Early Human Development 91 (2015) 511–517

Contents lists available at ScienceDirect

Early Human Development

journal homepage: www.elsevier.com/locate/earlhumdev

Effect of (minor or major) maternal trauma on fetal motility: A prospective study

Bloeme J. van der Knoop [a,*], Petra E.M. van Schie [b], Roland J. Vermeulen [c,1], Lourens R. Pistorius [d,2], Mirjam M. van Weissenbruch [e], Johanna I.P. de Vries [a,f]

[a] Department of Obstetrics and Gynaecology, VU University Medical Center, P.O. Box 7057, 1007 MB Amsterdam, The Netherlands
[b] Department of Rehabilitation Medicine and Physical Therapy, VU University Medical Center, P.O. Box 7057, 1007 MB Amsterdam, The Netherlands
[c] Department of Child Neurology, VU University Medical Center, P.O. Box 7057, 1007 MB Amsterdam, The Netherlands
[d] Department of Obstetrics and Gynaecology, University Medical Center, Utrecht, Utrecht, The Netherlands
[e] Department of Neonatology, VU University Medical Center, P.O. Box 7057, 1007 MB Amsterdam, The Netherlands
[f] Research Institute MOVE, VU University, Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 31 March 2015
Received in revised form 5 June 2015
Accepted 9 June 2015

Keywords:
Fetal motility
Trauma
Pregnancy
Neurological development

ABSTRACT

Background: Fetal motility represents the spontaneous activity of the central nervous system and as such can be used to evaluate its functional integrity. Maternal mechanical trauma in pregnancy is a risk factor for hypoxic ischemic brain injury and can potentially affect the CNS and fetal motility.
Aim: To study motility in fetuses after maternal trauma.
Study design: Prospective study; 1-h sonographic observations at 2–8 h (T1), 24–72 h (T2) and > 72 h (T3) after trauma.
Subjects: Fetuses exposed to trauma after 20 weeks gestational age.
Outcome measures: Motor aspects; differentiation into specific movement patterns, quality and quantity of general movements were compared to a normal population. Obstetrical outcome; neurological outcome at term and 1 year of age.
Results: Sixteen fetuses were examined between 2012 and 2014. Median gestational age at time of trauma was 25 + 6 (range 20–38) weeks. Most traumas were traffic accidents or falls, injuries were mainly minor. Motility assessment showed abnormal differentiation in 2/16; 2/14 and 0/16; abnormal quality in 2/16; 3/14 and 6/16; and abnormal quantity in 6/16, 9/14 and 9/16 at T1, T2 and T3 respectively. Preterm delivery occurred once. Neurological development was normal in 13/14 infants at term and 14/14 at one year.
Conclusions: This study shows that maternal trauma affected fetal motility in the majority of the fetuses. The changes in motility support the concern that even minor mechanical trauma may have influence on the functional integrity of the central nervous system, although no neurological sequelae were present at 1 year.

1. Background

Trauma in pregnancy occurs in about one out of twelve pregnant women [1–3]. First evaluation is focused on stabilizing maternal vital signs. Fetal assessment for direct effects like fetal injury, uterine rupture or placental abruption is performed thereafter [4–6]. International guidelines [5–7] advise, in case of maternal trauma after 20 weeks gestational age (GA), assessment of fetal condition by means of cardiotocographic (CTG) monitoring, Kleihauer-Betke laboratory examination to assess fetomaternal hemorrhage and ultrasonography (US) for assessment of the fetus, placenta, amniotic fluid, and/or fetal activity [4,8–12]. The current guideline at VU University Medical Center after 20 weeks GA is similar, with admission for observation during at least 24 h.

The abovementioned guidelines will enable the clinician to detect major short-term complications. Long term effects, however, are not taken into account. One aspect to consider is the functioning of the fetal central nervous system (CNS) which can be influenced by the consequences of shearing forces on the placenta, causing partial placental abruption or transient periods of suboptimal uteroplacental circulation and thereby hypoxemia. Secondly, increased maternal stress

Abbreviations: AIMS, Alberta Infant Motor Scale; bpm, beats per minute; CNS, central nervous system; CTG, cardiotocography; GA, gestational age; GM, general movement; US, ultrasound; IAM, isolated arm movement; ILM, isolated leg movement.

