The polyuric child
When should we worry?

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Pathologic polyuria or polydipsia?
Making the diagnosis

- **Step 1:** Attempt to categorise by a thorough history and examination. Look for signs of failure to thrive and dehydration.
  - How much is your child drinking per day?
  - What fluids does your child prefer?
  - Does your child drink by day and night, or by day only?
  - Does your child refuse water?
  - What sort of personality does your child have?
  - Is your child cared for at home or in a creche/playground?
  - Has either polyuria or polydipsia interfered with normal activities?
  - Is nocturia or enuresis present?

POLYURIA is defined as an increase in total daily outpout of urine

Urine outpout > 40 ml/kg/24h

or > 2000 ml/m^2/24h

preschool children >1l/24h

school children >2l/24h

adults >3l/24h

POLYURIA

- **Distinguish from:**

  frequent micturition

  nocturia

  enuresis

- Are not associated with an increase in the total urine output

POLYURIA

The volume of urine depends upon:

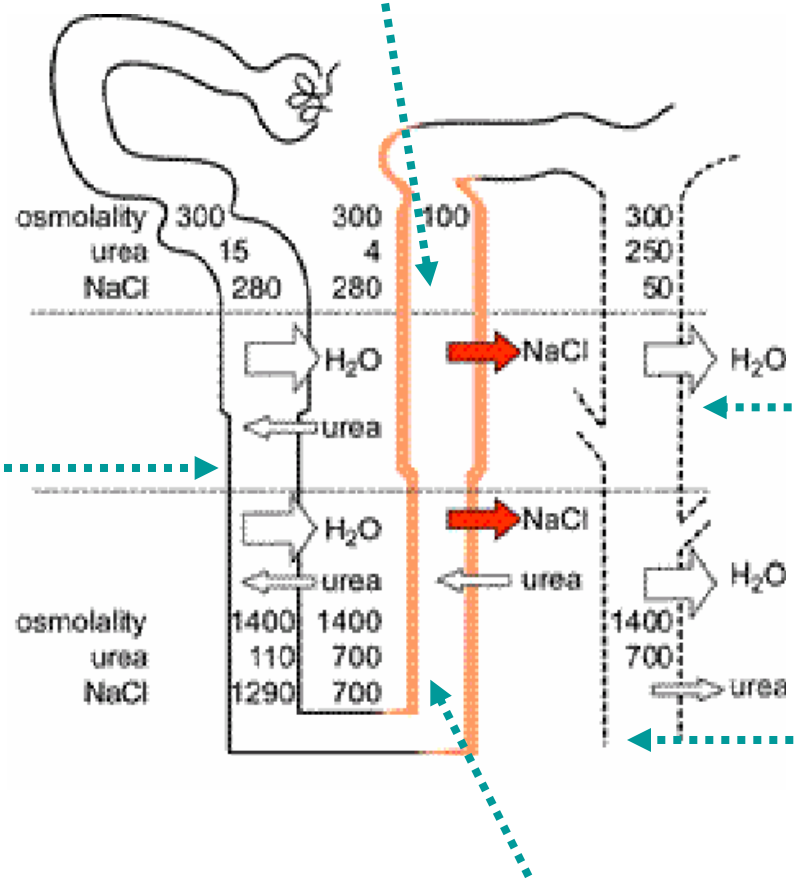
1. The amount of solute (solute load) and water ingested or produced by metabolism in excess of needs
2. The ability to concetrate or dilute the urine

The ability to concetrate the urine depends on:

- the presence of antidiuretic hormone (ADH) and
- A hyperosmolar medullary interstitium with an intact countercurrent multiplier system

Tubular concentration / dilution mechanism

3. Active sodium chloride transport in the thick ascending limb of loop of Henle (TAL)



1. Water permeable segment in the thin descending limb of loop of Henle

4. In the presence of ADH, collecting tubule highly permeant to water

5. Urea reabsorption in the collecting tubule

2. Passive reabsorption of sodium in the thin ascending limb of loop of Henle

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POLYURIA

- **Water diuresis** (urine osmolality <250mOsm/kg)

- **Solute diuresis** (urine osmolality >250 mOsm/kg)

Differentiating true and habit polydipsia

True polydipsia	Habit polydipsia
Desperate for drinks	Bottle “addiction”
Will drink anything offered	Preference for juices and sweetened drinks Refuses water
Waking at night for drinks	Sleeps through the night
Saturated nappies	
Failure to thrive	Thriving

Pathologic polyuria or polydipsia?
Making the diagnosis

- **Step 2:** Exclude diabetes mellitus.
- **Step 3:** Record ingested fluid volume, frequency and type of fluid.
- **Step 4:** Undertake basic investigations:
  - Serum osmolality
  - Serum sodium, potassium, glucose, calcium and BUN
  - Urinalysis: urine osmolality, specific gravity, glucose

Outpatient investigation

DIABETES INSIPIDUS
Serum osmolality >300 mOsm/kg
Urine osmolatity <300 mOsm/kg

PROBABLY NOT DIABETES INSIPIDUS
Serum osmolality <270 mOsm/kg
Urine osmolatity >600 mOsm/kg

