WHAT FLUIDS AND WHEN

Fluid and Electrolytes Balance

- Pregnancy
- Labor
- Pathological processes during pregnancy

Fluid and Electrolytes Balance – Non pregnant woman

Water homeostasis is a delicate balance between

- Intake regulation by central nervous system
- Output control by Kidneys.

Intake regulation by central nervous system

- Neurosecretory neurones Supra optic & para ventricular nuclei of hypothalamus release vasopressin and oxytocin into the neurohypophysis.
- The activity of vasopressin – arginine system is regulated by plasma osmorality and hypotension
- The receptors of glomerulus,collecting ducts in renal paranchyma respond differently to V-1 and V-2 receptors and regulate osmorality.

Physiological alterations during pregnancy-water

- Fall in plasma osmolarity of approximately 10 mOsm / kg is due to resetting of threshold of arginine-vasopressin system
- Accumulation of 6.5 liters of water
- These changes are noticeable by first trimester.
- What triggers this resetting is not known.
- Studies in well-nourished term women suggest that maternal body water, rather than fat, contributes more significantly to infant birth weight

Physiological alterations during pregnancy – electrolytes – Na & K

- 1000 mEq. Of sodium and 300 mEq. Of Potasium are retained.
- Glomerular filtration and tubular reabsorption – both increase.
- Plasma levels remain at the lower level of normal range.

Physiological alterations during pregnancy – electrolytes –Ca & Mg

- Total serum calcium levels decline due to lowered plasma albumin concentration and, in turn, the consequent decrease in the amount bound to protein.
- The levels of serum ionized calcium, however, remain unchanged
- Serum magnesium levels decline during pregnancy.
- Pregnancy is actually a state of extracellular magnesium depletion.
- Both total and ionized magnesium were significantly lower during normal pregnancy.
- Serum phosphate levels are within the non pregnant range. The renal threshold for inorganic phosphate excretion is elevated in pregnancy due to increased calcitonin .

Fluid and electrolyte management during labor

- Labor is like running a marathon or a grand prix!!

Fluid and electrolyte management during labor - Oral Intake:

- Traditionally, solid food is withheld during active labor and delivery because gastric emptying time is remarkably prolonged once labor is established
- According to the American Academy of Pediatrics and the American College of Obstetricians and Gynecologists (2002), sips of clear liquids, occasional ice chips, and lip moisturizers are permitted.

Fluid and electrolyte management during labor – parenteral fluids

- With longer labors, the administration of glucose, sodium and water to the otherwise fasting woman at the rate of 60 to 120 ml/hr prevents dehydration and acidosis.
- Garite and colleagues (2000) randomly assigned 195 women in labor to receive either 125 or 250 mL/hr of Lactated Ringer or isotonic sodium chloride solution. The mean volume of total intra venous fluid was 2008 mL in the 125 mL/hr group and 2487 mL in the 250 mL/hr group. Labor lasted more than 12 hours in significantly more (26 versus 13 percent) of the women given a 125 mL/hr infusion compared with those given 250 mL/hr.

Fluid ingestion orally by parturient mother and likelihood of developing hyponatremia.

- Hyponatraemia was found in 16 (26%) of the 61 mothers who received more than 2500 ml of fluid during labour. Two-thirds of fluids were orally ingested.
- Decrease in plasma sodium concentration during labour correlated with duration of labour and the total fluid volume administered.
- Hyponatraemia was significantly correlated with fluid volume ($P < 0.001$) but not with oxytocin administration or epidural analgesia.

Hyponatremia

- Hyponatraemia is not uncommon following labour. Tolerance to a water load is diminished during labour; therefore, even moderate fluid volumes may cause hyponatraemia. Women should not be encouraged to drink excessively during labour. Oral fluids, when permitted, should be recorded, and intravenous administration of hypotonic fluids should be avoided. When abundant drinking is unrecognised or intravenous fluid administration liberal, life-threatening hyponatraemia may develop. The possibility that hyponatraemia may influence uterine contractility merits further investigation.

Hazards of hyponatremia

- Hyponatraemia correlated significantly with prolonged second stage of labour, instrumental delivery, and emergency caesarean section for failure to progress
- Maternal hyponatraemia can also be reflected in the fetus, and some studies have reported increased incidence of respiratory distress and hyperbilirubinaemia in hyponatraemic infants.

