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Endocrine Emergencies in the
Pediatric ICU

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Pediatric Nurse Practitioners
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Experts in pediatrics. Advocates for children.

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Speaker Disclosure

- I have no disclosures


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Learning Objectives

- Describe endocrinologic emergencies that might be encountered in the pediatric population
- Explain the diagnostic evaluation of each endocrinologic emergency
- Interpret the diagnostic evaluation of each endocrinologic emergency
- Develop the therapeutic plan for each endocrinologic emergency


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Case 1

- Adolescent female seen by primary care provider for first time in three years
- Office laboratory values: Serum sodium 109 mmol/L, urine specific gravity 1.000
- Immediate referral to emergency department (ED)
- Patient is at neurologic baseline at time of presentation

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Case 1

- History:
 - born at 33 weeks
 - minimal NICU stay discharged without support
 - Speech delay early in life, graduated from speech therapy



Case 1

- History of present illness
 - Two to three months increased thirst with a reported 14 pound weight loss
 - Intermittent diarrhea, occasional nausea and vomiting
 - Increase frequency nausea vomiting over few weeks
 - Three pound weight loss over week prior to presentation
 - No known laxative use, purging
 - Only complaint is thirst

Case 1

- Review of systems
 - Weight loss, nausea, vomiting, diarrhea
- Physical exam
 - Cachectic, enamel erosion, fine tremor, increased hair on arms, chapped back of hands
 - Normal vital signs
 - Exam otherwise normal

Case 1

- Laboratory evaluation
 - Sodium 108 mmol/L
 - Chloride 76 mmol/L
 - BUN 8 mg/dL
 - Creatinine 0.71 mg/dL
 - Serum Osmolality 230 mOsm/kg
 - Urine osmolality <50 mOsm/kg
 - Specific gravity 1.001
 - Hemoglobin 9 g/dL
 - Microcytic anemia
 - Iron 26 mcg/dL
 - Thiamin 48 nmol/L
 - Potassium and glucose normal range

Case 1

- Initial resuscitation in ED
 - 0.9% saline 500 ml bolus
 - Thiamin administered
 - NPO
 - After bolus, D5 0.45% saline fluids started with restriction of 750 ml/m²/day
 - Frequent neurologic checks
 - Monitor for refeeding syndrome

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Case 1

- At two hours sodium 112, fluids changed to 0.225% saline
- At six hours sodium 117, scheduled desmopressin started, intravenous fluids stopped
- Patient allowed two ounces water every 2 hours due to constant complaint of thirst
- At 10 hours sodium 120
- At 14 hours sodium 125
- At 18 hours sodium 127; rate of rise stabilizes

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Case 1

- By day three oral intake liberalized, diet reinitiated, desmopressin stopped
- Additional evaluation
 - MRI noted only periventricular leukomalacia
- Consultations during this time
 - Endocrinology- no abnormal labs
 - Renal- meets criteria for stage 2 chronic kidney disease
 - Adolescent medicine- no eating disorder
 - Psychiatry- high functioning autism

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Case 1

- Sodium homeostasis
 - Primary cation of extracellular fluid
 - Vital for normal physiologic function
 - Regulated by antidiuretic hormone (ADH), renin-angiotensin-aldosterone system (RAAS)



(Bernal et al., 2023; Ruppel, 2022)

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Case 1

- Complications of hyponatremia
 - Cerebral edema
 - Seizures
 - Rhabdomyolysis
 - Central pontine myelinolysis (CPM)



(Ruppel, 2022)

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Case 1

- Desmopressin
 - Exogenous synthetic analog of vasopressin
 - Sodium rate of rise concerning for development of CPM
 - Monitor sodium and urine output closely
 - Wean as rate sodium rise and fluid restriction allow
 - No pediatric dosing recommendations for use in severe hyponatremia

(Taketomo, 2023)

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Case 1

- Diagnosis?
 - Sodium water imbalance can be challenging to discern
 - Detailed history including medications important
 - Differential is broad including endocrine, neurologic, renal, and behavioral/psychiatric diagnoses