Serum osmolality 270-300 mOsm/kg
Significant polyuria and polydipsia

↓

Water deprivation test
Diagnose diabetes insipidus
Differentiate central from nephrogenic causes

Water deprivation test

- Is not performed in newborns or very young infants
- Is not performed when plasma Na>145 mEq/l
- It should be performed in the hospital under medical supervision

The test is terminated when one of the end points are attained:

- Urine SG> 1020 or Urine osmolality > 600mOsm/kg
  (infant) 1015 >500
- Plasma osmolality >295 mOsm/kg or plasma Na >147mEq/l
- Loss of 5% of body weight or signs of volume depletion
- Period of water restriction

6hours in infants	< 6months of age
8 hours	6 months -2 years
12 hours	>2 years

dDAVP test

- Children who continue to have impaired urinary concentration despite reaching a plasma osmolality 295mosmol/kg or sodium of 150meq/L

  5-10µg desmopressin by nasal insufflation (20µg/m2)
  or 2,5-5U aqueous vasopressin subcutaneously

- **Accurate interpretation requires that exogenous ADH not given before the plasma osmolality has reached 295 mosm/kg**

- If ↑ urine osmol. **>100%** complete central DI
  15-50% partial central DI
  partial nephrogenic DI
  <10% complete nephrogenic DI

WATER DEPRIVATION TEST

Urine osmolality <600 mOsm/kg

DIABETES INSIPIDUS

dDAVP Test (Pitressin 1 U/m^2)

