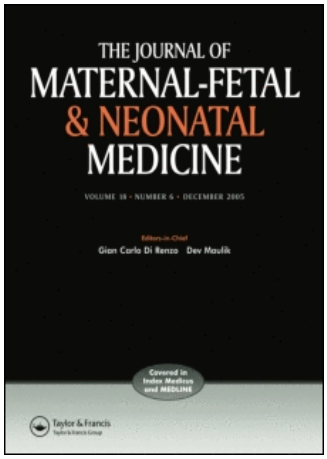

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The relationship between hiccups and heart rate in the fetus

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Abstract

Objective. The purpose of this study was to determine the effect of fetal hiccups on fetal heart rate from 20 weeks of gestation onward.

Methods. One thousand four hundred and fifty-six collected fetal heart rate tracings from three cohorts that participated in longitudinal studies of fetal neurobehavioral development were reviewed retrospectively for fetal hiccups. Tracings were recorded at four-week intervals from 20 weeks. A hiccup-free period before or after the episode of hiccups was used as the control fetal heart rate; thus each fetus was used as its own control. The paired *t*-test was used for statistical analysis.

Results. From 28 weeks onward, the mean fetal heart rate increased with hiccups reaching statistical significance at 32 weeks. Fetal heart rate variability was unaffected by hiccups until 36 weeks, at which time it decreased during hiccup periods.

Conclusion. This change in response to fetal hiccups may represent another neurodevelopment milestone for the fetus.

Keywords: *Fetal neurodevelopment, fetal hiccups, fetal heart rate*

Introduction

Fetal hiccups were described in the late nineteenth century and were considered a harbinger of healthy babies [1]. Hiccups have been identified as occurring as early as 9 weeks [2]. They have been reported to decrease in frequency with increasing gestational age and to be more common prior to 26 weeks [3]. Other researchers have reported that they begin in the second trimester and increase in frequency throughout gestation [4]. They show a diurnal variation in experimental data from monkeys with increased incidence at night [1]. Hiccups are more common in the active fetal state and are not associated with state changes [1,3].

The mechanism producing hiccups appears to be distinct from that producing fetal breathing as fetal breathing increases with gestational age, while most studies report hiccups decrease with gestational age [1,3]. No stimulus consistently elicits fetal hiccups [1].

Fetal hiccups are associated with decreased umbilical arterial and venous flow [5,6]. The transient reduced or even reversed umbilical artery flow seen during fetal hiccups has not been associated with adverse fetal outcomes and may be a normal finding [7].

Between 20 and 30 weeks, fetal hiccups have been reported to have no effect on fetal heart rate [5]. At term, hiccups are associated with a small increase in fetal heart rate independent of other movements of the fetus [2]. A report in the fetal testing literature states that fetal hiccups are not seen with non-reassuring fetal tracings [4].

The purpose of the current study was to systematically examine fetal tracings to investigate the frequency of fetal hiccups and the response of the fetal heart rate to fetal hiccups beginning at mid-gestation. To accomplish this we relied on previously collected data based on three cohorts that participated in longitudinal studies on fetal neurobehavioral development.

Methods

Data for this study were generated by a series of three cohorts of participants who took part in longitudinal investigations of normative fetal

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neurodevelopment. These studies focused on identifying normal developmental patterns of fetal heart rate, motor activity, and their interrelation during the second half of gestation. Eligibility for enrollment within each cohort was restricted to non-smoking women with uncomplicated pregnancies carrying singleton fetuses. Accurate dating of the pregnancy was required, based on early first trimester pregnancy testing or examination and/or confirmed by ultrasound. Gestational age was ultimately established by the best clinical estimate based on all available dating information. Women learned of the projects through advertisements placed in local hospital or university publications. The studies that generated each cohort were approved by the local institutional review board and all women gave informed consent.

