Kennsla læknanema á 5. námsári

Acute Kidney Injury in Children
Bráður nýrnaskaði

Vidar Orn Edvardsson, MD

Professor of Pediatrics, University of Iceland
Director of Pediatric Nephrology, Children´s Medical Center
Landspitali - The National University Hospital of Iceland
Reykjavik, Iceland

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Bráður nýrnaskaði - stigun og skilgreining

Þekkja þessa stigun AKI vel.

Table 2 | Staging of AKI

Stage	Serum creatinine	Urine output
1	1.5–1.9 times baseline OR ⩾0.3 mg/dl (⩾26.5 μmol/l) increase	<0.5 ml/kg/h for 6–12 hours
2	2.0–2.9 times baseline	<0.5 ml/kg/h for ⩾12 hours
3	3.0 times baseline OR Increase in serum creatinine to ⩾4.0 mg/dl (⩾353.6 μmol/l) OR Initiation of renal replacement therapy OR, In patients <18 years, decrease in eGFR to <35 ml/min per 1.73 m^2	<0.3 ml/kg/h for ⩾24 hours OR Anuria for ⩾12 hours

Kidney International Supplements (2012) 2, 19–36; doi:10.1038/kisup.2011.32

Bráður nýrnaskaði

Acute kidney injury (AKI), known previously as acute renal failure, is defined as an abrupt decline in renal function resulting in impaired elimination of waste products and dysregulation of electrolytes, acid–base status, and fluid balance

- Nýrun geta ekki lengur stýrt jafnvægi vökva, electrolýta, Ca++/fosfat og sýru- og basavægi ofl.
- Geta ekki skilið út úrgangsefni efnaskipta
- Oliguria oftast til staðar
  - <0.5 ml/kg/hr in children
  - <1.0 ml/kg/hr in newborns

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Hversu algengur er bráður nýrnaskaði hjá börnum

- Recent data suggest that AKI occurs in
  - 27% of children receiving intensive care
  - and in at least 5% of non-critically ill pediatric patients

a) McGregor TL et al, Am J Kidney Dis (2016) 67:384–390
b) Kaddourah A et al, N Engl J Med 376:11–20