Urine osmolality >750 mOsm/kg

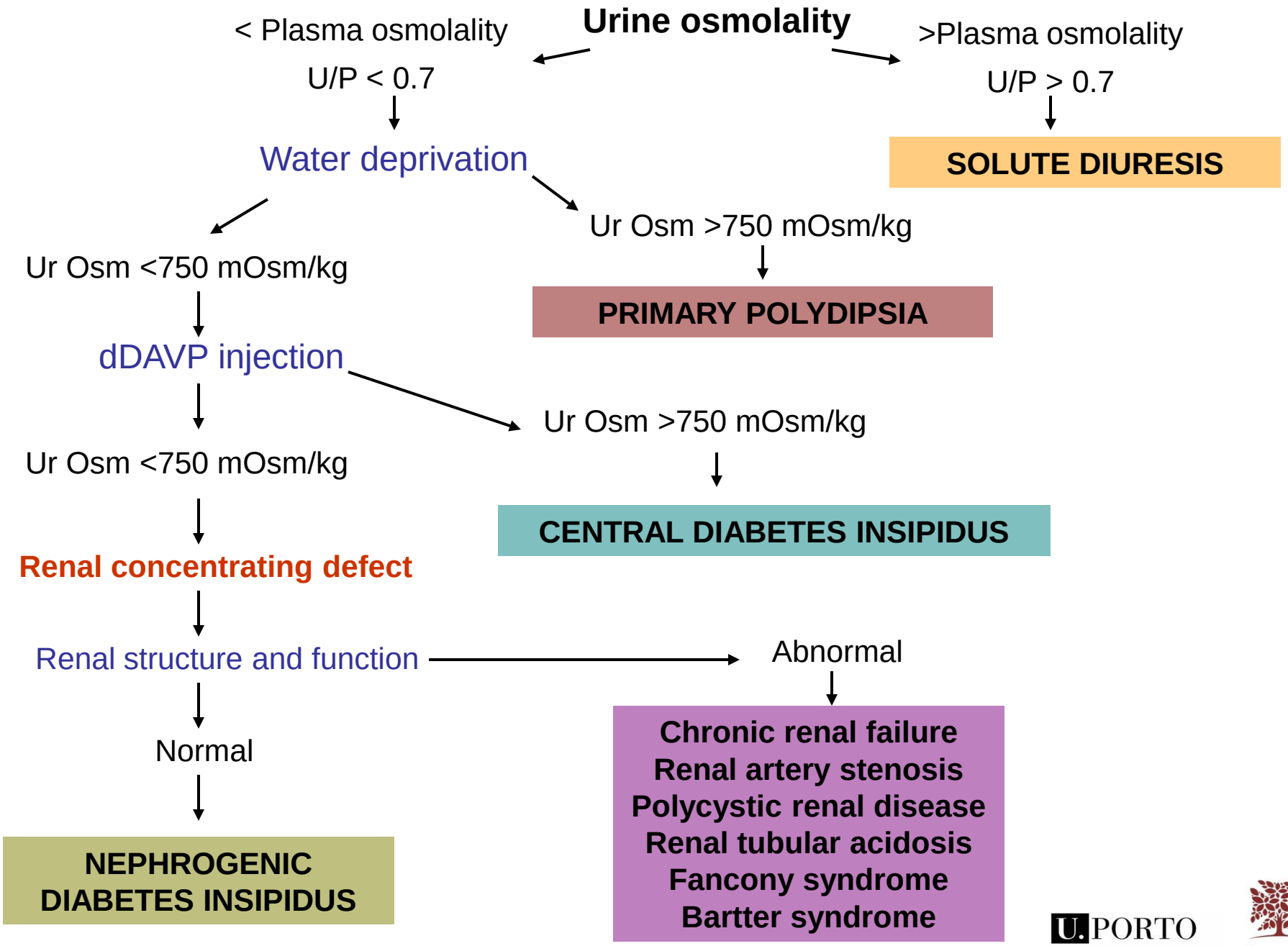
CENTRAL DI

Urine osmolality <750 mOsm/kg

NEPHROGENIC DI

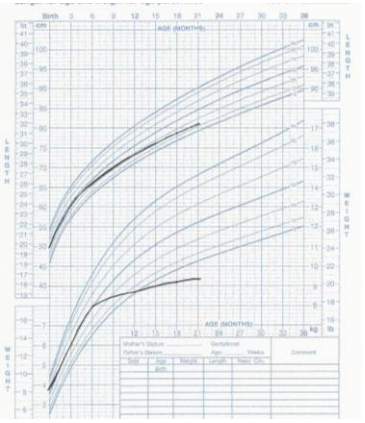
Urine osmolality >600 mOsm/kg

PRIMARY POLYDIPSIA


Urine osmolality
< Plasma osmolality
U/P < 0.7
>Plasma osmolality
U/P > 0.7
SOLUTE DIURESIS
Water deprivation
Ur Osm >750 mOsm/kg
PRIMARY POLYDIPSIA
Ur Osm <750 mOsm/kg
dDAVP injection
Ur Osm >750 mOsm/kg
CENTRAL DIABETES INSIPIDUS
Ur Osm <750 mOsm/kg
Renal concentrating defect
Renal structure and function
Abnormal
Chronic renal failure
Renal artery stenosis
Polycystic renal disease
Renal tubular acidosis
Fancony syndrome
Bartter syndrome
Normal
NEPHROGENIC DIABETES INSIPIDUS

