Clinical Guideline

FLUID AND ELECTROLYTE MANAGEMENT OF PAEDIATRIC NEUROSURGICAL PATIENTS AT RISK OF DIABETES INSIPIDUS (DI), SYNDROME OF INAPPROPRIATE ANTI DIURETIC HORMONE (SIADH) AND CEREBRAL SALT WASTING (CSW)

SETTING Bristol Royal Hospital for Children (BRHC)

FOR STAFF All paediatric medical, neurosurgical, pharmacy and nursing staff

PATIENTS All at risk paediatric patients post neurosurgical intervention

- Patients identified pre-operatively at risk of hypothalamo-pituitary dysfunction
- Posterior fossa tumours
- Supra-tentorial tumours
- Traumatic brain injury

GUIDANCE

All paediatric patients post neurosurgical intervention, especially pituitary and suprasellar surgery, and those post traumatic brain injury are at risk of major fluid balance and electrolyte derangements immediately post operatively but that can last up to 7-10 days.

To prevent significant morbidity and mortality ALL these patients need:

1) **Strict fluid balance monitoring to allow early identification of these conditions**
2) **Detailed fluid management plans that reflect changing urine output**
3) **Appropriate steroid cover**

CONTENTS

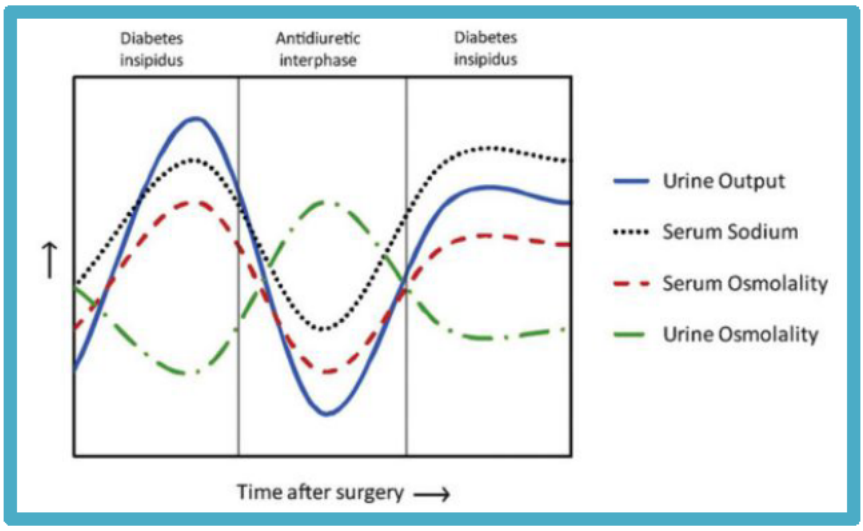
- Nursing SOP

BACKGROUND

Post neurosurgery and traumatic brain injury a classic tri-phasic response in anti-diuretic hormone (ADH) secretion can occur. However, each phase can also occur independently.

- Initial transient phase of diabetes insipidus (DI), due to oedema, manifesting within 24hrs post-op and lasting up to two days.
- Second phase is of either normal fluid regulation or inappropriate ADH secretion (SIADH), presumed secondary to neurosurgical induced vasopressin neuronal necrosis, lasting 1-14 days.
- A third phase of permanent DI can then follow, especially after prolonged and severe SIADH.

Cerebral salt wasting (CSW) can also develop, either as a primary neuronal insult or as a secondary response to SIADH. CSW is due to over secretion of atrial or brain natriuretic peptide causing natriuresis and diuresis. Cerebral salt wasting can rapidly lead to volume depletion and hyponatraemia.