(Ahmadi & Goldman, 2020; Nauwynck et al., 2021; Saller et al., 2017; Saller et al., 2017)

•Primary polydipsia

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Primary Polydipsia

- Referred to by multiple names
- Seen in neurodevelopmental disorders, intellectual disabilities, chronic psychiatric disorders
- Do not awaken to drink
- Patients with low solute or restrictive diets more likely to develop hyponatremia and renal dysfunction

(Ahmadi & Goldman, 2020; Nauwynck et al., 2021; Saller et al., 2017; Saller et al., 2017)

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Primary polydipsia

- Diagnosis
 - Water deprivation test
- Treatment
 - Fluid restriction
 - Treat underlying disorder
 - Cognitive behavioral therapy
 - At risk for recurrence



(Mirmadi & Goldman, 2020; Nauwynck et al., 2021; Saller et al., 2017; Saller et al., 2017)

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Case 2

- Adolescent male with history of ADHD has a four to five day history of progressively worsening frontal headaches
- Flulike symptoms one to two weeks prior to this development
- One day prior to presentation developed emesis in addition to headache
- Seen at an urgent care, symptoms prompted a head computed tomography exam (HCT)

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Case 2

- HCT results
 - multicompartamental sinusitis, anterior left frontal and interhemispheric hypodense extraaxial fluid collections with midline shift 3 mm, early tonsillar herniation; consistent with subdural empyema
- Sent immediately to the emergency department due to the need for neurosurgical evaluation and hospitalization

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Case 2

- Physical exam was unremarkable except for mild right pronator drift
- Vital signs normal
- Review of systems as noted with headache, vomiting
- Neurosurgery and otolaryngology emergently consulted
- Ceftriaxone administered
- What are we concerned about here?

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Case 2

- Laboratory evaluation
 - Sodium 134 mmol/L
 - ESR 108 mm/hr
 - CRP 292.2 mg/dL
 - WBC 15.4 K/cumm, 90% neutrophils
 - Blood culture sent
 - Other chemistries and hematologic studies normal

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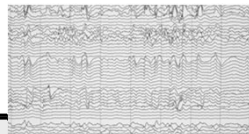
Case 2

- Emergent operative procedure
 - Decompressive craniectomy and washout
 - Subgaleal bulb drain placed
- Additional management during operative procedure
 - Hypertonic saline (HTS)
 - Levetiracetam prophylaxis
 - Decadron administration
 - Abscess culture sent
 - Extubated to room air post procedure

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Case 2

- In the immediate postoperative period he was noted to have a dense right hemiparesis
- Neuroprotective strategies implemented
- Isotonic parenteral fluids
- Neurology consulted, placed on continuous video electroencephalogram (EEG)



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Case 2

- Antibiotic coverage broadened to ceftriaxone, vancomycin, and metronidazole
- Within 12 hours
 - Abscess Gram stain revealed Gram + cocci and Gram - bacilli
 - Blood culture grew Gram + cocci in pairs and chains, ultimately speciated *Streptococcus anginosus*
 - Antibiotics narrowed to ceftriaxone



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Case 2

- Over the following three days
 - HCT showed worsening of empyema, cerebral edema
 - Brain magnetic resonance imaging (MRI) consistent with HCT findings
 - Sinus washout surgery per otolaryngology
- Day four
 - Brain MRI with worsening empyema, left frontal subarachnoid hemorrhage (SAH), sigmoid sinus and jugular venous thrombosis
 - Intracranial washout and subdural drain placed in operating room, sodium 133, HTS administered

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Case 2

- Day 6 clinical seizure activity noted
 - Sodium 135, HCT with increased empyema
 - HTS, levetiracetam load, continuous video EEG
- Day 7-8
 - Operative washout, extubated post procedure
 - Seizure, less wakeful, sodium 133, multiple antiepileptic medications
 - Unable to correct sodium despite HTS boluses
 - Seizures aborted

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Case 2

- Day 9-10
 - No additional seizures
 - Persistent mild hyponatremia despite HTS
 - Oral salt supplementation started, then increased to maximum dosing of 100 mEq orally four times daily
- Over following two weeks
 - Stable salt dosing for a week, slowly weaned to off day 23
 - No seizures, no additional operative procedures, started intensive rehabilitation

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Case 2

- Diagnosis?
 - Complex
 - Mild hyponatremia
 - Not only risk for development of seizure
 - Why was the sodium low?