Case 1

- 21 month-old boy, chronic gastroesophageal reflux

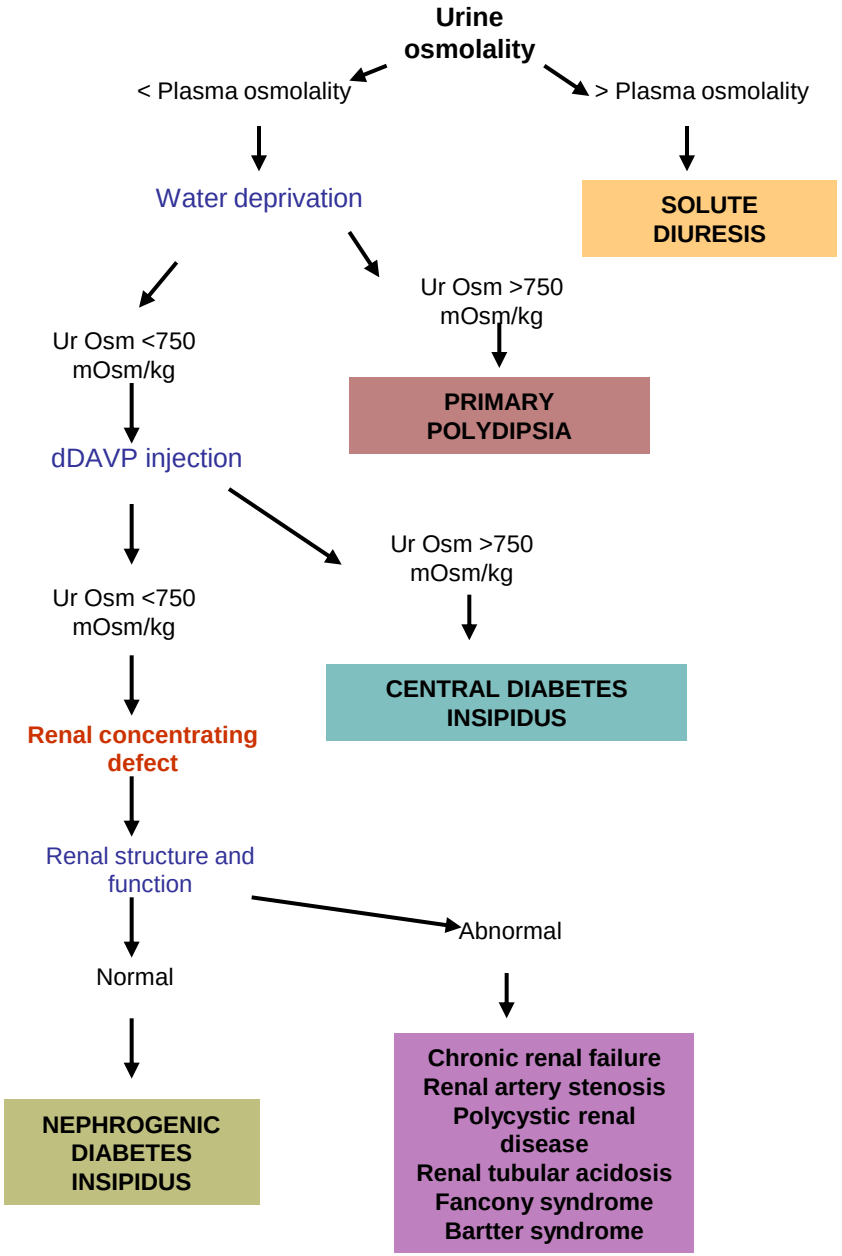


- Brought to the office
  - **Poor growth**
- Personal history
  - Born at term
  - Gastroesophageal reflux diagnosed at 3 weeks of age
  - Failure to thrive at 12 months (despite adequate calory intake)
    - Weight 75th – 5th percentile (6 months)
    - Height and head circumference 10th – 25th percentile
  - Intermittent episodes of constipation
  - Frequent colds and ear infections
  - Normal development

- Previous evaluation
  - CBC, electrolytes: normal
  - Thyroid function: normal
  - Cystic fibrosis and celiac disease screening: negative
  - Food allergy skin testing: negative
- Further questioning
  - Drinks 2-2.5L of fluid/day
  - Excessive thirst started at ~6 months of age
  - Wet diapers: 8-10/day incredibly heavy

- Complementary evaluation
  - Serum osmolality 300 mOsm/L
  - Serum chloride 109 mEq/L
  - Serum sodium 144 mEq/L
  - Urine osmolality <50 mOsm/L
  - Urine specific gravity: 1.005
  - Urine electrolytes
    - Sodium <5 mEq/L; K <20 mEq/L

- Admission to the hospital
  - Water deprivation test
    - Increase of serum sodium (144 – 152 mEq/L)
    - Increase in serum osmolality (297 – 310 mOsm/L)
    - No change in urine osmolality
    - Continued passage of dilute urine (specific gravity <1.003)
    - Weight decreased ~5%
    - Urine output: 16 mL/kg/hour
  - AVP injection
    - Urine osmolality and specific gravity remained low (70 and 1.005)



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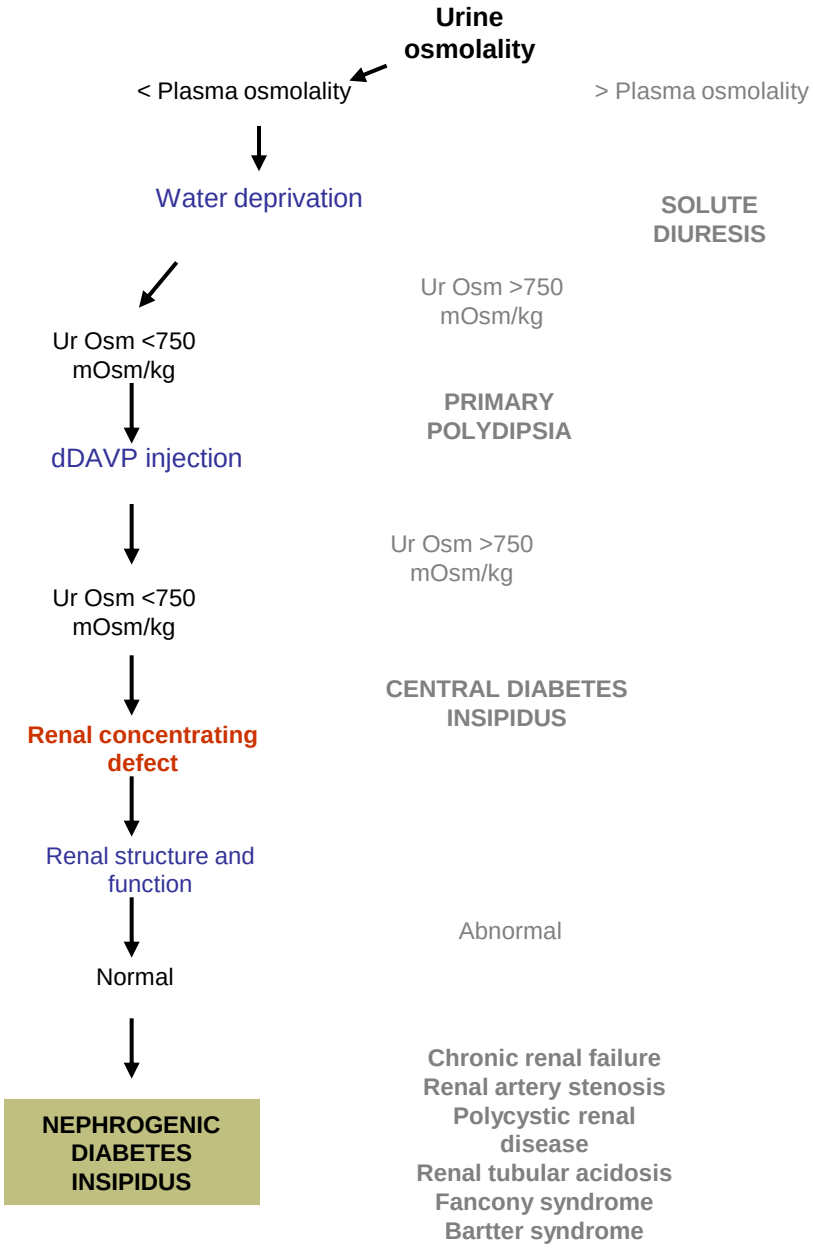