A total of 1456, 50-minute tracings distributed across the three cohorts were reviewed retrospectively for evidence of fetal hiccups. Identical fetal monitoring procedures were used in each study, although the number of visits varied, based on specific design features of each study. Gestational ages at assessment included 20, 24, 28, 32, 36 and 38 weeks (total 892 tracings) for cohort 1; 24, 28, 32, and 36 weeks for cohort 2 (468 tracings), and 32 and 36 weeks for cohort 3 (96 tracings). These studies were designed to examine the influence of maternal psychological stress, choroid plexus cysts, and maternal relaxation on fetal development, respectively. Most, but not all participants in each cohort were monitored at each gestational age; discontinuation of monitoring was due to delivery prior to the last scheduled visit, participant scheduling problems, or development of pregnancy complications. Representative complications included gestational diabetes and preterm labor and/or delivery. There were no non-reassuring tracings during this study. Fetal monitoring occurred at the same time of day for each visit (either 1:00 or 3:00 p.m.). Women were instructed to eat one hour prior to testing, and then to abstain from eating until after the monitoring period was over. A brief real-time ultrasound scan was conducted to optimize transducer placement. Fetal monitoring proceeded for 50 min, with the mother resting comfortably in a semi-recumbent, left-lateral position. Fetal data were collected using a Toitu (MT320) fetal actocardiograph. This monitor detects fetal movement (FM) and fetal heart rate (FHR) through the use of a single wide-array transabdominal Doppler transducer and processes this signal through a series of filtering techniques. The actograph detects fetal movements by preserving the remaining signal after band-passing frequency components of the Doppler signal that are associated with FHR and maternal somatic activity. Reliability studies comparing actograph based versus ultrasound visualized fetal movements have found the performance of this monitor to be highly accurate in detecting both fetal motor activity and quiescence [8–10]. The rhythmic movements of the fetal chest wall during hiccupping generate a particularly characteristic footprint on the actograph consisting of regular spikes with a frequency of 25–28 per minute [10]. This footprint on the actograph is distinct from fetal motion and has been validated by direct real-time ultrasound observation of the fetus [11,12]. Such a characteristic footprint can be seen in Figure 1. For this study an additional requirement was that the spikes must be five units on the actograph scale.

Hiccup episodes were identified by two investigators (JD and KC) during initial collection of the tracings. Analysis was done by a second investigator (FW) using a standard protocol. The duration of the hiccup episode was defined from the first partial minute to the last full minute. The control portion of the tracing was the 10 minutes prior to the hiccup episode unless there was less than 10 minutes of tracing prior to the onset of hiccups in which case the 10 minutes after the hiccup episode was selected as the control period. A control period of 10 minutes was selected because it exceeds the maximum mean duration of hiccups for any gestational period while providing a suitable frame of reference. Fetal somatic motor activity was recorded for both periods from the actograph tracing as present or absent.

Fetal heart rate data were collected from the output port of the monitor through an internal A/D board using streaming software. Data were analyzed off-line using software developed in our laboratory. Digitized heart rate data underwent error rejection procedures based on moving averages of acceptable values as needed. Fetal heart rate and variability (standard deviation of each 1-min epoch aggregated over time) were averaged to yield mean values for each hiccup and control period [13].

Statistical analysis was done utilizing SPSS for Windows (SPSS Inc, Chicago IL, USA). Paired *t*-tests were used to compare fetal heart rate means and fetal heart rate standard deviations thereby using each fetus as its own control.