Fluid and electrolyte changes in post partum and puerperium

- Loss of 2 to 3 liters of fluid especially water takes place within one week post partum. There is a reduction of 2 liters of sodium space during first week post partum. These reductions are chiefly in extra cellular compartment because, serum levels are minimally altered, if at all.

fluid and electrolytes balance for Anemic patient

- It is interesting to note that even in moderately severe anemic patients who does not have cardio – pulmonary – renal decompensation will not require any special modification of management for fluid and electrolytes.

Fluid and electrolytes during surgery in regional anesthesia

- Regional anesthesia leads to peripheral enlargement of vascular compartment and need to be rapidly filled to avoid dangerous hypotension due to pooling of blood in periphery.
- The randomized controlled trial have demonstrated that infusion of crystalloids at the rate of 30ml/kg/hour. Will result in minimum incidence of hypotension.

Fluid and Electrolytes in Hemorrhage and hemorragic shock.

- One need not transfuse blood or blood product till one estimates the loss around 10% of blood volume, in healthy patient.
- The evidence based guidelines for resuscitative measures recommend replacement by ringer lactate till red blood cells are available.
- Colloids or “volume expanders” are not recommended.

Fluid and electrolyte changes in Pre eclampsia

- Patient with pre-eclampsia is often in positive fluid balance on calculation of total body fluid, and the excess fluid is mainly in the interstitial space due to salt retention, low oncotic pressure, and increased capillary permeability. In marked contrast, the plasma volume is usually reduced and there is hemoconcentration

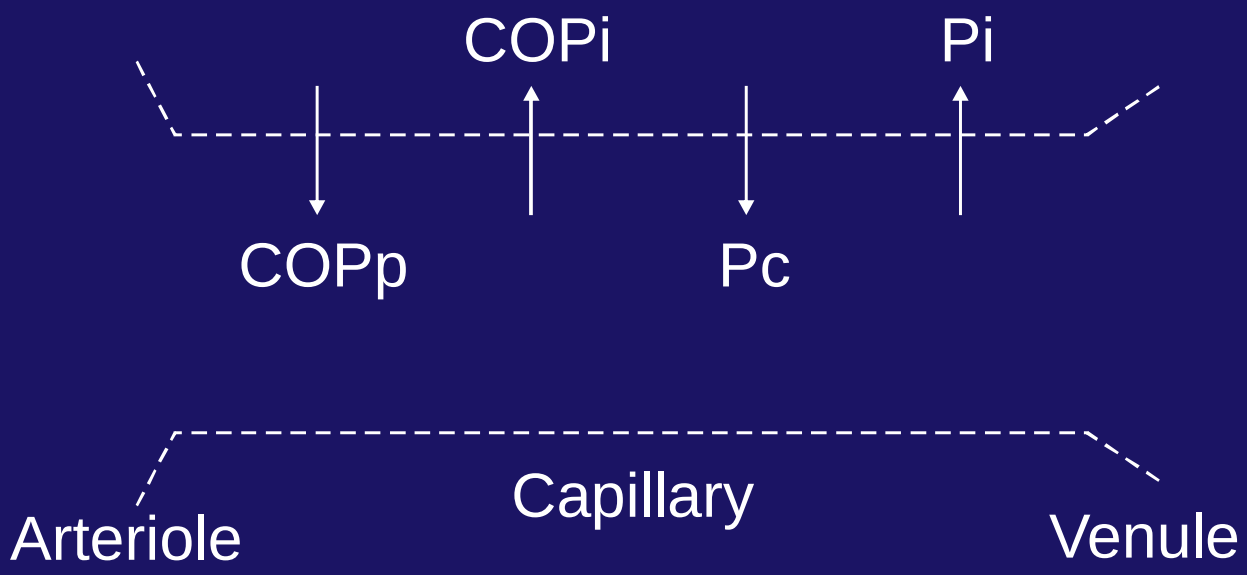

Fig. 1 Transcapillary fluid dynamics. COPp, plasma colloid osmotic pressure; COPi, interstitial colloid osmotic pressure; Pc, capillary hydrostatic pressure; and Pi, interstitial hydrostatic pressure.

The main goals of these management protocols are:

- To prevent renal complications
- To prevent pulmonary complications
- To provide best environment for the mother and the fetus.

