Research Article

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Critical Care Obstetrics and Gynecology
ISSN 2471-9803

2017
Vol.3 No.4:14

DOI: 10.21767/2471-9803.1000154

Objective Numeric Fetal Monitoring without FHR Pattern Classification

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Received date: August 30, 2017; **Accepted date:** October 13, 2017; **Published date:** October 15, 2017

Citation: Maeda K (2017) Objective Numeric Fetal Monitoring without FHR Pattern Classification. Crit Care Obst Gyne. Vol. 3 No. 4:14.

Abstract

Objective and numeric decision was introduced into computerized FHR Diagnosis including FHR score, hypoxia index, actocardiographic A/B ratio and frequency spectrum analysis, where computerized FHR analysis made it possible to satisfactory predet fetal outcome, where the system composed of these diagnostic tools, which directory reported the results attendant doctor improving perinatal outcome.

Keywords: Fetal monitoring; Computer; FHR pattern; FHR score; Hypoxia index; Frequency spectrum; A/B ratio

Introduction

Fetal heart rate patterns, including early late and variable decelerations [1,2] were diagnosed by human observation of FHR and contraction records to predict fetal outcome, while the diagnosis was obtained by doctor's subjective decision, including observer differences, but not objectively diagnosed by computer analysis of FHR changes. Thus, it was necessary to know the correlation of numeric FHR parameters and neonatal Apgar score and umbilical blood pH, and their regression

Equations to obtain numeric data by the application of computer, where numeric outcome is obtained automatically, where the numerization of long term outcome was proceeded to diagnose the outcome after births. As numerized computer outputs objective risky or hazardous FHR changes, a doctor received objective results but also clinical states obtained by regression equation, e.g., Apgar score is predicted by FHR score, which is directly and rapidly informed to attendant doctor, promoting correct fetal therapy.

Methods

Primarily an obstetrician is requested to prepare an obstetrically specialized small computer [3], which is connected to an external fetal monitor, which will be autocorrelation FHR monitor triggered by ultrasonic Doppler fetal cardiac signal or fetal heart tone. Fetal monitor will be an actocardiograph (ACG), to use fetal movement signal in the A/B ratio calculation, namely, the ACG records FHR and fetal movement [4].

FHR score

Table 1 Evaluation scores to calculate FHR score.

FHR changes	Evaluation
Baseline 110-130 or 160-180 bpm <110 or >180 bpm	1
Deceleration	3
The lowest FHR<100 bpm	2
Amplitude >50 bpm	2
Duration >60 sec	2
Lag time >40 sec	3
Recovery time >40 sec	3
Accompany no acceleration	2
W type (2 deceleratuons and loss of variability)	4

FHR changes are analyzed in 5 min analyzing FHR baseline and decelerations, where detailed data of FHR baseline and deceleration are obtained (**Figure 1**), which were studied by evaluation scores determined by Apgar scores in each data (**Table 1**), then the sum of evaluation scores in 5 min is the FHR score, which is calculated by the computer. Regression equations were obtained between FHR score and fetal outcome, including Apgar score and UApH, was calculated and reported attending doctor automatically by the computer (**Table 2**) [4]."

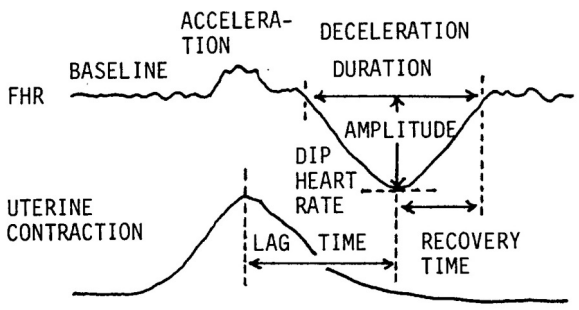

Figure 1 FHR curve analysis to calculate FHR score [2].

Hypoxia index

As rabbit bradycardia highly correlated its PaO_2 when it is 50 or less mmHg [5], and human fetal PaO_2 is 50 mmHg or lower [6], fetal bradycardia was utilized instead of PaO_2 in the hypoxia index, which expresses cumulative hypoxic effect in repeated FHR decelerations, namely, hypoxia index is the sum of durations of bradycardia (min) the lowest fetal bradycardia (bpm) × 100 [7].

Table 2 Computer FHR diagnosis to be directly reported doctor.

FHR score	Evaluation
FHR score in 1st stage of labor	<10; Apgar>6
	=10; Apgar 6,
	=15: Apgar 4,
	=20: Apgar 3
Frequency spectrum diagnoses of pathologic sinusoidal FHR, or the loss of variability.	
Hypoxia index is high in repeated decelerations or continuous bradycardia.	
The loss of variability, diagnosed by hypoxia index >24; develops fetal brain damage and cerebral palsy.	
Caesarean delivery before the loss of variability prevents cerebral palsy, where the hypoxia index is 20-24.	
C-delivery after the loss of variability does not prevent cerebral palsy.	
C-delivery is recommended in the loss of acceleration and decreased variability.	
Late deceleration should be tried by maternal lateral posture.	
Apgar >=7 and long term outcome is normal, if the A/B ratio >1.	
The information's are directly and rapidly reported to the doctor by cell phone or LAN.	

