The Regulation and Quality Improvement Authority

GAIN
GUIDELINES AND AUDIT IMPLEMENTATION NETWORK

Guideline for the Prevention, Diagnosis and Management of Hyponatraemia in Labour and the Immediate Postpartum Period

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Assurance, Challenge and Improvement in Health and Social Care

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Introduction

GAIN guidance for the management of hyponatraemia in adults is available[1], but labouring women are an at risk group for which no specific guidance currently exists.

Cases of peripartum dilutional hyponatraemia often referred to as water intoxication, have occurred in Northern Ireland and across the world affecting mothers and their babies[2-18].

GAIN funding was obtained and a multidisciplinary group established to explore the issue and produce guidance. This document summarises current evidence and offers a consensus view on the detection, prevention and management of dilutional hyponatraemia in labouring women over the age of 16.

Where a parturient is below 16 years of age a paediatric fluid balance chart should be used and consideration given to discussing intravenous fluid prescribing with a paediatrician.

Background

Many conditions and situations can lead to hyponatraemia but the focus of this guideline is on peripartum dilutional hyponatraemia which is hypotonic hyponatraemia. This occurs when a woman takes on more fluid of low sodium content than she can excrete leading to dilution of the blood and a fall in sodium concentration. An acute fall in the sodium level can result in cerebral oedema and life threatening symptoms. Maternal hyponatraemia also has serious implications for the fetus. Water freely diffuses across the placenta causing fetal blood sodium concentration and osmolality to reflect that of the mother. Therefore maternal hyponatraemia can lead to neonatal hyponatraemia[19 – 22].

Women in labour are at greater risk of developing hyponatraemia than non-pregnant women because of a lower baseline plasma sodium[23-27], an impaired ability to excrete water in the third trimester[28,29] and exposure to the anti-diuretic effect of oxytocin[30]. These issues are explored later in the guidance (Fluid and Electrolyte Balance in Pregnancy page 9).

Early reported cases were associated with the administration of large volumes of hypotonic intravenous fluids, most commonly 5% dextrose, as the carrier solution for oxytocin[3,4,5]. This led to the use of more concentrated oxytocin infusions with sodium containing solutions as the diluent. Despite this, cases of dilutional hyponatraemia persist. Since 2002 there have been fifteen reported cases amongst labouring women[2,6-16,18] and eleven cases of serious adverse neonatal events, including seizures and apnoeas, all attributed to dilutional hyponatraemia[8,12,13-16,18,31]. Worryingly, the majority of the mothers of these neonates appear to have been asymptomatic or shown only mild non-specific symptoms despite having severe hyponatraemia [8,12,13,16,31]. An observational study of Swedish women in labour found an 8% incidence of hyponatraemia at delivery. All of the women were asymptomatic. Relying on symptoms alone to identify cases of peripartum hyponatraemia will likely underestimate the incidence as the majority will have no symptoms or the symptoms will be so subtle as to go unrecognised.

Labour per se does not cause hyponatraemia[27] but it does predispose to its occurrence. Women in late pregnancy are less able to excrete excess free water. This is compounded in labour by raised levels of antidiuretic hormone and the additional antidiuretic effect of oxytocin. This causes labouring women to retain water, so that if excess fluid is administered or consumed hyponatraemia is more likely to occur.

An additional important peripartum risk factor is the total volume of fluid intake during labour, both intravenous and oral. This has the potential to affect both low and high risk parturients. As the volume of fluids received during labour increases, the risk of maternal hyponatraemia becomes greater. Women receiving less than 1 litre of fluid in labour were less likely to develop hyponatraemia compared to those who received more than 2.5 litres (1% vs 26%)[27]. The association between hyponatraemia and the use of large volumes of hypotonic intravenous fluids and oxytocin for induction and augmentation of labour has long been recognised[3,4,5,28]. However, in recent cases hyponatraemia occurred as a result of excessive oral fluid intake in a setting where little or no oxytocin or intravenous fluids

had been given[8-11,13, 14,16,18]. A repetitive theme in these cases is the absence of accurate fluid balance monitoring and recording.

In recent years there has been relaxation of fasting guidance for women in labour. Concerns regarding eating during labour relate to the risk of aspiration associated with general anaesthesia in the event of emergency. Modern practice has made this a rare event and a Cochrane review found no evidence to support restricting oral intake in women at low risk of requiring anaesthesia[32]. This coincides with the common antenatal advice for pregnant women to drink frequently in labour to prevent dehydration.

In summary the problem of peripartum dilutional hyponatraemia has the potential to cause severe harm to labouring women and their babies and it is likely that it is under recognised. Physiological factors predispose pregnant women to hyponatraemia, especially where additional risk factors such as excessive oral intake, intravenous fluids and exogenous oxytocin are present. The purpose of this guideline is to reduce the risk of hyponatraemia through the expedients of:

- Increased awareness
- Accurate fluid balance monitoring
- Earlier detection.

Methodology

Who is the guideline intended for?

The guideline is relevant to all healthcare professionals who come into contact with all women in labour and the immediate post-partum period, as well as to the women themselves and their carers.

It is also expected that the guideline will be of value to those involved in clinical governance in secondary care to help ensure that arrangements are in place to deliver appropriate care to this group of patients.

