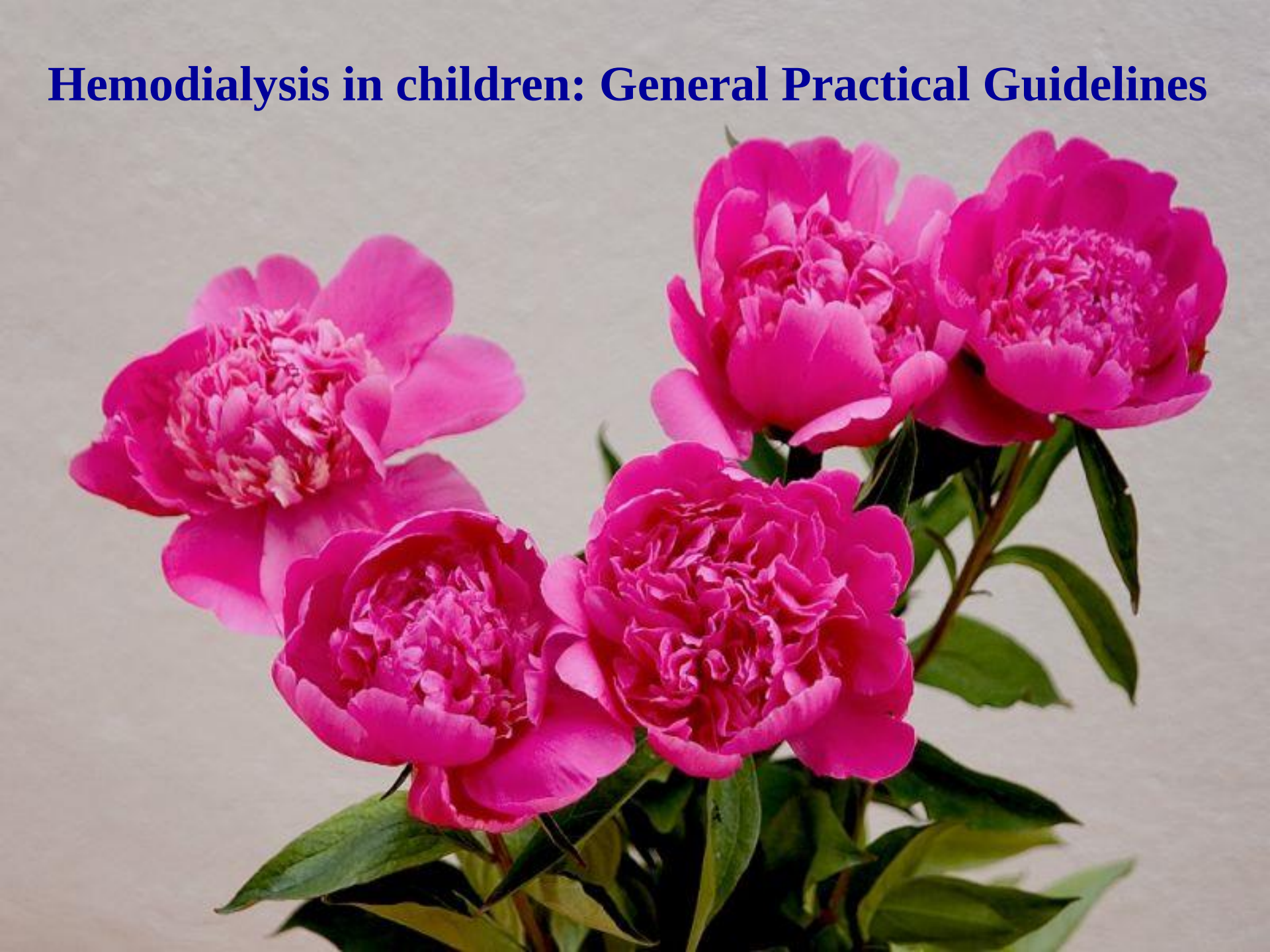
Hemodialysis in children: General Practical Guidelines



Introduction

- Hemodialysis in children progress over the last 20 years
- The morbidity of the sessions has decreased
- Technological progress, the availability of erythropoietin and of growth hormone enhanced dialysis dose increased quality of life
- Technically all children can underwent HD even infants

Primary renal diseases leading to chronic renal failure

	France%	North America%	Iran%
Primary Diagnosis			
GN	25.6	24.8	10.2
Malformation	25.6	34.1	47
Inherited Renal Disease	16.7	13.5	21.1
CIN	18.8	7	9.6
Vascular Disease	2.2	4.4	3.6
Unknown	11.1	16.2	8.5

