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Water balance during parturition and early puerperium: A prospective open trial

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ABSTRACT

Objectives: To investigate how water balance is regulated during labor and 27 h postpartum.

Design and methods: A prospective open trial with 49 women giving birth vaginally. Ringer-acetate was infused intravenously and combined with epidural analgesia in seven women (fluid group). Intravenous infusions of oxytocin in 5% glucose were given to 12 women (oxytocin group). Thirty women delivered their babies without infusion (nofluid group). Blood and urine samples were collected at arrival, at early stage 1, at early stage 2, and at aftercare, and 9, 15, and 27 h postpartum. Plasma osmolality, sodium, cystatin C, vasopressin, oxytocin, urine flow, urine osmolality, and urine sodium were measued.

Results: The oxytocin group had significantly lower plasma osmolality than the nofluid group before parturition, and they had lower plasma sodium concentration at early stage 1 and 2. Plasma vasopressin concentration was low and did not differ between groups or before and after parturition. Water diuresis developed postpartum in all groups. The cystatin C concentration decreased significantly after parturition in the oxytocin and nofluid groups.

Conclusions: The vasopressin levels were suppressed during parturition irrespective of the P-osmolality and the nongravid regulation of water balance had not returned within 27 h postpartum.

Introduction

At the end of pregnancy, fluid balance in women is characterized by an expanded extracellular fluid compartment, increased plasma volume, and lowered plasma osmolality and vasopressin concentration. When labor begins, water balance is regulated at the lower levels of osmolality and plasma vasopressin concentration [1–3].

Although vasopressin is the principal antidiuretic hormone, its partner hormone oxytocin can bind to the vasopressin R2 receptor in the kidney, activate aquaporin 2, and cause antidiuresis [4,5]. Levels of plasma oxytocin increase gradually during pregnancy [6,7] and, if given intravenously to stimulate uterine contractions during labor, its antidiuretic effect can result in water intoxication [8,9]. In this case, oxytocin acts as a pharmacologic substance and, since there is no physiological feedback mechanism i.e. cessation of oxytocin release when blood plasma has become diluted, it may cause severe hyponatremia [10].

Uterine contractions during labor are painful, and epidural analgesia [EDA] is recommended as a safe method for pain relief although it may prolong labor [11]. Rahm et al. [12] found decreased plasma oxytocin concentration in women treated with EDA and proposed that neurohypophyseal oxytocin plays a role during parturition, supporting work by Fuchs et al. [13]. However, the majority of reports claim that centrally released oxytocin does not increase during labor [6,14,15], and that locally produced oxytocin instead stimulates the upregulated oxytocin receptors [16–18].

The aim of this study was to investigate how water balance is regulated during labor until 27 h postpartum.

Materials and methods

A prospective, open trial was performed at the child birth unit and maternity wards of Mälardalen Hospital, Eskilstuna, Sweden. Healthy women with normal singleton pregnancies attending the antenatal clinics in Eskilstuna and Katrineholm were eligible. Women interested in participating in the study were given detailed oral and written information and gave their informed consent. For practical reasons, women that did not speak Swedish were excluded. The investigation conformed to good clinical practice and was approved by the Regional Ethics Committee (EPN, Stockholm, 2006/1512-31/2).

Sixty-six women consented to participate in the study. Two women withdrew, three were delivered by cesarean section and too few blood

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samples were obtained from 11 women. One woman had serious bleeding postpartum and was treated with large volumes of isotonic fluid solutions. Forty-nine women were included in the final analysis.

Blood pressure was measured on the left arm with the subject in sitting position before blood and urine collection. The cuff width was 15 cm when the arm circumference was > 32 cm, otherwise the width was 12 cm.

The women were weighed after blood and urine sampling. Two scales calibrated to each other were used, one at the childbirth unit and one at the maternity ward. Additionally, the weights of the baby, the placenta, and blood lost at parturition were recorded.

Pain relief and oxytoxin treatment

Different methods for pain relief were used, in accordance with normal routines at the clinic. Nitrous oxide in oxygen (50/50%) was inhaled by 34 women. Some women preferred tablets and took codeine + paracetamol (Citodon, AstraZeneca, Södertälje, Sweden). Other women were given analgesic drugs, either as intramuscular injections of morphine (Meda, Solna, Sweden, 10 mg/mL, 1 mL) or as epidural (EDA) injections of sufentanil (Sufenta, Janssen-Cilag, Sollentuna, Sweden). About 1 h before the epidural injection, an intravenous infusion of Ringer-acetate (131 mmol Na^+, 4 mmol K^+, 2 mmol Ca^{2+}, 1 mmol Mg^{2+}, 30 mmol Ac^-, 110 mmol Cl^-, 270 mosm/kg H_2O, pH 6; Fresenius Kabi, Uppsala, Sweden) was started and the women received up to 1000 mL or more during labor. If progress of labor was slow from the onset or slowed down after initially normal progress, the patients were offered an intravenous oxytocin infusions. The midwife picked a sealed envelope with a note instructing her to administer the oxytocin either as a continuous or as a pulsatile infusion.