* Corresponding author at: Department of Obstetrics and Gynaecology, ZH 8 B 087, VU University Medical Center, P.O. Box 7057, 1007 MB Amsterdam, the Netherlands. Tel.: +31 20 4443239, +31 20 4444444, pager 6112.
E-mail addresses: b.vanderknoop@vumc.nl (B.J. van der Knoop), pem.vanschie@vumc.nl (P.E.M. van Schie), jeroen.vermeulen@mumc.nl (R.J. Vermeulen), lou@maternalfetal.co.za (L.R. Pistorius), m.vanweissenbruch@vumc.nl (M.M. van Weissenbruch), jip.devries@vumc.nl (J.I.P. de Vries).
[1] Present address: Department of Child Neurology, Maastricht University Medical Center, P.O. Box 5800, 6202 AZ Maastricht, The Netherlands.
[2] Present address: Department of Obstetrics and Gynaecology, University of Stellenbosch/Tygerberg Hospital, Private Bag X3, Tygerberg, 7505, South Africa.

http://dx.doi.org/10.1016/j.earlhumdev.2015.06.003
0378-3782/

levels accompanying the involvement in an accident can influence the functioning of the fetal CNS. Previous research has shown an effect of maternal stress (not related to mechanical trauma) on the neurodevelopment of the fetus [13–15]. Acute, very intense maternal stress elicited by exposure to an earthquake has been described to induce hyperactive fetal movements during the first 8 h followed by inhibited motility over a few days, returning to normal after 72 h [16]. Fetal movements are specific and easily recognizable from their onset onwards throughout gestation, which makes them useful as indicator of the functioning of the CNS [17,18]. Fetal motility has previously been evaluated in several conditions [19–21]. Additionally, fetal heart rate pattern variation is closely related to fetal motility [22–26]. The effect of (minor) maternal trauma on motility as a predictor of the functioning of the fetal CNS has not been prospectively examined yet.

The aim of the present study was to evaluate whether differentiation of the various specific fetal movements, quality and quantity of fetal movements are affected by trauma in pregnancy. Our hypothesis was that trauma, even without evident physical injury, has a transient nfluence on fetal motility. The specific questions; are differentiation into specific movement patterns, quality and/or quantity of fetal movements changed over time after maternal trauma? In case there are changes, are they related to cause and severity of trauma, CTG abnormalities, maternal stress level and/or neurological outcome at 1 year of age?

2. Methods

This study was carried out at VU University Medical Center, Amsterdam, The Netherlands. All consecutive women admitted because of trauma in pregnancy from 20 weeks GA onwards were invited to participate. Approval from the local medical ethical committee was obtained. The cause of trauma was recorded per case and categorized (expected categories: motor vehicle accidents; cycle accidents; falls; diverse). Severity of the maternal trauma was assessed using the Injury Severity Score (ISS) [27,28]. This score ranges from 0 to 75. For clinical use and in accordance to other studies an ISS of ≥9 was considered severe [29–31]. For the purpose of this study small hematomas and abrasions were considered minor injury, whereas large hematomas, large abrasions and severe contusions were considered moderate injury. Furthermore, use of medication was recorded.

2.1. Assessment of fetal motility

Three 1-h real-time US observations were planned per woman. Scheduled observation times were: 2–8 h after trauma (T1); 24–72 h after trauma (T2) and >72 h after trauma (T3); in line with Ianniruberto and Tajani [16]. All observations were carried out on a Voluson E8 or Voluson Expert 730, GE Healthcare, Milwaukee, USA, by one investigator (BvdK) and recorded on DVD or video. Subsequent offline assessment of differentiation, quality and quantity of fetal motility was performed at random by two investigators (BvdK and JdV).

