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Intrapartum electrocardiogram alteration in fetuses with congenital heart disease: a case–control study

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ABSTRACT

Objective: To assess if the fetal electrocardiogram especially ST segment is modified by congenital heart diseases: modifications in frequencies of the different ST events and modifications in signal quality.
Study design: A retrospective case–control study, comparing frequencies of the different ST events and the quality of the signal between fetuses with congenital heart diseases and fetuses without congenital heart disease. From 2000 to 2011, fifty-eight fetuses with congenital heart disease had their heart rate recording using a STAN device during labor. Control group was fetuses who were born just before a case and had a STAN as a second line for intrapartum surveillance. Cases and controls were matched on parity, gestational age at birth, presence of growth restriction and umbilical artery pH. Frequencies of the different ST event and quality of the signal were first analyzed for the global labor recording, and then separately for the first and the second phase of labor.
Results: No statistically significant difference in ST event frequencies between fetuses with congenital heart disease and the control group was found. Regarding the quality of the signal, 11.49% (±18.82) of recording time is a signal loss for fetus with congenital heart disease whereas only 5.18% (±10.67) for the control group ($p = 0.028$).
Conclusion: This is the first study investigating for *intrapartum* electrocardiogram modification in fetus with congenital heart disease. Congenital heart diseases do not modify frequencies of ST events.

Introduction

Fetuses with congenital heart diseases are more likely to be delivered by C-section because of non-reassuring fetal heart rate monitoring [1,2]. Previous studies showed that fetal heart rate anomalies were more frequent in fetuses with CDH than controls, but with similar rate of umbilical cord acidosis, resulting in a higher rate of false positive in this population [1,3]. Thus another surveillance method rather than cardiotocography could benefit to fetuses with congenital heart disease. ST segment analysis of fetal electrocardiogram (STAN) has been developed to reduce fetal metabolic acidosis and unnecessary operative deliveries for suspected fetal distress [4–8]. So, STAN device could help to reduce the false positive rate of fetal heart rate monitoring and benefits to mothers with fetus with congenital heart disease.

STAN device analyses the ST segment morphology which is related to heart muscle oxygenation. A biphasic ST segment, like in adults, is associated with a high risk of hypoxia in heart muscle cells. The STAN device will send an alert called "biphasic ST event". An intervention is required to improve cardiotocography in twenty minutes if three repeated biphasic ST event messages appear on an intermediary CTG or two repeated biphasic ST event messages appear on an abnormal CTG during phase 1 of labor. Delivery in less than 10 min is required if repeated biphasic ST occur during phase 2.

The STAN device also analyses the T/QRS ratio, as T wave amplitude increase when potassium concentration rise due to glycogenolysis [9–11]. The rate of increase in T wave amplitude depends on the amount of glycogen the fetus needs to utilize to maintain its myocardial energy balance. An episodic rise T/QRS ratio corresponds to a short-lasting hypoxia. An intervention is required to improve CTG when it exceeds 0.15 with an intermediary CTG or 0.10 with an abnormal CTG. A baseline rise T/QRS ratio corresponds to a hypoxia situation lasting more than 10 min. An intervention is required if this rise exceeds 0.10 with an intermediary CTG and 0.05 with an abnormal CTG.

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However, fetuses with CHD have been excluded from STAN monitoring arguing that heart structure anomalies could modify electrical conduction and therefore the P-QRS-T complex morphology and generate inappropriate biphasic ST event. But, up to date, no study has evaluated the potential *intrapartum* modifications in ECG complex morphology in fetuses with CHD.

Actually, modification of electrocardiogram (ECG) complex is uncommon in CHD. Most of the time, CHD diagnosed postnatally are suspected on persistent cyanosis, heart murmur or signs of heart failure [12]. Arrhythmia is the most common ECG modification of the presence of a CHD after birth. Alteration of the ECG complex morphology is not commonly leading to CHD diagnosis. Rarely, modification in amplitude of QRS can be observed in fetuses with left or right ventricular hypertrophy. This modification is stable in time and should not affect the T/QRS ratio analysis which is using the fetus as its own control. ST segment anomalies like ST segment elevation or deep Q wave can be observed during myocardial ischemia complicating CHD but are extremely rare [11].

The main aim of our study was to determine the prevalence and types of ST event during labor in fetuses with CHD compared with controls. Signal quality was evaluated as secondary outcome.