The remit of the guideline is to develop guidance on the prevention, diagnosis and management of hyponatraemia in labour and the immediate post-partum period.

Terms of Reference

Terms of reference were developed by the Guideline Development Group (GDG). This guideline aims to raise awareness among medical and midwifery staff of the issue of hyponatraemia in labouring or recently delivered women and to ensure consistency of approach to their care in all units across the region.

Involvement of Stakeholders

Representation was sought and successfully obtained from all five HSC Trusts in Northern Ireland. The GDG included obstetricians, midwives, anaesthetists, clinical biochemists, a neonatologist, a nephrologist and a service user. The membership of the GDG for the Prevention, Diagnosis and Management of Hyponatraemia in Labour and the Immediate Postpartum Period guideline is recorded in Appendix 1.

Needs Assessment

Following case presentations at both the Ulster Obstetrical & Gynaecological Society (UOGS) and Northern Ireland Society of Anaesthetists (NISA) obstetric anaesthesia group, feedback expressed a need for formal guidance on hyponatraemia in labour.

An extensive literature search and review of published papers confirmed the clinical need for this guideline. Experts from the Royal College of Obstetricians and Gynaecologists (RCOG) and the Obstetric Anaesthetists Association (OAA) were contacted, confirming the absence of any existing national guidance on the subject. The GDG was convened and the process of developing the guideline commenced.

A literature search was conducted using Ovid MEDLINE (R) 1946 - 21 December 2015) with daily update, Embase, ERIC and MWIC databases. The following key word searches were performed: labor or labour + fluid balance, pregnancy + fluid balance, labor or labour + oral fluid, pregnancy + oral fluid, pregnancy + water homeostasis, hyponatraemia or hyponatremia + neonatal or neonate or baby or newborn, hyponatraemia or hyponatremia + labor or labour or pregnancy. This was supplemented by specific searching of relevant

papers and publications from individual paper reference lists. Online searches for relevant local and national guidelines were also performed.

Who Developed the Guideline?

Overview

The development of this guideline was based upon methods outlined in the 'Advice for Guideline Development in Northern Ireland' document[33]. A team of health professionals known as the GDG (Appendix 1), with support from GAIN, undertook the development of this clinical guideline.

The Guideline Development Group (GDG)

Following approval of the GAIN Committee to fund this project, requests for obstetric, anaesthetic and midwifery representatives were sent to each of Northern Ireland's five HSC Trusts.

No conflicts of interest were declared by any members of the GDG.

Guideline Development Group Meetings

Five meetings were held between June 2016 and March 2017. During each meeting clinical questions and evidence were reviewed, assessed and recommendations formulated.

The Chairs divided the GDG workload by allocating specific topics, relevant to their area of clinical practice to small sub-groups in order to simplify and speed up the guideline development process. These groups considered the evidence, as reviewed by the systematic reviewer, and synthesised it into draft recommendations prior to presenting it to the GDG as a whole.

Patient/carer Representatives

Dr Emma Borthwick participated as an active member of the GDG, providing both professional nephrology opinion and the personal perspective of hyponatraemia in labour.

Expert Advisers

Expert advice was sought during the course of the guideline development from a renal physician and clinical biochemists, with input from both at the GDG meetings.

Once drafted, the guideline was further reviewed by Regional and National experts as listed below: Dr David Hill (Associate Medical Director, South Eastern HSCT), Dr Ann Hamilton (Clinical Risk Manager, South Eastern HSCT), Professor Neil McClure (Professor of Obstetrics & Gynaecology, Queen's University, Belfast) and Professor Catherine Nelson-Piercy (Professor of Obstetric Medicine, King's College London and Consultant Obstetric Physician, Guy's and St Thomas' Foundation Trust, Imperial College Health Trust, London).

Updating the Guideline

It is normal GAIN practice that all guidelines are reviewed on a three yearly basis. However, as this guideline is the first to address this issue and much of the content is based on consensus opinion, the GDG have agreed to review the guideline initially after one year in 2018.

Funding

The GDG was commissioned by GAIN to develop this guideline.

Audit

Due to the short timeframe of review, the implementation of this guideline should be audited after six months and thereafter compliance audited yearly.

Fluid and Electrolyte Balance in Pregnancy

Blood sodium concentration and osmolality are lower in pregnancy with 130 - 140 mmolL^{-1} being considered the normal range[19,23,25-27] compared to 135 – 145 mmolL^{-1} in non-pregnant adults[1]. In this guideline hyponatraemia in pregnancy is defined as a blood sodium concentration below 130 mmolL^{-1}.

Lower baseline plasma sodium

Physiological changes affecting fluid and electrolyte balance occur as early as six weeks of amenorrhoea. Renal blood flow increases and there is expansion of the plasma volume and retention of sodium. Normal pregnancy is thus a state of positive sodium and water balance: by term women will have accumulated an additional 7-10 litres of total body water[34]. As the volume regulatory mechanisms underlying this are complex and involve adaptations in the renin angiotensin aldosterone system and resetting of the osmotic threshold for antidiuretic hormone (ADH) release[28].

