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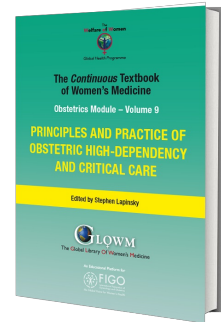
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### **PRINCIPLES AND PRACTICE OF OBSTETRIC HIGH-DEPENDENCY AND CRITICAL CARE**

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## *Chapter*

# **Fluid Management in the Complicated Obstetric Patient**

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## **INTRODUCTION**

Fluid management is one of the cornerstones of patient care, particularly in the critically ill, and the most common intervention in acute medicine.<sup>1</sup> Management of the volume state is vital for maintaining adequate cardiac output, blood pressure and oxygen delivery, with maintenance of tissue bed and organ perfusion. In any critical illness this is vital, but in pregnancy particularly so as to preserve uteroplacental flow and placental perfusion. Unlike many other tissue beds, the uteroplacental circulation autoregulates poorly,<sup>2</sup> leaving it reliant on maternal cardiac output, blood pressure and metabolic homeostasis in order to function correctly and avoid fetal compromise. In addition, the pregnant woman undergoes a number of physiological adaptations in pregnancy that impact upon fluid management, including an increase in the circulating volume and a reduction in systemic vascular resistance.<sup>3</sup>

Fluid resuscitation is a key component of patient care, especially in scenarios such as trauma, hemorrhage,<sup>4,5</sup> and sepsis.<sup>6</sup> However, injudicious or aggressive fluid therapy and volume overload have been associated with harm in a number of settings,<sup>7,8,9,10</sup> including precipitation of pulmonary edema in the maternity population.<sup>11,12</sup> In addition, persistently positive fluid balances have been associated with poorer outcomes in a variety of critical illness scenarios.<sup>13,14</sup>

The complicated obstetric patient may have a number of additional factors that make fluid management more challenging. Amongst other problems, cardiac, pulmonary or renal disease (pre-existing or acquired during pregnancy), sepsis, hemorrhage and hypertensive disorders of pregnancy all pose management dilemmas regarding the administration and optimization of fluid therapy. To make matters more challenging, in general, there is a lack of high-quality evidence to guide practice.

Finally, around the globe these women are cared for in a wide variety of healthcare settings with huge variations in both

resource and skills availability.

## PHYSIOLOGICAL CHANGES IN PREGNANCY THAT IMPACT FLUID MANAGEMENT

Normal pregnancy is associated with a number of physiological changes that may impact on fluid management (Table 1). Pathophysiological changes in the pregnant population need to be interpreted in light of the expected physiological alterations. Physiological changes may partially disguise the signs of pathological processes rendering early recognition of conditions such as sepsis more difficult.<sup>15</sup> Accurate assessment may be extremely challenging in the setting of acute deterioration superimposed upon complex or chronic maternal illness.

**Table 1** Physiological changes that may impact fluid management.

Organ system	Change in pregnancy
Cardiovascular	↑ Cardiac output ↑ Heart rate ↓ Systemic vascular resistance ↑ Circulating volume
Renal	↑ Glomerular filtration rate ↓ Creatinine
Respiratory	↑ Minute volume Respiratory rate unchanged
Hematological	Dilutional anemia ↑ White cell count
Metabolic	↓ PaCO <sub>2</sub> /respiratory alkalosis ↓ Bicarbonate

## AIMS OF FLUID THERAPY

Fluid may be prescribed and administered for a number of indications or reasons. Most commonly in the critically ill or complex patient it is given to treat hypotension and/or to replace volume losses, and to improve cardiac output and tissue perfusion. This may be in response to obvious hemorrhage, a physiological sign presumptive of hypovolemia (e.g. hypotension or tachycardia), or to assess the response to fluid of a surrogate marker of tissue hypoperfusion, e.g. low urine output or rising lactate. However, the decision to administer fluids (and how much to give) is not necessarily straightforward: some causes of the above-mentioned abnormalities do not respond to fluid administration, the response to fluid is not assured or may be transient, some methods to predict volume responsiveness are not straightforward or repeatable outside of the ICU environment,<sup>16</sup> and the administration of fluids in the wrong clinical context may be harmful or even catastrophic.

In later pregnancy, hypotension in the supine position may occur from the gravid uterus pressing on the inferior vena cava, and to a lesser extent the aorta. Therefore, lateral maternal positioning or lateral displacement of the uterus is necessary to remove the obstruction to venous return.<sup>17</sup> Fluid therapy will not be effective in the absence of correct positioning.

Other indications for IV fluid may be to provide electrolytes, correct acid-base disorders, provide glucose or artificial nutrition, or as a carrier for medications that need to be given intravenously. Often a combination of factors may require simultaneous correction.

