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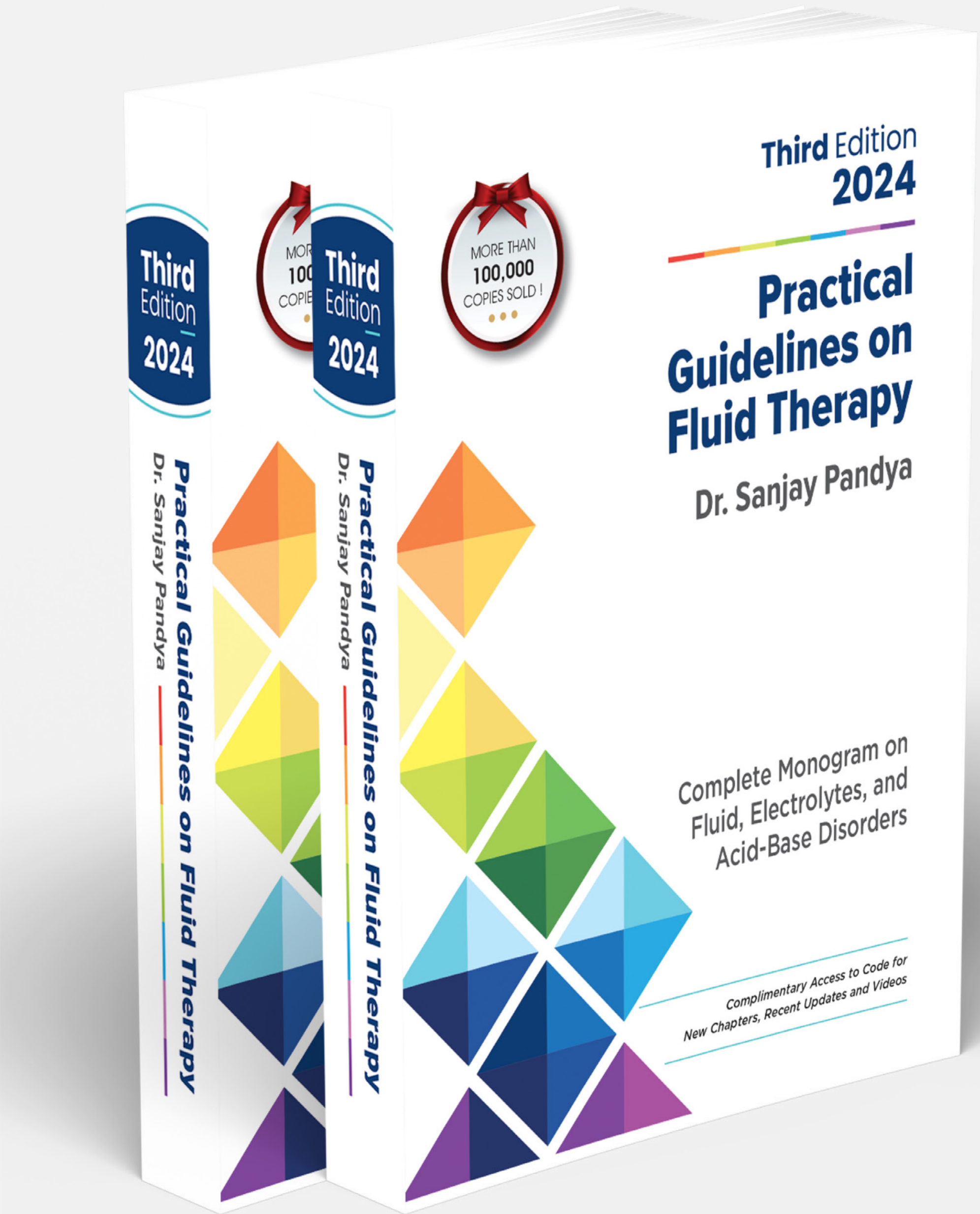
Chapter 51:

Maternal Changes and Fluid Management during Pregnancy



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During pregnancy, delivery, and in the postpartum period, administration of IV fluids may be required. It is essential to provide appropriate and timely fluid management whenever needed. This chapter aims to provide a basic understanding of the physiological changes that occur in the mother during pregnancy, as well as guidelines for fluid management in the cases of hyperemesis gravidarum and normal delivery.