Results

A total of 138 episodes of hiccups were identified from the tracings. Nineteen individual fetuses had hiccup episodes detected at more than one gestational age. Table I reports hiccup detection frequency and duration by gestational age. When analyzed as a group irrespective of gestational age, the mean fetal heart rate increased with hiccups from 144.92 ± 7.40 (mean $\pm$ standard deviation) to 146.22 ± 7.20 (mean $\pm$ SD), $p < 0.002$. The variability in the mean

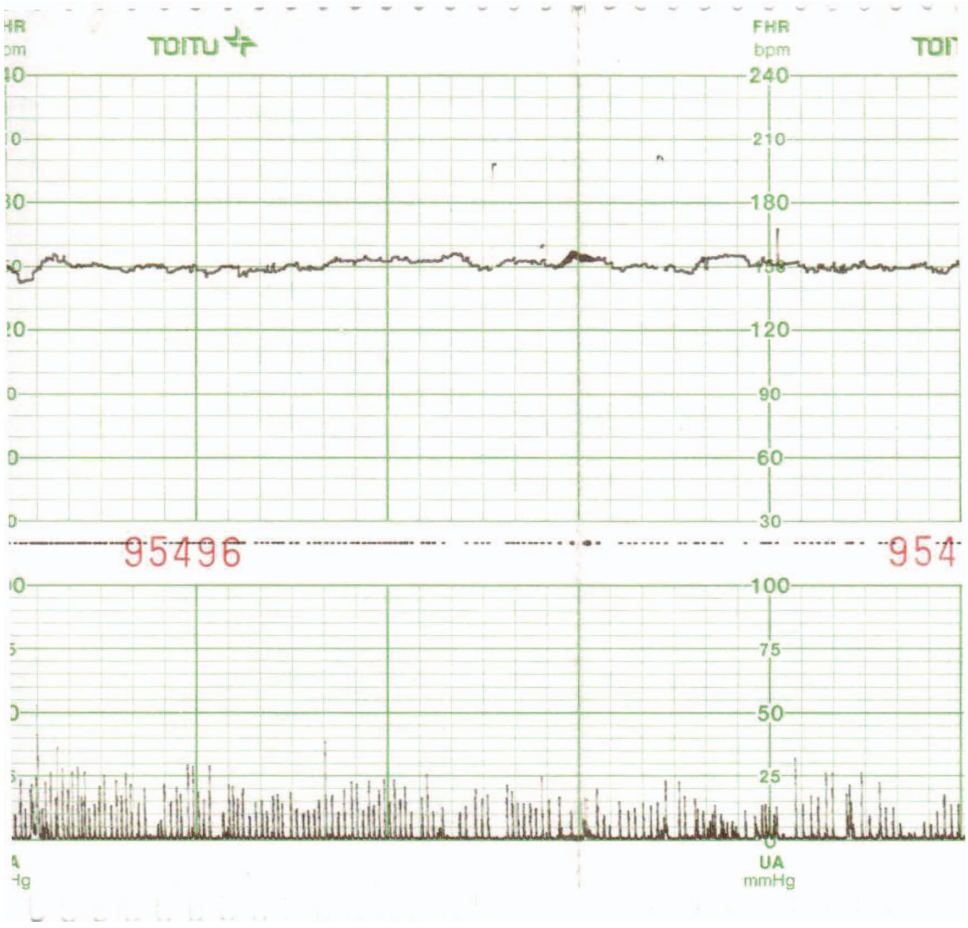

Figure 1. Fetal heart rate tracing with actograph for a normal 28-week fetus. The characteristic hiccup footprint is present on the actograph tracing.

Table I. Hiccup incidence and duration at six gestational ages.

Gestational age	Tracings reviewed	Tracings with hiccups	% Tracing with hiccups	Mean duration (min)
20 weeks	173	25	14.5	6.78
24 weeks	268	34	12.7	8.23
28 weeks	262	29	11.1	8.44
32 weeks	297	27	9.1	7.42
36 weeks	279	21	7.5	7.82
38 weeks	79	3	3.8	7.67

fetal heart rate as measured by its standard deviation did not change (4.59 ± 1.69 (mean $\pm$ SD) without hiccups versus 4.45 ± 1.52 (mean $\pm$ SD) with hiccups $p = 0.300$).