Differentiation was assessed for the presence of the following specific movement patterns: general movement (GM), startle, breathing, hiccup, isolated arm and leg movement (IAM and ILM), hand–face contact, isolated retroflexion, anteflexion and rotation of the head, jaw opening, sucking and swallowing and yawning, during each 1-h observation [32]. The number of specific movement patterns was plotted against the median, 5th and 95th centile derived from unpublished data from the longitudinal study of a normal population by de Vries et al. [32,33].

The quality of fetal movements (regarding GM, IAM and ILM) was assessed for amplitude (optimal: variable; suboptimal: predominantly small and/or predominantly large), speed (optimal: variable; suboptimal: predominantly slow and/or predominantly fast) and direction of the movements (optimal: variable; suboptimal: low variability/mostly in one direction) and the presence of waxing and waning of activity and fluency of the performance [32,34]. In case all abovementioned aspects were optimal, the quality was considered normal. Quality was considered suspect if one or two items had suboptimal scores for amplitude, speed, direction, waxing and waning and fluency for IAM, ILM and/or GM, and abnormal if three or more items were suboptimal.

The quantity of fetal movements was indicated in GM percentage. The GM percentage was defined as the percentage of assessable observation time in which GMs were present. The total assessable observation time was calculated by subtracting the sum of seconds in which the fetal motility could not be properly assessed (due to scanning or scanner artifacts or maternal movements) from the total scanning time of the observation in seconds.

The offline assessment for GM quantity took place on a personal computer using event recording software specially designed to mark fetal body movements (GM or other movements) and periods that were not scorable (videoscorer, Palmer, VUmc, Amsterdam, The Netherlands). Two GMs that occurred within 1 s apart were considered one single GM; this aspect was embedded in the digital scoring system. Normal values of GM quantity were derived from de Vries et al. [33].

2.2. CTG assessment

In line with the current policy in our hospital, all women beyond 26 weeks GA underwent CTG registration of at least 45 min at the beginning and end of the trauma admission and in case of complaints. CTG examinations were stored digitally in Mosos CTG (Buro Medische Automatisering, The Netherlands). Offline assessment of fetal heart rate was performed according to the FIGO guideline by (consensus scores of) BvdK and JdV [35].

2.3. Maternal endocrinological stress measurements

The concentration of cortisol in maternal saliva reflects the levels of the unbound hormone in blood and can therefore be used as an endocrinological measure of maternal stress [36,37]. Since cortisol levels are influenced by gestational age (elevated levels in third trimester) and diurnal rhythm [38,39], six saliva samples were taken per woman according to the following schedule. A first set of three samples on the day of trauma: 1. as soon as possible after trauma; 2. in the evening at 11 PM; 3. the next morning at 8 AM or directly after waking up. The second set was taken at least 2 weeks after trauma on an eventless day, as a control. Normal saliva cortisol values for non-pregnant women in the morning are 5–29 nmol/l and in the evening <4.5 nmol/l. All samples were analyzed at the same time to minimize random measurement errors between samples.

2.4. Obstetrical and neurological outcome

The gestational age, weight and physical examination at birth were recorded. The infants were seen for neurological examination according to Prechtl [40] at term equivalent age, and Touwen [41] and Alberta Infant Motor Scale (AIMS) [42] at 1 year. The Prechtl and Touwen neurological examinations are observational assessment tools; both examinations are expressed by a numerical score with a maximum of 60. Three outcome levels were considered: optimal, a score of ≥58; suspect, score within 54–57; and abnormal, score of <54 [43]. Outcome of the AIMS z score was considered normal if >−1; suspect if >−2 and <−1; and poor if score was <−2.

2.5. Statistical analysis

Analysis of difference in fetal motility over time between the fetuses with three observations was performed using Friedman two-way analysis of variance. In case of a significant difference, subsequently a Wilcoxon signed rank test was performed between observations at T1&T2; T2&T3 and/or T1&T3 thereafter. A Wilcoxon signed rank test