Circulatory dynamics in pre-eclampsia

- As a consequence of arterial vasospasm, the mean arterial pressure and SVR are usually high.
- Pulmonary vascular resistance is usually normal and pulmonary artery pressures (PAPs) may be low, particularly in the presence of severe vascular depletion.
- normal heart rate and cardiac output for pregnancy. The ventricular function is usually hyperdynamic but a minority have depressed left ventricular function associated with severely elevated systemic vascular resistance (SVR).
- The central venous pressure (CVP) is usually normal in pre-eclampsia and therefore is not a reliable measurement of of blood volume.
- It does not correlate well with pulmonary capillary wedge pressure, due to differential responses of pulmonary and systemic vascular systems. The pulmonary capillary wedge pressures (PCWPs) may be low, normal or high but it is usually low normal reflecting intravascular volume depletion. PCWP is a poor guide to cardiac output therefore.

Renal Pathology in Pre-eclampsia

- Reduced renal blood flow secondary to reduced circulating volume (pre-renal component)
- Afferent arteriolar vasoconstriction and glomerular damage secondary to deposition of fibrinogen degradation products in the capillary bed (intrinsic renal components).
- There may also be a small effect from ureteric compression in late labor (post-renal component).
- In women who suffer placental abruption and severe hypovolaemia, acute tubular necrosis may also develop (intrinsic renal component).

- The alteration in renal function affects both water homeostasis (oliguria / anuria) and the ability to excrete metabolites (decreased creatinine clearance).
- These two often run hand-in-hand but it is common to have a degree of dissociation;
  - oliguria with no alteration in intrinsic renal function (creatinine clearance).
  - A good fluid output being maintained despite a marked increase in serum creatinine levels. This is an important observation with reference to fluid management;

- It is also crucial to understand that oliguria does not necessarily indicate severe volume depletion, particularly around the time of delivery.
- It may be a reflection of sever glomerular damage , the progress of which will not be modulated by fluid challenge, but more often it is simply the response to physiological stress (mediated through arginine vasopressin release from posterior pituitary).
- An unpublished study of hourly urine production rates after cesarean section in normal woman undertaken in Bristol found a high rate of oliguria. It should also be borne in mind that urine flow is also reduced at night (again AVP-mediated nocturnal oliguria).
- Against this, it must be recognized that acute renal failure is extremely rare in the absence of HELLP syndrome and placental abruption.

Pulmonary Oedema

- 70% of cases of pulmonary edema present between 16 to 72 h following delivery
- Threshold of Pulmonary capillary wedge pressure at which pulmonary oedema develops appears to be lower in pregnancy than in non-pregnant adults
- Altered capillary permeability associated with pre-eclampsia causes a non-cardiogenic from a pulmonary oedema, similar to adult respiratory distress syndrome (ARDS).

- Pulmonary oedema can arise spontaneously in pre-eclampsia (without the infusion of fluids)
- Analysis of cases by Lehmann and co-researchers in the 1980s indicates that it is highly probable that the chance of pulmonary oedema is increased by excessive intravenous fluid infusion. It may also be made more likely by pre-existing cardiac disease and certain medication such as β-mimetic tocolytics.
- There were also concerns that labetalol therapy increased the risk of pulmonary oedema but recent studies concluded that it is the severity of the disease process rather than the use of labetalol *per se*.

MANAGEMENT OF FLUID BALANCE IN PRE-ECLAMPSIA -Preventing problems

- Perhaps the most important intervention is timely delivery, both in terms of decision making and decision to delivery interval.
- One study has shown that expectant antepartum management for preterm disease improves neonatal outcomes but increases the chances of maternal complications.

Prevention of renal dysfunction, fluid imbalance and pulmonary oedema

- Timely delivery
- Strict fluid balance including hourly urometry
- Avoid sharp falls in blood pressure (sublingual nifedipine and bolus i.v. oxytocin)*
- Avoid simultaneous pharmacological interventions
- Avoid β-mimetic tocolysis
- Avoid ergometrine@
- Replace sudden blood losses promptly but carefully
- Avoid non steroidal anti-inflammatory agents

* Includes combining epidural anesthesia and anti-hypertensive agents. @ Widely known for hypertensive effect – also increases PCWP by 35%

- Avoid Non-steroidal anti-inflammatory agents. These can induce sudden anuria in susceptible patients.
- Sudden large losses of blood should be replaced promptly and acute hypovolaemia avoided. Women with pre-eclampsia who lack the normal hypervolaemia of pregnancy are much less tolerant of blood loss at delivery.
- A loss of grater than 500 ml and / or that which causes tachycardia should be taken seriously.