DIFFERENTIATING BETWEEN DI, SIADH, DDAVP EXCESS, CSW

	Diabetes insipidus	SIADH/DDAVP excess	Cerebral salt wasting
Plasma Sodium (Na)	Rising/High	Low	Low
Plasma osmolality	High	Low	Low
Urine output (UO)	High	Low	High
Urine Sodium (Na)	Low/Normal	Normal/High	High
Urine osmolality	Low	High	High
Fluid balance	Negative	Positive	Negative
Fluid status	Depleted with polyuria	Overloaded with concentrated oliguria	Depleted with polyuria

Management	Fluid replacement +/- DDAVP	Fluid restriction	Fluid and Na+ replacement

OVERVIEW FLOWCHART

All patients at risk of fluid and electrolyte imbalance post neurosurgery or traumatic brain injury need
- Initial HDU/PICU care
- Early liaison with paediatric endocrinology team
- Strict fluid balance monitoring charts
- Regular paired plasma and urine electrolytes and osmolalities
- A minimum of daily weights
- Clear and well documented fluid management plan starting immediately post-operatively aiming for a neutral fluid balance plus insensible losses
- Reassessment of their fluid balance status and adjustment of their fluid management plan at least every 6hrs but likely to be needed more frequently initially or if concerns

Euvolaemic State
Plasma Na 132-150
Osmolality normal

Stable biochemistry
Normal urine out-put
Neutral fluid balance (input=output plus insensible losses)

Continue above management plan
Close monitoring for early signs of triphasic response

Hypernatraemic State
Plasma Na >150
Plasma osmolality >300

Concentrated oliguria
Urine out-put <1ml/kg/hr
Fluid challenge 10mls/kg
Consider increasing fluid intake

Dilute polyuria
Urine out-put >5mls/kg/hr for 2 consecutive hrs
1) Possible post op polyuria and mild hypernatraemia (Na <155) secondary to intra-operative fluid type and volumes
2) Possible DI
Fluid management plan (UO + insensible losses)
MUST DISCUSS WITH ENDOCRINE

Hyponatraemic State
Plasma Na < 132
Plasma osmolality <270

Assess urine out-put, fluid balance, volume status, body weight and check urinary Na
DISCUSS WITH ENDOCRINE

Polyuria
(may be masked if severely dehydrated)
Urine Na >70
+/- weight loss
Possible CSW
Fluid and sodium replacement

Oliguria
Urine Na 20-50
+/- weight gain
Possible SIADH
Fluid restrict

ESSENTIAL MONITORING

- **Please involve paediatric endocrinology team before going to theatre and as soon as possible post operatively**
  - Please could the admitting team contact the attending consultant paediatric endocrinologist via switchboard, or the endocrinology registrar on bleep [redacted] (if out of hours, bleep [redacted] if patient on DaisyHDU or bleep [redacted] if on wards)
  - Ensure daily liaison with the endocrinology team with up to date information including:
    - fluid balance, total fluid input and output including urine output (mls/kg/hr)
    - plasma and urine electrolytes and osmolalities
    - current fluid management plan
    - all medication including desmopressin (DDAVP) and any steroids
  - Arrange a joint HDU ward round or telephone consultation with endocrinology consultant in the morning and evening, especially during the early stages

- **Essential monitoring**
  - Initially patients should be monitored on HDU, with low threshold of escalation to PICU if increasing concerns with fluid balance and electrolyte derangements
  - Daily weights (at same time of day)
  - Minimum of four hourly blood pressures
  - At least 3 hourly strict fluid balance (unless directed otherwise)
  - A urinary catheter should be inserted pre/intra op to allow accurate fluid balance monitoring and less disturbance to patient
  - Paired serum and urine electrolytes and osmolality immediately post op with blood gas electrolytes and then
    - Blood gas electrolytes 3hrly (**CAUTION**- at extremes of sodium levels the gas sodium is unreliable therefore also check a lab sample before making a clinical decision to change fluid management plan or give DDAVP)
    - Serum electrolytes 6hrly
    - Daily or twice daily urinary sodium

*__NOTE:__ These are classified as urgent osmolality requests. The laboratory **MUST** be informed prior to sending to ensure sample analysis is prioritised and samples **MUST** be sent in red bags. Laboratory contact numbers are: Normal working hours (Monday – Friday 9:00 -17:30) - Duty Biochemist on ext. [redacted]. Outside of normal working hours - Biomedical Scientist on bleep [redacted]