Case 2

- Four year-old girl
- Brought to the Pediatric Nephrology Unit:
  - **Study of polyuria and polydipsia**
  - Personal history
    - Born at term
    - No relevant previous illnesses
    - Normal growth (50th percentile)
    - Normal development
  - No family history of renal disease, polyuria or diabetes insipidus

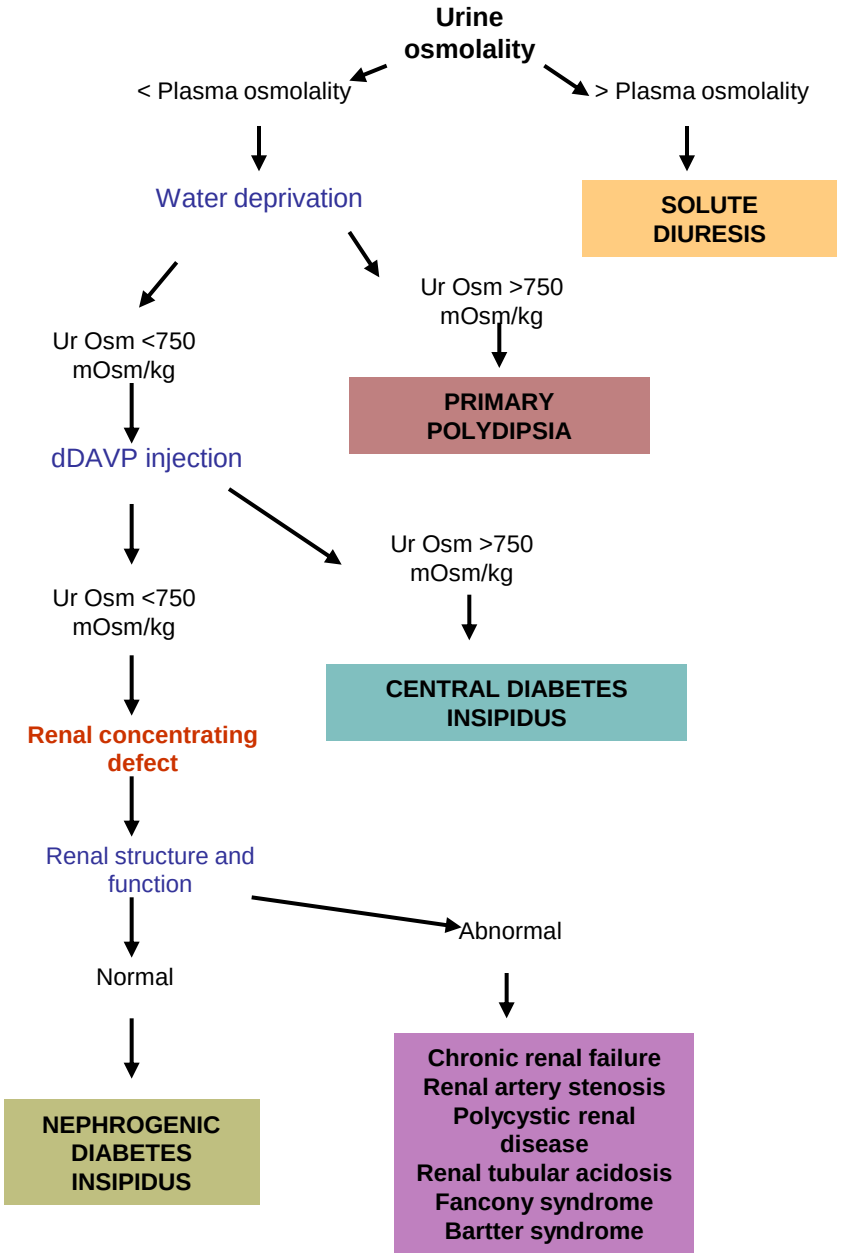
- Present illness
  - 3 weeks
  - Polydipsia (8 L water/day)
  - Polyuria (urine output 9 mL/kg/day)

- Previously evaluated by General Paediatrician
  - Observed by Pedopsychiatrist
    - Suspected of compulsive water drinking
    - Behavioural approach (no success)

Pediatric Nephrology Unit

- Laboratory evaluation
  - Normal CBC
  - Normal serum glucose, creatinine and urea
  - Serum sodium 137 mEq/L; potassium 4.2 mEq/L; calcium 2.4 mmol/L
  - Venous blood gas: pH 7.39; bicarbonate 25.3 mmol/L
  - Urinalysis: pH 5.5; specific gravity 1.005; no protein, glucose or ketones
  - Urine osmolality: 65 mOsm/L
  - Serum osmolality: 275 mOsm/L