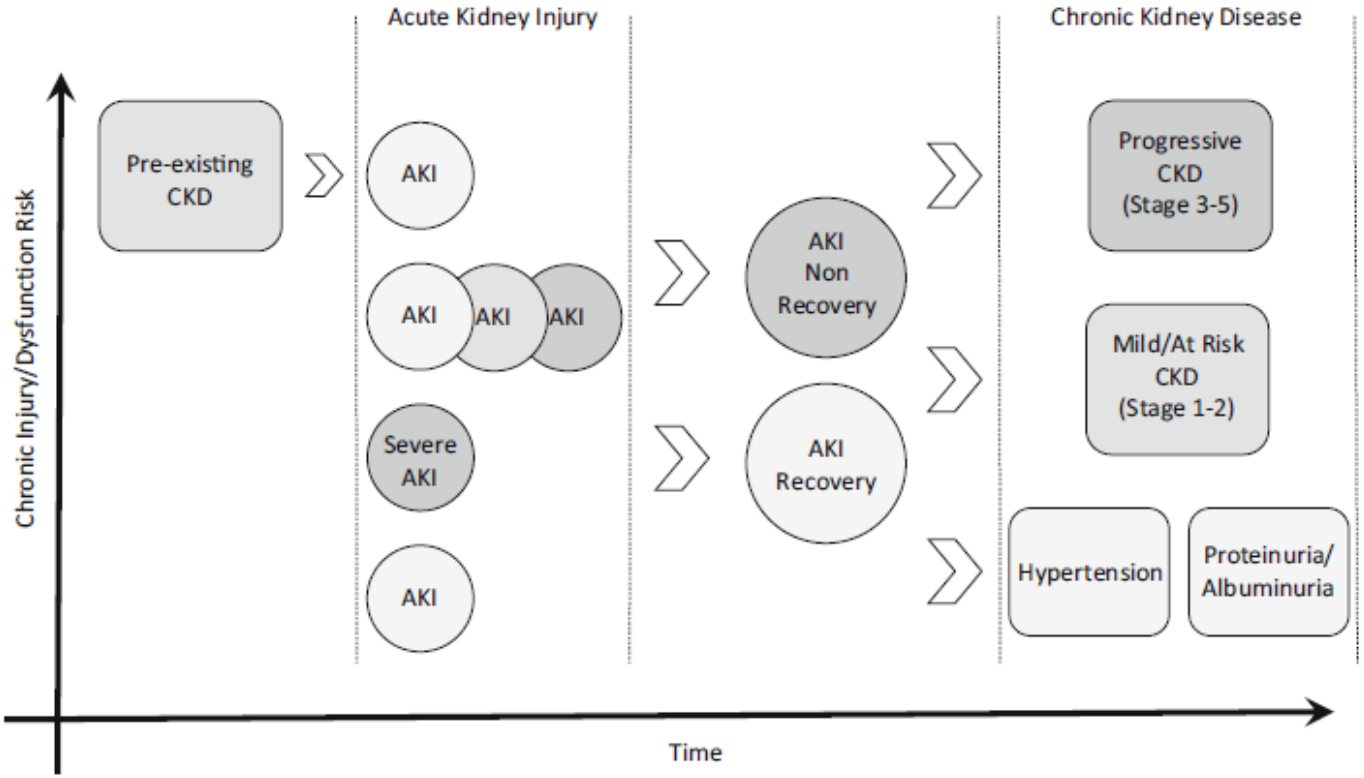

Fig. 1 Risk for developing chronic kidney disease (CKD) across the spectrum of acute kidney injury (AKI). In the setting of AKI, observational evidence suggests that severe AKI events are more likely to be associated with chronic findings than mild events; so are repeated AKI events, independent of severity. Perhaps the greatest risk for chronic renal disease after AKI is pre-existing CKD. As the events which precipitated AKI abate, renal function begins to recover; non-recovery of AKI has been associated with greater CKD risk. Chronic renal injury has gradation as well. At its most mild form, chronic renal injury may manifest as proteinuria or hypertension. More severe injury may manifest with a mildly reduced glomerular filtration rate, and the most severe injuries may be associated with moderate/severe CKD

Pediatr Nephrol (2018) 33:2047–2055: Sigurjonsdottir V et al

Undirliggjandi ástæður - I

- Nýrun fá ekki nægt blóðflæði (pre-renal)
  - Minnkaður æðatónus (vascular tone)
    - Septískt sjokk
  - Minnkað vökvarúmmál í æðum
    - Alvarlegur þurrkur
    - Bruni
    - Sjokk vegna blæðingar
    - Diabetes insipidus
  - Hjartabilun / opnar hjartaaðgerðir
    - Meðfæddur hjartasjúkdómur
    - Hjartaígræðsla

Lykilatriði:
a) pre-renal;
b) renal
c) post-renal

Undirliggjandi ástæður - IIa

- Skemmdir á nýrnavef (renal parenchymal injury)
  - Æðasjúkdómar (vascular disease)
    - HUS
    - Thrombosis
      - » Slagæðar / bláæðar (renal venous thrombosis)
    - Cortical necrosis
      - » Langvarandi alvarleg hypotension
  - Gauklabólga (Glomerulonephritis)
    - Post-infectious glomerulonephritis
    - Lupus
    - HSP glomerulonephritis
    - ANCA jákvæður glomerulonephritis
    - Aðrir gauklasjúkdómar

Lykilatriði:
a) pre-renal;
b) renal
c) post-renal

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Undirliggjandi ástæður - IIb

- Skemmdir á nýrnavef (renal parenchymal injury) frh.
  - Acute tubular necrosis
    - Langvarandi hypotension
    - Hypoperfusion og NSAID´s eða ACE hemlar
    - Tubulointerstitial nephritis
    - Idiopathic, drug induced, pyelonephritis
  - Exogenous toxins
    - NSAID´s, ACE-inhibitors, antibiotics (aminoglycosides, vancomycin), chemotherapeutics (methotrexate etc), radiographic contrast agents
  - Endogenous toxins (myoglobin, hemoglobin)

Lykilatriði:
a) pre-renal
b) renal
c) post-renal

Undirliggjandi ástæður - III

- Rennslishindrun frá nýrum (post-renal/obstructive)
  - Stífla í báðum þvagleiðurum
  - Eitt nýra og frárennslishindrun
  - Stífla í frárennsli blöðru
    - Steinar, túmorar ofl., posterior urethral valves (drengir)

Lykilatriði:
a) pre-renal
b) renal
c) post-renal

Undirliggjandi ástæður - IV

- Munið
  - Því fleiri nýrnaáverkar á sama tíma, því meiri líkur á bráðum nýrnaskaða.
    - Sepsis/dehydration
    - Hjartabilun
    - Nephrotoxic lyf (því fleiri lyf á sama tíma því verra)
    - Önnur nefrotóxín, t.d. radiographic contrast agents
    - Undirliggjandi langvinnur nýrnasjúkdómur
    - Rhabdomyolsis
    - Hemoglobinuria (hemolysis)
    - osfrv

Clinical evaluation

- Clinical findings
  - Determine hydration status, perfusion and oxygenization, (Capillary refill, BP, HR, RR, oral mucosa), sensorium
  - Hypotension (<5th percentile)
    - Age 0-28 days SBP <60 mmHg
    - Age 1-12 months SBP <70 mmHg
    - Age 1-10 years SBP <70+ (age in years) x 2 mmHg
    - Age > 10 years SBP <90 mmHg
  - Hypertension, fever, rash (petichiae/vasculitis), edema, evidence of dehydration, leathargy

Þarf ekki að muna, en vita að mat á mögulegri hypotension er lykilatriði

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Laboratory evaluation and imaging

- Laboratory investigation
  - Serum chemistries and hematology
    - ↑ Se-Cr, BUN, hyperkalemia, acidosis, anemia, thrombocytopenia, coagulopathy, DIC
  - Urinalysis
    - Hematuria (red cells, hemoglobin, myoglobin), proteinuria, urine sediment (cells, crystals (cystine, 2,8-DHA))
  - FeNa
    - <1% prerenal azotemia, glomerulonephritis
    - >2% ATN,TIN (tubulointerstitial nephritis)
  - Urine osmo
    - >400-500 (pre-renal azotemia, glomerulonephritis; (due to tubular water reabsorption))
    - <350 (ATN, interstitial nephritis; water losses)
- Medical imaging (renal ultrasound)