MATERNAL PHYSIOLOGICAL CHANGES DURING PREGNANCY

Many physiological hemodynamic changes occur during pregnancy, starting just after conception and resolving within six weeks of delivery. An increase in weight gain during pregnancy is attributable to an increased size of the gravid uterus and breasts and an increase in blood volume and extravascular extracellular fluid [1]. Pregnancy-induced hemodynamic and cardiovascular changes ensure optimal growth and development of the fetus, and it also helps in the prevention of blood loss during delivery.

It is essential to understand changes in the circulatory system during pregnancy, such as an increase in cardiac output, retention of sodium and water leading to an expansion of blood volume, and a reduction in systemic vascular resistance and blood pressure. These physiological changes can significantly impact fluid management in pregnant patients, so understanding these changes can help in planning for fluid management in pregnant patients more efficiently.

A. Blood volume changes

Maternal plasma volume and red blood cell increase as early as the fourth week of pregnancy and peak at 28 to 34 weeks of gestation. During pregnancy, there is a retention of 900 to 1000 mEq of sodium and 6 to 8 liters of total body water, causing the expansion of total body volume [2–4].

The increased blood volume during pregnancy helps the body to meet the increased circulatory needs of the feto-placental unit, which are necessary to sustain the pregnancy. This increased blood volume also allows most women to tolerate significant blood loss during childbirth.

The maternal plasma volume increases by 40% to 50% during pregnancy. In comparison, the red cell volume only increases by 15% to 20%, resulting in hemodilution and a condition known as physiological anemia of pregnancy or relative anemia [5, 6].

B. Cardiovascular system changes

During pregnancy, cardiac output increases by 30% to 40%. The maximum increase usually occurs around 28–30 weeks of gestation [7]. This increase is due to both increased stroke volume and heart rate.

C. Blood pressure changes

Reduced systemic vascular resistance leads to a fall in blood pressure (BP) during pregnancy. The BP typically falls early in gestation and is usually 10 mmHg below baseline in the second trimester [2]. However, in the third trimester of pregnancy, systemic vascular resistance gradually increases, leading to a slow increase in blood pressure reaching nonpregnant levels by the end of the pregnancy [8].

D. Changes during labor and delivery

During labor and delivery, significant hemodynamic changes occur due to anxiety, exertion, pain, uterine contractions, uterine involution, and bleeding. During the first stage of labor, each uterine contraction displaces about 300 to 500 ml of blood into the general circulation and increases central blood volume by as much as 500 ml. As blood volume increases, the stroke volume of the heart also increases, leading to a 50% increase in cardiac output with each contraction.

In addition, maternal pushing efforts in the second stage of labor can further increase cardiac output. Immediately postpartum, cardiac output increases to 80 percent above pre-labor values due to significant autotransfusion associated with uterine involution.

Thus, the cardiac output can increase to 75% above its baseline level during labor and delivery. An increase in blood volume and cardiac output protects the mother from average blood loss of delivery (300–400 ml for a vaginal delivery and 500–800 ml for a cesarean section).

FLUID THERAPY IN HYPEREMESIS GRAVIDARUM

Nausea and vomiting of pregnancy (NVP) is the most frequent problem in the first trimester of pregnancy, which affects 50%–90% of all pregnant women [9, 10]. These symptoms are worse in the morning (but often persist throughout the day) and are usually limited to the first trimester of pregnancy.

Hyperemesis gravidarum (HG) is a severe form of nausea and vomiting that affects a small percentage of pregnant women, ranging from 0.3% to 3%.

It can lead to significant weight loss, dehydration, ketoacidosis, hypokalemic metabolic alkalosis from the loss of gastric hydrochloric acid, and nutritional deficiencies [11–15].

Two serious nutritional deficiencies reported with hyperemesis in pregnancy are vitamin B1 (thiamine) deficiency (which can cause Wernicke's encephalopathy) and vitamin K^+ deficiency (which can cause maternal coagulopathy and fetal intracranial hemorrhage) [16].