ENSURE APPROPRIATE STEROID COVER

- **If known cortisol deficiency or cortisol status unknown in at risk patients**:
  - Ensure hydrocortisone 2mg/kg (max 100mg) at induction of anaesthesia followed by an intravenous infusion of hydrocortisone (see table below)
  - When able to take medications orally, transfer to oral hydrocortisone at double the patient's usual oral dose or start hydrocortisone at 30mg/m^2/day in 4 divided doses
  - When the patient is well return to their normal replacement dose or reduce to 8-10mg/m^2/day of hydrocortisone in 4 divided doses
  - Continue post-operatively until review by endocrinology team and formal provocation tests have been performed

Hydrocortisone infusion	**Hydrocortisone 50mg in 50mls diluent (either 5% glucose or 0.9% chloride)**		
Weight (kg)	<10	10-20	>20
Infusion rate (ml/hr)	1	2	3

- **If started on dexamethasone by the neurosurgical team** there is no need for intra-operative hydrocortisone cover but there needs to be a clear plan regarding dose reduction and conversion to hydrocortisone agreed with endocrinology

IMMEDIATE FLUID MANAGEMENT POST-OPERATIVELY

The aim is to keep the child in a neutral fluid balance but allowing for insensible losses of 300-400mls/m^2/day i.e. overall fluid balance should be positive by 300-400mls/m^2/day

This alone allows prompt identification of derangements in fluid balance with early recognition of development of DI, SIADH or CSW and avoids complications of severe dehydration or water overload

- Immediate fluid management should start in recovery and continue when on HDU with hourly fluid calculation and replacement
- If the child cannot drink then up to 4 IV fluids bags should be set up (NB different fluid used for each bags)
  - **1) for replacement of insensible losses**
  - **2) for replacement of urine output (bags 1+2 are essential for all patients)**
  - 3) to correct any fluid deficit
  - 4) to replace any enteric or CSF losses (bags 3+4 are only needed if replacing a fluid deficit or GI/CSF losses only)

- **Fluid balance and assessment should be made hourly in the immediate post operatively period**
  - Fluid calculations should be made using the formula below:

Hourly fluid intake over next 1hr = $\frac{\text{previous 1hrs urine output + 1hrs insensible losses}}{1}$

*1) **Insensible losses***
- are calculated by body surface area (BSA) m^2, see appendix A
- insensible losses are calculated as 300mls/m^2/day (use 400ml/m^2/day for children <1 year) i.e. BSA 0.9 m^2 Insensible losses = 0.9 x300 = 270ml. Hourly rate is 270/24 = 11mls per hour
- replace insensible losses with **plasmalyte + 5% glucose,** unless different fluid specified by neurosurgical/HDU/endocrinology teams or anaesthetist

*2) **Urine output***
- replace urine output with **0.45% sodium chloride + 5% glucose,** unless different fluid specified by neurosurgical/HDU/endocrinology teams or anaesthetist

3) Fluid deficit
- Assess volume status and correct to euvolaemia if required
- If shocked treat shock
- Assess for a fluid deficit e.g. clinical signs of dehydration, fall in weight
- Any deficit may need to be added to the fluid rate over 48 hours
- replace fluid deficit with **plasmalyte + 5% glucose**, unless different fluid specified by neurosurgical/HDU/endocrinology teams or anaesthetist

4) Enteric and/or CSF losses
- Replace any enteric or CSF losses ml for ml every 4 hours, using 500ml bags of **0.9% sodium chloride with 10 or 20mmols of potassium chloride**

- Include any oral fluids, IV flushes and medications in total fluid input

- Initial fluid management plan should be prescribed by anaesthetist in recovery
- Ensure fluid management plan documented in notes and discussed with nursing staff
- Ensure nursing staff aware to do strict fluid balance and to call HDU team (bleep [redacted] in daytime hours or [redacted] out of hours) if urine out-put is >5mls/kg/hr or <1mls/kg/hr for 2 consecutive hours
- The patient should be switched to oral fluids as soon as can be tolerated but need to be continued on the above strategy of fluid replacement
- Any deviation from this initial fluid management plan should be clearly documented in the patient notes with reasons given

ONGOING FLUID MANAGEMENT – to be discussed with endocrine team

- Reassessment at least every 3 hours
  - volume status
  - urine output
  - extra losses
  - fluid balance
  - paired serum and urine osmolality's and electrolytes
- Document new fluid management plan and discuss clearly with nursing staff
- For example if 3hrly reassessment required

