ACKNOWLEDGEMENTS

This curriculum was developed with technical assistance from the University of Malaya Medical Centre. Materials were contributed by the Ministry of Health, Singapore, the United States Centers for Disease Control and Prevention, and the University of Malaya Medical Centre.

MODULE 8A: IV Fluid Principles
### Factors that change haematocrit levels in dengue

<table>
<thead>
<tr>
<th>Haematocrit levels</th>
<th>Increase</th>
<th>Decrease</th>
<th>NO CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease progression</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment related</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disease + Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Disease factors that change HCT levels

<table>
<thead>
<tr>
<th>Haematocrit levels</th>
<th>Increase</th>
<th>Decrease</th>
<th>NO CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease progression</td>
<td>Plasma leakage</td>
<td>1. Bleeding</td>
<td>Plasma leak + bleeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Reabsorption</td>
<td></td>
</tr>
<tr>
<td>Treatment related</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disease + Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Treatment factors that change HCT levels

<table>
<thead>
<tr>
<th>Hematocrit levels</th>
<th>Increase</th>
<th>Decrease</th>
<th>NO CHANGE</th>
</tr>
</thead>
</table>
| Disease progression | Plasma leakage | 1. Bleeding  
  2. Reabsorption | Plasma leak + bleeding |
| Treatment related | Blood transfusion | IV fluid therapy:  
  Crystalloids  
  Colloids  
  Plasma | |
| Disease + Treatment | | | |
## Disease and treatment factors that change HCT levels

<table>
<thead>
<tr>
<th>Haematocrit levels</th>
<th>Increase</th>
<th>Decrease</th>
<th>NO CHANGE</th>
</tr>
</thead>
</table>
| Disease progression| Plasma leakage                                | 1. Bleeding  
2. Reabsorption | Plasma leak + bleeding         |
| Treatment related  | Blood transfusion                             | IV fluid therapy:  
Crystalloids  
Colloids  
Plasma |                                    |
| Disease + Treatment| Plasma leakage + blood transfusion            | Bleeding + IV fluids          | Plasma leak + IV fluids  
OR  
Bleeding + blood transfusion |
**Haematocrit should not be interpreted on its own**

Haematocrit should always be interpreted in the context of and “in phase” with:

1. **Haemodynamic evaluation** at time of sampling
2. Before or after IV fluid therapy?
3. Before or after transfusion with whole blood or packed cells?
4. Phase of disease, where in the clinical course is the patient: day 2 vs day 5

**IMPORTANT REMINDER:**

Haemodynamic state should be the principal driver of IV fluid therapy

Haematocrit level should only be a guide

NOT the other way around!
Interpretation of rising or persistently high haematocrit

A rising or persistently high haematocrit

**Unstable vital signs**

**Active plasma leakage**

Need for further fluid replacement

A rising or persistently high haematocrit

**Stable haemodynamic status**

**Does not require extra intravenous fluid**

Continue to monitor closely. HCT should start to fall within next 24 hours as plasma leakage stops.
Interpretation of a decrease in haematocrit

A decrease in haematocrit + Unstable vital signs = Major haemorrhage

A decrease in haematocrit + Stable haemodynamic status = Haemodilution and/or reabsorption of extravasated fluids

IV fluids should be reduced in step-wise manner or discontinued immediately to avoid pulmonary oedema
When to start and stop intravenous fluid therapy

Febrile phase

Limit IV fluids (refer to later slides for oral fluid advice)
Early IV therapy may lead to fluid overload especially with non-isotonic IV fluid

Critical phase

IV fluids are usually required for 24–48 hours
NOTE: For patients who present with shock, IV therapy should be <48 hours

Recovery phase

IV fluids should be stopped so that extravasated fluids can be reabsorbed
What type of intravenous fluid therapy should we use?