Whatever the indication, fluid administration in the complex obstetric patient should be treated like the administration of a drug or other medication: there should be an indication, a prescribed dose and an assessment of response in order to modify or continue the treatment. A similar principle of “fluid stewardship” has been proposed in the general critical care population.<sup>7,13</sup> Side-effects should be considered and monitored (see Complications, below)

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## WHICH FLUID?

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Pregnant women have generally been either excluded<sup>18,19,20,21</sup> or undifferentiated (and hence not reported)<sup>22,23,24</sup> as a subgroup in trials looking at fluids in critical care settings. This includes both trials comparing different fluids and trials looking at fluid resuscitation as part of a care bundle. There is as a result limited evidence to guide the choice of fluids. Whilst evidence is scarce, in the critically ill pregnant patient isotonic crystalloids represent a safe initial choice in a wide variety of maternal conditions. Other synthetic colloids and starches have some significant risks associated with anaphylaxis,<sup>25</sup> excess kidney injury<sup>18</sup> and increased mortality<sup>23</sup> and should be avoided in critical illness.<sup>26,27,28</sup> A Cochrane review did not find a difference between crystalloids and colloids in preventing hypotension during cesarian section, but small numbers prevented detection of adverse events.<sup>29</sup> Albumin solutions are probably safe outside of maternal traumatic brain injury scenarios,<sup>22,30</sup> although solid evidence for widespread utility is lacking.<sup>30</sup> Albumin solutions may have significant cost implications in various parts of the world.<sup>30</sup>

Fluid therapy in the hemorrhaging obstetric patient is discussed elsewhere, but generally isotonic crystalloids are used as first-line fluid resuscitation until appropriate blood and blood products become available.

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## MONITORING AND ENDPOINTS

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Hemodynamic monitoring is discussed elsewhere, but in the majority of instances fluid therapy is guided by both hemodynamic endpoints (e.g. pulse rate and blood pressure) and surrogate markers of hemodynamic adequacy/oxygen delivery (such as urine output, mentation, lactate levels, central or mixed venous oxygen levels, etc). In situations of adequate resource, echocardiography is a quick, non-invasive and repeatable tool to look at ventricular function, find evidence of cardiac tamponade or pulmonary embolism, diagnose severe valvular disease, estimate the filling state, measure cardiac output and help guide ongoing management.<sup>31,32,33</sup> It has been shown to be useful in a variety of obstetric critical illness scenarios.<sup>31</sup> Dynamic measurements to delineate fluid responsiveness are recommended in the literature,<sup>6,16</sup> however, invasive (static) pressure monitoring techniques such as central venous pressure (CVP) measurement are still used in practice. The utility of this latter approach has been questioned due to poor specificity and sensitivity.<sup>34</sup> Normal values in pregnancy are the same as in the non-pregnant population.<sup>35</sup>

Generally fluid therapy endpoints comprise the attainment and maintenance of an adequate circulatory state, providing adequate blood pressure and tissue oxygenation (including placental perfusion) with the resolution of shock. It must be remembered that fluid therapy in and of itself comprises only a component of the treatment of most shock states, but that optimization of the circulating volume/cardiac output and blood pressure (resuscitation) is vital in **all** of the shock states. A causative diagnosis should be sought urgently and definitive treatment should occur as soon as is possible in the circumstances (e.g. surgical treatment of bleeding, antibiotics and source control in sepsis, etc.).

There is a lack of evidence for the optimal method of monitoring for resolution of the shock state in the maternity population. Monitoring should include an assessment of fetal well-being and end organ function. In addition to the normalization of hemodynamic parameters, the change in lactate concentration has been shown in quite diverse populations to have prognostic significance.<sup>36,37,38</sup>

In conditions where fluid therapy is not primarily aimed at hemodynamic endpoints but rather at the provision of a specific therapy such as electrolyte replacement, care should be given to frequent assessment of the volume state and close monitoring of the electrolyte and acid-base state.

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## COMPLICATIONS OF FLUID THERAPY

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Fluid therapy may be harmful if the incorrect fluids are given, if fluids are given in inadequate amounts, or if too much fluid is administered. Correct timing of fluid resuscitation is also vital to maximize benefit and minimize harm.<sup>34</sup>

## Inappropriate fluid type

As noted above, colloids may be associated with anaphylaxis,<sup>25</sup> whilst starches have been associated with excess renal failure<sup>18</sup> and mortality in ICU populations<sup>23</sup> and should be avoided. The tissue accumulation of hydroxyethyl starches is widespread and rapid, and may be harmful.<sup>39</sup> Although starches have been used safely to prevent hypotension during cesarean section,<sup>25</sup> any effects on the fetus from prolonged exposure in utero are unknown.