We tested a pump designed to give pulsatile infusions of oxytocin (Octapump Injection System 1, Octagon, Uppsala, Sweden). Pulsatile or continuous infusions were randomized by asking the midwife to pick a sealed envelope containing a note on which either 'continuous' or 'pulsatile' was written. The concentration of the oxytocin solution was 10 IU oxytocin (Syntocinon, Novartis Sverige, Täby, Sweden) per 1000 mL 5% glucose (Glucose 50 mg/mL, Fresenius Kabi). Continuous infusion of oxytocin started at a rate of 15 mL/h (Braun Infusomat, Braun Melsungen, Melsungen, Germany) and the rate was adjusted by the midwife in communication with the patient until the desired frequency of 3–5 uterine contractions per 10 min was reached. The maximum infusion rate was 120 mL/h. A total of 22 women got amniotomy and 15 of them responded with a progress in cervical opening but 7 did not respond to the treatment. Three were treated with amniotomy in the fluid group and two responded. Eight in the oxytocin group were treated with amniotomy and two responded to the treatment. In the nofluid group, 11 got amniotomy and all responded with a progress in cervical opening rate. Pulsatile infusion started from a low level with one pulse (injection) of 0.2 mL every 6.7 min, i.e. 9 pulses per hour corresponding to about 1.8 mL/h. If needed, the pulse volume was increased by the midwife in communication with the patient until the desired frequency of 3–5 uterine contractions per 10 min was reached [19].

Groups

An overview of collected data showed that 12 women were treated with oxytocin in glucose solution, and this was preceeded by Ringer-acetate and EDA in nine of the 12 (oxytocin group). Seven women were treated with Ringer-acetate and EDA but no oxytocin (fluid group). Thirty women were given no fluid treatment (nofluid group).

Postpartum

A bolus dose of oxytocin (10–30 IU) was given to six women in the fluid group, to five women in the oxytocin group, and to 14 women in the nofluid group after the child was born in order to stimulate detachment of the placenta and to prevent major bleeding.

The time for placental expulsion, its weight and volume of vaginal discharge after giving birth (lochia) were noted (Table 1). The condition of the child was checked by Apgar score and by acid–base analysis of umbilical cord blood (pH and base excess). The baby was placed on the mother's breast as soon as possible to induce suckling and the mothers were encouraged to breastfeed. All women did so, except two who had had breast surgery. These two women were given a dopamine/prolactin inhibitor to suppress lactation (Dostinex, Pfizer, Sollentuna, Sweden).

Blood and urine samples

Labor length and intensity are unpredictable, and the exact time for parturition cannot be determined beforehand. Efforts were made to take samples at arrival, early stage 1 and early stage 2, and the time span for sampling was relatively wide before parturition (Table 2). Sample four was taken in connection with aftercare, before sandwiches and tea or coffee were offered. Samples five, six, and seven were scheduled at 9, 15, and 27 h postpartum, respectively. The women were asked to urinate as close to blood sampling as possible.

Blood samples were collected from an antecubital vein into two 10 mL vacutainer tubes (Becton Dickinson, Rutherford, NJ, USA): one serum tube and one tube containing K_3—ethylenediaminetetraacetic acid (EDTA) and aprotinin (Trasylol®, Bayer, Leverkusen, Germany, 5000 KIE/10 mL). The EDTA-tube was immediately put on ice, then transported to the laboratory and centrifuged at + 4 °C (2000$g \times 10$). The serum tube was centrifuged for 10 min at 2000 × g at room temperature. The plasma and serum were kept at −70 °C until analysis. The women were asked to collect all urine, and the volume and time of urination were recorded. If urination occurred more than once between blood sampling occasions, the urine collections were mixed carefully before saving the sample for analysis. The samples were kept at −70 °C until analysis.

Analyses

Plasma and urine sodium concentrations were analyzed with an Architect ci8200 (Abbott Laboratories, Abbott Park, IL, USA) according to manufacturer's recommendations. Cystatin C was analyzed with the

Table 1
Characteristics of participating women.

	Nofluid ($n = 30$)	Fluid ($n = 9$)	Dystocia ($n = 11$)
Age (years)	29.7 ± 3.6	25.5 ± 1[a]	30.8 ± 3.4[#]
Height (cm)	169 ± 0	170 ± 0	166 ± 0
Gestational age (wks)	40 ± 1.2	40.1 ± 0.8	40.3 ± 1.2
Body weight (kg)			
Arrival	80 ± 11	80 ± 8	81 ± 12
Aftercare	75 ± 11	75 ± 7	76 ± 12
BMI (aftercare)	26.3	26.0	27.6
Primigravidae	9	6	8
Multigravidae	21	3	3
Maternal blood loss (mL)	352 ± 254	385 ± 233	425 ± 261
Placenta detachment (min)	12 ± 6	11 ± 4	17 ± 4[*,#]
Birth weight (g)	3582 ± 394	3597 ± 557	3685 ± 551
Opening rate, cervix (cm/h)	3.3 ± 3.0	1.6 ± 1.0[a]	0.6 ± .2[*,#]
Oxytocin			
Continuous (total amount, IU)		0.4 ± 0.3 ($n = 3$)	2.5 ± 1.1[#, †] ($n = 6$)
Pulsatile (total amount, IU)			0.40 ± 0.50 ($n = 5$)

Values are means and SD, IU = international units
[a] $P < 0.05$ or less compared with nofluid group.
[*] $P < 0.05$ or less compared with normal group.
[#] $P < 0.05$ or less compared with fluid group.
[†] $P < 0.05$ or less compared with pulsatile infusions (unpaired t-test).

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