The body tightly regulates the osmolarity of blood maintaining it around 285 mOsmokg^{-1} in non-pregnant adults. With dehydration osmolarity increases, that is blood becomes more concentrated, and the body responds by increasing the secretion of ADH from the posterior pituitary gland. ADH binds to receptors in the kidneys causing water to be reabsorbed leading to a fall in blood osmolarity as volume is restored. In response to excessive intake of water the osmolarity will fall and the secretion of ADH will be reduced resulting in less water being reabsorbed by the kidneys and a greater volume being excreted in the urine with subsequent rise in the blood osmolarity. In pregnancy blood osmolarity is lower at around 280 mOsmokg^{-1} and the physiological mechanisms working to maintain this include lower thirst and ADH secretion thresholds[35,36].

Antidiuretic effect of oxytocin

Oxytocin is the hormone responsible for uterine contractions. Secreted from the posterior pituitary gland it has a structure similar to ADH giving it an antidiuretic action at high concentrations. In labour higher quantities of endogenous oxytocin are present and synthetic oxytocin is commonly administered intravenously to induce or augment labour. Oxytocin can contribute to dilutional hyponatraemia when large volumes of sodium free fluids are consumed or given intravenously simultaneously[30]. This is compounded in late pregnancy by a reduced ability to excrete excess water.

Impaired ability to excrete water in the third trimester

During the first and second trimesters women are able to excrete excess fluid in the urine as effectively as non-pregnant adults. In the third trimester this ability to excrete excess water is reduced, predisposing to fluid retention[28,29].

Signs and Symptoms of Hyponatraemia

For detailed guidance on recognition of hyponatraemia refer to the 2010 GAIN guideline Hyponatraemia in Adults[1].

Signs and symptoms of hyponatraemia are primarily related to dysfunction of the central nervous system. Cerebral oedema may develop and early manifestations of hyponatraemia include:

- Anorexia
- Nausea
- Lethargy
- Apathy
- Headache

Early symptoms are non-specific and may be attributed to pregnancy, labour and common conditions such as pre-eclampsia.

More advanced signs and symptoms include:

- Disorientation
- Agitation
- Seizures
- Depressed reflexes
- Focal neurological deficits
- Cheyne-Stokes respiration
- Coma

Symptoms correlate with the severity of hyponatraemia and the speed of change in sodium concentration. Rapid changes can cause fluid shifts between extracellular and intracellular compartments with no opportunity for physiological compensation leading to acute symptoms.

Prevention and Diagnosis of Hyponatraemia in Labour

Maternal dilutional hyponatraemia during labour can be prevented by keeping a neutral fluid balance and can be recognised by fluid balance monitoring and clear documentation with blood sodium testing when necessary.

Healthy women in labour who are in a neutral fluid balance are at low risk of developing hyponatraemia. As fluid intake in labour increases so to does the risk of hyponatraemia[27]. Women who have a fluid intake of up to 1 litre in labour will have a 1% incidence of hyponatraemia at delivery, between 1 to 2.5 litres intake increases this to 5% and above 2.5 litres 26% will be hyponatraemic[27].

In cases of hyponatraemia a thorough review of the clinical history, medications, fluid input and output is necessary to establish the cause. Alternative causes of hyponatraemia should always be considered, particularly in severe hyponatraemia, where concurrent illness exists or symptoms and laboratory results pre-date labour. Blood osmolality, urine sodium and urine osmolality tests are useful in determining the cause of hyponatraemia.

Detailed information on diagnosis and management of hyponatraemia is available in the 2010 GAIN guideline Hyponatraemia in Adults[1], reference sheet included in Appendix 2.

Guidance on peripartum fluid balance and sodium monitoring

a) Guidance for the care of women undergoing the induction of labour process

1. The importance of accurate fluid balance monitoring during labour should be explained to all women.
2. Fluid balance observations should be commenced and recorded on the regional fluid balance chart.
3. Women should be encouraged to record their own oral fluid intake at least four hourly.
4. Women should be encouraged to void 2-4 hourly and should measure and record their own urine output.
5. Women should have other fluid losses measured and recorded e.g. vomit.
6. If a woman's fluid balance exceeds positive 1500 mls a blood sodium should be checked and the patient commenced on the Peripartum Sodium Monitoring Pathway (page 16).
7. Before transfer from the induction area to another clinical area, a cumulative fluid balance total should be recorded on the regional fluid balance chart.

b) Guidance for the care of women <u>on</u> the Northern Ireland Normal Labour & Birth Care Pathway (suitable for midwifery led care)

1. The importance of accurate fluid balance monitoring during labour should be explained to all women.
2. Once in established labour, fluid balance observations should be commenced and recorded in the comments section of the partogram (example in Appendix 3).
3. Women should have oral intake recorded at least four hourly.
4. Women should be encouraged to void 2-4 hourly and should have urine output measured and recorded.
5. Women should have other fluid losses measured and recorded e.g. vomit.
6. A four hourly cumulative fluid balance should be recorded on the partogram.
7. Before transfer to another clinical area a cumulative fluid balance total should be recorded.
8. If a woman has greater than 1500 mls positive on her fluid balance, a blood sodium should be checked. If the result is within normal limits (equal to or greater than 130

mmolL^{-1}) the woman may stay under midwifery led care, a regional fluid balance chart should be commenced and the Peripartum Sodium Monitoring Pathway should be followed.

