IV Fluids
Do you know what you are doing?

Probably not
Intravenous fluid therapy

Intravenous fluid therapy in adults in hospital
Drowning in the brine of an inadequate knowledge base

(Lobo et al Clinical Nutrition 2001;20:125-130)

Telephone survey 100 HOs in 25 DGH & Teaching Hospitals:

HOs did 89% the fluid and electrolyte prescribing

27% did not know minimum urine 24h output

76% did not know Na & Cl content of 0.9% saline

82% did not know Na\(^+\) daily requirements

98% did not know Na & Cl content of gelofusine

26% prescribed > 2L 0.9% saline/day (4 x normal requirement)
Claude Bernard (1813-1878)

‘La fixité du milieu intérieur est la condition de la vie libre;’

Preservation of cellular environment

Fluid and electrolyte homeostasis

Sea Water

Na$^+$ 133 mmol/L
K$^+$ 2.8 mmol/L
Cl$^-$ 92 mmol/L
Ca$^{++}$ 2.9 mmol/L
Perhaps, due to the fact that our physiology has evolved in an environment with wide variations in water availability but a relative paucity of salt, the response to a low sodium intake is both rapid and efficient.

In contrast, we have not been exposed to excessive salt intake or infusion until recent times, so that the response to sodium excess is sluggish and even normal subjects are slow to excrete an excess sodium load.
**Effects of 2000 mL acute fluid loading in 10 volunteers. Blind cross over trial**

(Lobo et al. Br J Surg 2001)

<table>
<thead>
<tr>
<th></th>
<th>2 L Saline</th>
<th>2L Dextrose</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mins to 1st micturition</td>
<td>212</td>
<td>78</td>
<td>0.002</td>
</tr>
<tr>
<td>Micturitions over 6 hrs</td>
<td>1.7</td>
<td>3.4</td>
<td>0.002</td>
</tr>
<tr>
<td>Post iv 6h urine vol</td>
<td>563</td>
<td>1663</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Urine K mmol/6hrs</td>
<td>37</td>
<td>10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pooled urine osmol</td>
<td>630</td>
<td>129</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Effects of 2000 mL acute fluid loading in 10 volunteers. Blind cross over trial (Lobo et al Br J Surg 2001)
Effects of 2000 mL acute fluid loading in 10 volunteers. Blind cross over trial (Lobo et al Br J Surg 2001)

Serum chloride following 2L Saline or Dextrose in normal subjects

- **Saline**
- **Dextrose**

<table>
<thead>
<tr>
<th>Hours</th>
<th>Serum chloride mmol/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>102</td>
</tr>
<tr>
<td>2</td>
<td>98</td>
</tr>
<tr>
<td>3</td>
<td>102</td>
</tr>
<tr>
<td>4</td>
<td>104</td>
</tr>
<tr>
<td>5</td>
<td>106</td>
</tr>
<tr>
<td>6</td>
<td>108</td>
</tr>
</tbody>
</table>
Chloride-Dependent Vasoconstriction

- Critical range of vasoconstriction (50-100%) lies in the physiological Cl⁻ range of 80-110mmol/L

Hansen et al, Hypertension 1998
Factors influencing illness/injury
salt and water retention

- ADH/Renin – angiotensin – aldosterone/Corticosteroids

- Capillary permeability

- Catabolic solute loading individuals with reduced capacity to produce concentrated or dilute urine.

- K depletion
Potassium depletion in illness and injury

- Aldosterone and cortisol

- Catabolic loss of intracellular -ve charge

- GI losses

- Sick-cell pump failure

- Malnutrition +/- refeeding uptake

- Recovery uptake
Iatrogenic salt and water overload

– Lack of junior knowledge and poor senior review

– Large volumes given during anaesthesia/resuscitation for sepsis

– Antibiotics and other drugs with high sodium and fluid content

– Poor fluid balance charts and ‘vicious cycle’

– MEWs
## Fluid and electrolyte balance 24 hr post major surgery

<table>
<thead>
<tr>
<th></th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid</td>
<td>8000 mL</td>
<td>1000 mL Urine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000 mL insensible</td>
</tr>
<tr>
<td>Sodium</td>
<td>1200 mmol</td>
<td>25 mmol</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>600 (catabolism)</td>
<td>400 mmol</td>
</tr>
<tr>
<td>Other</td>
<td>500 mmol</td>
<td>75 mmol</td>
</tr>
<tr>
<td>mOsmoles</td>
<td>3500</td>
<td>500</td>
</tr>
</tbody>
</table>

6000 mL positive fluid balance
3000 mosmoles positive Na balance
Requires 6 litres of urine to clear sodium + N\textsubscript{2}
(500 mosm/L maximum concentration)
Fluid gain on the ITU

- Septic patients on ITU gain as much as 12.5 L of body water during the first two days of resuscitation.