Hyperemesis gravidarum is the major reason for hospitalization during the first half of pregnancy and remains the second leading cause of hospitalization throughout pregnancy [17, 18].

Management

Management of hyperemesis gravidarum includes adequate hydration, antiemetic medications, electrolyte replacement, vitamin supplementation, and dietary management [19, 20]. Intravenous hydration is an essential intervention aimed at fluid resuscitation and correcting fluid deficit, ketones, electrolytes deficit (primarily hypokalemia), and acid-base balance [21]. In addition, as pregnant women are in a catabolic condition, sufficient caloric requirements must be administered [22].

1. Indications of IV fluids

Common indications of IV fluid administration in hyperemesis gravidarum are [23, 24]:

- Persistent vomiting (three or more times per 24 hours) despite antiemetic medical therapy.
- 5% or more weight loss of prepregnancy weight.
- Severe dehydration with the presence of signs and symptoms due to significant fluid loss such as fatigue, dizziness, decreased skin turgor, postural changes in blood pressure and pulse, ketonuria, electrolyte imbalance, acid-base abnormality like hypochloremic metabolic alkalosis, increased hematocrit, increased BUN to creatinine ratio and abnormal urine specific gravity.

2. Outpatient vs. inpatient IV hydration

Ambulatory (outpatient) intravenous hydration is the recommended first-line treatment for patients with severe or persistent nausea and vomiting. Multiple studies have found this treatment option to be as effective as inpatient care [25, 26].

Hospitalization is recommended if vomiting persists even after rehydration and outpatient management fails [27].

3. Selection of IV fluids

Normal saline (NS) and Ringer's lactate are the mainstay of the management of dehydration and are equally effective in treating complications of hyperemesis gravidarum [28, 29]. Usually, Ringer's lactate (RL) is preferred for the initial aggressive rehydration, and normal saline is used for the subsequent slower rehydration [30].

Why is Ringer's lactate preferred for the initial aggressive rehydration and in patients of HG with severe hyponatremia?

The speed at which one rehydrates depends on the severity of their dehydration. In patients of hyperemesis gravidarum with severe dehydration, 2 liters of Ringer's lactate is infused rapidly initially (first 1 liter RL over 2 hours followed by second 1-liter RL over 4 hours). In severe hyponatremia, avoid rapid administration of a large volume of high sodium containing normal saline (sodium 154 mEq/L), as it can lead to rapid correction of sodium levels and may cause central pontine myelinolysis [30].

Therefore in symptomatic and severe hyponatremia (serum sodium <120 mEq/L), choose low sodium containing Ringer's lactate (130 mEq/L sodium) which carries lower risk of rapid correction of hyponatremia.

Why is normal saline preferred for the subsequently slow rehydration in and in patients of HG with less severe hyponatremia associated with hypochloremia?

For hospitalized women with hyperemesis gravidarum who are hypovolemic with minimal symptoms of hyponatremia and have serum sodium levels >120 mEq/L (low risk of rapid correction) and hypochloremia, normal saline is an appropriate choice for rehydration. Normal saline containing 154 mEq/L sodium and chloride is a preferred fluid in HG for hydration because it corrects vomiting-induced hypochloremia, hyponatremia, hypokalemia, and metabolic alkalosis effectively [31].

If hypokalemic, the woman may require potassium supplementation [12, 32]. Usually, 20 mEq/L of potassium chloride is added to either normal saline or half-normal saline (depending on the serum sodium status) and infused slowly (over 6 to 8 hours) to correct hypokalemia.

In severe hypokalemia, consider potassium replacement using one liter of normal saline with 40 mEq potassium chloride to be infused over 4–6 hours. 10 mEq of potassium per hour is a safe infusion rate if urine output is adequate.