Indication of RRT and Dialysis

- Renal Function, GFR?, before uremic symptoms
- Fluid status
- Biochemical abnormalities
- No well being: physical and psychological
- Growth retardation

Acute Renal Failure

Oligoanuria, resistant volume overload, hyperkalemia, mAc, uremic encephalopathy, uremic pericarditis, TLS with uric acid ≥10, Inborn metabolic syndromes, Intoxication, BUN

Guideline 1: The Dialysis Unit

- **Taking care of a child with ESRF necessitates an engaged team consisting of doctors, nurses, dietician, psychologist, school teacher, play therapist, and social worker (second family or support team)**
- **Nutrition, growth, and educational support are of major importance**
- **Hemodialysis: a frequency of three times per week for most patients. This frequency may be increased in babies and/or adolescents requiring "more dialysis"**

Guideline 2: Water Quality

- **Blood contact with 120 cc water during a dialysis sessions**
- **adequate in terms of biochemical composition**
- **Free from microbiological contamination (germs and endotoxins)**
- **Pure versus ultra pure water (High Flux, High flow hemofiltration, conventional HD?)**

Guideline 3: The Dialysis Machine

Specific Feature that are necessary in a pediatric hemodialysis machine

- **Precise control of ultrafiltration volumetric assessment**
- **Capable of low blood flow speeds**
- **Ability to use lines of varying blood volums**
- **Measure and remove very small amounts of fluids**
- **Continuous blood volume monitoring during the session**
- **Buffered bicarbonate**
- **Specific material available for babies/infants**

Guideline 4: blood lines

- **Available in infants/babies size**
- **High biocompatible material**

Examples of the volumes of lines available for dialysis according to the size of the patient

Patient size	Venous (mls)	Arterial (mls)	Total (mls)
Mini-neonatal (<6 kg)	21	8	29
Neonatal (6–12 kg)	22	18	40
Pediatric	42	30	72
Adult	70	62	132

Guideline 5: principles of blood purification

Guideline 6: extracorporeal blood access and circulation

Extracorporeal blood flow rate and volume

- 150–200 mL min−1 m−2
- 5–7 mL/min/kg up to 8 cc/kg/min
- (BW+10)×2.5=*Q*B (mL min−1) in small infants
- Arterial blood aspiration pressure : 150–200 mmHg to limit endothelial trauma
- The venous return pressure should not be more than +200 mmHg to prevent endothelial vascular trauma
- The total extracorporeal blood volume : 7- 10 % of patient total blood volume (<8cc/kg)
- System priming with saline, albumin, and blood
- Double-needle technique: standard, single needle with double pump system: alternative

Anticoagulation in the extracorporeal circuit

- Infants and small children are sensitive to anticoagulation because of cerebral hemorrhage
- Conventional, heparin: continuous infusion of 20 to 30 IU kg/ h through arterial line, or 25-50 u/kg loading dose and 10u/kg/hr.
- Clotting time is the best monitor for heparin dose in first dialysis (1.25-1.5 Nl range, PTT: 120-160)
- Low-molecular-weight heparin at 1 mg/kg as a bolus at the beginning of the dialysis session, bleeding↓, improved lipid metabolism, half life↑, cost↑
- Citrate anticoagulation especially with acute dialysis, IV calcium at venous line 0.3-0.5 mmol/l
- Heparin free dialysis, minimal heparinization
- TPA 1mg/ml for one hour preferably overnight


Vascular Access

- Catheters (cuffed, uncuffed), AV Fistula, AV Graft
- The type of access depending on :

  Factors in different units and countries, surgical experience, patient age and size, the time available before dialysis, the waiting time before transplantation, and patient choice
- Tunneled cuffed catheter for short term HD
- Fistula vascular access is preferred for long-term chronic hemodialysis

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*** The types of vascular access:**

- Catheter:

***Rt/Lt Int jugular> femoral>subclavian, 8-12 F**

***Double lumen cuffed/uncuffed catheter, 8 French**

***In small infants a single lumen catheter with the alternative clamps technique**

***Complications is more common in children than adults**

***Real time Ultrasound**

***Cathetr malfunction: kinking versus intraluminal thrombosis**

-AV Fistula

- >25 kg in some centers and >10 kg in centers with microsurgery
- Preoperative evaluation and protection of the vessels, upper limb venography, hydrated and above dry weight and adjustment of antihypertensive drugs, prophylactic ASA (1-5mg/kg/day)
- Selection of vein: 4 mm diameter with 40 mmHg cuff
- The time for venous development depends on the age and the place of the AVF (distal or proximal).
- Usually 4-6 wk for maturation, in young children, less than 15 kg, the time needed to develop a fistula before it can be used could be some months (up to 4 mo)
- Complications: Thrombosis, Infection, Stenosis (recirculation>10%), Aneurysm, neuropathy, CHF
- **Recirculation% = S-A/S-V ÷100**
- 2/3 is functional after 4 years
- Distal fistuals more complicated in children