- It will take up to 3 weeks for patients to excrete this excess load.

Iatrogenic salt and water overload – misunderstanding of hyponatraemia

• Water as well as Na retained post-op & in sepsis so dilutional hyponatraemia if given excess glucose or glucose/saline.

• Hyponatraemic oedematous patients have high total body sodium and so prevention/management should be by fluid restriction rather than more Na (difficult when capillary leakage)

• However, must be awareness of genuine high Na loss
Problems of Na, Cl + Fluid Excess

• Left ventricular failure
• Oedema
• Skin breakdown
• Hyperchloraemic acidosis
• Renal perfusion
• GI
  – Ileus especially post op
  – Post op anastamotic and wound dehiscence
  – Post op PN requirement (was 20% - 30% of 120 surgical patients per year)
Iatrogenic salt and water overload: A prospective RCT involving 20 post op surgical patients.

Lobo DN et al. Lancet, May 2002

**CONTROL**
- Standard Fluid Regimen
  - Vol 3L
  - Na\(^+\) 154 mmol
  - K\(^+\) 40-60 mmol
- n=10

**INTERVENTION**
- Restricted Fluid Regimen
  - Vol 2L
  - Na\(^+\) 77mmol
  - K\(^+\) 40-60 mmol
- n=10
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Standard group (n=10)</th>
<th>Restricted group (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>58.9 (55.3–66.7)</td>
<td>62.3 (52.5–67.2)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6 (60%)</td>
<td>8 (80%)</td>
</tr>
<tr>
<td>Female</td>
<td>4 (40%)</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.61 (1.58–1.74)</td>
<td>1.69 (1.56–1.77)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.6 (67.9–74.7)</td>
<td>73.3 (61.8–80.3)</td>
</tr>
<tr>
<td>Body-mass index (kg/m²)</td>
<td>26.4 (24.3–29.6)</td>
<td>23.6 (22.2–27.5)</td>
</tr>
<tr>
<td>Serum creatinine (mmol/L)</td>
<td>73.0 (65.8–83.8)</td>
<td>91.0 (72.8–97.8)</td>
</tr>
<tr>
<td>Blood urea (mmol/L)</td>
<td>5.4 (4.2–6.3)</td>
<td>5.5 (4.1–5.8)</td>
</tr>
<tr>
<td>Serum albumin (g/L)</td>
<td>38.0 (36.8–40.0)</td>
<td>38.5 (36.5–40.3)</td>
</tr>
<tr>
<td>Serum osmolality (mOsm/kg)</td>
<td>292 (290–295)</td>
<td>292 (288–295)</td>
</tr>
<tr>
<td>Haemoglobin (g/L)</td>
<td>136 (123–153)</td>
<td>134 (123–148)</td>
</tr>
<tr>
<td>Consultant surgeon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>4 (40%)</td>
<td>7 (70%)</td>
</tr>
<tr>
<td>B</td>
<td>3 (30%)</td>
<td>1 (10%)</td>
</tr>
<tr>
<td>C</td>
<td>3 (30%)</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Type of operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hemicolecotmy</td>
<td>2 (20%)</td>
<td>3 (30%)</td>
</tr>
<tr>
<td>Left hemicolecotmy</td>
<td>1 (10%)</td>
<td>1 (10%)</td>
</tr>
<tr>
<td>Sigmoid colectomy</td>
<td>7 (70%)</td>
<td>6 (60%)</td>
</tr>
</tbody>
</table>

Values are median (IQR) or number (%).