•Cerebral salt wasting

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Cerebral salt wasting (CSW)

- Diagnostics
- At times difficult to discern from diabetes insipidus (DI) or syndrome of inappropriate antidiuretic hormone (SIADH)
- Hyponatremia, increased urine output, low intravascular volume are the key findings
- Laboratory evaluation likely reveals low serum sodium, high urine sodium, low serum osmolality and high urine osmolality
- Researchers have noted fractional excretion of urate might be a way to evaluate the difference between CSW and SIADH (Bardanzellu et al., 2022)

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Cerebral salt wasting

- Risk factors include SAH, tumor resection, central nervous system infection, head injury
- Transient or permanent
- Treatment
 - Exogenous sodium administration
 - 100 mEq sodium chloride = one teaspoon table salt
 - Fludrocortisone sometimes used

(Arieff et al., 2017; Bardanzellu et al., 2022; Sterns & Silver, 2008)

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Case 3

- School age female with moderate persistent asthma, cyclic vomiting presents to emergency department (ED) with fever of 105° F and persistent, frequent emesis
- Initial vital signs include fever, tachycardia, tachypnea, and most notably a blood pressure of 70s/30s
- Capillary refill of 5 seconds, cool extremities, answering questions but not at neurologic baseline per caregivers
- Resuscitation with isotonic crystalloid started immediately, no improvement after 50 ml/kg, started on vasoactive

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Case 3

- | | |
|-----------------------------|--|
| • Laboratory evaluation | • WBC 14.2 K/cumm with neutrophil predominance |
| • Sodium 131 mmol/L | • Lactate 1.8 mmol/L |
| • Potassium 3.4 mmol/L | • Prothombin time 18.2 sec |
| • CO ₂ 23 mmol/L | • INR 1.6 |
| • Creatinine 0.6 mg/dL | • Cortisol 4 mcg/dL |
| • Glucose 76 mg/dL | |
| • ESR normal | |
| • Mild elevation CRP | |

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Case 3

- Additional laboratory evaluation
- D-Dimer 1187 ng/mL
- Troponin 0.09 ng/mL
- B-type natriuretic peptide (BNP) 2164 pg/mL
- Oxyhemoglobin 80%
- Lactic dehydrogenase and triglycerides normal
- Respiratory viral panel positive for rhinovirus/enterovirus and COVID
- COVID antibody negative
- Blood culture sent

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Case 3

- Review of systems as noted- fever, emesis
- Additional history
 - Prior hospitalizations for vomiting and dehydration
 - Mild hypoglycemia at the time of these admissions
 - No reported hypotension
 - Medications include twice daily inhaled corticosteroid (ICS)

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Case 3

- Admitted to the PICU, required intubation, central and arterial venous access, and ultimately three continuous vasoactive medications
- Hydrocortisone stress dose was initiated
- Broad spectrum antibiotics were given
- Within 48 hours all the vasoactives were stopped and she was successfully extubated

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Case 3

- Treated for community acquired pneumonia though infectious evaluation was negative outside of viral panel
- Transferred to floor and weaned off hydrocortisone
- Discharge diagnosis was COVID/multisystem inflammatory syndrome in children (MIS-C) not meeting full criteria
- Echocardiogram was normal, troponin and BNP normalized by discharge

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Case 3

- One month later
 - Fever and emesis for one day
 - At ED presentation blood pressure 70s/30s, oxygen saturations 80s
 - Started on high flow nasal cannula
 - Blood culture sent, no cortisol obtained
 - Fluid resuscitation, single vasoactive, antibiotics started
 - Infectious evaluation negative
 - Off vasoactives within 24 hours

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Case 3

- Due to acute, profound presentations and cortisol of 4 on first admission, endocrinology was consulted
- What was the recommendation?
- Adrenocorticotrophic hormone (ACTH) stimulation test
- What is the concern?