9. If the sodium level is less than 130 mmolL^{-1} or if sodium testing is not readily available, the on call obstetric registrar should be contacted and clinical judgement used, particularly with regard to parity and progress in labour to decide whether transfer to labour ward is required.

c) Guidance for the care of women <u>not on</u> the Northern Ireland Normal Labour & Birth Care Pathway (requiring consultant led care)

1. The importance of accurate fluid balance monitoring during labour should be explained to all women.
2. All fluid balance observations should be recorded on the regional fluid balance chart.
3. Women should have oral intake documented at least four hourly.
4. Women should have intravenous (IV) fluid intake documented hourly.
5. IV fluids must have a prescribed reason documented on the fluid balance chart.
6. IV fluids must be prescribed in millilitres (ml) per hour.
7. IV fluids must be administered via volumetric pumps (in exceptional circumstances such as fluid resuscitation during haemorrhage this can be waived).
8. IV fluids are not routinely required with epidural analgesia.
9. IV fluids should not routinely be prescribed for the treatment of ketosis in non-diabetic women.
10. Women should be encouraged to void 2-4 hourly and to have urine output volume measured and recorded.
11. Women should have other fluid losses measured and recorded e.g. vomit.
12. Women require sodium monitoring (Peripartum Sodium Monitoring Pathway, page 16) if they are:
    a. On an oxytocin infusion (includes induction and augmentation of labour, treatment of postpartum haemorrhage)
    b. In labour and require IV insulin and dextrose.
    c. Noted to have a blood sodium below 130 mmolL^{-1} for any reason.
    d. Greater than 1500 mls positive on their fluid balance.

Sodium Monitoring

Peripartum

When an oxytocin infusion is commenced a blood sodium level should be checked using point of care testing (POCT) where available. It is not necessary to await the result prior to starting the infusion.

Where an oxytocin infusion is commenced as prophylaxis against uterine atony in the setting of elective Caesarean section sodium monitoring is not routinely required.

It is essential that blood samples are not taken from a limb attached to an intravenous infusion as this may lead to inaccurate results.

Results should be referenced against the Peripartum Sodium Monitoring Pathway to guide frequency of repeat testing and further management (page 16).

All women requiring intravenous insulin and dextrose infusions during labour should have a blood sodium level checked at least four hourly.

Where blood sodium is equal to or greater than 130 $mmolL^{-1}$ further testing is necessary 8 hourly unless either of the following occurs:

- the change in sodium concentration has been greater than 1 $mmolL^{-1}$ per hour (eg. 10$mmolL^{-1}$ over 8 hours), this rapid fall in sodium increases the risk of developing symptoms and so 4 hourly testing is necessary.
- a positive fluid balance of more than 1500 mls is achieved: this necessitates an immediate repeat sodium check.

The paediatric team should be made aware of babies born to hyponatraemic mothers.

In cases where the maternal sodium is below 125 $mmolL^{-1}$ oxytocin should be stopped while senior clinical advice is sought. The decision regarding further oxytocin administration should be made following assessment of the woman's clinical condition and circumstances after discussion with a consultant obstetrician.

Following delivery if a woman remains on an oxytocin infusion, for example as treatment for postpartum haemorrhage, she should remain on the Peripartum Sodium Monitoring Pathway.

Postpartum

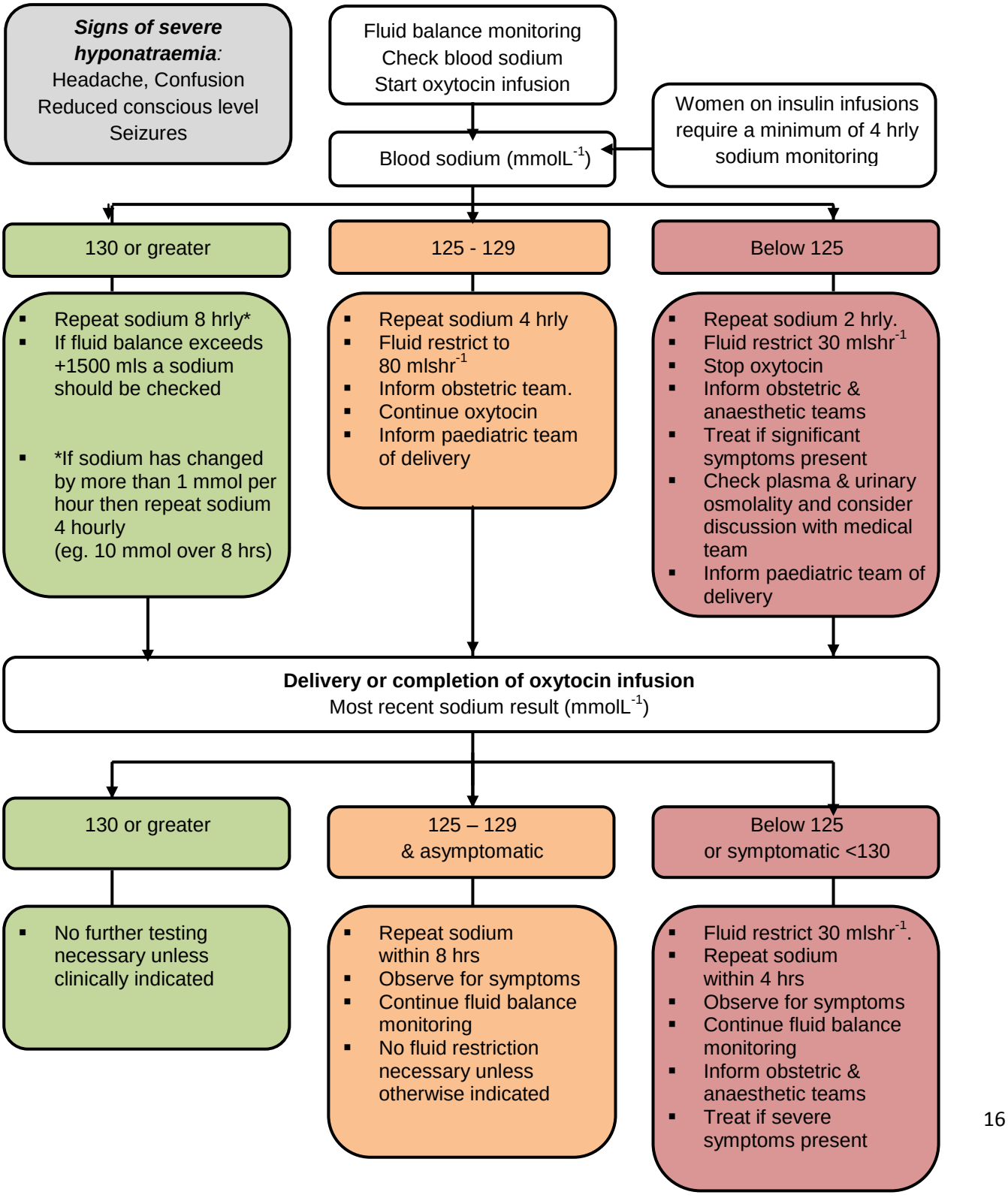
Once a woman has a blood sodium level equal to or greater than 130 $mmolL^{-1}$ no further sodium checks are necessary unless clinically indicated.