4. Role of dextrose solutions

Avoid dextrose-containing IV fluids for the initial fluid replacement, but it may be beneficial for the subsequent IV fluid infusion. Two reasons to avoid dextrose containing IV fluids for the initial fluid replacement are [33]:

- Risk of Wernicke's encephalopathy: As thiamine (vitamin B1) deficiency occurs in about 60% of hyperemesis gravidarum patients [34], dextrose-containing IV fluids can precipitate Wernicke's encephalopathy in such patients [10]. Supplement 100 mg of thiamine intravenously with the initial IV fluid on the first day and another 100 mg daily for the next two or three days to prevent Wernicke's encephalopathy [25, 33, 35].
- Risk of worsening of hypokalemia: Hypokalemia is a common electrolyte abnormality in hyperemesis gravidarum [16]. It is recommended to avoid using dextrose-containing solutions for initial fluid replacement, as dextrose administration stimulates insulin release, which can cause extracellular potassium to be shifted into cells and worsen hypokalemia.

After thiamine supplementation and supplementing potassium, maintain hydration with the dextrose-based solution as it fulfills the caloric requirement and helps in faster improvement of nausea [36]. In addition, evidence suggests better improvement with dextrose saline than normal saline in moderate-severe cases [37]. Finally, select 10% dextrose to provide nutritional supplementation rather than the low-calorie-containing 5% solution [38].

Continue administering IV hydration until ketosis and vitamin deficiencies are corrected, and the patient is able to tolerate oral fluids. Afterward, check and address any associated magnesium, calcium, and phosphorus deficits.

To effectively address fluid deficit with hyponatremia and hypokalemia, it is crucial to monitor the input-output chart and check the blood urea and serum electrolyte levels daily [25]. This will allow for the accurate selection of the appropriate IV fluids necessary for treatment.

FLUID THERAPY DURING NORMAL LABOR AND VAGINAL DELIVERY

Labor is a period of prolonged and vigorous exercise for pregnant mothers. During labor, effective skeletal and smooth muscle contractions require increased energy demand. Glucose is an essential source of maternal energy, which plays an important part in the improvement of muscle performance and overcoming fatigue. Depletion of glycogen stores and fat metabolism to meet glucose demands may cause ketonemia, hypoglycemia, and acidosis. An adequate resource of glucose is needed to maintain exercise tolerance and muscle efficiency during labor. Dehydration adversely affects exercise performance and may be a factor contributing to a longer duration of labor. Providing adequate dextrose and fluids to pregnant mothers during labor can help to provide the necessary energy and hydration they need and may also lead to a faster labor process, shorter labor duration, and potentially a reduced need for oxytocin and cesarean delivery [39, 40]. To assess the hydration status, it is important to monitor urinary output and the presence or absence of ketonuria [41].

A. Oral liquid intake

Previously, the policy during active labor was "nil by mouth," or restriction of oral intake. This policy was based on the concern that a woman may require general anesthesia for an emergency cesarean section and inhale stomach contents during surgery, leading to aspiration pneumonia [42]. However, the risk of aspiration pneumonia is very low [43], and restricting oral intake can cause dehydration and ketosis [44]. Therefore, this policy is not necessary and may cause harm to the woman [44].

Women with low complication risks and at low risk of cesarean section delivery are allowed and encouraged to consume moderate amounts of clear liquids orally during labor [45–47]. However, to avoid aspiration during uncomplicated labor, it is more important to consider how much suspended particulate matter the fluid ingested contains rather than the volume of fluid permitted to be consumed [45].

During labor, it is necessary to restrict oral intake in patients who are at high risk of aspiration (e.g., morbid obesity, diabetes mellitus, and difficult airway) or those who may need a cesarean section [45].

B. Oral solid food intake

Avoiding particulate-containing fluids and solid food during active labor and delivery is the standard practice and a recommendation by the American College of Obstetricians and Gynecologists (2009) and the American Society of Anesthesiologists Task Force on Obstetric Anesthesia (2016) [45–47]. This recommendation is because gastric emptying time is remarkably prolonged during labor.

However, the incidence of aspiration is low with current obstetric anesthesia techniques in recent literature. Therefore, solid food restriction in women at low risk of requiring general anesthesia is questioned [42, 48, 49].