Vandamál tengd bráðum nýrnaskaða og meðhöndlun þeirra

- Vökvajafnvægis
- Hyperkalemíu
- Hyponatremíu
- Efnaskiptablóðsýringar (metabolic acidosis)
- Raskanir á efnaskiptum Ca^{++} og fosfats
- Háþrýstings
- Næring
- Breyta/minnka lyfjaskammta (yfirfara lyfjalistann)
- Ábendingar fyrir skilun (dialysis)
- Val á skilunaraðferð
- Meðhöndlun undirliggjandi sjúkdóms

Þekkja helstu fylgikvilla AKI

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Management of fluid balance

- Give repeated 20 ml/kg boluses of isotone fluids until circulatory sufficiency is established
- Replace insensible water losses (500 mL/m^2/24h or 35% of calculated maintenance IVF) with plain 5-10% glucose in sterile water (D5-10W)
- Replace all urine output with a solution containing Na^+ (most often NaCl) in the range of 100-140 mEq per liter
- Replace all other fluid losses with appropriate solutions
  - GI (nasogastric tube, diarrhea), drain fluid (pleura, periocardium, peritoneal, bile, pancreatic juice etc)
- Place a foley catheder to monitor urine output
- Record weight and fluid balance in great details

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Management of hyperkalemia

- Do not prescribe any potassium containing fluids, food or medication unless patient is severely hypokalemic.
- Induce K^+ losses
  - If patient has urine output, give furosemide.
  - Give anion exhange resins 1g/kg/dose (p.o, p.r), to be repeated for se- K^+ > 5.0 mEq/L.
- Induce K^+ shift
  - Give i.v. $NaHCO_3$ boluses, 1 mEq/kg/dose
  - Insulin 0.1 U/kg and 1 g glucose/kg iv over 30 minutes
    - Dæmi: 10% glúkósa = 100 mg/mL (1 g=1000 mg=10mL)
    - 10 kg barn; 10 kg x 10 mL = 100 mL 10% glúkósa
    - Insulin = 0,1 eining/kg = 1 eining, gefist á sama tima.
  - Beta-2 agonists (salbutamol, iv and inhalation)
- Stabilize cell membranes (cardiac)
  - Calcium chloride 0.1-0.2 mmol/kg/dose

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Management of hyponatremia

- Commonly caused by the administration of hypotonic fluids to oligoanuric patients
  - se-Na^+ >120 mEq/L
    - Fluid restriction or water removal by dialysis
  - se-Na^+ <120 mEq/L
    - Rapidly raise by 3-5 mmol/L and then slowly to 120-125 mEq/L with 3% NaCl (513 mmol/L)
    - Avoid overcorrection in chronic hyponatremia
      - <10 mmol/l in 24 hours (0.5 mmol/l per hour).
    - In the case of dialysis adjust dialysate Na^+ to the desired serum Na^+ level (10 mmol/l above serum Na+).

Management of metabolic acidosis

- In renal failure the kidneys can not excrete the daily acid load of 1-3 mEq/kg/day
- Aim for a pH >7.30
- Treat alkali deficit/negative base excess
  - Use oral citrate or bicarbonate or iv bicarb
  - Calculate alkali dose for correction
    - mEq $NaHCO_3$ required = base deficit per liter x body wt (kg) x 0.5 (Vd for bicarbonate)
    - Avoid overcorection
      - » May cause acute lowering of se-ionized calcium
- Prevent metabolic acidosis
  - Administer alkali, 1-3 mEq/kg/day

Management of arterial hypertension

Þekkja lyfjaflokkana en ekki skammta

- Correct hypervolaemia
- Treat with oral medications
  - Diuretics – thiazides, furosemide (if volume overload), β-blockers (propranolol, atenolol), Ca^{++}-channel blockers (amlodipine)
  - Varast, ACE, ARB (enalapril, capropril, valsartan, losartan) í bráðum nýrnaskaða.
- Do not lower BP to fast (may cause cortical blindness)
- Intravenous medications
  - α- and β-blockers
    - Labetolol 0.3-1 mg/kg/dose or max 3 mg/kg/h as an infusion
    - Max single dose is 40 mg iv
  - Vasodilator
    - Dihydralazin 0.1-0.4mg/kg/dose (Nepresol®)
    - Sodium nitroprusside 0.5-8 µg/kg/min cont. infusion (cyanide toxicity)
    - Nicardipine infusion 0.5-1 µg/kg/min cont. infusion, max 3 µg/kg/min
    - Avoid sublingual nifedipine and i.v. diazoxide as response is unpredictable

Nutrition in ARF - I

- Catabolic state
- Immediate and adequate nutrition supply is essential
  - Metabolic demands increased
  - Provide
    - Protein 1.5 – 2,5 g/kg/day
    - Calories > 130% of basic needs
- Enteral nutrition is preferred

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Adjustment of medication dosages

