Spontaneous Fetal Behaviour as Observed in Early Diabetic Pregnancy

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Keywords: Diabetes, Fetal behaviour, Fetal well-being, CNS, Teratogen

Abstract: This study investigated, in the first trimester, the spontaneous behaviour of the fetus of a mother who had insulin dependent diabetes mellitus. Fetal behaviour was recorded ultrasonically at weekly intervals for half-hour periods from weeks 6–12 of gestation and compared with a group of matched fetuses of non-diabetic mothers. The occurrence of startles, general movements, leg movements, and arm movements was recorded. Biochemical measures indicated that the control of the mother's diabetes was good throughout the observation period. However there were clear differences in the behaviour of the diabetic fetus when compared to the controls. A greater number of movements were exhibited by the fetus of the diabetic mother compared to the control fetuses, and the behaviour of the diabetic fetus was delayed in its emergence. It would appear that despite good biochemical control, maternal diabetes exerts an affect on the fetus's behaviour and hence its CNS. This study highlights the need for early and continuous behavioural monitoring in diabetic pregnancies, as a satisfactory biochemical indication that glucose control is good may not fully describe the condition of the fetus. The study reaffirms the importance of behaviour as a tool for assessing fetal well-being.

Zusammenfassung: *Spontanes fötales Verhalten während der frühen Schwangerschaft bei Diabetes der Mutter.* Diese Studie untersucht im ersten Trimester das spontane Verhalten eines Fötus einer Mutter, die einen Insulinabhängigen Diabetes hatte. Fötales Verhalten wurde mit Ultraschall in wöchentlichen Abständen für eine halbe Stunde von der 6. bis zur 12. Woche der Schwangerschaft aufgezeichnet und mit einer Durchschnittsgruppe von Föten von Müttern ohne Diabetes verglichen. Die Häufigkeit von reflexhaften Bewegungen, allgemeinen Bewegungen, Beinbewegungen und Armbewegungen wurde aufgezeichnet. Biochemische Messungen zeigten, daß der Diabetes der Mutter während der ganzen Zeit gut eingestellt war. Und doch gab es deutliche Unterschiede im Verhalten des Fötus mit der Mutter mit Diabetes im Vergleich zur Kontrollgruppe ohne Diabetes. Der Fötus mit der Diabetes-Mutter zeigte vergleichsweise eine größere Zahl von Bewegungen und das Verhalten war dabei verzögert. Offensichtlich hatte der mütterliche Diabetes trotz seiner guten Einstellung eine Wirkung auf das Verhalten des Fötus und folglich auf sein Zentralnervensystem. Diese Studie unterstreicht die Notwendigkeit einer frühen und kontinuier-

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lichen Verhaltensbeobachtung bei diabetischen Schwangerschaften, da die Glukosewerte allein die Situation des Föten nicht ausreichend erkennen lassen. Die Studie unterstreicht die Wichtigkeit der Verhaltensbeobachtung als eines Mittels zur Beurteilung des fötalen Wohlbefindens.

Introduction

Diabetes mellitus is a common condition world-wide and is described by Pearson (1991) as a heterogeneous group of varying aetiology, severity and treatment. Despite advances in the treatment of pregnant diabetic women, the perinatal mortality rate for the fetuses of diabetic women remains twice that of the general population. It is well established that maternal diabetes exerts an effect on the fetus's central nervous system (CNS) at a gross level e.g. anencephaly and spina bifida. Furthermore, recent evidence suggests that maternal diabetes exerts an effect on the functioning of the fetus's CNS, this effect being more common in fetuses than the morphological effects. Infants of diabetic mothers tend to be more excitable, exhibit deviant sleep patterns, and show psychomotor development (Bloch Peterson, Pederson, Griesen, Pederson & Molsted-Pederson 1988). Lower intelligence levels have been recorded using the Stanford Binet Intelligence Scales at 3 and 5 years (Sobotkova & Mandys 1988). These observations suggest that maternal diabetes may exert an effect on the CNS of the fetus.