AV Graft

- Rarely used in children
- Complication: stenosis and thrill, clotting, Infection with difficulty in eradication
- Straight Graft in small children and loop Graft in larger patients
- Long term complications is high in children

Guideline 7: which dialyzer membrane to “choose”

The choice of a dialyzer membrane should take into account the following

- **Type of membrane: biocompatibility toward complement system**
- **Initial blood volume needed, i.e. area-related**
- **Molecular permeability: Highly permeable membranes give the theoretical potential for middle-molecular-weight**
- **Hydraulic permeability (*C*UF) : High flux vs low flux**
- **high flux membranes need ultrapure dialysate**
- **Surface area (0.25-1.7): no more infant surface area**
- **Cost**

improved removal of middle molecules by high flux, large pore, biocompatible membranes : reduction of uremia related amyloidosis, inflammation, malnutrition, anemia, dyslipidemia, and mortality.

Guideline 8: the dialysate

- Bicarbonate buffered (35 meq/l)
- low calcium level (1.25-1.5 mmol L−1)
- glucose concentration at physiological level: 1 gr/l (prevent cellular potassium shift)
- “Zero”, “low” (1–1.5 mmol/l), “normal” (2–2.5 mmol/l), and “high” (3–3.5 mmol/l) potassium dialysate
- Sodium concentrations:138 to 144 mmol/l (difference: 10-15 mmol/l), hypernatremia, change during a dialysis (sodium modeling)
- The dialysate FR 300 to 800 mL min−1 (1.5 BFR).
- Thermal degree: 34.5-37, Dialytic thermal exchanges, for babies and/or high-flow dialysate use
- Dialysate quality control (germs and endotoxins) is required

Guideline 9: post-dialytic dry weight assessment and adjustment

- Difficult to define in growing children especially infants

-Hypotensive tendency during a dialysis (plasma refilling rate capacity)

-Total body water ratio to total body mass, is variable with age, especially during infancy and puberty

- need for regular assessment in a growing child

Monthly in infants, ↑anabolic conditions (GH), ↓Catabolic conditions (low intake, illness)

- close collaboration with pediatric renal dietician

- no “unique” optimum method, importance of a clinical “pediatric” experience

  -assessment of TBW by bioelectrical impedance analysis, continuous measurement of hematocrit by non-invasive methods during dialysis, plasma ANP or cyclic guanosine monophosphate determination, by echography of the inferior vena cava (IVC) diameter of the IVC (IVCD), An IVCD between 8.0 and 11.5 mm m^{-2} and a collapse index between 40 and 75 % is considered as representing normovolemia

  -crash hematocrite, Flat HCT curve, more precise

Guideline 10: urea dialytic kinetic, dialysis dose, and protein intake assessment (nutrition)

- In children the criteria of adequate hemodialysis is not clear as adults
- Growth and development is the most important indicator of adequate dialysis
- Urea kinetic modeling (UKM) , A marker of middle molecules?, increasing urea clearance above accepted target, underdialyzed patients and dietary compliance

- **normalized protein catabolic rate (nPCR)**
- **Urea dialytic reduction rate (URR)**

+URR is proportional to dialysis efficiency, and thus to urea dialytic clearance.

+The ratio post/pre ≤ 0.35 and the difference between pre and post-urea, divided by the pre dialysis value≥ 0.60

- ***Kt/V*** **:dialyzer urea clearance (*K*) multiplied by duration (*t*) of the dialysis session and divided by urea volume (*V*) of distribution**

+A minimum *single pool Kt/V* level of 1.2–1.4 : desirable

+ in small children *single pool Kt/V* more than 1.4

Formulas enabling calculation of the volume of distribution of urea in liters (total body water) using height, weight, sex and age

- **Boys:**

  Ht<132.7 cm, *V*=1.927+0.465/BW (kg)+0.0045/ht (cm)
  Ht>132.7 cm, *V*=−21.1933+0.406/BW (kg)+0.209/ht (cm)

- **Girls:**

  Ht<110.8 cm, *V*=0.076+0.507/BW (kg)+0.013/ht (cm)
  Ht>110.8 cm, *V*=-10.313+0.252/BW (kg)+0.154/ht (cm)