Use isotonic solutions (normal saline, Ringer’s lactate)

Colloids are preferred if the blood pressure has to be restored urgently (e.g. Group C patients)\(^1,2,3\)

<table>
<thead>
<tr>
<th>Solution</th>
<th>Na</th>
<th>K</th>
<th>Cl</th>
<th>Lactate</th>
<th>Ca</th>
<th>Osm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal saline (NS)</td>
<td>154</td>
<td></td>
<td>154</td>
<td></td>
<td></td>
<td>292</td>
</tr>
<tr>
<td>D5% NS</td>
<td>154</td>
<td></td>
<td>154</td>
<td></td>
<td></td>
<td>565</td>
</tr>
<tr>
<td>Ringer’s lactate</td>
<td>130</td>
<td>4</td>
<td>109</td>
<td>28</td>
<td>3</td>
<td>274</td>
</tr>
<tr>
<td>Hartmann’s solution</td>
<td>131</td>
<td>5</td>
<td>111</td>
<td>29</td>
<td>2</td>
<td>278</td>
</tr>
</tbody>
</table>

\(^1\) Dung NM, Day NP, Tam DT. *Clin Infect Dis*, 1999, 29:787–794;  
What intravenous fluids should not be used?

Hypotonic solution, e.g. 0.45% saline, even during the febrile phase

Dextrose solutions should be limited to avoid hyperglycaemia, but may be used in hypoglycaemia with close blood glucose monitoring

Albumin solutions

Fresh frozen plasma

1Lum LCS et al, J Pediatr 2003;143:682-4
Why isotonic fluids?

1 / 3 of Total Body Water

2 / 3 of Total Body Water

Vascular space – ¼ of ECF

Extracellular

60 to 70% of body weight is water, higher % in young children and lower % in adults and obese persons

Intracellular

What % of body weight is water?

Infusion of Isotonic Fluid

1 liter 0.9 NS → 1 L to ECF → 250 cc (1/4) to vascular space

Infusion of Hypotonic Fluid (low sodium)

1 liter 0.45 NS → 333 cc to ECF → 83 cc (1/12) to vascular space

60 to 70% of body weight is water, higher % in young children and lower % in adults and obese persons

Vascular space – ¼ of ECF

60 to 70% of body weight is water, higher % in young children and lower % in adults and obese persons

Vascular space – ¼ of ECF
What happens in the critical phase?

Fluid shifts – in a capillary leak situation

- **Expanded extracellular fluid (ECF)**
  - Infusion of Hypotonic fluid (low sodium)
    - 1 litre 0.45 NS → 333 cc to ECF → << 83 cc (1/12) to intravascular space

- **Expanded intracellular fluid (ICF)**
  - Infusion of Isotonic fluid
    - 1 litre 0.9 NS → 1 L to ECF → << 250 cc (1/4) to vascular space

**Contracted vascular space**
Colloid therapy in dengue shock

When are colloids given?

• Hypotensive shock\(^1,2,3\)
• Repeated shock – 2nd or 3rd shock and onwards
• After >20 to 30 ml/kg of crystalloids
• HCT does not decrease after crystalloid administration in shock state

**DOSE:** Limited to 30 to 50 ml/kg/day

---

Why use colloid therapy in dengue shock?

EFFECTS
Stays longer in circulation
Faster reduction in HCT\textsuperscript{1-3}
Restores cardiac index faster

NOTE: If NO clinical improvement with reduced HCT, think significant occult bleeding

SIDE-EFFECTS
Allergic reactions
Impair coagulation
Potential renal impairment

HOW MUCH & HOW FAST to run intravenous fluid?

HOW MUCH & HOW FAST?
Give the minimum IVF required to maintain good perfusion and urine output of about 0.5 ml/kg/hr

Volume based on ideal body weight if overweight

Titrate to haemodynamic state and age

What does “titrate IVF rate to haemodynamic state” mean?

Reassess haemodynamic responses immediately after every IV bolus

AFTER correction of shock:
REDUCE IV infusion rate in step-wise manner whenever:
- Haemodynamic state is stable
- Rate of plasma leakage decreases towards end of critical phase indicated by:
  - Improving haemodynamic signs
  - Increasing urine output
  - Adequate oral fluid intake
  - Haematocrit decreases below baseline value in a stable patient
## HOW MUCH & HOW FAST to run intravenous fluid?

<table>
<thead>
<tr>
<th>HOW MUCH &amp; HOW FAST?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adult</strong></td>
</tr>
<tr>
<td>Compensated shock: 5 to 10 ml/kg over one hour</td>
</tr>
<tr>
<td>Hypotensive shock: 10 to 20 ml/kg over 15 to 30 minutes</td>
</tr>
<tr>
<td><strong>Child</strong></td>
</tr>
<tr>
<td>Compensated shock: 10 to 20 ml/kg over 1 hour</td>
</tr>
<tr>
<td>Hypotensive shock: 20 ml/kg over 15 to 30 minutes</td>
</tr>
</tbody>
</table>
When to stop intravenous fluids?