The behaviour of the fetus is recognised as an excellent indicator of its well-being (Hepper 1990). In pregnancies where there is a chromosomal abnormality (Boué, Vignal, Aubry, Aubry & Mac Aleese 1982), IUGR (Pederson & Molsted-Pederson 1982), exposure to cocaine (Gingras 1992), alcohol (Olegard, Laegard, Wahlstrom & Conradi 1987) or smoking (Goodman, Visser & Dawes 1984) fetuses affected or exposed exhibit behaviour different from that observed in unaffected pregnancies.

Diabetes during pregnancy is considered a risk factor, one where behavioural teratogens may be at work (Frienkel 1980). The thorough examination of the behaviour of the fetus in a pregnancy complicated by insulin dependent diabetes may reveal how its CNS is being affected. A previous study on the behaviour of the fetus of a diabetic pregnancy reports that with the exception of breathing movements, which are observed for the first time at an earlier age than in the control fetuses, the behaviours of a fetus of mothers with IDDM tend to emerge 1–2 weeks later than in uncomplicated pregnancy (Mulder & Visser 1991). This study examines in detail the behaviour of a single fetus in a pregnancy complicated by insulin dependent diabetes mellitus, in order to detail the emergence and pattern of behaviour from 6 to 12 weeks gestational age and hence the effect of maternal diabetes on the CNS of the fetus.

Method

Subjects

This study was of an observational nature and had a single subject, the fetus of a mother with diabetes as its main focus.

I. The mother was 27 years old with insulin dependent diabetes mellitus recruited from the Royal Maternity Hospital, Belfast. The diabetes was classified as maternal diabetes type-1 and under White's classification, category C. The mother was a non-smoker and alcohol intake during pregnancy was nil. The clinical glucose control was good throughout the pregnancy and no episodes of hypoglycaemia or hyperglycaemia were reported. No complications arose either throughout the pregnancy or during labour and delivery at thirty-nine weeks three days was normal. The Apgar score was greater than 7 at 1 and 5 minutes and there were no physical abnormalities present in the newborn.

II. A control group of nine fetuses from low-risk, uncomplicated pregnancies were also recruited from the antenatal clinic at the Royal Maternity Hospital. They were matched to the diabetic fetus in that the mothers did not smoke, consumed no alcohol during pregnancy, were of the same parity and had no complications during labour or birth.

Apparatus

The movements of the fetus were observed using a real time ultrasound scanner, ATL Ultramark 4 Plus with a 5MHz curvilinear scan head.

Procedure

The fetuses were scanned each week from six to twelve weeks gestation (inclusive) on each occasion for thirty minutes. A longitudinal section of the head, arms and legs was obtained and maintained throughout the session. Scanning occurred with the mother resting in a semi-recumbent position. Each scan was recorded on video tape for later independent analysis.

The following measures of behaviour were recorded.

1. The No. of General Movements; General movements were defined following Sival (1993) as movements in which more than one part of the body was moving and may last from a few seconds to one minute. The number of general movements observed in the 30 minute observation period was recorded.

2. The No. of Arm Movements; Arm movements were defined as rapid or slow movements of the arms and may involve the extension, flexion, external and internal rotation, or abduction and adduction without movements of other body parts. Amplitude can vary from small to very large (de Vries, Visser & Prechtl 1982). The number of arm movements observed in the 30 observation minute period was recorded.

3. The No. of Leg Movements; Leg movements were defined as rapid or slow movements of the legs and may involve the extension, flexion, external and internal rotation, or abduction and adduction without movements of other body parts. Amplitude can vary from small to very large (de Vries, Visser & Prechtl 1982). The number of leg movements observed in the 30 minute observation period was recorded.

4. The No. of Startles; A startle is defined as a quick generalised movement of the whole body initiated in the limbs and sometimes spreading to the neck and trunk, it is generally short, lasting only one second. Startles may occur either as single events or follow each other in quick succession (de Vries, Visser &

Prechtl 1982). The number of startles observed in the 30 minute observation period was recorded.