Hourly fluid intake over next 3hrs = $\frac{\text{previous 3hrs urine output + 3hrs insensible losses}}{3}$

- Liaise regularly with the paediatric endocrinology team
- Closely monitor for development of DI, SIADH and CSW

REMEMBER that good fluid management alone, keeping the child in a neutral fluid balance plus insensible losses, is a safe and effective treatment of DI, SIADH. DDAVP excess and CSW

IF DIABETES INSIPIDUS SUSPECTED

- **Diagnosis may include:**
  - Polyuria (>5mls/kg/hr for 2 consecutive hours)**,** Hypernatraemia (plasma Na >150mmol/L)**,** Plasma hyper-osmolality (>300mOsmol/kg) with a urine hypo-osmolality (<700mOsmol/kg)
  - **But be aware** that intra-operative fluid overload with subsequent hypo-osmolar polyuria may masquerade as DI in the early post-operative period.
- **Initial management is with continued replacement of fluid losses ml for ml.**
- **DI can be safely managed by careful fluid balance alone without the need for desmopressin (DDAVP). This will allow early recognition of changing urine output that heralds the resolution of transient DI or the development of SIADH**
  - If DI is difficult to manage with careful fluid balance alone or is likely to be permanent in nature, liaise with the endocrine team to establish a plan for judicious administration of DDAVP
  - Consultant advice should be sought before use of DDAVP as inappropriate administration carries the risk of water overload and hyponatraemic convulsions
  - DDAVP can be considered when urine output exceeds 3-4ml/kg/hr for 2 consecutive hours
  - Serum sodium is usually high or normal in DI. If serum sodium <135mmol/L discuss with endocrinology consultant before giving DDAVP
  - **Do NOT give DDAVP if serum sodium is <130mmol/L**
  - If serum sodium >150mmol/L or serum osmolality >300mOsm/kg and no endocrinology consultant is available, DDAVP may need to be started by HDU or PICU consultant
  - A starting guide is: See **appendix B** for desmopressin information

Weight (kg)	Desmopressin (subcutaneously)
<3 kg	0.12 micrograms
3-10 kg	0.3 micrograms
10- 30 kg	0.5 micrograms
> 30 kg	1 microgram

- No further dose to be given until urine output again exceeds at least 3-4ml/kg/hour for 2 consecutive hours or agreed plan with endocrinology team
  - Regular DDAVP should only be prescribed when DI is stable & permanent. This may take 7-10 days post-op to be confirmed
  - The aim is to achieve an appropriate 24hr urine output for the child's age and weight with at least once daily pre-dose breakthrough polyuria to avoid water intoxication
- **Possible complications include DDAVP excess/acute water overload**
  - Strongly positive fluid balance, weight gain and rapidly falling serum sodium levels
  - Treatment is fluid restriction to insensible losses only until weight and serum sodium return to normal
  - Withhold DDAVP until back in neutral fluid balance, normal serum sodium and urine output >3-4mls/kg/hr for 2 consecutive hours

IF SYNDROME OF INAPPROPRIATE ADH (SIADH) SUSPECTED

- **Diagnosis may include**
  - Hyponatraemia with mild urine sodium loss (urine sodium between 20-50 mmol/L)
  - Clinical picture of positive fluid volume
  - Low serum osmolality with inappropriately high urine osmolality (urine to plasma osmolality ratio >1.5)
  - A concentrated oliguria (<1 ml/kg/hour)
  - Changes in body weight may be less sensitive
- **Management includes**
  - Fluid restriction to essentially insensible losses as oliguric but may need to restrict further if sodium dropping <130mmol/L
  - Close monitoring of fluid balance, electrolytes and osmolality
  - Sodium replacement is only required in prolonged SIADH