If a woman has a sodium level below 130 $mmolL^{-1}$ she should be reviewed by the obstetric team and consideration given to alternative causes, the patient's clinical condition and the severity of the hyponatraemia, and a decision made as to whether she is suitable for discharge.

Peripartum sodium monitoring pathway

Women require sodium monitoring if they are:

a. On an oxytocin infusion (includes induction and augmentation of labour, treatment of postpartum haemorrhage)
b. In labour and require IV insulin and dextrose.
c. Noted to have a blood sodium below 130 mmolL^{-1} for any reason.
d. Greater than 1500 mls positive on their fluid balance.



Point Of Care Testing

To facilitate monitoring of blood sodium levels point of care testing devices should be available to provide rapid, local, accurate analysis of blood sodium concentration.

Laboratory analysis of samples will give accurate results but long turn around times limit its usefulness in the dynamic clinical setting of labour where frequent sampling and changes in clinical management may be necessary.

It is necessary that staff utilising point of care testing devices are appropriately trained in their use.

Departments are responsible for the maintenance of any point of care testing devices to ensure they produce consistent and accurate analysis.

Management of Symptomatic Hyponatraemia

For more detailed guidance on the investigation, diagnosis and treatment of hyponatraemia refer to the 2010 GAIN guideline Hyponatraemia in Adults[1], reference sheet included in Appendix 2.

In a patient with significant clinical symptoms believed to be due to hyponatraemia (for instance, seizures or loss of consciousness), 200 mls of 2.7% saline should be given immediately as an IV bolus over 30 minutes. Consider co-administration of 20 mg IV furosemide if there is any evidence of fluid overload. This will raise serum sodium by approximately 2 – 4 $mmolL^{-1}$ and will reduce cerebral oedema. The assistance of an experienced clinician should be sought to guide further treatment. Senior members of obstetric and anaesthetic teams should be involved and the patient transferred to a critical care environment for ongoing management.

Following administration of hypertonic saline it is necessary to monitor sodium levels 2 - 4 hourly. Rapid increases in blood sodium concentration can cause serious harm including central pontine myelinolysis. Therefore, the level should rise by no more than 12 $mmolL^{-1}$ in a 24 hour period.

Appendix 1

Membership of the GAIN guideline development group for prevention, diagnosis and management of hyponatraemia in labour and the immediate postpartum period

Chairmen

Damien Hughes	Consultant Anaesthetist	South Eastern HSC Trust
Kristine Steele	Consultant Obstetrician	South Eastern HSC Trust

Members

Agnieszka Zawislak	Consultant Obstetrician	Belfast HSC Trust
Andrew Eggleton	Consultant Anaesthetist	South Eastern HSC Trust
Brenda McClafferty	Delivery Suite Manager	Western HSC Trust
Claire Hardy	Consultant Obstetrician	South Eastern HSC Trust
Ellie Duly	Consultant Biochemist	South Eastern HSC Trust
Emma Borthwick	Consultant Nephrologist & Service User	Belfast HSC Trust
Gillian McKeown	Consultant Obstetrician	Southern HSC Trust
Jacqueline Cartmill	Consultant Obstetrician	Western HSC Trust
Kathryn Spence	Consultant Anaesthetist	Northern HSC Trust
Laura McMorran	Consultant Obstetrician	Northern HSC Trust
Maureen Ritchie	Practice Development Midwife	South Eastern HSC Trust
Nicola Porter	Guideline & Audit Manager	GAIN
Patricia Scott	Practice Development Midwife	South Eastern HSC Trust
Rachel Mathers	Consultant Anaesthetist	Southern HSC Trust
Rebecca Barr	Consultant Anaesthetist	Western HSC Trust
Richard Laird	Consultant Anaesthetist	Western HSC Trust
Robert Mercer	Regional Clinical Audit Facilitator	GAIN
Roisin Cosgrove	Lead Midwife - Intrapartum Services	Belfast HSC Trust