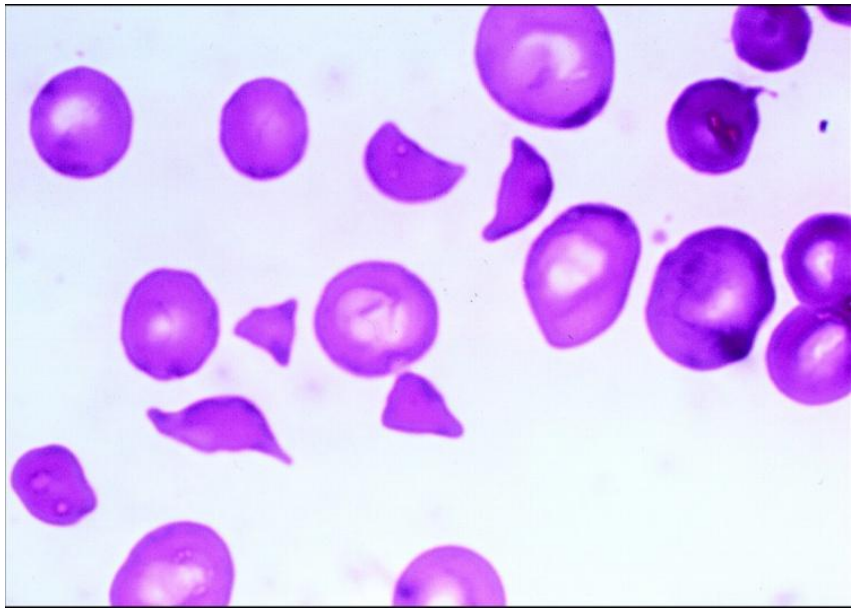
- Most medications require dose adjustment when glomerular filtration rate (GFR) is less than 30–40 mL/min/1.73m^2
  - Dose reduction
  - Interval change (q12°-24° instead of q8°)
  - Both a dose reduction and interval change
- Follow blood levels when possible
  - Vancomycin, aminoglycosides etc
- Always consult your references

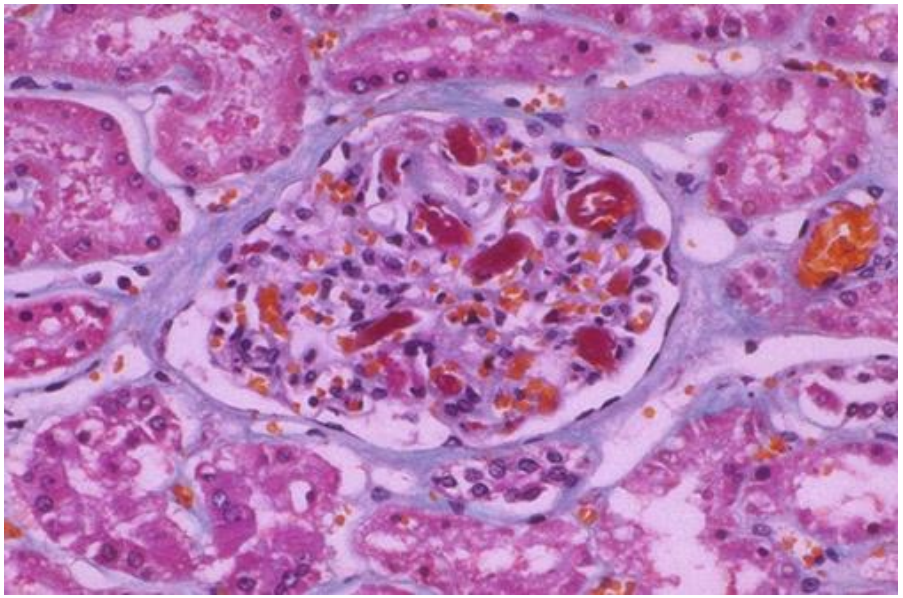
AKI - cases

Skemmtileg tilfelli, góð viðbót við fyrirlestur um gauklasjúkdóma (HUS)

Hemolytic uremic syndrome

- Verotoxin/shiga like toxin (oftast frá E. Coli (STEC)) veldur endothelial dysfunction
  - Microangiopathic hemolýtísk anemía, blóðflögufæð, bráð nýrnabilun, thrombotic microangiopathy (nýru, heili, bris, lungu ofl)





Nýleg HUS tilfelli í íslenskum börnum

- Tvö börn greind með HUS 2014
  - 2 ½ árs stúlka í mars 2014
  - 4 ára drengur í ágúst 2014
- Eitt barn greint með HUS árið 2015
  - 4 ára stúlka
- Öll höfðu niðurgang og toxin frá shiga toxin E. Coli (STEC) fannst í hægðum

Stúlka 4 ára D + HUS

- Blóðugur niðurgangur, uppköst og kviðverkir.
- Bráður nýrnaskaði á 3. degi með anuriu.
- Verulega meðvitundarskert, MRI breytingar í heila dæmigerðar fyrir HUS.
- Kviðskilunarmeðferð í 3 vikur.
- Þurfti insúlín á tímabili (HUS í brisinu).
- Hefur nú algerlega eðlilega nýrnastarfsemi og er aftur orðin lík sjálfri sér.