IF CEREBRAL SALT WASTING (CSW) SUSPECTED

- **Diagnosis may include**
  - Hyponatraemia with natriuresis (urine sodium 10 – 20 times normal - usually >140mmol/L)
  - NB it can be difficult to interpret Urine Sodium if on IV fluids
  - Clinical evidence of volume depletion
  - A low serum osmolality with inappropriately high urine osmolality
  - A polyuria (>5ml/kg/hour). Of note: Severe dehydration will reduce the polyuria, which can be unmasked by saline challenge.
  - High haematocrit and serum urea
- **Management includes**
  - Fluid replacement titrated against urinary losses
  - Sodium supplementation to reflect urinary sodium losses (this may be oral or intravenous supplements).
  - Where DI and CSW co-exist, cautious continuation of DDAVP (higher DDAVP doses increase renal free water re-absorption and aggravate hyponatraemia therefore should be avoided)
  - Close monitoring of fluid balance, electrolytes and osmolality
  - Renal tubular dysfunction and diuretics are other causes of urinary salt loss that require consideration

HYPONATRAEMIA AND HYPERTONIC SODIUM CHLORIDE USE

In rare situations of symptomatic hyponatraemia or severe salt wasting, sodium replacement with 2.7% hypertonic sodium chloride may be required. This should include careful calculations of sodium balance and cautious correction with defined volumes and short infusions. This is beyond the scope of this guideline and should be agreed by PICU, HDU or endocrinology consultants.

CAUTION: RISK OF OSMOTIC DEMYLINATION WITH RAPID CORRECTION OF HYPONATRAEMIA

Clinical Standard Operating Procedure (SOP)
NURSING PAEDIATRIC NEUROSURGICAL FLUID AND ELECTROLYTE PATHWAY

SETTING	Bristol Royal Hospital for Children
FOR STAFF	All paediatric medical, neurosurgical and nursing staff
PATIENTS	All at risk paediatric patients **post neurosurgical intervention** Patients identified pre-operatively to be at risk of hypothalamic-pituitary dysfunction: • Posterior fossa tumours • Supra-tentorial tumours • Traumatic brain injury requiring a neurosurgical intervention • Established Diabetes Insipidus pre-operatively

All paediatric patients post neurosurgical intervention, especially pituitary and suprasellar surgery, and those with post traumatic brain injury are at risk of major fluid balance and electrolyte derangements immediately post operatively but that can last up to 7-10 days.

To prevent significant morbidity and mortality ALL these patients need:

1) **Strict fluid balance monitoring (even when on oral fluids) to allow early identification of these conditions until told to stop by endocrine or HDU team**

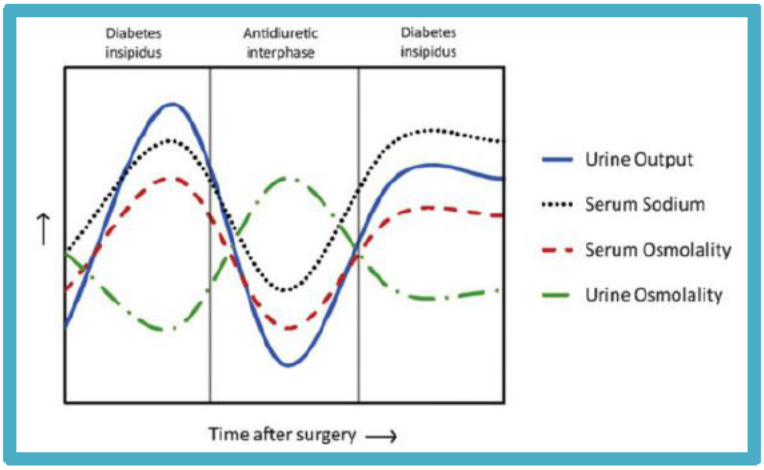
2) **Detailed fluid management plans that reflect changing urine output**

3) **Appropriate steroid cover**

BACKGROUND

Post neurosurgery and traumatic brain injury a classic tri-phasic response in anti-diuretic hormone (ADH) secretion can occur:

- An initial transient phase of impaired ADH secretion (transient diabetes insipidus (DI))
- A second phase of either normal fluid regulation or inappropriate ADH secretion (SIADH)
- A third phase of permanent diabetes insipidus (DI)
- Each phase can occur independently
- Cerebral salt wasting (CSW) may also develop, but is less common



STANDARD OPERATING PROCEDURE

- **Start the neurosurgical fluid and electrolyte pathway (NSX) for all at risk patients**
  - Wardview
  - Nursing e-handover
  - Patient's bedspace
  - Patient notes
- **All NSX pathway patients should be managed on neurosurgical HDU or PICU**
- **Ensure admitting team have contacted the paediatric endocrinology team**
  The in and out of hours contact details are found at the bottom of this document or by following this link: **QUERIES AND CONTACT**
- **All NSX pathway patients must have strict monitoring and investigations as below**