Shona Hamilton	Consultant Midwife	Northern HSC Trust
Teresa McCann	Practice Development Midwife	Southern HSC Trust
Tina Newell	Obstetric Registrar	Belfast HSC Trust

Advisory

Carl Harris	Consultant Neonatologist	South Eastern HSC Trust
Hannah McCauley	Team Leader, Lagan Valley MLU	South Eastern HSC Trust
Katherine Robinson	Ward Manager, Home from Home AMLU	South Eastern HSC Trust

PPI Representative

Emma Borthwick	Consultant Neonatologist & Service User	Belfast HSC Trust

Peer Reviewers

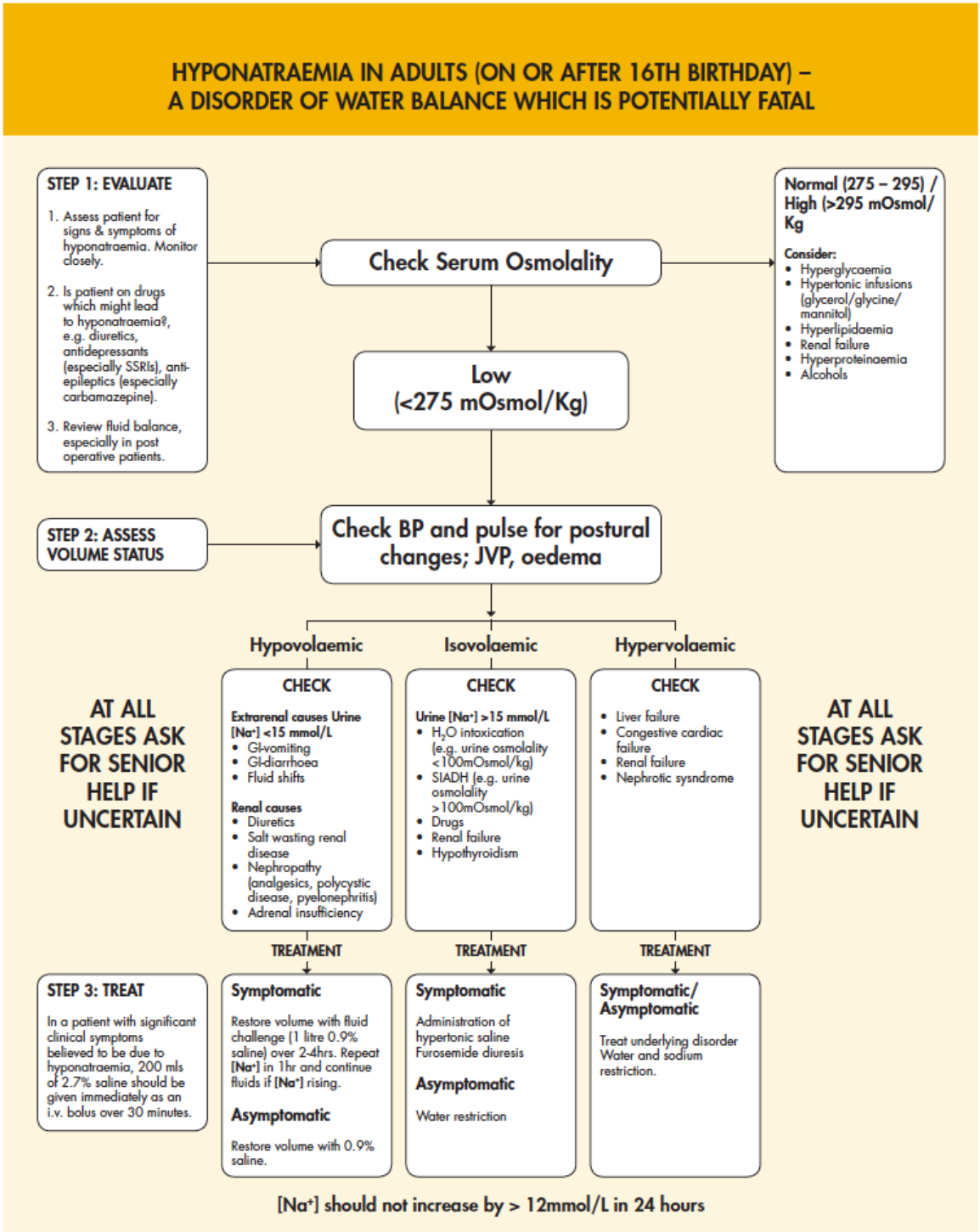
Neill McClure	Professor of Obstetrics & Gynaecology	QUB
David Hill	Associate Medical Director	South Eastern HSC Trust
Ann Hamilton	Clinical Risk Manager	South Eastern HSC Trust