Fetal motion was present 89.9% of the time in hiccup periods and 90.6% of the time in control periods. Within individuals, there was correspondence in the presence of motor activity during hiccup and control periods in 127 (92%) of the tracings. Motion was detected in both periods in 119 tracings (86.2% of total); quiescence during both was detected in eight tracings (5.8% of total). Of the remaining 11 tracings, motion was present during hiccups but not the control period in six tracings (4.3% of total) and during the control period but not hiccups in five instances (3.6% of total). Thus, mean fetal heart rate changes related to hiccups do not reflect a difference in fetal activity levels between hiccup and control periods.

When the fetal tracings were stratified by gestational age the relationship between fetal hiccups, mean fetal heart rate and mean fetal heart rate variability was more complex (see Tables II and III). Hiccups were detected in only three tracings at 38 weeks, so these cases were excluded from the stratified analysis. Fetal heart rate did not change statistically with hiccups prior to 28 weeks of gestation. From 28 weeks onward, the fetal heart rate increased during periods of hiccups. The magnitude of the effect on fetal heart rate was amplified between 28 and 36 weeks with differentials of 1.7 bpm, 3.4 bpm and 4.1 bpm, respectively. These increases were of borderline statistical significance at 28 weeks and statistically significant at 32 and 36 weeks. Variability in the fetal heart rate as

Table II. Mean fetal heart rate.

Gestational age in weeks	Mean fetal heart rate (bpm)			
	Hiccups	Control	*n*	*p*
20	145.48 ± 4.85	146.14 ± 4.89	24	0.266
24	145.18 ± 6.41	146.37 ± 6.13	34	0.075
28	145.05 ± 6.99	143.27 ± 7.41	29	0.050
32	146.26 ± 8.01	142.84 ± 7.74	27	0.002
36	151.01 ± 8.37	146.93 ± 9.70	21	0.004

Results are mean ± standard deviation; bpm, beats per minute.

Table III. Fetal heart rate variability.

Gestational age in weeks	Fetal heart rate variability			
	Hiccups	Control	*n*	*p*
20	3.54 ± 1.50	3.73 ± 1.33	24	0.590
24	4.34 ± 1.26	3.99 ± 1.28	34	0.189
28	4.20 ± 1.15	4.20 ± 1.44	29	0.994
32	5.31 ± 1.57	5.63 ± 1.68	27	0.108
36	4.96 ± 1.74	5.84 ± 1.74	21	0.037

Results are mean ± standard deviation.

measured by the standard deviation did not change statistically with fetal hiccups until 36 weeks, at which point it showed a decrease during hiccups.

Discussion

The results of this study indicate that the normal fetus has a statistically significant increase in mean heart rate with fetal hiccups beginning after 28 weeks of gestation. This confirms a previous observation on term fetuses [2] and partially confirms an earlier report of no effect between 20 and 30 weeks of gestation [5]. The current study detected a borderline significant influence of hiccups on heart rate elevation beginning at 28 weeks of gestation, which reached statistical significance at 32 weeks of gestation; the discrepancy may be a result of limited sample size ($n = 17$) and inability to stratify by gestational age in the prior report [5].

Fetal heart rate variability was unaffected by fetal hiccups until 36 weeks of gestation at which time hiccups resulted in a decrease in fetal heart rate variability. For this study, fetal heart rate variability was quantitated mathematically, rather than by the semi-quantitative method used clinically. As such, it may not be directly comparable to the assessment of variability used in clinical practice.

The initiation of a fetal heart rate response to fetal hiccups observed at 28 weeks of gestation is consistent with observations of a transitional period of maturation observed between 28 and 32 weeks of gestation in numerous indicators of fetal neurological maturation [13]. Thus, this change in response to fetal hiccups may represent another neurodevelopment milestone for the fetus. We were unable to precisely determine the gestational age at which this begins because recordings were made at four-week intervals. Further research is needed to determine if deviations from this normative pattern might be useful indicators of fetal health status.

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