Table 1: Baseline patients' characteristics
<table>
<thead>
<tr>
<th>Endpoints</th>
<th>Standard group (n=10)</th>
<th>Restricted group (n=10)</th>
<th>Difference (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day on which flatus first passed</td>
<td>4.0 (4.0–5.0)</td>
<td>3.0 (2.0–3.0)</td>
<td>2 (1–2)</td>
<td>0.001</td>
</tr>
<tr>
<td>Day on which stool first passed</td>
<td>6.5 (5.8–8.0)</td>
<td>4.0 (3.0–4.0)</td>
<td>3 (2–4)</td>
<td>0.001</td>
</tr>
<tr>
<td>Day on which intravenous infusion</td>
<td>6.0 (4.8–6.3)</td>
<td>4.0 (3.8–4.0)</td>
<td>2 (1–3)</td>
<td>0.001</td>
</tr>
<tr>
<td>discontinued</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day on which solid food intake</td>
<td>6.5 (5.5–7.0)</td>
<td>4.0 (4.0–4.3)</td>
<td>2 (1–3)</td>
<td>0.002</td>
</tr>
<tr>
<td>resumed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative hospital stay (days)</td>
<td>9.0 (7.8–14.3)</td>
<td>6.0 (5.0–7.0)</td>
<td>3 (1–8)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Values are median (IQR). Mann Whitney U test applied.

Table 3: Secondary endpoints
Saturday afternoon:

- 85 yr old woman found in bed in morning by daughter. Usually lives alone. Last spoke on Wednesday.
- No other Hx available. No known PMH but ‘takes water tablet’

**OE**

- T 38C, P95AF, BP 100/60, JVP low, poor capillary refill, skin turgor decreased, HS normal, chest clear, abdo soft.
- WBC 13.6, Na 132, K 4.7, Cr 198, Ur 13.2, Urine dipstick protein ++, CXR normal, ECG normal. Urine and blood to micro

**Diagnosis** – Probable UTI. Admitted AMU.

**Rx** – Antibiotics, IV fluids – 2L N Saline over 4 hrs each

Transferred to ward Saturday evening
Monday a.m ward round

- Patient very SOB
- JVP raised, P115, BP105/70, HS – psm + gallop
- Crackles to mid zone
- LVF

Review of IVs and fluid balance:
- 2 L saline from AMU – Saturday
- 1L saline + 2L dextrose prescribed 01.00 Sunday
- 1L saline prescribed 02.00 Monday (bag empty)

Catheter inserted Saturday night after arrival on ward 450 ml Sunday + 300 ml


Patient weight approx 52 kg

Given diuretics
Thursday a.m ward round

- Patient very SOB
- Pyrexial, p 130AF
- Course generalized crackles
- Pneumonia in CXR
- Admitted to ITU

Following Monday
- Deteriorating with multi-organ failure

Thursday
- Dies
Guidance needed for medical staff in general ward settings rather than ITU, inotropes, intra-operative.
Guidance specifically excluded blood transfusion, severe liver/renal disease, diabetes, burns, pregnancy or traumatic brain injury.
Wanted – volunteers for randomized, placebo controlled trial

Patients with an undoubted need for fluid support cannot be randomized
Problems with IV fluids
evidence for ward settings

Historical drivers of customary usage

Trials in heterogenous groups which vary type, volume and timing of fluid with varied outcome measures (compared to drug trials)

No immediate resuscitation trials so reliance on ITU trials (delayed intervention +/- inotropes) and anaesthetic/surgical hypovolaemia
Key recommendations:

All IV fluid prescribers should understand the principles of fluid balance in health and disease

All hospitals should organize appropriate training

Monitor adverse, IV fluid related events

Standardised approach to prescribing
The 5Rs are a cornerstone of the guideline and a recommended change in practice, as described in section 1; these five concepts should form the basis of fluid therapy protocols and IV fluid management plans.
4.2.1 Algorithms for IV fluid therapy

Algorithm 1: Assessment

Does the patient need fluid resuscitation?
- Assess volume status taking into account clinical examination, trends and context. Possible indicators include: systolic BP<100mmHg; capillary refill >2s and peripheries are cold to touch; heart rate >90bpm; respiratory rate >20 per min; NEWS >5/6; 45" passive leg raising test positive

Yes

Algorithm 2: Reassessing

Initiate treatment
- Give high-flow oxygen.
- Secure large bore IV access.
- Identify cause of deficit and respond.

Give a fluid bolus of 500 ml of crystalloid

Does the patient have complex fluid or electrolyte replacement or abnormal distribution issues?
- Look for: existing deficits or excesses, ongoing losses, abnormal distribution or other complex issues.