Results

Figure 1 depicts the total number of movements exhibited by the fetus of the diabetic mother and the mean number ($\pm$ s.e.) of movements exhibited by the control fetuses. Two observations can be noted: first the increase in movement is greater for the diabetic fetus, second the onset of movements is slightly later in the diabetic fetus.
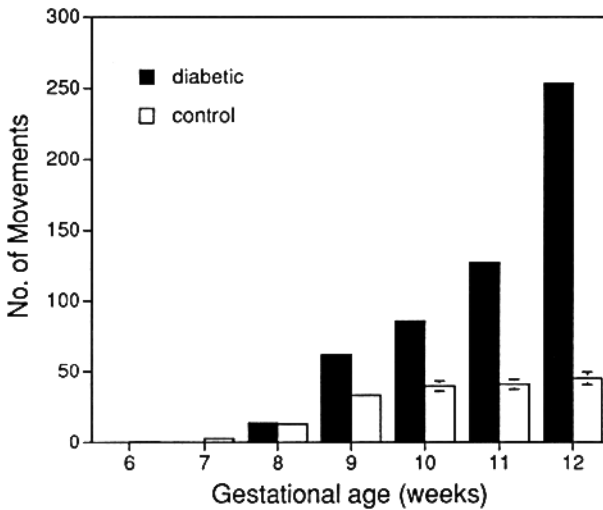

Fig. 1. The total no. of all movements observed for the "diabetic" fetus and the mean number ($\pm$ s.e.) for the control fetuses at each gestation.

The graph (Figs. 2a–d) shows the number of movements for each behaviour type exhibited by the fetus of a diabetic pregnancy and the mean number ($\pm$ s.e.) for the control fetuses. (Note that the standard error bars are present but very small and not visible.)

For all behaviours the number of movements exhibited by the diabetic fetus is greater than that exhibited by the control fetuses. Furthermore the difference in behaviour between the diabetic and control fetuses increases as pregnancy progresses. This deviation is greatest in the final weeks of observation. The greatest difference in the number of movements for a behaviour occurs for arm

and leg movements, where the number of movements elicited by the fetus of the diabetic mother is much greater than the number shown by the control fetuses.

The pattern of movements exhibited by the control fetuses are similar to those reported by de Vries, Visser & Prechtl (1985) for fetuses of similar ages. It is possible that a CNS mediated effect is responsible for this difference.

The results confirm previous observations that movements in the fetus of the diabetic mother may be delayed (cf. Figs. 2c and d). However the results advance our knowledge of the effects of diabetes on the fetus by demonstrating that even in
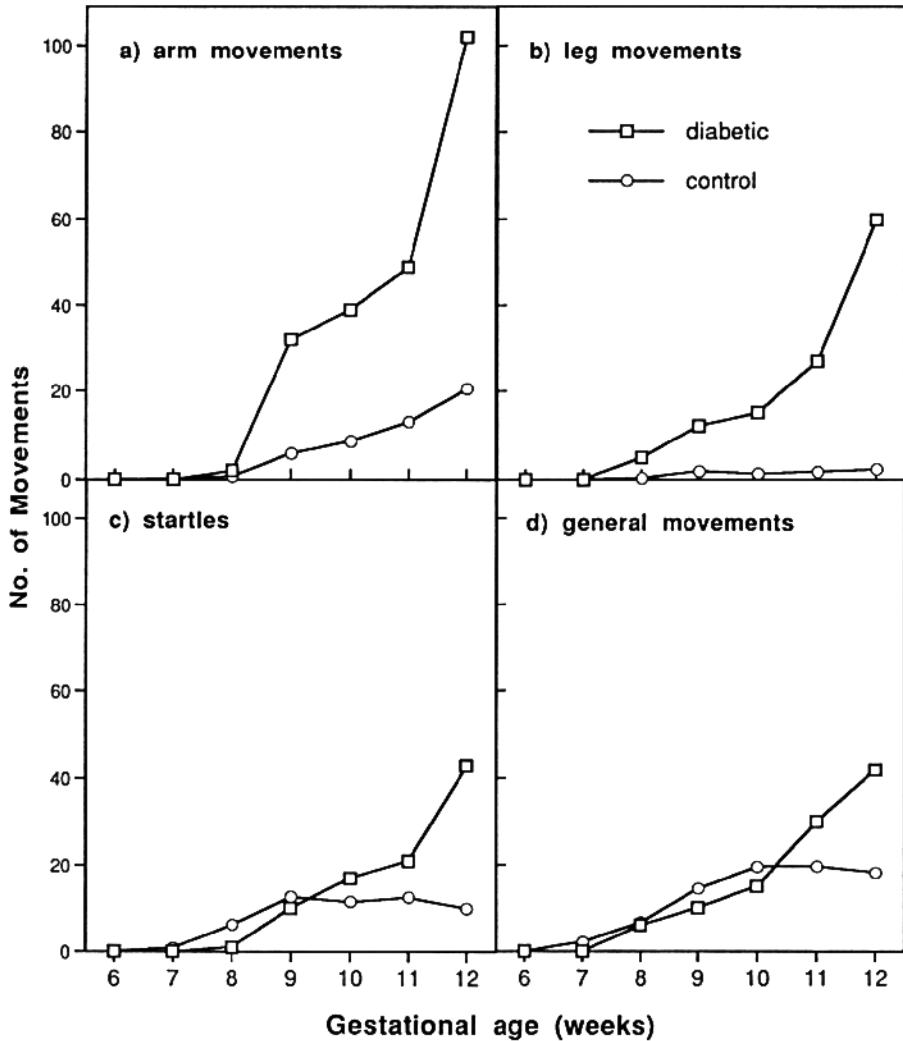
Fig. 2a–d. The number of movements exhibited by the "diabetic" fetus and the mean number (± s.e.) for the control fetus at each gestation for (**a**) arm, (**b**) leg, (**c**) startle and (**d**) general movements.