•Adrenal insufficiency

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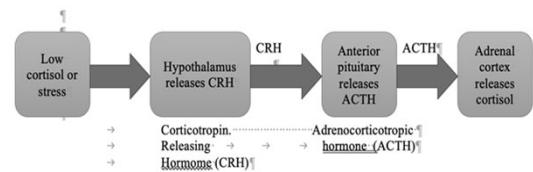
Adrenal insufficiency

- Dysfunction of the adrenal gland cortex
 - Impaired secretion of glucocorticoids with or without mineralocorticoid deficiency
- Types
 - Primary
 - Secondary
 - Tertiary
 - Relative adrenal insufficiency
 - Neonatal adrenal insufficiency



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Hypothalamus Pituitary Adrenal Axis (HPA)



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Adrenal insufficiency

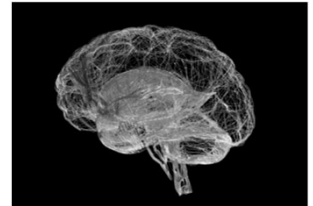
- Primary
 - Destroyed or inactive adrenal gland or hormone production failure
 - Autoimmune
 - Adrenal hemorrhage
 - Sepsis
 - Metastasis
 - Removal
 - Congenital Adrenal Hyperplasia

(Auron & Raïssouni, 2015; Eyla et al., 2019; Marino, 2022; Quinkler et al., 2021)

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Adrenal insufficiency

- Secondary
 - ACTH deficiency
 - Hypopituitarism
 - Primary pituitary disease
 - Congenital pituitary lesion
 - Anencephaly
 - Holoprosencephaly
 - Craniopharyngioma



(Auron & Raïssouni, 2015; Eyla et al., 2019; Marino, 2022; Quinkler et al., 2021)

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Adrenal insufficiency

- Tertiary
 - HPA axis suppression
- Relative adrenal insufficiency
- Neonatal adrenal insufficiency
- Adrenal crisis
 - rapid, overwhelming, potentially fatal adrenocortical insufficiency
 - Treatment is glucocorticoid replacement

(Auron & Raïssouni, 2015; Eyla et al., 2019; Marino, 2022; Quinkler et al., 2021)

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Adrenal insufficiency

- Diagnosis
 - Baseline morning cortisol, ACTH levels
 - Administration of 250 mcg of ACTH IV/IM
 - Cortisol level drawn at 30 and 60 minutes
 - An increase in cortisol by less than 9 mcg/dL is diagnostic

(Marino, 2022)



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Adrenal insufficiency

- Treatment
 - Hydrocortisone 8-10 mg/m²/day orally divided in 2-3 doses for physiologic replacement
 - Major stress/surgery hydrocortisone 50-100 mg/m²/day IV divided 3-4 times a day
 - Can consider a 50 mg/m² bolus does in cases of critical presentation
 - Mild to moderate stress hydrocortisone 20-50 mg/m²/day IV or PO divided 3-4 times a day

(Taketomo, 2023)

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Adrenal insufficiency

- Questions regarding this patient
 - Why diagnosed at this age
 - Could ICS play role
 - Vomiting and hypoglycemia mild presentation