External Peer Reviewer

Catherine Nelson-Piercy, Professor of Obstetric Medicine & Consultant Obstetric Physician King's College London, Guy's and St Thomas' Foundation Trust, Imperial College Health Trust, London

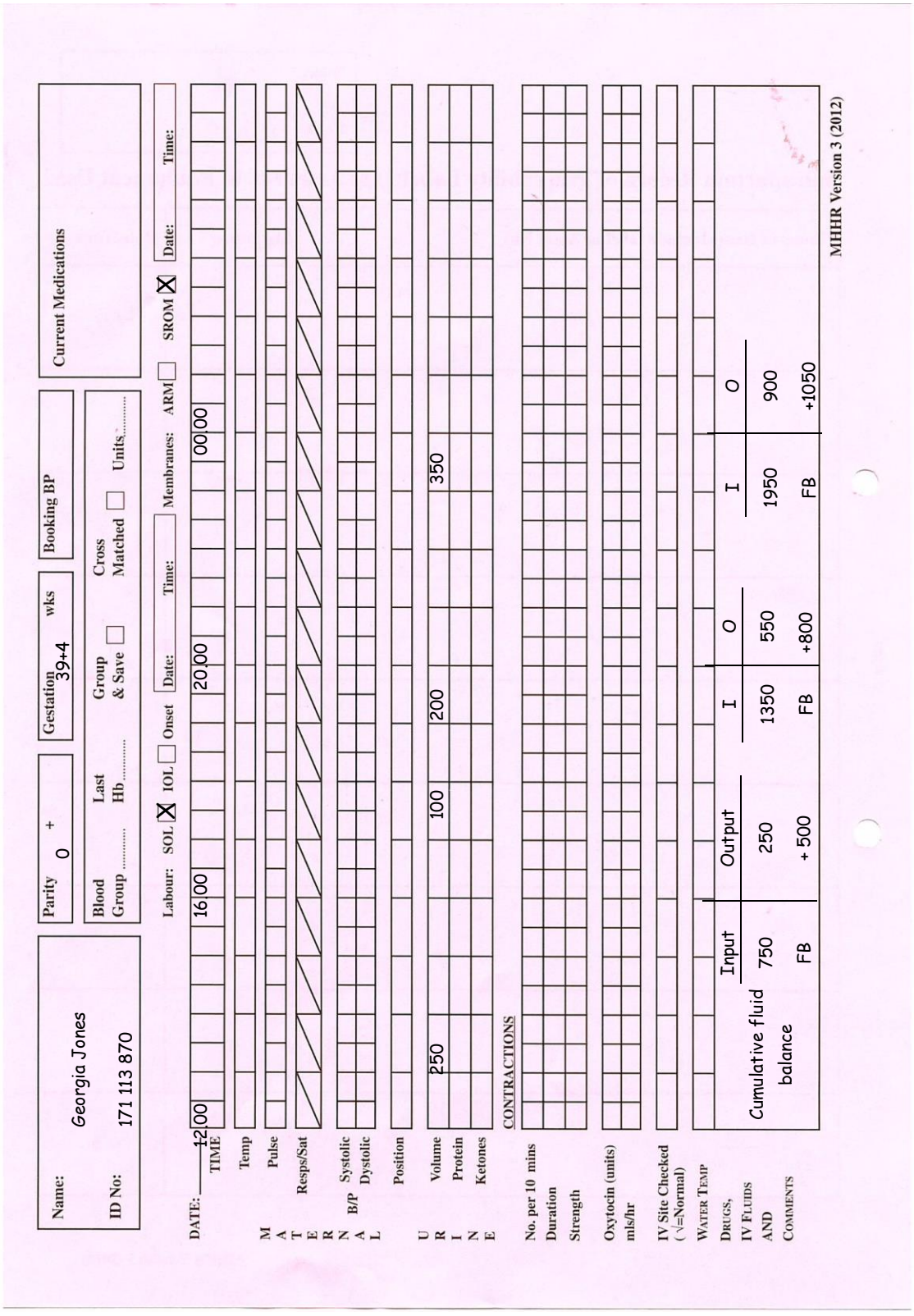
Appendix 2

Hyponatraemia in adults reference sheet, 2010 GAIN[1] (reproduced with permission)