- Rapid or vigorous treatment of hypertension, particularly with vasodilators like sublingual nifedepine or bolus of hydralazine can lead to collapse requiring fluid resuscitation. This fluid can be later displaced into interstitial tissues as vasodilatation reverses and blood pressure rises. This also applies to intravenous bolus doses of oxytocin (10 IU or more) which promote vasodilatation;Oxytocin infusion are preferred if large doses are needed. Tocolysis with β-adrenergic agents is also contra-indicated because of the risk of precipitating non-cardiogenic pulmonary oedema.

Monitoring - Clinical

- Pre-eclamsia is an unpredictable condition, particularly postpartum and high dependency care is advised for all women regardless of (apparent) severity
- Regular review of symptoms together with frequent cardiovascular and respiratory measurements (pulse, blood pressure and respiratory rate as well as temperature and oxygen saturation using a digital transcutaneous oximetry, hourly urine output).

Monitoring - Invasive

- Indications: Refractory hypertension, refractory pulmonary oedema, and refractory severe oliguria in presence of HELLP syndrome, severe haemorrhage, and multi organ failure.

CVP monitoring

- The central venous pressure (CVP) indicates preload to the right side of the heart and is a (rough) guide to circulating blood volume; underfill and overfill.
- CVP monitoring is often used to guide fluid management and monitor fluid administration, during haemorrhage for example.
- In pre-eclampsia lower reading of CVP should be expected and 0-5 mmHg suggests full vascular compartment; pulmonary oedema can develop at lower pressure because of increased capillary permeability. The CVP response to fluid infusion is probably of more value than the absolute level of a single reading (**Fig-2)**.

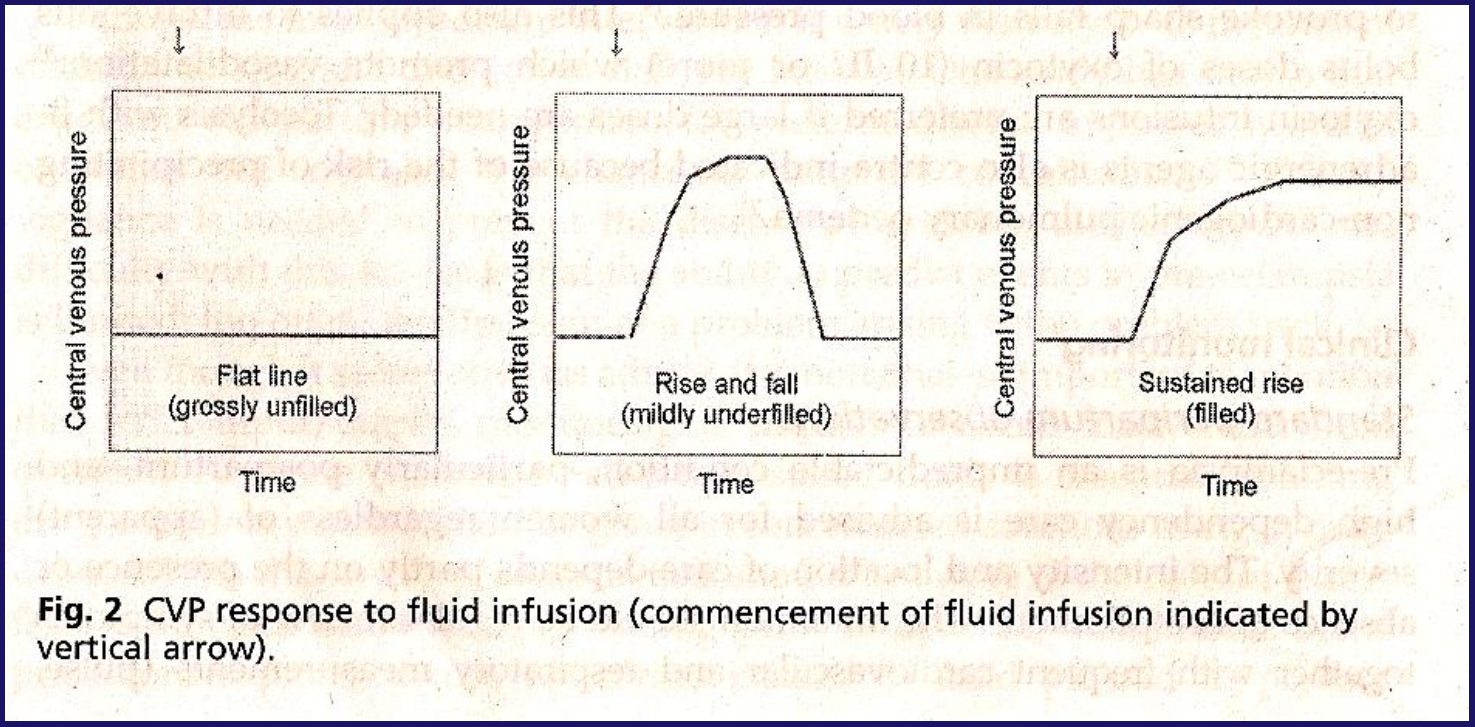

Fig. 2 CVP response to fluid infusion (commencement of fluid infusion indicated by vertical arrow).