Guideline 11: dialysis dose and outcome

Hemodialysis prescription for children: adequate, before optimum

- Blood pressure control, normal myocardial morphology and function
- urea dialysis dose, removal middle molecules and overall phosphate, a minimum *Kt/V* level of 1.2–1.4 : desirable, urea clearance 3-4cc/kg/min
- Dialysis frequency and duration : adjusted to the tolerance of ultrafiltration to reach the dry weight.
- UFR=W-Wd+I/T, UFR=TMP×KUF
- Ultrafiltration rate should not exceed 1.5±0.5% of body weight per hour (in theory no more than 5% BW loss per whole session). 10cc/kg/hr as safe starting point for water removal. No more than 0.2 cc/kg/min

Hemodialysis prescription for children: adequate, before optimum

- A regular diet
- Too fast ultrafiltration (more than 5% BW) → hypotension and cramps during the second half time session, and fatigue and/or hang over after dialysis
- A small solute, e.g. urea, clearance which is too high is a factor of disequilibrium syndrome usually after the first half/or one hour session time with headache, even seizures, nausea, vomiting, sleepiness or a hypertensive tendency with a narrow range between systolic and diastolic pressure values. Symptoms usually disappear a few hours after the end of the dialysis

Guideline 12: the dialysis session, prescription, and monitoring

Importance of first session:

- **Pain relief, Emotional support**
- **Prevention of recirculation**
- **First contact with the "extracorporeal" material, dyspnea, burning heat throughout the body or access site, angioedema, flushing or vascular collapse, or with minor symptoms such as itching, rhinorrhea, lacrymation, urticaria, or abdominal cramping). Prevention: Biocompatible membranes, steam-sterilized material, adequate flushing of the circuit**
- **Prevention of disequilibrium syndrome**

-The BFR should be ≤ 3 mL kg−1 BW (or 90 mL m−2)

-Short dialysis time (less than 2 hr)

-Mannitol infusion (0.5- 1 g kg/ BW/ 1 to 2 h during dialysis)

- Urea clearance: 1.5-2 cc/kg/min

- Sodium modeling

-selection of dialyzer

- **Hemodynamic assess (asymptomatic and without compensation)**

- **Movement of fluid from extracellular to the Intracellular space**
- **Impaired sympathetic activity**
- **Vasodilation due to warm dialysate**
- **Splanchnic pooling of blood while eating during dialysis**
- **Excessive UF**
- **Antihypertensive agents**
- **Low Diasylate sodium**

Symptoms of hypotension: pallor, cyanosis, vomiting, irritability, drowsiness, sudden cry, sweating, headache, Seizure, check BP at 1 hr +monitoring + pulse oximetry: children <20 kg

Next sessions

Usually a blood flow rate of 150 to 200 mL/ min/ and three sessions per week for 3 to 4 h per session achieve the minimum target prescription of 1.2 to 1.4 *Kt/V*

- **The duration of a dialysis session is often prescribed to reach the anticipated dry weight at the end of the session, DSA/BSA × Dialysis Index (13-18)**
- **Continuous blood volume monitoring during the session for ultrafiltration tolerance (with crash HCT)**
- **Intensified HD: 6-8 HR/3-7/WK, 2-3 HR/5-7/WK: chronic fluid overload, ph↑, poor growth, infancy**
- **A weight gain over 10% dry BW during the interval of two sessions: Non compliance**

- **optimum dialysis obtained with longer (4 and more hours) and/or more frequent (daily: 5 to 6) sessions to achieve phosphate purification and maintain the calcium×phosphorus product in the optimum range of 3.3 to 4.4 mmol/mL and in following patients:**

Infants, Malnutrition, Growth retardation, chronic overhydration, Intractable HTN, LVH, Primary hyperoxaluria

Injections during Dialysis

- **Albumin: small boluses through arterial line at the beginning of dialysis**
- **Blood: small boluses at the beginning of dialysis**

blood required (ml): weight (kg) × 3 × grams of Hb is to be raised

- **EPO: More dose in infants and children and IV**

Complications

- **Intradialytic Hypotension**
- **Disequilibrium**
- **Hemolysis**

-Overheating, contamination, Hypotonicity, Kinking of lines, pump malfunction

- Dialysis should be stopped and potassium checked immediately

-pains, nausea, dark appearance of venous blood

- **Air Embolism**

Rare, one ml/kg is fatal, fitting and coma in upright patient and chest symptoms in recombinant patient

Head Down, left lateral position and 100% oxygen, Aspiration from the ventricle

- **Anaphylaxis**

  +First use syndrome, prevention by dialyzer reuse and predialysis rinsing or dialyzer change in severe reactions

  +Stop dialysis and blood should not be retained to patient

  +Normal saline, Epinephrine (SC, IM), Hydrocoprtisone

- **Amyloidosis**

  Unusual in children, 7-10 yr after HD clinically

جهان يادگار است و ما رفتني به گيتي نماند مگر مردمي

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