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References

- Ahmadi, L. & Goldman, M. B. (2020). Primary polydipsia: Update. *Best Practice and Research. Clinical Endocrinology and Metabolism*, 34, 1-16. <https://doi.org/10.1016/j.beem.2020.101469>
- Arief, A. I., Gabbai, R., & Goldfine, I. D. (2017). Cerebral salt wasting syndrome: diagnosis by urine sodium excretion. *The American Journal of Medical Sciences*, 354(4), 350-354.
- Auron, M., & Raissouni, N. (2015). Adrenal insufficiency. *Pediatrics in Review*, 36(3), 92-103. <https://doi.org/10.1542/pir.36-3-92>
- Bardanzellu, F., Marciallis, M. A., Frassetto, R., Mellis, A., & Fanos, V. (2022). Differential diagnosis between syndrome of inappropriate antidiuretic hormone secretion and cerebral/renal salt wasting syndrome in children over 1 year: proposal for a simple algorithm. *Pediatric Nephrology*, 37, 1469-1478. <https://doi.org/10.1007/s00467-021-00525-1>
- Bernal, A., Zafra, M. A., Simon, M. J., & Mahia, J. (2023). Sodium homeostasis, a balance necessary for life. *Nutrients*, 15, 1-23. <https://doi.org/10.3390/nu15020395>
- Eyal, O., Levin, Y., Oren, A., Zung, A., Rachmiel, M., Landau, Z., Schachter-Davidov, A., Segev-Becker, A., & Weintraub, N. (2019). Adrenal crises in children with adrenal insufficiency: epidemiology and risk factors. *European Journal of Pediatrics*, 178, 731-738. <https://doi.org/10.1007/s00421-019-03348-1>
- Marino, K. J. (2022). Adrenal disorders. In B. N. Bolick, K. Reuter-Rice, M. A. Madden, P. N. Severin (Eds.), *Pediatric Acute Care: A guide for interprofessional practice* (2nd ed., pp. 316-321). Elsevier.
- Nauwynck, E., Van De Maele, K., Vanbesien, J., Staels, W., De Schepper, J., & Gies, I. (2021). Psychogenic polydipsia in a female adolescent without a psychiatric background: A case report. *Clinical Case Reports*, 9, 1937-1042. <https://doi.org/10.1002/ccr3.3910>

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References

- Quinkler, M., Murray, R. D., Zhang, P., Marelli, C., Peterman, R., Isidori, R., & Ekman, B. (2021). Characterization of patients with adrenal insufficiency and frequent adrenal crises. *European Journal of Endocrinology*, 184, 761-771. <https://doi.org/10.1530/EJE-20-1324>
- Ruppel, R. (2022). Electrolyte Imbalances. In B. N. Bolick, K. Reuter-Rice, M. A. Madden, P. N. Severin (Eds.), *Pediatric Acute Care: A guide for interprofessional practice* (2nd ed., pp. 374-375). Elsevier.
- Sailer, C. O., Winzeler, B., & Christ-Crain, M. (2017). Primary polydipsia in the medical and psychiatric patient: characteristics, complications, and therapy. *Swiss Medical Weekly*, 1-7. <https://doi.org/10.4414/smww.2017.14514>
- Sailer, C. O., Winzeler, B., Nigro, N., Suter-Widmer, I., Arici, B., Bally, M., Schuetz, P., Mueller, B., & Christ-Crain, M. (2017). Characteristics and outcomes of patients with profound hyponatremia due to primary polydipsia. *Clinical Endocrinology*, 87, 492-499. <https://doi.org/10.1111/cen.13384>
- Sterns, R. H., & Silver, S. M. (2008). Cerebral salt wasting versus SIADH: What difference? *Journal of the American Society of Nephrology*, 19, 194-196. <https://doi.org/10.1681/ASN.2007101118>
- Taketomo, C. K. (2023). Hydrocortisone. *Pediatric and Neonatal Dosage Handbook* (30th ed.). Lexicomp. <https://online.lexi.com/lco/action/doc/retrieve/docid/pdf/f/2892255?cesid=9u0dtr3eXV0&searchUrl=%2Fico%2Faction%2Fsearch%3Fq%3Dhydrocortisone%26t%3Dname%26acs%3Dtrue%26acq%3Dhydrocor#parentdoc-tab-content>
- Taketomo, C. K. (2023). Desmopressin. *Pediatric and Neonatal Dosage Handbook* (30th ed.). Lexicomp. <https://online.lexi.com/lco/action/doc/retrieve/docid/pdf/f/130065?cesid=9u0dtr3eXV0&searchUrl=%2Fico%2Faction%2Fsearch%3Fq%3Ddesmopressin%26t%3Dname%26acs%3Dtrue%26acq%3Ddesmopre#parentdoc-tab-content>

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