Essential Monitoring

- Daily weights (same time of day)
- Minimum 4hrly blood pressures
- Strict 6hrly fluid balance charts
  - Include all oral fluids, IV flushes and medications in total fluid input
  - Include any enteric, CSF or drain losses in total fluid output
- Hourly urine output calculation (mls/kg/hr)
  - Urinary catheter should be inserted (ideally inserted in theatre)
- Minimum of 3hrly fluid balance calculations
  - May be needed more frequently if directed by medical team or immediately post op

Essential Investigations

- Paired serum and urine electrolytes and osmolality** immediately post op
- Blood gas electrolytes immediately post-op
- Blood gas electrolytes 3hrly (ideally using the same blood gas machine)
- Plasma electrolytes 6hrly thereafter
  - May be needed more frequently if directed by medical team
- Daily or twice daily urinary sodium

****NOTE:** Urgent electrolyte and osmolality requests. The laboratory **MUST** be informed prior to sending to ensure sample analysis is prioritised and samples **MUST** be sent in red bags.
Laboratory contact numbers are: Normal working hours (Monday – Friday 9:00 -17:30) - Duty Biochemist on ext. [redacted]. Outside of normal working hours - Biomedical Scientist on bleep [redacted]

FLUIDS

- **All NSX pathway patients must have a clearly documented fluid management plan**
  - This should be reviewed by medical team on patient arrival to HDU from recovery
  - Fluid balance status should be reassessed by medical staff **at least every 3hrs** (this will be **with hourly replacement in the immediate post-operative** period initially or if there are concerns with fluid balance or electrolytes)
  - Fluid management plans should be clearly documented **at least every 3hrs**

Fluid target will be set by the medical plan
Generally, the aim is to keep the child in a neutral fluid balance but allowing for insensible losses of 300-400mls/m^2/day i.e. overall fluid balance should be positive by 300-400mls/m^2/day

How to work out the fluids

- Immediate fluid management should start in recovery and continue when on HDU with hourly fluid calculation and replacement
  - **Applies to IV and/or oral fluids**
  - **Include all oral/IV fluids /flushes/drugs in calculations**

- If the child cannot drink then up to 4 IV fluids bags should be set up (NB different fluid used for each bags):
  1) for replacement of insensible losses
  2) for replacement of urine output (bags 1+2 are essential for all patients)
  3) to correct any fluid deficit
  4) to replace any enteric or CSF losses (bags 3+4 are only needed if replacing a fluid deficit or GI/CSF losses only)

- **Fluid balance and assessment should be made hourly in the immediate post operatively period**

  - Fluid calculations should be made using the formula below:

Hourly fluid intake over next 1hr = $\frac{\text{previous 1hrs urine output + 1hrs insensible losses}}{1}$

1) ***Insensible losses***
- are calculated by body surface area (BSA) m^2, see appendix A
- insensible losses are calculated as 300mls/m^2/day (use 400ml/m^2/day for children <1 year) i.e. BSA 0.9 m^2 Insensible losses = 0.9 x300 = 270ml. Hourly rate is 270/24 = 11mls per hour
- replace insensible losses with **plasmalyte + 5% glucose**, unless different fluid specified by neurosurgical/HDU/endocrinology teams or anaesthetist

2) ***Urine output***
- replace urine output with **0.45% sodium chloride + 5% glucose,** unless different fluid specified by neurosurgical/HDU/endocrinology teams or anaesthetist

3) Fluid deficit
- Assess volume status and correct to euvolaemia if required
- If shocked treat shock
- Assess for a fluid deficit e.g. clinical signs of dehydration, fall in weight
- Replace fluid deficit with **plasmalyte + 5% glucose**, unless different fluid specified by neurosurgical/HDU/endocrinology teams or anaesthetist

4) Enteric and/or CSF losses
- Replace any enteric or CSF losses ml for ml every 4 hours, using 500ml bags **of 0.9% sodium chloride with 10 or 20mmols of potassium chloride**

Outside the immediate post op period fluids may be calculated over a longer period e.g. 3 hrly using the same equation:

Hourly fluid intake over next 3hrs = $\frac{\text{previous 3hrs urine output + 3hrs insensible losses}}{3}$

- **Ensure all NSX pathway patients have adequate steroid cover**
  - Either dexamethasone as prescribed by the neurosurgical team
  - Or intravenous hydrocortisone infusion as below which will be changed to enteral hydrocortisone four times a day when appropriate.