- Complementary evaluation
  - Water deprivation test
    - Increase in serum osmolality (283 – 310 mOsm/L)
    - Increase in urine osmolality (149 – 253 mOsm/L)
    - Continued passage of dilute urine (specific gravity 1.005)
    - Weight decreased ~3%
    - Urine output: 4 mL/kg/hour
  - AVP injection
    - Increased urine osmolality (784 mOsm/L) and urine specific gravity (1.030)



- Complementary evaluation
  - Water deprivation test
    - Increase in serum osmolality (283 – 310 mOsm/L)
    - Increase in urine osmolality (149 – 253 mOsm/L)
    - Continued passage of dilute urine (specific gravity 1.005)
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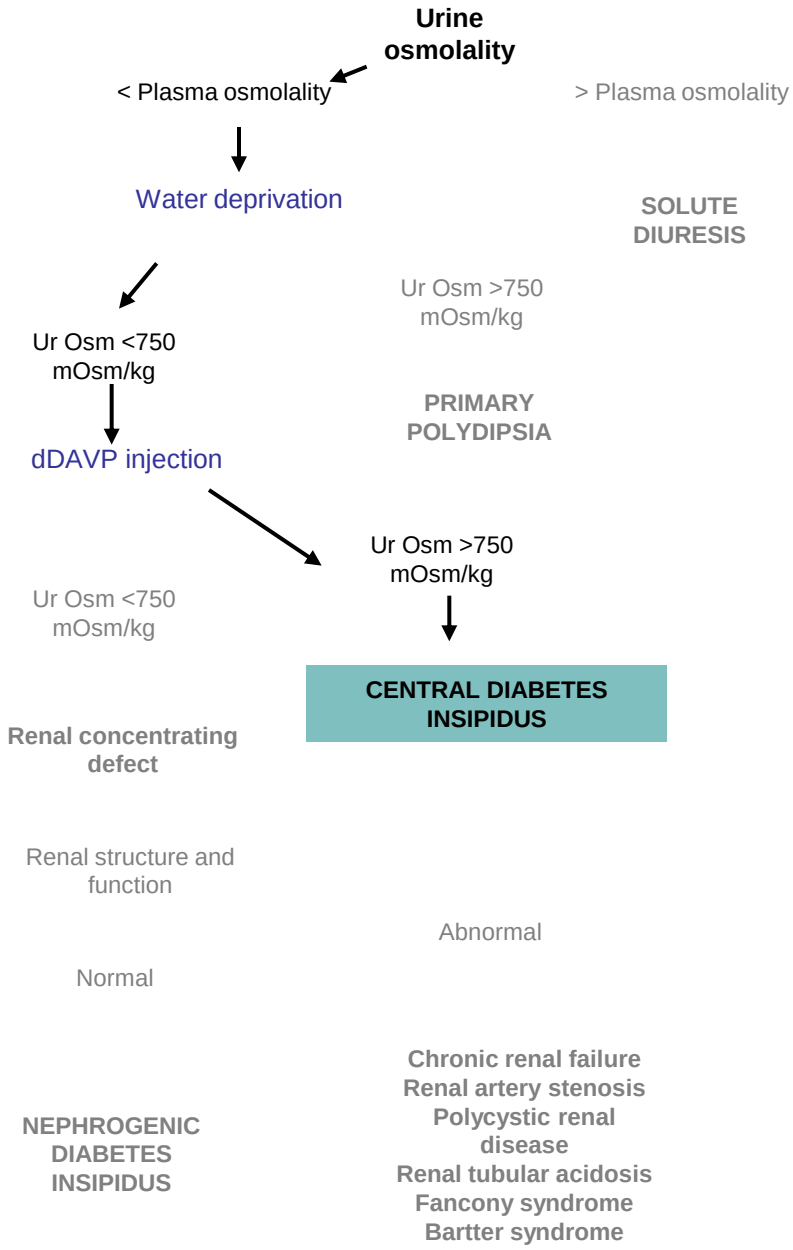