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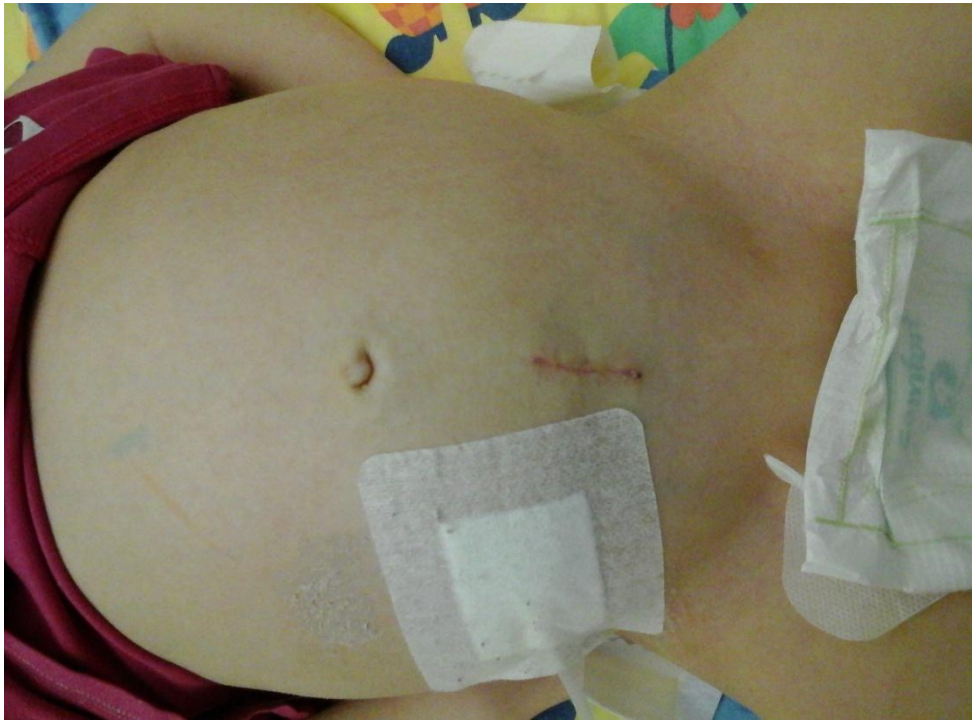

Stúlka 4 ára D + HUS

	Dagur 1	Dagur 3	Dagur 5	Dagur 60
Hgb	139 g/L	104 g/L	70 g/L	109 g/L
Flögur	484.000	75.000	33.000	294.000
S-kreatínín	35 µmol/L	66 µmol/L	215 µmol/L	32 µmol/L
LDH	-	1395	3200	-
Þvagútskilnaður	200 mL	0 mL	0 mL	Eðlilegur
Blóðstrok		Fragmenteruð rauð blóðkorn	Fragmenteruð rauð blóðkorn	

Stúlka 2 ára D+HUS

- Uppköst og niðurgangur í 4 daga fyrir innlögn
- Bráður nýrnaskaði, ekkert þvag í 3 vikur, skilun í 4 vikur
- Öndunarvél í 10 daga
- Flog (staðfest með EEG), lengi meðviðtundarskert, ischemía í heila samkv MRI.
- Talerfiðleikar og skert hreyfigeta
- **Hgb 65g/L, blóðflögur 36.000, s-kreatínín 420µmól/L, LDH 3815U/L haptóglóbín <0,05g/L**

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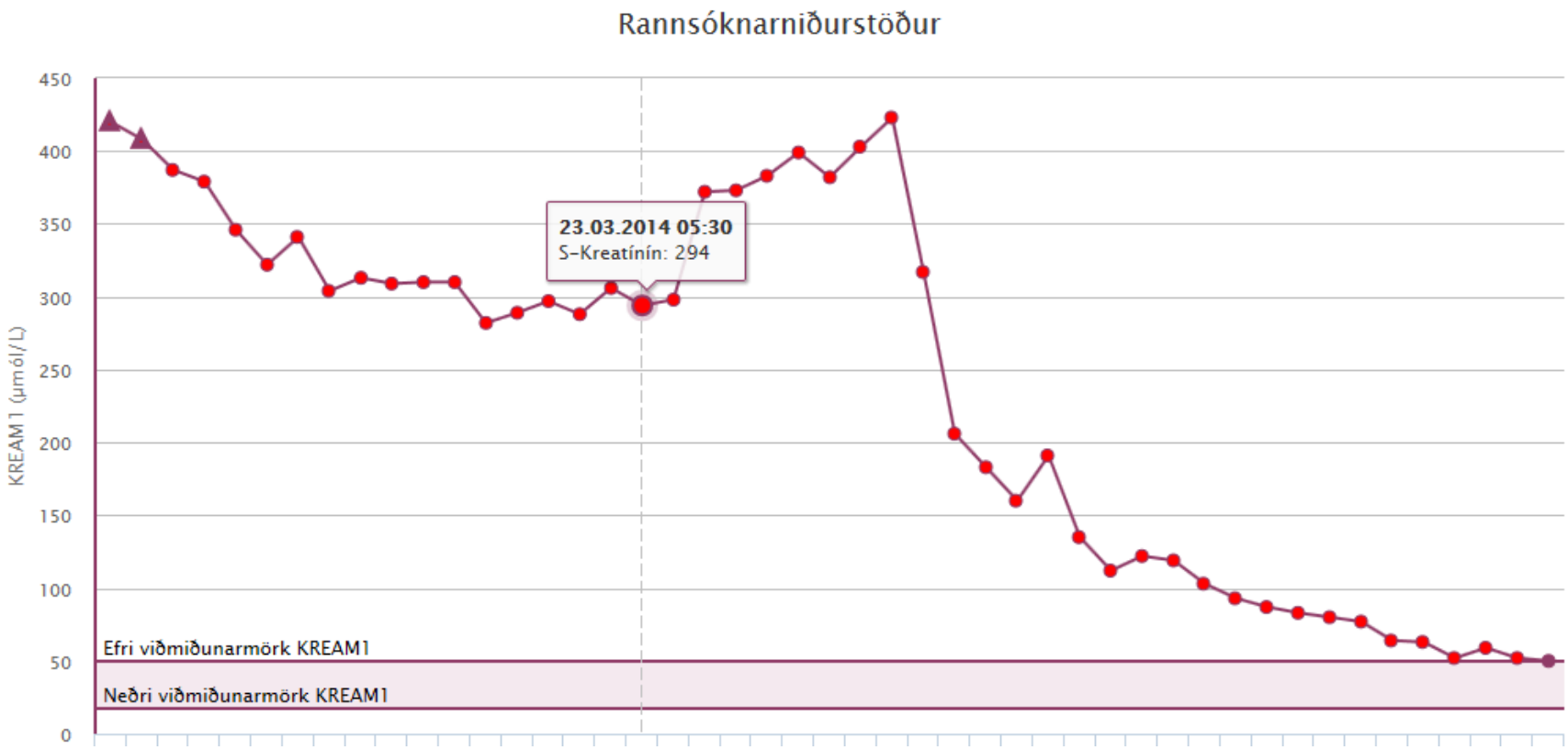
Stúlka 2 ára D+HUS