Hydrocortisone infusion	**Hydrocortisone 50mg in 50mls diluent (either 5% glucose or 0.9% chloride)**		
Weight (kg)	<10	10-20	>20
Infusion rate (ml/hr)	1	2	3

Desmopressin (DDAVP) use

The aim of DI management with DDAVP is to achieve an appropriate 24hr urine output for the child's age and weight but also to avoid water intoxication

- Consultant advice should be sought before use of DDAVP as inappropriate administration carries the risk of water overload and hyponatraemic convulsions
- **Do NOT give DDAVP if serum sodium is <130mmol/L**
- If serum sodium >150mmol/L or serum osmolality >300mOsm/kg and no endocrinology consultant is available, DDAVP may need to be started by HDU or PICU consultant
- DDAVP should be administered strictly according to prescription. Ensure to check correct preparation, dose and route of administration
- A starting guide is:

Weight (kg)	**Desmopressin (subcutaneously)**
<3 kg	0.12 micrograms
3-10 kg	0.3 micrograms
10- 30 kg	0.5 micrograms
> 30 kg	1 microgram

- No further DDAVP to be given until urine output again exceeds at least 3-4ml/kg/hour for 2 consecutive hours or agreed plan with endocrinology team

- **DDAVP pharmacy information**
  - Do not dilute DDAVP injection with doses of 4microgram or less, as the peptide may adhere to surfaces when in diluted solutions.
  - Draw up DDAVP from the glass ampoule using a blue needle. Do not use a filter needle as this result in complete loss of the dose. The needle for administration will depend on the route and size of the patient.
  - **Insulaflon devices should NOT be used as the dose will get lost in the dead space**.

Appendix A – Body Surface Area Calculation based on body weight

BODY SURFACE AREA IN CHILDREN

Body-weight under 40kg

Body-weight (kg)	Surface area (m^2)
1	0.10
1.5	0.13
2	0.16
2.5	0.19
3	0.21
3.5	0.24
4	0.26
4.5	0.28
5	0.30
5.5	0.32
6	0.34
6.5	0.36
7	0.38
7.5	0.40
8	0.42
8.5	0.44
9	0.46
9.5	0.47
10	0.49
11	0.53
12	0.56
13	0.59
14	0.62
15	0.65
16	0.68

Body-weight (kg)	Surface area (m^2)
17	0.71
18	0.74
19	0.77
20	0.79
21	0.82
22	0.85
23	0.87
24	0.90
25	0.92
26	0.95
27	0.97
28	1.0
29	1.0
30	1.1
31	1.1
32	1.1
33	1.1
34	1.1
35	1.2
36	1.2
37	1.2
38	1.2
39	1.3
40	1.3

Values are calculated using the Boyd equation

Note Height is not required to estimate body surface area using these tables

BODY SURFACE AREA IN CHILDREN

Body-weight over 40kg

Body-weight (kg)	Surface area (m^2)
41	1.3
42	1.3
43	1.3
44	1.4
45	1.4
46	1.4
47	1.4
48	1.4
49	1.5
50	1.5
51	1.5
52	1.5
53	1.5
54	1.6
55	1.6
56	1.6
57	1.6
58	1.6
59	1.7
60	1.7
61	1.7
62	1.7
63	1.7
64	1.7
65	1.8

Body-weight (kg)	Surface area (m^2)
66	1.8
67	1.8
68	1.8
69	1.8
70	1.9
71	1.9
72	1.9
73	1.9
74	1.9
75	1.9
76	2.0
77	2.0
78	2.0
79	2.0
80	2.0
81	2.0
82	2.1
83	2.1
84	2.1
85	2.1
86	2.1
87	2.1
88	2.2
89	2.2
90	2.2