WHEN TO STOP?

Knowing when is critical to dengue management

Step-wise reduce IV infusion rate until it is stopped, same as in earlier slide.

Definite stop:

Features of intravascular compartment overload
  - Hypertension with good volume pulse
  - Breathing difficulties, pulmonary oedema

48 hours after defervescence
Summary of IV fluid therapy in dengue

Inadequate
- Hypovolaemia
- Compensated shock
- Hypotensive shock
  - Bleeding
  - DIC
  - Multi-organ failure

Adequate
- Improved circulation and tissue perfusion
  - Capillary refill <2 seconds
  - Normal heart rate
  - Normal blood pressure
  - Normal pulse pressure
  - Urine 0.5ml/kg/hr
  - ↓ HCT to normal
  - Improving acid-base

Excessive
- Fluid overload:
  - Pulmonary oedema
  - Respiratory distress
  - Worsening pleural effusion and ascites
  - Clinical deterioration
Calculations for normal maintenance of intravenous fluid infusion

Normal IV fluid maintenance per hour by Holliday-Segar formula:

- 4 mL/kg/h for first 10 kg body weight
- + 2 mL/kg/h for next 10 kg body weight
- + 1 mL/kg/h for subsequent kg body weight

For overweight/obese patients, calculations for normal maintenance of IV fluid should be based on ideal body weight (IBW)

(Adapted from WHO 1997)
How to calculate ideal body weight for overweight/obese patients

Ideal body weight (IBW) for overweight/obese adults can be estimated based on the following formula*

**Female:**
45.5 kg + 0.91(height – 152.4 cm) or
45.5 kg + 2.3 kg for each inch over 5 ft

**Male:**
50.0 kg + 0.91(height – 152.4 cm) or
50 kg + 2.3 kg for each inch over 5 ft

Example:
A 90 kg man 5’ 5” tall:

IBW = 50 kg + (2.3 kg x 5) = 61.5 kg

Maintenance fluid = (4 x 10) + (2 x 10) + (1 x 41.5) = 101.5 ml/hr (~2.4 litres/day)

*Gilbert DN, et al 2007*
How to calculate ideal weight for overweight/obese children

There is no consensus on the best method for calculating IBW for children.¹

If a child is overweight or obese (i.e. BMI-for-age ≥85% and ≥95%, respectively) use US growth charts²:

Calculate IBW using Body Mass Index Method:

- [BMI at the 50th percentile for that child's age × (height in metres)^2]

Example:

What is the IBW of a girl who is 4 years old and 105 cm tall?

(BMI at 50th percentile for age/sex is 15.3)²

IBW = 15.3 × 1.05 × 1.05 = 16.9 kg.

## Quick reference table for ideal body weight of obese/overweight adults

<table>
<thead>
<tr>
<th>Height (cm)</th>
<th>Female (kg)</th>
<th>Male (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>45.5</td>
<td>50</td>
</tr>
<tr>
<td>160</td>
<td>52</td>
<td>57</td>
</tr>
<tr>
<td>170</td>
<td>61.5</td>
<td>66</td>
</tr>
<tr>
<td>180</td>
<td>70</td>
<td>75</td>
</tr>
</tbody>
</table>
Quick calculation for normal maintenance regime

For adults with IBW >50 kg:
1.5 to 2 ml/kg/hr

For IBW 50 kg:
2 to 3 ml/kg/hr
## Quick reference for normal maintenance rate of intravenous fluid according to ideal body weight

<table>
<thead>
<tr>
<th>Ideal body weight</th>
<th>Normal maintenance rate of IVF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ml/hour</td>
</tr>
<tr>
<td>70 kg</td>
<td>110</td>
</tr>
<tr>
<td>60 kg</td>
<td>100</td>
</tr>
<tr>
<td>50 kg</td>
<td>90</td>
</tr>
<tr>
<td>40 kg</td>
<td>80</td>
</tr>
<tr>
<td>30 kg</td>
<td>70</td>
</tr>
<tr>
<td>20 kg</td>
<td>60</td>
</tr>
<tr>
<td>10 kg</td>
<td>40</td>
</tr>
</tbody>
</table>