Materials and methods

This retrospective case–control study was carried out in the Department of Obstetrics in the Public Academic Hospital Femme-Mère-Enfant (HFME) in Lyon, a tertiary referral center for high risk pregnancies and fetal medicine, with about 4400 deliveries per year. This hospital is located on the same site than a cardiology hospital taking care of all newborns with congenital heart disease of the region. About forty fetuses with congenital heart disease are born each year in our department. STAN technology (Neoventa Medical AB System, Mölndal, Sweden) without fetal blood sampling is used as a second line method for intrapartum surveillance in term fetuses in our department from 2000, except for fetuses with major malformations in accordance with the manufacturers' guidelines [13–15]. However, fetal heart rate was occasionally recorded with STAN 21 or 31 devices in fetuses with major malformation, when the medical staff in charge of the patient required for internal recording with scalp electrode. Medical staff was aware that STAN data should not be used in these specific cases, and labor and delivery had to be managed only on the base of fetal heart rate pattern. Fetuses with congenital heart disease diagnosed at antenatal ultrasound examination and confirmed in the postnatal period were included in the case group. Inclusion criteria were: singleton pregnancy, gestational age superior or equal at 36 weeks, cephalic presentation, FHR recording using the STAN device during labor, and arterial umbilical cord pH documented. Patients with multiple pregnancy, non-cardiac malformations or multiple malformations and chromosomal abnormalities were excluded from the study. Were included in the control group, fetuses who were born just before a case, matched on parity (nulliparous or multiparous), gestational age at birth (37 < WG[1]; 37–41 WG; >41 WG), presence of growth restriction (birth weight under the ten percentile for sex) and gestational age at birth of the AUDIPOG reference curve [16] and umbilical artery pH (pH ≤ 7.05; 7.05 < pH < 7.20; pH ≥ 7.20).

Cases and controls fetal heart rate recordings and STAN file were analyzed by the principal investigator (EG). For each fetus, the total recording and the first and second phase of labor recordings were separately analyzed. Main outcomes were the total number of ST event defined as episodic rises in the T/QRS ratio exceeding 0.10, baseline rises in the T/QRS ratio exceeding 0.05, repeat biphasic ST segments of type 2 or 3. To control for confounding factor due difference in the recording duration, we analyzed the frequencies rather than the absolute number of ST events. Frequencies of the total and different type of ST events were calculated for the global recording time and separately for the first and the second phase of labor. Secondary outcomes included the rate of abnormal fetal heart rate recordings defined as at least 60 min of pathological recording as defined by the modified FIGO classification [17], the number of operative deliveries for non reassuring fetal status based on STAN analysis for the controls and FHR analysis for the case group, and STAN signal quality. Signal quality was evaluated in the presence of a signal loss message as displayed by the STAN hardware, the duration of signal loss defined as the total number of minute indicated by the STAN hardware and the number of gap of four consecutive minutes without a cross [18]. Percentage of time of signal loss was then calculated by dividing the duration of signal loss by the duration of the total recording. In 2007, the recommendations from the European Expert Group state that at least 1 T/QRS/min was necessary to get reliable information and gaps in T/QRS ratios for more than 4 min may result in missed ST events [19]. As fetuses for which operative deliveries for non-reassuring fetal heart rate (NRFHR) was performed may have more ST event, this subgroup was analyzed separately.

Statistical analysis

Quantitative data are expressed as mean ± standard deviation and qualitative data as percentage. Comparisons were performed using Student's *t*-test or Wilcoxon rank sum test for quantitative data and Chi-square test for qualitative data, as appropriate. All analyses were performed with IBM SPSS statistics 19 (SPSS Inc., Chicago, IL). A p-value <0.05 indicated statistically significant difference.

Results

During the study period, there were 37 896 alive birth, including 58 fetuses with congenital heart disease and internal fetal heart rate recording using a STAN device during labor who were included in the case group for further analysis. Seventeen different types of CHD were observed (Table 1). Table 2 displayed basic maternal and neonatal characteristics which were similar in both groups. There was not any case born during the 36-week of

Table 1
Different types of congenital heart disease.

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Conotruncal anomalies (four-chamber view of the heart is normal)	
Transposition of the great arteries	18
Pulmonary atresia with intact ventricular septum	1
Common arteriovenous troncus	1
Double outlet of the right ventricle	1
CHD with abnormal four-chamber view	
Tetralogy of Fallot	9
Interventricular septal defect	6
Hypoplastic left or right heart syndrome	7
Univentricular heart	3
Common arteriovenous canal	2
Septal defect like atrial septal defect	1
Valvular aortic stenosis	1
Pulmonary stenosis	1
Tricuspid atresia	1
Pulmonary atresia with ventricular septum defect	1
Double discordance	1
Coarctation of the aortic arch	3
Biventricular dilated myocardiopathy	1

[1] Week of gestation.