Swan-Ganz or CVP ?

- An alternative to CVP measurement is the pulmonary artery or Swan-Ganz catheter (SGC) to aid assessment of cardiac function.
- The SGC is a better means of monitoring aggressive fluid replacement and vasoactive drug therapy than isolated CVP measurement in pre-eclampsia.
- It is true that in sever pre-eclampsia there is more discrepancy between CVP and pulmonary artery pressure dynamics.
- It is associated with a high rate of serious complications reported in 3-24% of cases. These adverse events include fatal cardiac arrhythmias, thrombo-embolism, pulmonary infarction, sepsis and pneumothorax.
- Moreover, a recently published trial of SGC use in a general ITU showed no evidence of benefit. As there are no studies that demonstrate any benefit from SGC monitoring in pre-eclampsia their use is not advised as a routine for severe oliguria, if at all.

Intravenous Fluid Therapy
Crystalloid or colloid?

- Because serum oncotic protein levels are low, many advocate the use of colloid infusions (synthetic products or human albumin solutions). These do initially increase the colloid osmotic pressure. In contrast, crystalloid solutions dilute the oncotic protein and reduce COPp.
- A recent study found that the elimination and distribution of crystalloid fluid is faster in women with pre-eclampsia than with matched controls.
- Although this hypothesis probably holds true in the short term, colloid will also move across the capillary membrane into the interstitial causing a rise in COPi and drawing more fluid into the interstitial tissues.
- There is no evidence to suggest that use of colloid fluid improves clinical outcome in pre-eclampsia. So crystalloids remain the most commonly used fluid in practice.[41]

Crystalloid or colloid?

- A randomized, controlled trial of colloid and crystalloid infusion in critically ill patients (non-gestational cases) used all-cause mortality rates to compare outcome. No benefit was found.
- The recent SAFE trial comparing use of human albumin versus saline solution in intensive care found that there were similar outcomes in both groups.
- A systematic Cochrane review went further and stated that mortality was increased with use of albumin in critical care situations.
- A recent Cochrane review of use of plasma volume expansion with colloid for the antenatal treatment of pre-eclampsia concluded that there was insufficient evidence to determine the effects.
- In the absence of any proven benefit, with reason to believe it might be harmful, and because its cost is much greater, we advise that colloid should be avoided in favor of crystalloid solution.

Ringer Lactate solution or normal saline?

- Reid and colleagues compared the effects of a 1-h infusion of 2 L normal (0.9%) saline with 2 L Hartmann's solution (Composition of which is similar to Ringer Lactate solution) in healthy, non-pregnant subjects. They found that plasma volume expansion is greater and more sustained with normal saline than with Hartmann's solution. However, those subjects infused with Hartmann's solution developed their diuresis more quickly and to a greater degree (1000ml. over 6 h compared with 450 ml). These data suggest that Hartmann's solution might be more suitable for women with pre-eclampsia but specific research would be necessary to confirm this.

Sliding scale insulin infusion

- In women with diabetes mellitus who are on a sliding scale insulin regimen, care should be taken with infusion of dextrose solution as these become simple water after metabolism of the glucose. Consideration should be given to use of 10% solutions at half rate so as to limit the water load which will distribute to all tissues.

Standard fluid volume regimen

- The crux is to avoid renal failure and to prevent pulmonary edema.
- Aggressive volume expansion → unacceptably high rate of pulmonary oedema,
- no comparative trial data to determine which practice is best. However, Cunningham and Pritchard have reported that conservative fluid management of a series of 245 women with eclampsia (not pre-eclampsia) resulted in no cases of renal failure. Cunningham later confirmed this result on 400 patients and wrote:
- “For these reasons, until it is understood how to contain more fluid within the intravascular compartment and at the same time less fluid outside the intravascular compartment, we remain convinced that, in the absence of marked fluid loss, fluid can be administered safely only in moderation.” This information strongly supports restricted fluid replacement for those with oliguria in the absence of HELLP syndrome.