Excess crystalloid fluid administration in women with postpartum hemorrhage may result in worsening anemia, shock and coagulopathy.<sup>40</sup> Use of hypotonic (or less commonly hypertonic) fluids may lead to severe dysnatremias<sup>41</sup> and other electrolyte abnormalities, with resultant potentially catastrophic neurological complications. Excessive administration of chloride-rich fluids may lead to a normal anion gap metabolic acidosis.

## Inadequate fluid volume

Fluid resuscitation is an integral part of the treatment of a variety of complex and critical illnesses. In particular, sepsis,<sup>42</sup> trauma and hemorrhage<sup>4</sup> require early, balanced and focused fluid resuscitation in the early stages. There is still debate about optimal strategies in the non-pregnant population, and little to no evidence in the maternity group, but lack of fluid resuscitation is associated with poorer outcomes.<sup>43</sup>

## Excessive fluid volume

Normal pregnancy is marked by an increase in the maternal circulating volume.<sup>17</sup> Both pre-existing and superimposed conditions such as cardiac disease and renal dysfunction may exacerbate this, and hypertensive disorders of pregnancy may be associated with significant edema and varying degrees of volume state disturbance. Pre-eclamptic women are also at considerably increased risk of developing pulmonary edema,<sup>11</sup> which has been associated with increased maternal mortality.

There is considerable evidence that volume overload and persistently positive fluid balance are associated with poorer outcomes in non-obstetric ICU admissions.<sup>7,8,9,14,43</sup>

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## SPECIFIC SCENARIOS

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### Hypertensive disorders of pregnancy

The hypertensive disorders of pregnancy are a unique group of disorders that are, along with obstetric hemorrhage, the leading causes of intensive care admission in the obstetric population.<sup>44</sup> The multisystem nature of these disorders can make fluid therapy challenging, and there have been conflicting findings and views over time about the circulation and volume state in these women, as well as how best to manage them. Injudicious fluid management has been implicated as a contributor to maternal death.<sup>45</sup>

Traditional teaching has long held that the intravascular volume state is contracted in pre-eclampsia,<sup>46</sup> although this notion has been questioned.<sup>47,48</sup> More recent work has looked at total body water content and ratio of intracellular to extracellular fluid.<sup>49</sup> Two distinct phenotypes of the illness based on onset before or after 34 weeks' gestation and with different levels of intravascular filling<sup>50</sup> have been proposed. In addition, the seemingly contradictory therapies of diuretics<sup>51</sup> and volume expansion<sup>52</sup> have both been trialed as therapies in pre-eclampsia. All of this provides a window into some of the challenges faced in managing fluids in these women. Although a number of strategies have been suggested, a recent systematic review found that there was insufficient evidence to recommend a specific fluid strategy.<sup>53</sup>

Severe pre-eclampsia is associated with maternal cardiovascular changes, including altered maternal left ventricular (LV)

morphology.<sup>54</sup> Left ventricular systolic function may be impaired, but often the development of LV hypertrophy and reduced LV relaxation occurs, resulting in primarily diastolic dysfunction.<sup>55</sup> This, combined with capillary leak, abnormal lung permeability<sup>56</sup> and severe hypertension contributes to the increased risk of pulmonary edema. However, a poorly compliant ventricle needs higher filling pressures (and adequate time) in order to fill normally and hence maintain stroke volume and cardiac output, vital for uteroplacental flow. This may account for the precipitous fall in blood pressure occasionally seen in these women following antihypertensive therapy.<sup>47</sup> Echocardiography (if available) is useful to determine maternal cardiac function and help guide therapy. Minimizing IV fluid volumes is recommended.<sup>57,58</sup> It should be remembered that **no** intravenous fluid therapy may be necessary, and that careful reduction of the volume state with diuretics (and fetal monitoring) may be required, especially if pulmonary edema occurs.

Hypertensive disorders of pregnancy may first manifest in the peri/postpartum period. This is a period associated with significant fluid shifts, often with mobilization of extravascular fluid and normally a postpartum diuresis. Therefore fluid therapy (if any) should be carefully considered. In the absence of pre-existing renal disease or rising creatinine, oliguria may be tolerated over a number of hours.<sup>59</sup> Therapeutic diuresis in the postpartum setting may be easier to achieve in the absence of the need to maintain uteroplacental circulation, and may reduce the need for additional antihypertensive therapy.<sup>51,60</sup>

## Obstetric hemorrhage

Obstetric hemorrhage is one the leading causes of maternal mortality worldwide.<sup>61</sup> Management should focus on stopping the bleeding, replacing circulating volume, and avoiding/ameliorating the consequences of massive hemorrhage, including coagulopathy, acidosis, hypothermia and end organ dysfunction. It is discussed in detail elsewhere, but a few brief points on fluid management are noted below.