serum - kreatínín



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Drengur 4 ára D+HUS

- Óblóðugur niðurgangur og kviðverkir
- Bráður nýrnaskaði, oliguria en ekki anuria
- Hraður bati án skilunar
- Ekki einkenni frá taugakerfi

- **Hgb 65g/L, blóðflögur 28.000, kreatínín 169 µmól/L, LDH 1700 u/L, habtóglóbín <0,05g/L.**

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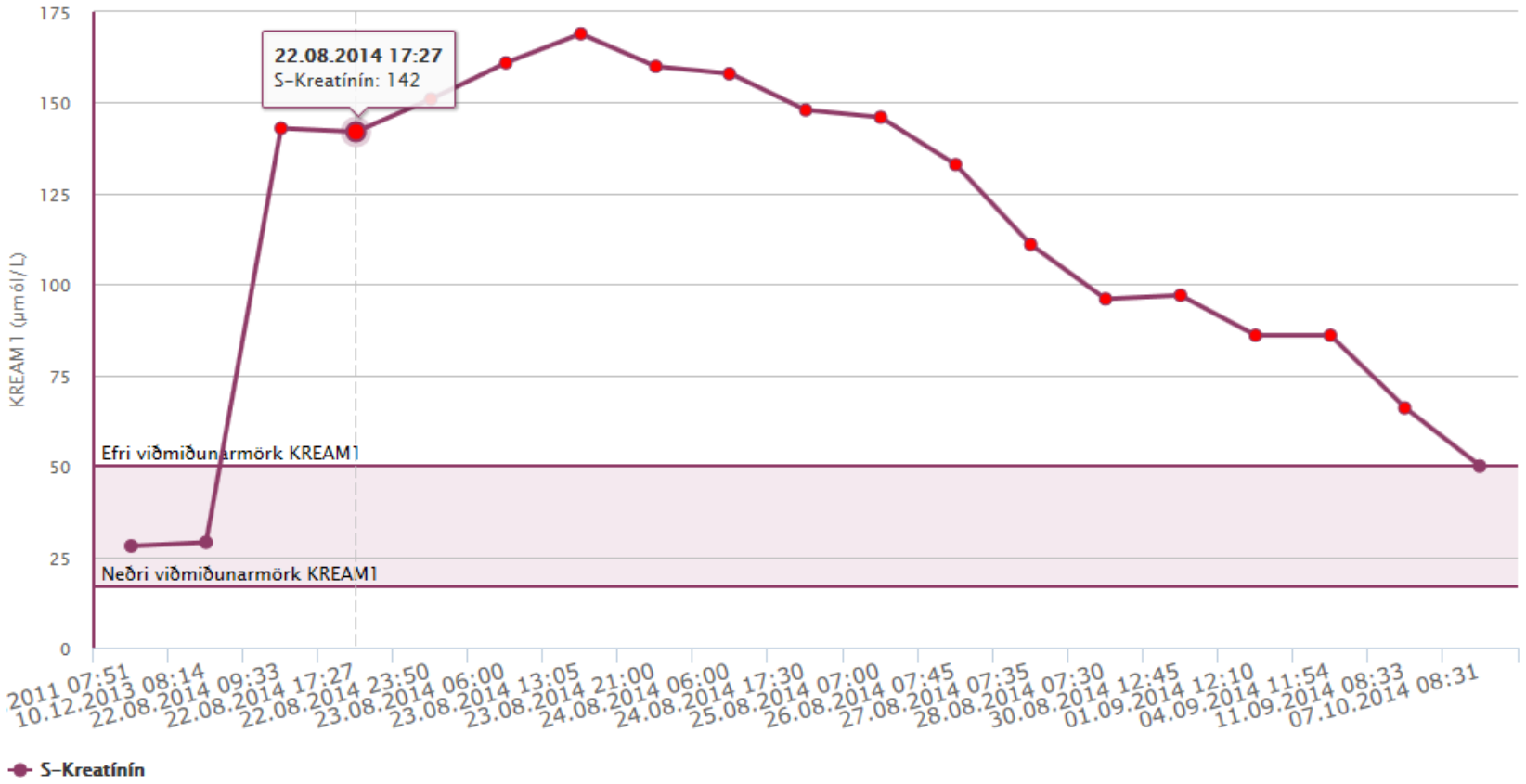
Drengur 4 ára D+HUS
- serum kreatínín