Yes

Algorithm 3: Routine Maintenance

Give maintenance IV fluids
- Normal daily fluid and electrolyte requirements:
  - 25-30 ml/kg/24h
  - 1 mmol/kg/day sodium, potassium, chloride
  - 50-100 g/day glucose (e.g. glucose 5% contains 5g/100ml)

No

Algorithm 4: Replacement and Redistribution

Are there existing fluid and/or electrolyte deficits or excesses?
- Check for:
  - Dehydration
  - Fluid overload
  - Hyperkalaemia/hypokalaemia

Yes

Are there any ongoing abnormal fluid or electrolyte losses?

Yes

Are there other complex issues?
- Check if allowance required for:
  - Gross oedema
  - Severe sepsis
  - Hypertension
  - Renal, liver and/or cardiac impairment

Yes

Ensure nutrition and fluid needs are met. Refer NICE guidance on Nutrition support.

No

Reassess and monitor the patient
- Stop IV fluids when no longer an appropriate indicator.
- Nasogastric fluids or enteral feeding are preferable when maintenance needs are >3 days

Seek expert help urgently

> 2000 ml given

No

Give a further fluid bolus of 250-600 ml of crystalloid

Yes

No

Evaluate and monitor the patient

Monitor and reassess fluid and biochemical status by clinical and laboratory monitoring

Prescribe for routine maintenance requirement plus additional fluid and electrolyte supplements to replace the 'measured' abnormal 'on-top' losses.

Seek expert help promptly
Algorithms for IV fluid therapy

Algorithm 1: Assessment

Does the patient need fluid resuscitation?
Assess volume status taking into account clinical examination, trends and context. Possible indicators include: systolic BP < 100 mmHg; capillary refill > 2s and peripheries are cold to touch; heart rate > 90 bpm; respiratory rate > 20 per min; NEWS > 6; 45° passive leg raising test positive.

Algorithm 2: Resuscitation

Can the patient meet their fluid and/or electrolyte needs orally or enterally?

Algorithm 3: Routine Maintenance

Algorithm 4: Replacement and Redistribution

Ensure nutrition and fluid needs are met. Refer NICE guidance on Nutrition support.

Assess the patient’s likely fluid and electrolyte needs:
- History: previous fluid intake, abnormal losses, comorbidities.
- Clinical examination: pulse, BP, capillary refill, JVP, oedema (peripheral/ pulmonary), postural hypotension.
- Clinical monitoring: NEWS, fluid balance charts, weight.
- Laboratory assessments: FBC, urea, creatinine and electrolytes.

Does the patient have complex fluid or electrolyte replacement or abnormal distribution issues?
Look for: existing deficits or excesses, ongoing losses, abnormal distribution or other complex issues.
Algorithm 1 - Assessment

Does the patient need fluid resuscitation?

Can the patient meet fluid and electrolyte needs orally or enterally?

Assess fluid and electrolyte needs from Hx, examination, monitoring, lab values

Does patient have replacement of redistribution issues?
Algorithm 2: Resuscitation

Initiate treatment
- Give high-flow oxygen.
- Secure large bore IV access.
- Identify cause of deficit and respond.

Give a fluid bolus of 600 ml of crystalloid

Reassess the patient using the ABCDE approach (Airway, Breathing, Circulation, Disability, Exposure)

Does the patient still need fluid resuscitation?

Yes

Does the patient have signs of shock?

Yes

Assess patient’s likely fluid and electrolyte needs (Algorithm 1, Box 3)

No

No

 >= 2000 ml given

Yes

Seek expert help urgently

No

Give a further fluid bolus of 250-600 ml of crystalloid
NICE review - Fluids for Resuscitation

NICE compared NaCl 0.9%, Ringer’s lactate/acetate, Hartmann’s, gelatins, HES and albumin NOT dextrans or high molecular weight penta- and hexa-starches

Gelatins had no advantage over other colloids or crystalloids

Tetrastarch had no advantage and 3 large ICU studies suggested increased AKI (1 increased mortality)

Albumin 4% had no advantage but decreased mortality in 1 study examining its use in a pre-defined sepsis subgroup

No studies compared colloids in balanced physiological solutions to those in sodium chloride 0.9%.
NICE - Resuscitation Recommendations

If patients need IV fluid resuscitation use crystalloids that contain sodium in the range 130-154 mmol/l, with a bolus of 500 ml over less than 15 minutes

Do not use tetrastach

Consider albumin 4-5% in severe sepsis
Algorithm 3: Routine Maintenance

Give maintenance IV fluids
Normal daily fluid and electrolyte requirements:
- 25–30 ml/kg/d water
- 1 mmol/kg/day sodium, potassium, chloride
- 50–100 g/day glucose (e.g. glucose 5% contains 5g/100ml).