How conservative is "Conservative"?

- The precise nature of a conservative fluid regimen varies from unit to unit. Some employ a simple formula such as a maximum of 2.5 L in 24 h or 1 ml/kg/h, whereas others prefer to calculate the rate as previous hour's urinary output plus 40 ml, or 1ml/kg/h. Once a patient is able to tolerate oral intake, it is sensible to allow free oral fluids and decrease intravenous fluids steadily in line with this.

Table: 2 Options for management of Oliguria

Diagnosis – full clinical and biochemical review

- Check urinary catheter
- Look for evidence of sepsis and haemorrhage (and correct)
- Test for HELLP syndrome

Treatment of moderate oliguria in absence of HELLP syndrome

- Reduce magnesium sulphate infusion (to avoid toxicity)
- Maintain close observation
- Continue to infuse crystalloid fluid slowly (1 ml/kg/h of Hartmann's solution)
- Monitor for pulmonary oedema

Treatment of severe oliguria in presence of HELLP syndrome*

- Either continue with expectant management
- Or measure central venous pressure
- Underfilled – consider fluid infusion ± furosemide infusion
- Filled or overfilled – consider low dose dopamine infusion

*Insufficient data to determine best practice.

Management of Oliguria (Table 2)
Diagnosis

- The first consideration is the cause of the reduced output. It should not be assumed automatically that it is exclusively the result of the pre-eclamptic process. Often it is simply physiological oliguria and, in the case of sudden onset anuria it may be nothing more than blockage of the urinary catheter. More rarely, it might reflect occult haemorrhage or sepsis and these require specific therapy. In some cases, it will be a sign of worsening pre-eclampsia and the patient should be completely reviewed including a repeat blood screen to test for HELLP syndrome.

Magnesium Sulphate

- Because magnesium is cleared almost exclusively by renal clearance, infusions of magnesium should be reduced by half if oliguria develops to avoid toxic accumulation in blood.
- The effects of magnesium on fluid dynamics also deserve special consideration. It has been shown to promote a natriuresis in pregnant women with essential hypertension, but in the context of tocolysis, magnesium therapy was found to be associated with a risk of pulmonary oedema.

Management of Low-risk cases

- Given that renal failure is very rare in the absence of HELLP, sepsis or haemorrhage, there is much to be said for an expectant approach for those with moderate oliguria;
- How long to maintain a conservative approach is another important question. Some advocate action after 6 h or so, but other choose not to act unless a complication or severe oliguria intervenes. In the absence of evidence of benefit and with the knowledge of risk of pulmonary oedema, expectant management is continued for moderate oliguria.

Management of high risk cases

- For those women who develop sever oliguria / anuria in the presence of HELLP, sepsis or haemorrahage, the risk of renal failure is much greater.
- Although it seems logical to conclude that improved outcome from an interventionist approach with HELLP syndrome is more likely, the balance between benefit and harm has not been demonstrated clinically. Controlled studies have shown that treatment with either continuous furosemide or renal dose dopamine infusion will promote a diuresis,but all cause morbidity and mortality rates have not been reported yet.
- If intervention is contemplated, the first step is to measure CVP and decide action according to the degree of vascular filling

CVP indicates grossly underfilled vascular compartment

- A pre-renal effect is then the most likely component and more fluid should be given alone in the first instance (250 ml of Hartmann's solution over 30 min – see **fig. – 2**). This will be followed by a diuresis in about 25% of women but it is not clear whether this is cause or co-incidence. Next, a furosemide infusion (5 mg/h) can be used if there is no response. Most will respond to this. If the response is great (> 200 ml/h), it is important to replace the fluid to avoid volume depletion.

CVP indicates filled vascular compartment

- If the vascular compartment is filled, then an intrinsic renal component is more likely (afferent arteriolar spasm or glomerular capillary damage). Dopamine administration (3 µg/kg/min) with fluid restriction is then a more logical approach as this will treat any arteriolar vasoconstriction (but not glomerular capillary damage).
- Mantel and colleagues were able to triple the urine output to > 50 ml/h without any deterioration in pulse or blood pressure.

Conclusion:

- Pregnancy and various pathological processes alter the fluid and electrolyte balance significantly.
- Proper management needs multi specialty team with timely intervention for delivery.
- Several areas are still grey and evidence based management is not yet agreed upon.