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Ábendingar fyrir skilun hjá einstaklingum með bráðan nýrnaskaða

- Alvarleg hyperkalemia
- Ofvökvun (volume overload)
  - Hjarta- og eða öndunarbilun
  - Alvarlegur háþrýstingur
  - Háræðaleki/mikill bjúgur
- Óviðráðanleg efnaskiptablóðsýring
  - Lactic acidosis
    - Léleg blóðrás (aukin framleiðsla)
    - Lifrarbilun (truflað niðurbrot)
  - Acidosis due to renal failure
- Inability to supply adequate nutrition
  - Fluid overload
  - Accumulation of nitrogenous waste products (urea)

Choice of mode of dialysis

- Choice of a mode of dialysis will to a great extent depend on the local expertise with respect to personnel and equipment resources
  - Peritoneal dialysis
  - Intermittent hemodialysis
  - Continous renal replacement therapy (CRRT)
    - CVVH
    - CVVHDF

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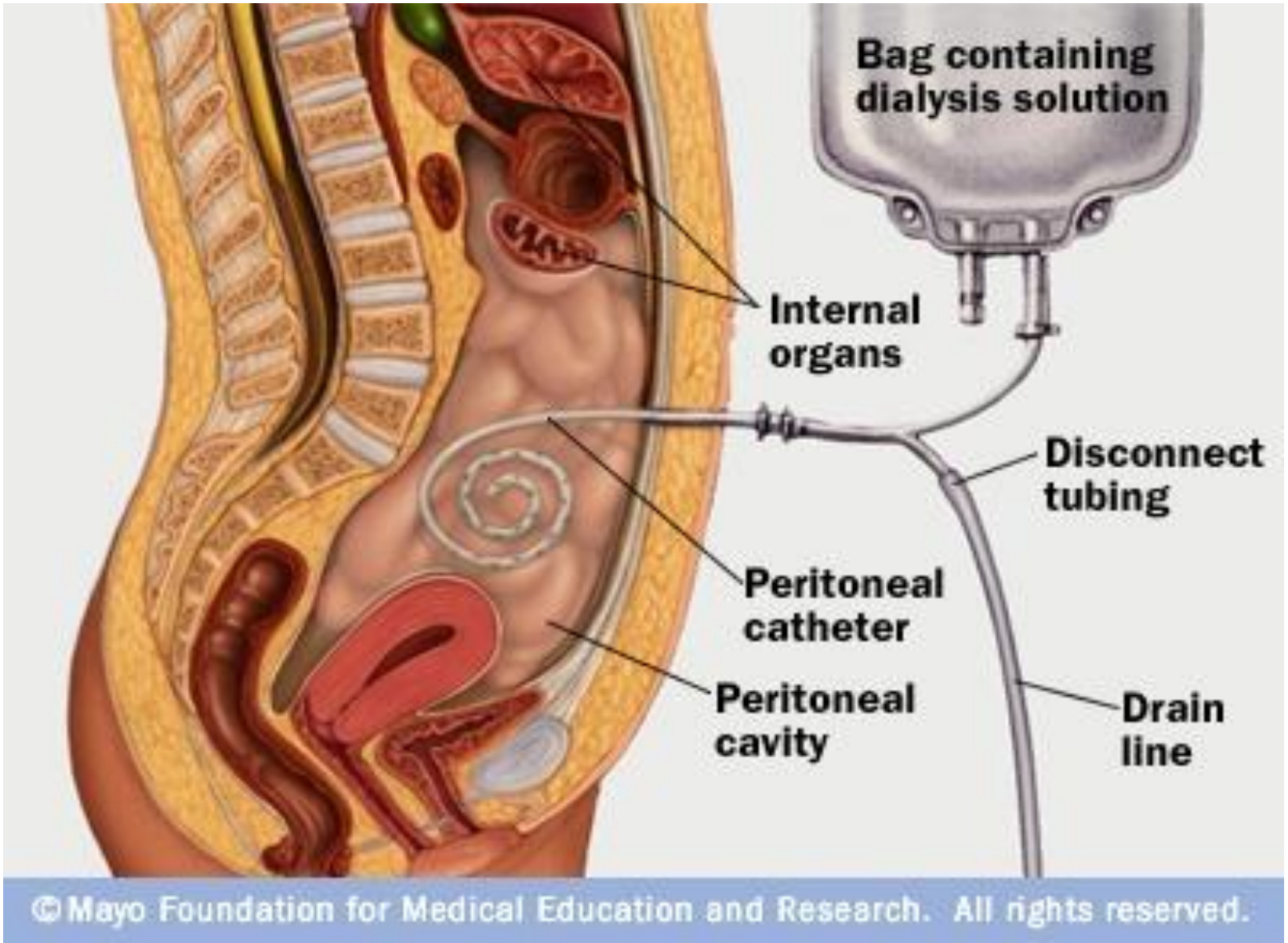
Kviðskilun