Reassess and monitor the patient
- Stop IV fluids when no longer an appropriate indication.
- Nasogastric fluids or enteral feeding are preferable when maintenance needs are >3 days.
NICE Review - Fluids for Routine Maintenance

No studies simply compared different maintenance fluids

4 RCTs compared ‘restricted’ IV fluid regimens (lower NaCl and less fluid) with ‘standard’ regimens

  2 less mortality and shorter LOS
  2 same mortality with 1 prolonged LOS

BUT ‘restricted’ given fluid 1.5 - 2.5 l/d vs 2.0 - 4.0 l/d
and NaCl 62 - 231 mmols/d vs. to 154 - 231 mmol/d.
NICE recommendation that for routine maintenance

Initial prescription approx: 25–30 ml/kg/day water
1 mmol/kg/day of potassium, sodium and chloride; and 50–100 g/day of glucose.

Can be achieved using 25–30 ml/kg/day of NaCl 0.18% in 4% glucose with 27 mmol/l potassium

Explicitly warned about hyponatraemia (risks small if <2.5 l/d) and these are initial prescriptions with further prescribing to be guided by monitoring.

Do not exceed 30ml/kg/d and give less fluid (e.g. 20–25 ml/kg/day) in elderly/frail, renal impairment, cardiac failure or malnutrition.
Algorithm 4: Replacement and Redistribution

Are there existing fluid and/or electrolyte deficits or excesses?
- Check for:
  - Dehydration
  - Fluid overload
  - Hyperkalaemia/hypokalaemia

Yes

Estimate deficits or excesses and add to or subtract from normal daily maintenance requirements.
- Check for:
  - Vomiting and nasogastric tube loss
  - Billiar drainage loss
  - High/low volume ileal stoma loss
  - Diarrhoeal/colostomy loss
  - Ongoing blood loss e.g. melena
  - Sweating/fever/dehydration
  - Pancreatic/ejunal fistula/stoma loss
  - Urinary loss e.g. post AKI polyuria

Yes

Prescribe for routine maintenance requirement plus additional fluid and electrolyte supplements to replace the ‘measured’ abnormal ‘ongoing’ losses.

No

Are there any ongoing abnormal fluid or electrolyte losses?

No

Are there other complex issues?
- gross oedema
- severe sepsis
- Hyponatraemia/hypernatraemia
- renal, liver and/or cardiac impairment.

Yes

Seek expert help promptly

No

Monitor and reassess fluid and biochemical status by clinical and laboratory monitoring.
Replacement & redistribution

Add or subtract from maintenance estimates to account for existing fluid and/or electrolyte deficits or excesses, ongoing losses or abnormal distribution.

See expert help if patients have complex fluid and/or electrolyte redistribution issues or imbalance, or significant comorbidity e.g. gross oedema, severe sepsis, hypo- or hypernatraemia, renal, liver, cardiac impairment.
Ongoing losses
# Gastrointestinal Secretions

<table>
<thead>
<tr>
<th>Secretion</th>
<th>Na⁺ (mmol/L)</th>
<th>K⁺ (mmol/L)</th>
<th>Cl⁻ (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saliva</td>
<td>40</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Gastric juice</td>
<td>70-120</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Bile</td>
<td>140</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Pancreatic juice</td>
<td>140</td>
<td>5</td>
<td>75</td>
</tr>
<tr>
<td>Small intestine</td>
<td>110-120</td>
<td>5-10</td>
<td>105</td>
</tr>
<tr>
<td>Diarrhoea (adult)</td>
<td>120</td>
<td>15</td>
<td>90</td>
</tr>
<tr>
<td>Sweat</td>
<td>30-70</td>
<td>0-5</td>
<td>30-70</td>
</tr>
</tbody>
</table>
Remember

‘It is very easy to give salt & water to surgical or septic patients but very difficult to remove’

‘Before a patient can recover they must excrete the water, sodium and chloride given during surgery or sepsis’