Values are calculated using the Boyd equation

Note Height is not required to estimate body surface area using these tables

Taken from BNF for Children March 2023

Appendix B- Desmopressin instructions

- Desmopressin injection must not be diluted with doses of 4microgram or less, as there is a tendancy for the peptide to adhere to surfaces when in diluted solutions.
- Desmopressin injection adheres to plastic tubing/syringes. Therefore, when administering small doses as above (below 4micrograms) a significant proportion of the dose may not be received by the patient.
- For administration doses should be always be drawn up from the glass ampoule using a blue needle as this limits the risk of particles. Do not use a filter needle as this result in complete loss of the dose. The needle for administration will depend on the route and size of the patient.
- **Insulaflon devices should NOT be used as the dose will get lost in the dead space.**

Appendix C: UHB wards that stock desmopressin

See drug finder (on Connect home page) for most up to date list

⊟ **DESMOPRESSIN 100 microgram Tablets**
BCH E500 (BLUEBELL)
BCH E510A (CATERPILLAR)
BCH E512 (DAISY)
⊟ **DESMOPRESSIN 4 micrograms/1mL Solution for Injection Ampoule**
BCH E510A (CATERPILLAR)
BCH E510B (CATERPILLAR)
BCH E512 (DAISY)
BRI A600 EAST
BRI A600 WEST
CHILDREN'S EMERGENCY DEPARTMENT (RESUS) (BRHC)
PHARMACY EMERGENCY CUPBOARD (BRHC)

Appendix D – Evidence of Learning from Incidents

The following table sets out any incidents/ cases which informed either the creation of this document or from which changes to the existing version have been made.

Incidents	Summary of Learning
Incorrect administration of desmopressin	Medication not administered and left patient with high urine output
Clinical Audit	Variation in early recognition of fluid imbalance, monitoring and fluid management
No out of hours endocrine team	To review guideline to ensure clear guidance when endocrine team not on call

Table A

REFERENCES	• Body Surface Area chart taken from BNFC
RELATED DOCUMENTS AND PAGES	• Management of paediatric patients with diabetes insipidus (DI) admitted with inter-current illness or for surgery • Endocrine management of paediatric surgical patients with cortisol deficiency • Fluid Management in Paediatric Patients • Dexamethasone in Neurosurgery

AUTHORISING BODY	Nurse Practice Group Paediatric Endocrine Governance Group Clinical Effectiveness Committee
SAFETY	No concerns
QUERIES AND CONTACT	○ In working hours (0830-1730 mon-fri) ▪ On-call Paediatric endocrine consultant available on mobile via switchboard ▪ Endocrine registrar bleep [redacted] ▪ Endocrine SHO bleep [redacted] ▪ HDU registrar bleep [redacted] ○ Out of hours (1730-0830 mon-fri, 24hrs sat and sun) ▪ HDU consultant ext. [redacted] (0800-1945) ▪ Neurosurgical HDU registrar bleep [redacted]

Plan Elements	
The Dissemination Lead is:	[redacted]
Is this document: A – replacing the same titled, expired guideline, B – replacing an alternative guideline, C – a new Guideline:	A The SOP "Paediatric Neurosurgical Fluid and Electrolyte pathway" will now be obsolete as it is impeded as a Nursing SOP in this guidance
If answer above is B: Alternative documentation this guideline will replace (if applicable):	
This document is to be disseminated to:	PICU, Daisy HDU, Caterpillar HDU nursing staff Paediatric junior doctors PICU/HDU consultants Paediatric Anaethetists
Method of dissemination:	Email, shared at local meetings
Is training required and how will this be delivered:	Via Nurse Educators, Hospital-wide SIM sessions and to paediatric trainees and junior doctors via hospital-wide teaching programme To anaesthetic staff via clinical lead for paediatric anaesthesia together with endocrine consultants

Document Change Control

Date of Version	Version Number	Lead for Revisions	Type of Revision	Description of Revision
March 23	1	Consultant Paediatric Endocrinology Governance Lead	Major/ Minor	Update from previous document: 30mg/m2 for hydrocortisone replacement, adjusted fluid type for insensible losses and urine output replacement, added in body surface area charts