Cochrane review (2013) found no evidence to support restriction to eating or drinking in women at low risk of requiring anesthesia for Cesarean section [50]. However, a recent systematic review (Ciardulli et al. 2017) of 10 randomized trials in women with a low-risk singleton (one fetus) pregnancies found that less restrictive policies resulted in a slightly shorter duration of labor [51].

C. Parenteral fluids in normal labor

During normal labor, intravenous fluids are usually administered for proper hydration and to prevent prolonged labor. But as per current evidence from the Cochrane database of systematic reviews (2013), the World Health Organization (2014), and the American College of Obstetricians and Gynecologists (2019), continuous IV fluid infusion is not routinely recommended in normal labor [39, 52].

Regardless of solution type, possible harmful effects to mother and newborn due to the administration of intravenous fluids during labor are:

1. Discomfort, stress, and restriction in freedom of movement.
2. Peripheral swelling and increased risk of fluid overload due to excessive IV fluids.
3. Postpartum breast swelling and feeding issues due to the large volume of IV fluids infusion [53].
4. Fetal volume expansion causes a bloated newborn at birth and greater weight loss of the newborn after birth [54, 55].

Moreover, oral food and liquids are more effective than intravenous fluids in providing energy and nutrition for the increased demand during labor [50]. Thus, instead of administering intravenous fluids to all women during labor, they should be given only to selected patients, considering their limitations and drawbacks.

Conclusion: During normal labor, avoid the "nil by mouth" policy and do not administer intravenous fluids routinely to prevent dehydration and ketosis [39, 52].

1. Indications of IV fluids during labor

When oral fluid intake is restricted, administering IV fluids in a moderate amount shortens the course of labor [39]. So the administration of IV fluid is indicated in selected pregnant mothers.

Common indications for intravenous fluid administration during labor include:

- High-risk pregnancies or restricted oral intake because of the possible need for cesarean delivery.
- Women who develop ketosis in labor [39].
- Following epidural or spinal anesthesia for cesarean delivery to prevent or treat hypotension [56].
- Infusion of oxytocin for induction or augmentation of labor.
- Need to administer intravenous fluids for other clinical reasons such as nausea, vomiting, diarrhea, maternal exhaustion, prolonged labor, blood volume loss, and administration of antibiotics or other medications [57].

2. Type and volume of IV fluids

When IV fluids are indicated, the selection of the type, the volume, and the infusion rate of IV fluid differ on the clinical status of individual women and the anticipated duration of labor [39].

For nulliparous women who are not allowed oral intake during labor, the infusion of dextrose solution significantly reduces the total labor length without increasing the complication rate [40, 58–60].

Because of its cost-effectiveness, safety, and advantages, dextrose should be the default solute for IV fluids during labor [59, 61]. Maintenance intravenous fluid usually administered is 5% dextrose in 0.45 percent saline, normal saline, or Ringer's lactate solution [62]. Avoid administering sodium-free 5% dextrose solution because it may cause maternal and neonatal hyponatremia and increase maternal and newborn morbidity [39].

Rate of infusion: IV fluid administration at a rate of 250 ml/hour, rather than 125 ml/hour, is associated with a shorter duration of labor and lesser need for cesarean section delivery. This data support increased hydration among nulliparous women in labor when oral intake is restricted [63].

PREOPERATIVE ORAL INTAKE

A. Liquid intake

The uncomplicated patient undergoing elective cesarean delivery may have clear liquids up to 2 hours before induction of anesthesia (American Society of Anesthesiologists (ASA) recommendation 2016) [45]. Consuming high-calorie carbohydrate drinks up to two hours before surgery can reduce preoperative thirst, hunger, anxiety, and the risk of dehydration in patients undergoing abdominal surgery [64, 65].

In pregnant women with a higher risk for aspiration during labor (e.g., morbid obesity, diabetes mellitus, and difficult airway), the recommendation is to restrict oral liquid intake for 6 or more hours, determined on a case-by-case basis [45].

B. Solid food intake

During elective surgery (e.g., planned cesarean delivery or postpartum tubal ligation) recommended fasting period for solid food is 6 to 8 hours [45].

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