There are a variety of guidelines<sup>62,63,64</sup> discussing fluid management and blood product administration in obstetric hemorrhage. A recent international consensus statement (incorporating FIGO) suggests initial restrictive resuscitation with crystalloid solutions, using 1–2 ml per ml of blood loss.<sup>65</sup> Continuous resuscitation with crystalloid solutions at the expense of blood product replacement should be avoided as worsening oxygen delivery and dilutional coagulopathy<sup>40</sup> will result. The ideal blood component ratio and fluid regime in massive obstetric hemorrhage is still under investigation and requires further research.<sup>65</sup>

## Cardiac disease

This encompasses a wide variety of conditions, including congenital cardiac abnormalities, pulmonary hypertension, coronary artery disease, valvular lesions and peripartum cardiomyopathy. Conditions seen vary between developed and developing countries.<sup>66</sup> The demands of pregnancy may unmask previously unknown cardiac lesions or exacerbate known problems. Fluid therapy can be very problematic in these women and injudicious fluid therapy harmful, whilst superimposed acute instability from sepsis or bleeding (or other pathology) may be extremely challenging to manage, even in an ICU setting. Any need for fluids should be carefully considered and these complex, unwell women should ideally be managed by a multidisciplinary team<sup>67</sup> including obstetricians, obstetric physicians, cardiologists and intensivists.

## Sepsis

Initial fluid resuscitation in sepsis is vital to restore circulating volume and prevent sepsis induced end organ dysfunction secondary to hypoperfusion.<sup>6</sup> However, in different healthcare settings and different patient populations the expected benefit has not always been observed.<sup>68</sup> Unfortunately, (as noted above) pregnant women have been generally excluded from trials on initial resuscitation in sepsis, and so extrapolation from more general populations is required to guide management. Generally pregnant women can be managed in a similar fashion to non-pregnant women, although caution needs to be applied to avoid iatrogenic fluid overload in the setting of pre-existing volume expansion.

There are guidelines and suggested algorithms available for fluid therapy in maternal sepsis.<sup>15,69</sup> An initial (repeatable) bolus of isotonic crystalloid is suggested,<sup>15</sup> with early source control and swift escalation to more intensive supportive

therapies in the case of minimal or transient response. However, further research is required to determine optimal fluid resuscitation regimens in obstetric sepsis.<sup>28</sup>

## Trauma

Trauma in pregnancy has generally been approached from the viewpoint of recognizing the changes in maternal physiology and anatomy, and their impact on investigation and management. This includes the potential for different injury patterns and hidden injuries. In addition, the need to exclude fetomaternal hemorrhage, assess for fetal well-being and consider imminent delivery is emphasized.<sup>70</sup> Robust evidence for specific fluid and other resuscitation protocols in pregnant women is lacking.

Fluid resuscitation for hypovolemia in trauma is generally suggested to follow that in the non-pregnant woman (with lateral displacement of the uterus to avoid aortocaval compression). Excessive use of crystalloid fluids should not occur,<sup>4</sup> and blood and blood products should be administered<sup>5,70</sup> early.

## PRACTICE RECOMMENDATIONS

### Practice points regarding fluid management in hypertensive disorders of pregnancy

- Multisystem disorder with multiple organ systems affected.
- Preservation of uteroplacental flow is vital in the antepartum period.
- Intravenous fluid may worsen hypertension (and its sequelae).
- Maternal circulatory dynamics are altered.
- There may be significant maternal cardiac effects to consider.
- Echocardiography may help guide therapy.
- These women are very prone to volume overload and pulmonary edema.
- Renal failure may be prominent, exacerbating volume overload and hypertension.
- Minimizing intravenous fluid volumes is recommended.
- Senior obstetrician input should occur early regarding delivery.
- Hypertensive disorders may first manifest in the postpartum period.

### Practice points regarding fluid management in sepsis

- An initial fluid bolus should be administered promptly to restore circulating volume and cardiac output/blood pressure.
- An isotonic crystalloid is recommended as first line.
- Initial bolus should be approximately 20 ml/kg up to a suggested maximum of 2 L.
- Depending on the situation and environment, a second bolus may be indicated but strong consideration should be given to early vasopressor support.
- Excessive fluid administration and ongoing positive fluid balances may be harmful.
- Cultures/antibiotics and source control should all occur as early as practically possible, alongside resuscitative measures.
- Assessment of fetal well-being should form part of the early management.



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