Bag containing dialysis solution
Internal organs
Disconnect tubing
Peritoneal catheter
Peritoneal cavity
Drain line
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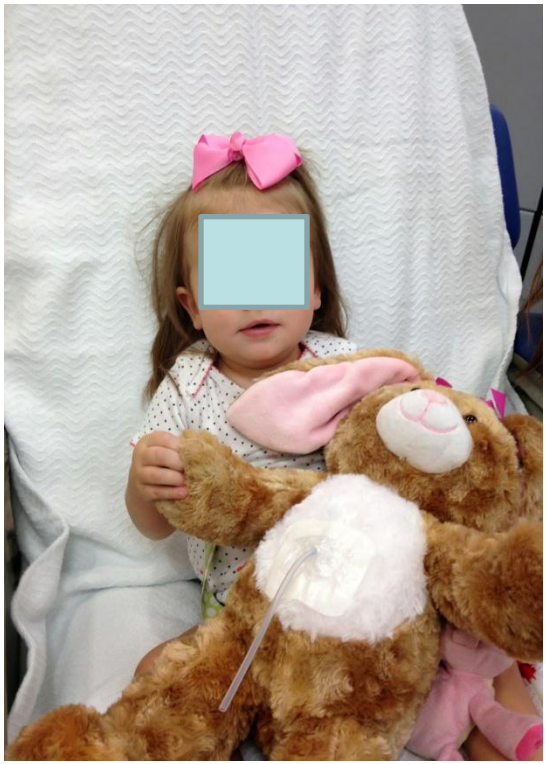
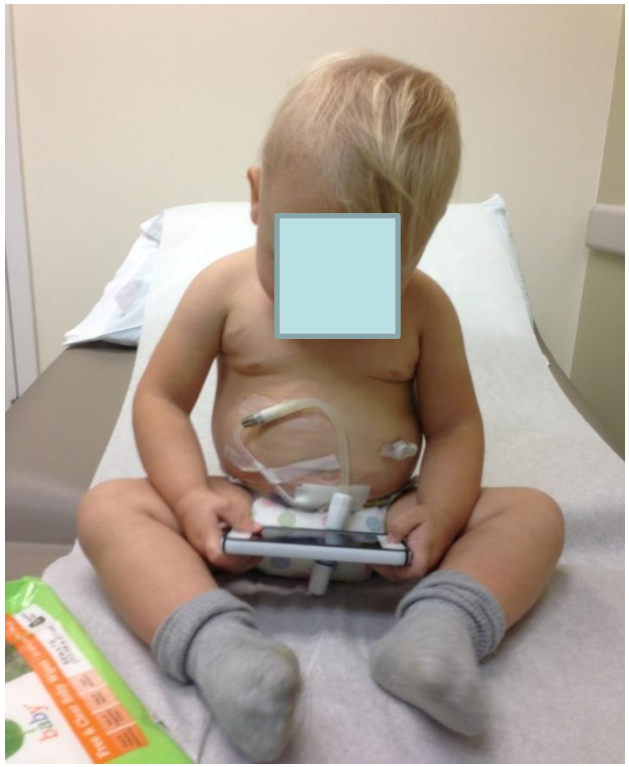
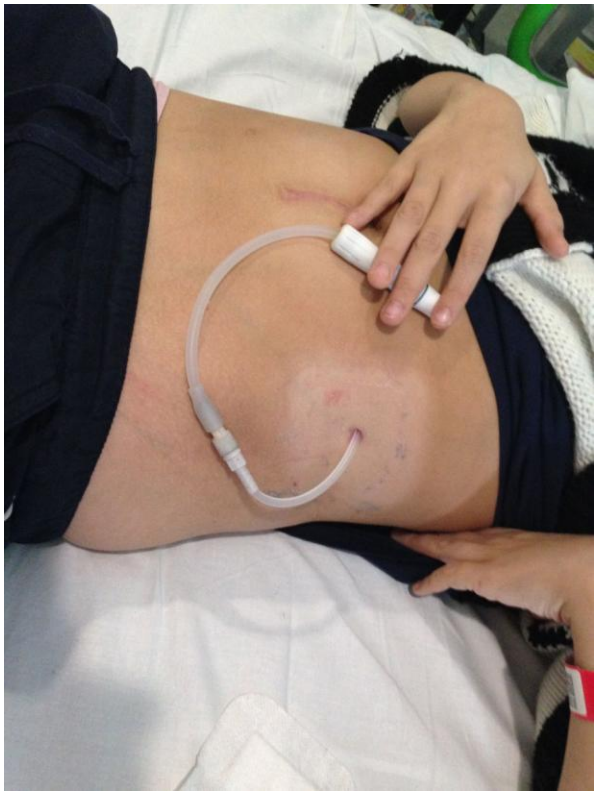
Kviðskilun







Comparison of modalities of renal replacement therapy for acute renal failure

Comparison of modalities of renal replacement therapy for acute renal failure

Type	Complexity	Use in hypotension	Efficiency	Volume control	Anticoagulation
Peritoneal dialysis	Low	Yes	Moderate	Moderate	No
Intermittent haemodialysis	Moderate	No	High	Moderate	Yes
CVVH	Moderate	Yes	Moderate	Good	Yes
CVVHDF	High	Yes	High	Good	Yes

CVVH, continuous veno-venous haemofiltration; CVVHDF, continuous veno-venous haemodiafiltration.

Acute Kidney Injury in Children - summary

- Children at risk for acute kidney injury are frequently cared for in the PICU.
- Prompt dectection and treatment of underlying causes and complications improves outcome.
- The use of KDOQI criteria improves the diagnosis of AKI in children. Using urine output criteria improves sensitivty of the KDOQI criteriae.
- Anticipation of problems is a key issue in the managment of all patients at risk for kidney failure.
- The choice of RRT modality in the PICU setting will depend on the local expertise and equipment resources.

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