Appendix 3

Example of fluid balance recording on a partogram



REFERENCES

1. GAIN Hyponatraemia in Adults (on or after 16th birthday). February 2010.
2. R Barr, C Curry, G Fitzpatrick and M Molloy. Intravenous Fluids in Labour: An Improvement in Practice. International Journal of Obstetric Anesthesia. May 2014. Supplement 1 P35:S30
3. Bilek W, Dorr P. Water intoxication and grand mal seizure due to oxytocin. C.M.A Journal. 1970. 103:379-382
4. Mckenna P, Shaw RW. Hyponatremic fits in oxytocin augmented labors. Int J Gynaecol Obst. 1979. 17:250-252
5. Singhi SC, Chookang E. Maternal fluid overload during labour; transplacental hyponatraemia and risk of transient neonatal tachypnoea in term infants. Archives of Disease in Childhood. 1984. 59:1155-1158.
6. Bergum D. Lonnée H, Hakli TF. Oxytocin infusion: acute hyponatraemia, seizures and coma. Acta Anaesthesiol Scand. 53:826-827. 2009.
7. Halaweh SAA, Aloweidi AS, Quadaisat IY, Al-Kazaleh FA. Iatrogenic water intoxication in healthy parturient causing convulsions and fractured mandible. Saudi Med jnl. 2014. 35(2):192-194.
8. Johansson S, Lindow S, Kapadia Hand Norman M. Perinatal water intoxication due to excessive oral intake during labour. Acta Pñ diatr 91: 811± 814. 2002.
9. Robert KM, Funk D, Margarites C. Acute postpartum altered mental status. Air Medical Journal Associates. 2007. 27:3
10. Green A, Popham P. Hyponatraemia complicating vaginal delivery. International Journal of Obstetric Anesthesia. 2008. 17:93-94.
11. Graham K, Palmer J. Severe hyponatraemia as a result of primary polydipsia in labour. Australian and New Zealand Journal of Obstetrics and Gynaecology. 2004. 44:586-587.
12. Aldana-Valenzuela C, Prieto-Pantoja JA, Hernandez-Acevedo A. Oxitocina y síndrome de secreción inapropiada de hormona antidiurética neonatal. Reporte de un caso de hiponatremia severa temprana y revisión de la bibliografía. Ginecol Obstet Mex. 2010;78(12):692-696
13. West CR, Harding JE. Maternal water intoxication as a cause of neonatal seizures. J. Paediatric Child health. 2004. 40:709-710.

14. Chapman TH, Hamilton M. Water intoxication presenting as maternal and neonatal seizures: a case report. Journal of medical Case Reports. 2008. 2:366.
15. Kamdar T, Burton DJ. Acute hyponatraemia in labour secondary to water intoxication: a case report. BJOG: E-posters, labour and Obstetric Complications. 2015. Pg 184.
16. Walter KN, Montgomery J, Amess P, Rabe H. Hyponatraemia and brain oedema in newborns following oral water intoxication during prolonged labour. Klinische Paädiatrie. 2012. 224(4):266-267
17. Paech MJ. Convulsions in a healthy parturient due to intrapartum water intoxication. IJOA. 1998. 7:59-61.
18. Jellema J, Balt J, Broeze K, Scheele F, Weijmer M. Hyponatraemia during pregnancy. The Internet Journal of Gynecology and Obstetrics. 12(1): 1-6.
19. Tarnow-Mordi WO, Shaw JCL, Liu D, Gardner DA, Flynn FV. Iatrogenic hyponatraemia of the newborn due to maternal fluid overload: a prospective study. BMJ. 1981 283:639-643
20. Spencer SA, Mann NP, Smith ML, Woolfson AMJ, Benson S. The effect of intravenous therapyduring labour on maternal and cord serum sodium levels. BR J Obstet Gynaecol. 1981 88:480-483.
21. Singhi S, Singh M. Asymptomatic transplacental hyponatraemia following oxytocin infusion during labour. Indian J Med Res 1979;70:55-7.
22. Dahlenburg GW, Burnell RH, Braybrook R. The relationship between cord serum sodium levels in newborn infants and maternal intravenous fluid therapy. Br J Obstet Gynaecol 1980;87:519-22.
23. Nelson-Piercy, C. Handbook of Obstetric Medicine 5th Edition. London: CRC press. 2015.
24. Shakmatova EI, Osipova NA, Natochin YV. Changes in osmolality and blood serum ion concentrations in pregnancy. Hum Physiology. 2000 26:92
25. Abassi-Ghanavanti M, Greer LG, Cunningham FG; Pregnancy and laboratory studies. Obstetrics & Gynecology. 2009 14(6): 1326-1331.
26. Larsson A, Palm M, Hansson LO, Axelsson O. Reference values for clinical chemistry tests during normal pregnancy. BJOG 2008; 115:874-81.
27. Moen, V, Brudin, L, Rundgren M, Irestedt, L. Hyponatraemia complicating labour - rare or unrecognized? A prospective observational study. BJOG. 2009 116:552-561.

28. Lind T. Fluid balance during labour a review. Journal of the Royal Society of Medicine. 1983. 76:870-875.
29. Hytten FE, Klopper AI. Response to a water load in pregnancy. J Obstet Gynaecol Br Commonw. 70:811-6, 1963 Oct.
30. Smith JG, Merrill DC. Oxytocin for induction of labour. Clinical Obstetrics and Gynecology. 49(3):594-608.
31. Siba P, Basude S, Smith-Collins A. Maternal over hydration in labour can cause dilutional hyponatremia in neonates. Indian Journal of Pediatrics. 2014. 81(7):637-638
32. Singata M, Tranmer J, Gyte GML. Restricting oral fluid and food intake in labour (Review). Cochrane Database of Systematic Reviews. 2013 Iss 8.
33. Advice for Guideline Development in Northern Ireland (2016)
34. Hytten FE; Thomson AM; Taggart N.Total body water in normal pregnancy. Journal of Obstetrics & Gynaecology of the British Commonwealth. 73(4):553-61, 1966.
35. Lindheimer MD. Osmoregulation of thirst and vasopressin release in pregnancy. Am J Physiol 1989;257:F159-69.
36. Lindheimer MD, Davison JM. Osmoregulation, the secretion of arginine vasopressin and its metabolism during pregnancy. Eur J Endocrinol 1995;132:133-43.

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