Case 3

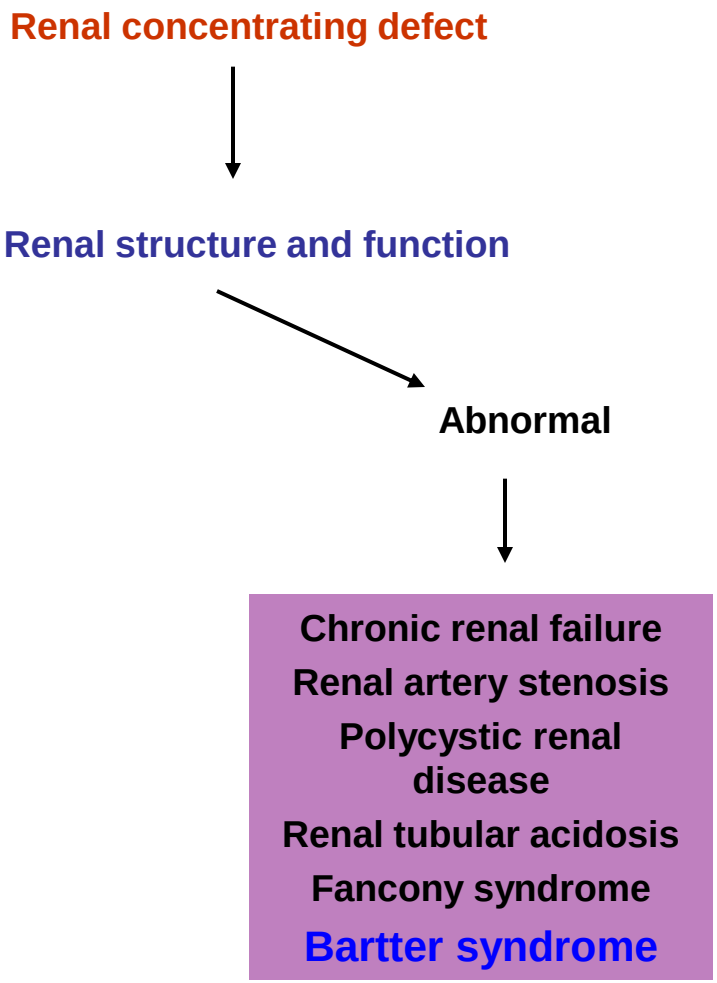
- Six year-old boy, development delayed

- Principal complaint
  - **Polydipsia, polyuria and nocturia** (several months)
  - Personal history
    - 3-4 years delayed in language, motor and social skills
  - Physical examination
    - Healthy good looking child
    - Height and weight 5th – 10th percentiles
    - Normal vital signs
    - No abnormalities

- Laboratory evaluation
  - Normal CBC and differential leukocyte count
  - Serum Na 136 mEq/L; K 2.8 mEq/L; Cl 90 mEq/L
  - BUN 12 mg/dL; serum creatinine 0.4 mg/dL
  - Hands and wrists radiographs: normal bone age
  - Arterial blood gas: pH 7.62; PCO2 32 torr (36-46); BE +11.1 (± 2.3); total CO2 34.2 (23-27)
  - Urine: pH 8; specific gravity 1.005; no glucose, protein, blood or ketones

- **Suspected Bartter syndrome**
  - Hypokalemia
  - Metabolic alkalosis
  - Patient with severe development delay, polyuria and nocturia

  - Complementary evaluation
    - Elevated plasma levels of renin and aldosterone
    - High urinary levels of potassium and chloride



Case 4

  - 4 year-old girl
- Admitted to Paediatric intensive Care Unit
  - **Hypertensive encephalopathy**
- Present illness
  - Afebrile generalized seizure (<5min duration, espontaneous recovery)
  - Headache and drowsiness (during previous 24h)
    - No history of head trauma, unknown history of medication intake
  - **Polyuria and polydipsia** (>2months duration)

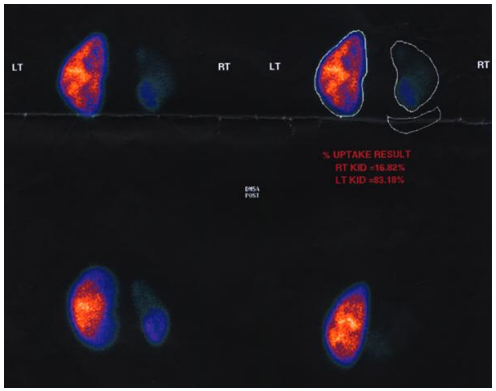
- Previous history
  - Full-term uncomplicated pregnancy, adequate birth anthropometry
  - Normal growth and development
  - No relevant previous illnesses, accidents or hospitalizations
  - No family history of hypertension or other cardiovascular, renal or endocrinal diseases
  - Unknown hereditary diseases

- Physical examination
  - Conscious, normal size and reactive pupiles, normal fundoscopy
  - Normal skin examination
  - Negative meningeal signs
  - Apiretic, no signs of respiratory distress, tachycardia, blood pressure 158/124 mmHg (>95th percentile + 20%)
  - No other abnormalities

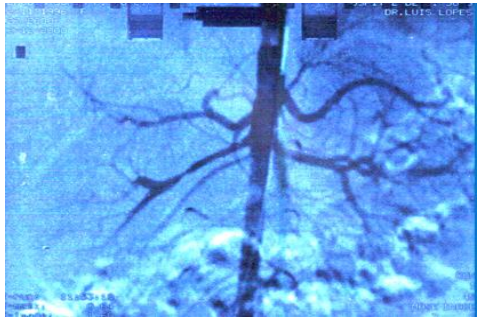
- Laboratory evaluation
  - Normal CBC
  - Serum sodium 127 mEq/L; potassium 3.2 mEq/L; chloride 82 mEq/L
  - Normal BUN and creatinine
  - Venous blood gas: pH 7.5; $HCO3^-$ 26 mEq/L; BE +8
  - Urinalisys: sodium 60 mEq/L (FE Na^+ >1); potassium 20 mEq/L; no proteinuria
  - Urine output: 5,5 mL/kg/hour