a biochemically well-controlled fetus, the behaviour of the fetus is clearly different from that observed in fetuses of non-diabetic mothers.

Discussion

This study clearly demonstrates that differences in behaviour exist between the fetus of the diabetic mother and the fetuses of non-diabetic mothers. Mulder & Visser (1991) reported that even in a well-controlled diabetic pregnancy (one with pre-conception counselling) delays in both growth and motor development were found. This study also found a delay in the emergence of the behaviours (startles

and general movements) under observation in the diabetic fetus compared with the control fetuses. However the quantity of behaviours observed in the fetus of the diabetic pregnancy and in the fetuses of the control pregnancies differed with more movements being observed in the fetus of the diabetic mother. The most likely cause of the difference is the mother's diabetes. Maternal diabetes is a known risk factor for perinatal mortality and morbidity. However the evidence presented here suggests that diabetes exerts an effect on the functioning of the CNS. More importantly, differences in behaviour, representing neural integrity and functioning, were noted even when maternal glucose control was good during the pregnancy and no hyperglycaemic or hypoglycaemic attacks were noted.

These abnormalities in behaviour were observed in the first trimester, highlighting the need for monitoring early during pregnancy. Maternal hyperglycaemia during the first trimester is a cause of congenital anomaly (Brudenell 1991) and delayed fetal growth may be observed by 12 weeks gestation (Pedersen & Molsted-Pedersen 1982). This early period may also be the time of greatest risk for functional abnormalities in the fetus's CNS, potentially via the existence of a specific diabetes related influence (Mulder & Visser 1991).

Pregnant women with insulin dependent diabetes mellitus rarely achieve the glucose control that non-IDDM pregnant women do. Fluctuations in glucose levels occur from minute to minute, and exogenous insulin therapy cannot equal the control offered by the natural secretion of insulin from the human pancreas. Glucose levels experienced by the fetus in diabetic pregnancies will thus be more varied than in non-diabetic pregnancies. Oxygen levels may also be affected in fetuses of diabetic pregnancies. All fetuses of diabetic pregnancies, not just those in the diabetic pregnancy complicated by vascular complaints, are at risk of intrauterine hypoxia (Brudenell 1991). Furthermore maternal diabetes may produce alterations in red blood cell oxygen release and placental blood flow (Madsen 1986). The increased variability in glucose and oxygen levels experienced by the fetus of diabetic pregnancies may affect its CNS resulting in behavioural abnormalities.

The study demonstrates the value of using the behaviour of the fetus to monitor its well-being during pregnancy. Maternal diabetes may affect the development of the fetus in the absence of physical abnormalities and where maternal glucose control is good hence there is a need for a more sophisticated method of monitoring such pregnancies. The behaviour of the fetus may be one potential method for monitoring the fetus's health. Further work is required to examine in more detail the neuro-behavioural development of the fetus of diabetic mothers and so enable its development to be optimized.

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