The index was 25 and 26 in 2 cases of the loss of variability followed by cerebral palsy, and 20-24 in severe FHR changes preserving the variability without cerebral palsy [7]. Thus, the hypoxia index is reported attending doctor.

Actocardiographic A/B ratio

It is the sum of FHR Acceleration duration, divided by the sum of fetal movement Burst duration in a definite period of actocardiogram determined by the computer. Apgar score is 7 or more, when A/B ratio is 1 or more. While Apgar score is less than 7, when A/B ratio is less than 1 [8]. Also A/B ratio and calculated Apgar score is directly and quickly reported doctor.

FHR frequency spectrum analysis

Pathologic sinusoidal heart rate is pathologic sinusoidal FHR. When the spectrum data is very large in its analysis [9], and the loss of variability is diagnosed when the data is very small [10], andreported doctor.

FHR chart record

As no visually recognized FHR pattern was studied in fetal diagnosis in numeric computerized FHR, there was no chart recorder in the computer system. The computer hard copy traced FHR curve by the order to computer in necessary case.

It is particularly useful computer function to directly and quickly report risky and hazardous changes to attending doctor before or at the fetal hypoxic damage using objective data (**Table 2**) [11].

Results

Apgar score and umbilical arterial pH (UApH) are predicted by FHR score in the 1st stage of labor by the regression equations;

Apgar score=9.361-0.335 × FHR score

UApH=7.31-0.01 × FHR score

Namely, Apgar score >=7, if FHR score<10

=6, if FHR score is 10,

=4, if FHR score is 15

The neonate was acidosis, if FHR score is 15.

The Apgar score is 7 or more, if A/B ratio is 1.0, and Apgar is less than 7, if A/B ratio is less than 1 [10]. Thus, Caesarean delivery is recommended if FHR score is 15 or more in the 1st stage of labor.

Caesarean delivery was also recommended when hypoxia index is 20-23, where FHR acceleration is lost and the variability reduced to 5 bpm, which were the states immediately before the loss of variability followed by cerebral palsy [7].

Apgar score was normal if actocariographic A/B ratio was 1 or more.

Fetal outcome was favorable, if HI was less than 10, even in case of late deceleration or bradycardia.

Frequency spectrum analysis

Pathologic sinusoidal FHR, which was severe fetal anemia close to fetal death, was diagnosed by the FHR frequency

spectrum analysis of FHR, when the La/Ta ratio was 30% or more and PPSD was 300 bpm^2/Hz or more [8].

The loss of baseline variability was diagnosed, when La/Ta ratio was less than 15% and the PPSD was less than 60 bpm^2/Hz [9]. Clinical diagnosis is reported doctor in both cases.

Improved perinatal states in the update computerized fetal monitoring

Three conditions were compared by Dr. Utsu, in no computerized period, centralized computer without direct reporting to doctor, and the update system in 2012 which directly and quickly reported FHR abnormality to the doctor. There was significant decrease of perinatal mortality and no case of cerebral palsy in the update system, i.e., the advantage was recognized in the update system [11].

Specificity of fetal hiccupping motion

Fetal hiccuppings are recorded as sharp spikes in actocardiogram, of which intervals were regularly 2-3 sec. It repeats for more than 10 min. It does not associate acceleration, while no hypoxia was found, because it will be local diaphragmatic contraction. No FHR acceleration is detected against fetal movements with 2 sec interval spikes of fetal hiccupping, where no FHR change was detected as neither deceleration n or acceleration, nor pathologic change (**Figure 2**).

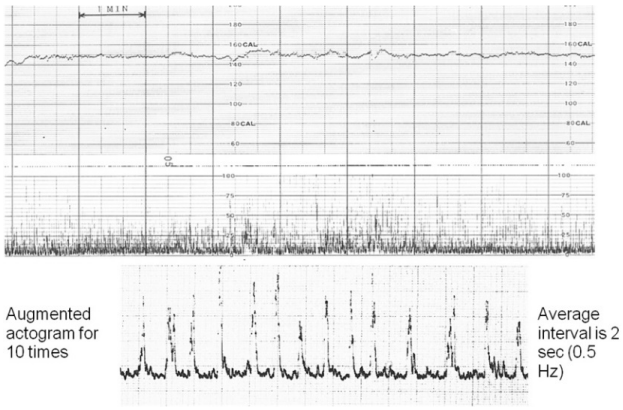

Figure 2 Actocardiogram of fetal hiccupping movements.

New clinical fetal monitoring computer

FHR score software had been completed and it is working in fetal monitoring. In FHR diagnosis, fetal A/B ratio was used to the diagnosis of controversy late deceleration and in sick sinus bradycardia. Pathologic sinusoidal heart rate was checked in computerized FHR diagnosis [11], while the hypoxia index needs the correlation to the Apgar score. While direct reporting system was successful in multiple delivery monitoring [11]. All components of this report were completed and waiting the production of new personal system in near future.

Conclusion

FHR score, hypoxia index, A/B ratio and frequency spectrum are main functions of computerized numeric FHR analysis. A computer connected to actocardiogram is the simple setting of numeric analysis, and also multiple times sharing system, handling 50 deliveries at the same time, using in large hospital [11]. Medical diagnosis is reported doctor instead of numeric data.

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