoretical knowledge was retained 6 or 7
269 months after CTG training and that repetitive testing led to a marked improvement in
270 performance. After a 1997 survey on perinatal deaths in England, it was recommended that
271 CTG knowledge of healthcare professionals should be tested every 6 months.

272 Froc et al [19] also showed the interest of CTG analysis training in improving short-term and
273 long-term knowledge in the Auvergne-Rhône-Alpes perinatal network. Their evaluation used
274 a single choice questionnaire filled in before (T0) and immediately after (T1) theory training
275 in maternity units in the form of an “outreach visit”. Long-term evaluation took place over a
276 4-year period via “e-Learning”. Froc et al observed a significant decrease in T2 scores
277 compared to T1 showing once again the importance of repeated training.

278

279 We first could discuss that the knowledge improvement observed might be the effect of any
280 CTG training programme. Our study could not confirm the superiority of this programme
281 based on fetal physiology versus another programme.

282 Quite predictably, the highest rate of participation was at T0 and decreased over time (236
283 participants at T0, 107 at T1 and 73 at T2). This decrease may be explained by the fact that
284 the correction was not given immediately, the tracings were not easy to scroll through, and it
285 took time to fill in the clinical cases. There is, therefore, a selection bias, as the participants
286 who answered all three times were probably the most motivated. Nevertheless, our study

permitted us to collect exhaustive data representative of the network, even if the participants were mostly midwives (80%) and healthcare professionals mainly from the public sector. Even if the neonatal outcome remained hidden until T2, there may also be a memorization bias **since there were only three practical cases.**

Our study provides an overview of the situation in the Mediterranean Network in order to target its actions and respond better to practitioners' expectations. Despite the biases mentioned above, we think that one of the important roles of the network is to continue to harmonize professional practices. We observed inequalities in care organization and access to education within the perinatal network. CTG training was significantly more important in level II and level III maternity units compared to level I. Half of the participants declared that this was their first teaching course on CTG, and the majority of the other half declared to have only received very occasional training. This mainly took place during service meetings and was mostly in level II and III maternity units, which also correlated with the number of obstetrical staff members reported. They were reported to be present daily in less than half of the maternity units, all units combined, and present weekly in just over a third of them. We consider that this needs to be improved.

Care networks play an essential part in the definition of protocols and their dispersion [20] but their impact is sometimes limited by the motivation of the healthcare workers, geographical location (9 maternity units did not take part in the training programme, 4 of which were in the Vaucluse area) or financial cost. On the contrary to the study by Froc et al. in which type II maternity unit scores were better than type I scores, we found no significant differences between the types of unit. We were not able to compare the private and public sectors due to insufficient numbers.

Recent papers mainly state [18] that it is important to invest in a teaching policy that would motivate healthcare workers to make improvements in their practice [30], some going as far as suggesting compulsory knowledge tests [17]. Young et al. showed that the main causes for intrapartum mortality were a delay in responding to recognized CTG anomalies or failure to identify them [31]. These examples show that human factors are involved in adverse fetal outcomes, they are the cause for variability in the interpretation of CTG and must be limited. Education is one of the levers for reducing "improvisation" in healthcare. It demands investment such as programmes for the prevention of serious adverse incidents, help in staff communication and the development of medical technology.

In order to durably anchor knowledge into clinical practices, recommendations need to be simple and reproducible, this is why the simplified 2013 version of the CNGOF classification combined with a proposition of decision tree algorithms appeared to be a real solution. However, in a study by Cheurfa et al [32] the diagnostic value of a coloured table simplified by Carbonne remained limited in predicting acidosis (AUC <0.7) even though it made CTG interpretation easier. One of the limitations of “3 or 5 tier” standard recommendations possibly resides in the fact that they rely on the recognition of “patterns” for which our analysis is mainly descriptive. The identification of the different types of hypoxia, via a better comprehension of physiological processes at the origin of changes in CTG, is a method of analysis which would probably allow an optimization in the use of this monitoring tool [33]. The diagnostic performance of this type of approach needs to be assessed, with objective markers used in current practice to measure the clinical impact before and after a generalized teaching programme including fetal physiology (Kirkpatrick levels 3 and 4). **Indeed, no study has yet shown a significant impact on neonatal outcomes by using a more physiological interpretation of CTG.** Here we studied Kirkpatrick level 1 which gave a positive feedback for the training course.

A collaboration between perinatal networks could be the answer to help consolidate best practices, thanks to sharing experiences and acting in compliance with mortality-morbidity reviews. Then training on fetal physiology could be organized in each maternity unit by professionals to relay knowledge and consolidate unity within the teams (Safety Attitude Questionnaire). As in the United Kingdom and in other medical fields, trainee and experienced professionals could be offered standardized education to maintain their CTG knowledge, at a rhythm that remains to be defined. In any case, access to continuing medical education should be made easier as it helps guarantee patient safety.

5. Conclusion:

A CTG training course based on fetal physiology was associated with a significant improvement in knowledge at short-term and stable results at long-term. However, it is probably necessary to repeat education courses to correctly maintain and improve long-term acquisitions.

The objective of our study was not to assess the impact of CTG interpretation via an approach involving fetal physiology on newborn and maternal health, and therefore it needs to be evaluated in current practice using objective criteria. **It would be interesting to assess if it**

355 reduces the use of second line exams such as STAN or fetal scalp blood sample, operative
356 deliveries and the rate of umbilical cord artery pH < 7.

357 Our study backs our belief that continuing medical education and investment in a solid health
358 policy are the means of reinforcing the field of global skills connected with care and safety in
359 the delivery room.

360

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