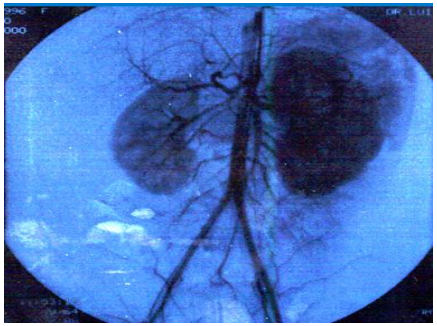
- Complementary evaluation
  - Elevated peripheral renin activity
  - Elevated serum aldosterone
  - Echocardiogram: mild concentric left ventricular hypertrophy
  - Renal ultrasound: renal asymmetry with left hypertrophy and hyperechogenicity and right parenchyma atrophy

- Renal DMSA: Reduced uptake by the right kidney; right kidney hypofunction (left 83,18%; right 16,82%)



- Renal artery angiography: Right renal artery stenosis





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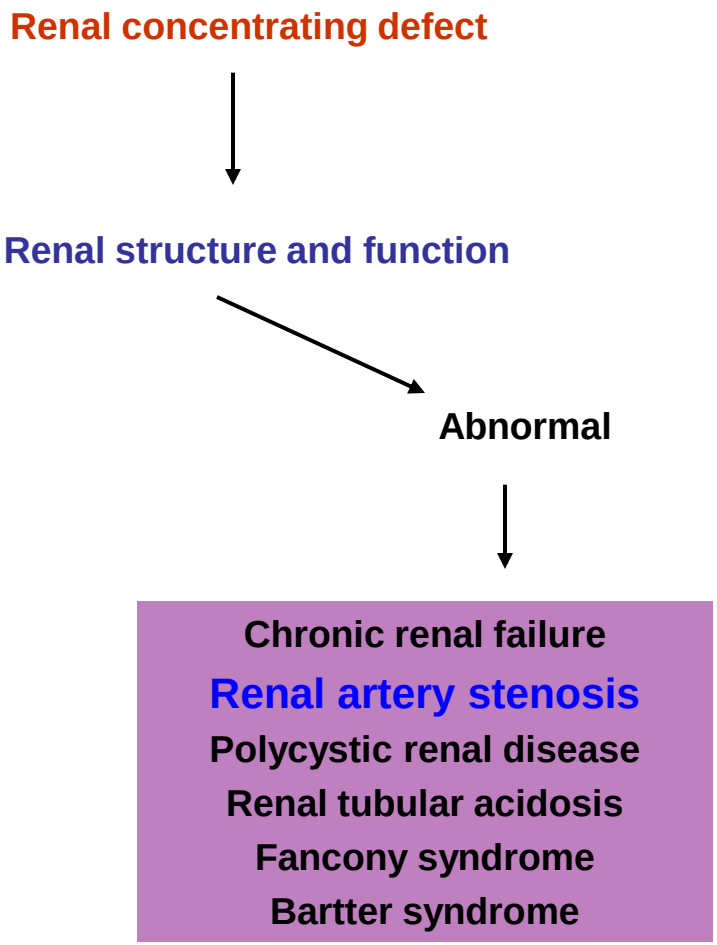
- **Diagnosis**
  - Renovascular hypertension
  - Renal artery stenosis
  - Hyponatremic hypertensive syndrome



Take home message

- Polyuria and polydipsia are common phenomenon in children
- Solute diuresis (U/P osmolality > 0.7)
  - Diabetes mellitus must always be excluded
- Water diuresis (U/P osmolality < 0.7; urine specific gravity < 1.010)
  - Always must be considered
    - Psychogenic disorders (compulsive water drinking)
    - Inadequate ADH production (CDI)
    - Insensitivity to ADH (NDI)
    - Renal concentrating defect with abnormal renal function

Practical approach

- **Psychogenic disorders** should be considered if:
  - Normal urine osmolality (>600 mOsm/L) and serum osmolality (<270 mOsm/L)
  - No need to drink during the night
  - Normal growth and development
- **Diabetes Insipidus** should be considered if:
  - Low urine osmolality (<300 mOsm/L) and high serum osmolality (>300 mOsm/L)
  - Distinction between **Central** and **Nephrogenic DI** is based on response to administration of vasopressin
    - A rise in urine osmolality of more than 50% is suggestive of **CDI**
    - In **NDI** the increase in urine osmolality is nil or minimal
- **Renal dysfunction** should be considered if:
  - Growth retardation, failure to thrive
  - Refractory rickets
  - Renal calculi, nephrocalcinosis
  - Unexplained hypertension
  - Hydro electrolytic disorders