
به نام
خداوند
بخشنده و مهربان

PEDIATRIC DIALYSIS

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Incidence and Prevalence of RRT

- Incidence: In children < 19 years worldwide
  - 9 cases (range 4 to 18) pmarp
- Prevalence:
  - Ranging from 18 to 100 pmarp.

Vascular Access in Children

- The number of ESRD children tripled over the course of 30 years
- Most children on HD in the USA (78.7%) and Europe (60%) are dialyzed with a CVC

LOCATION OF AVF

- Distal before proximal: (radio-cephalic)
- Autogenous before prosthetic
- Non dominant arm preferred to dominant
- Dominant arm preferred to lower limb
- Thigh AVF preferred to AVG?
- In children with small vessels brachio-basilic vein is preferred (basilica vein located deeper)

COMPARING ADVANTAGES OF AVF & CVC

AVF

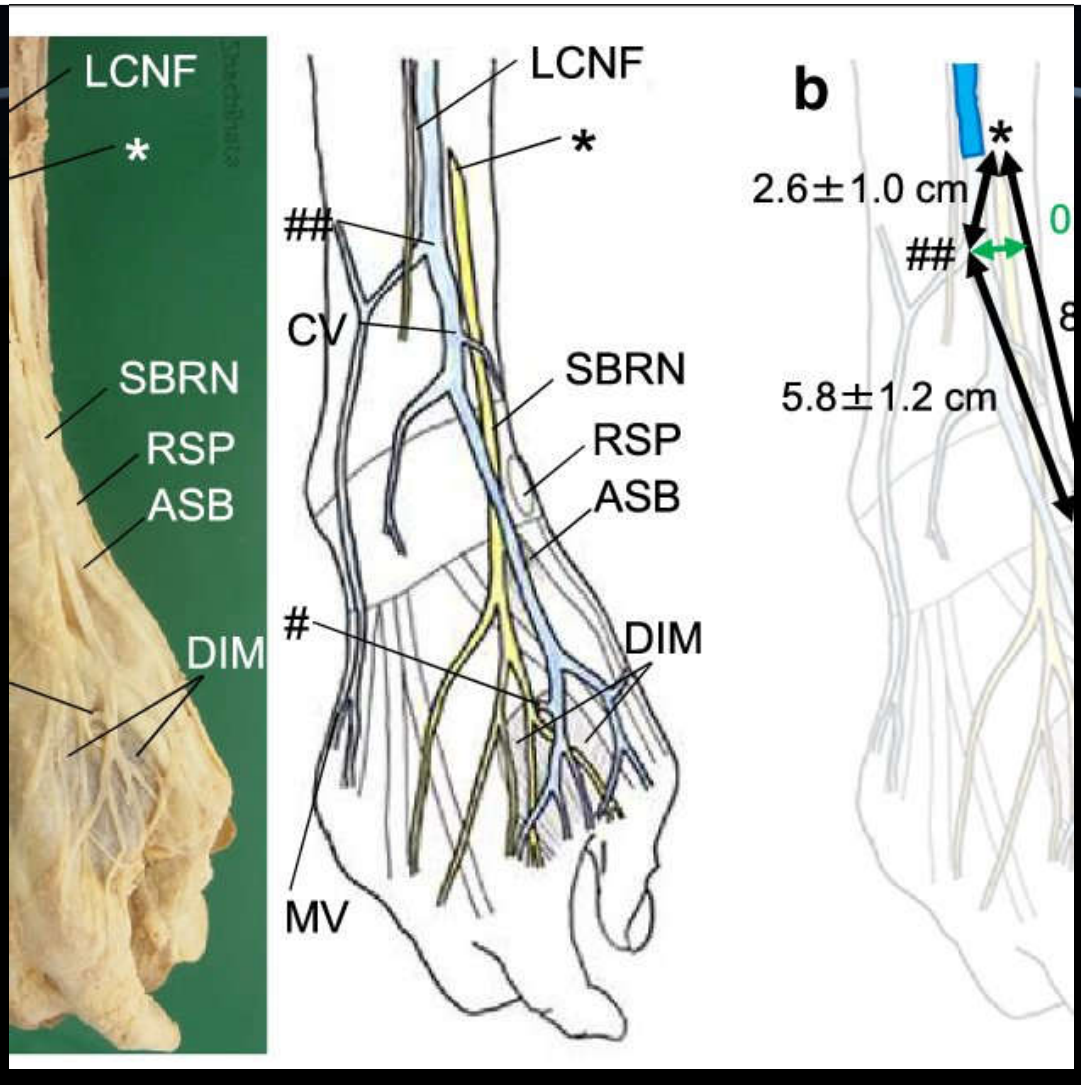
- Higher Blood flow rates
- Best long term survival
- Higher albumin & Hgb
- Bath and swim without restriction

CVC

- Ease to use
- painless
- No limb deformity
- Right jugular vein is preferred
- Split catheter is preferred in small children

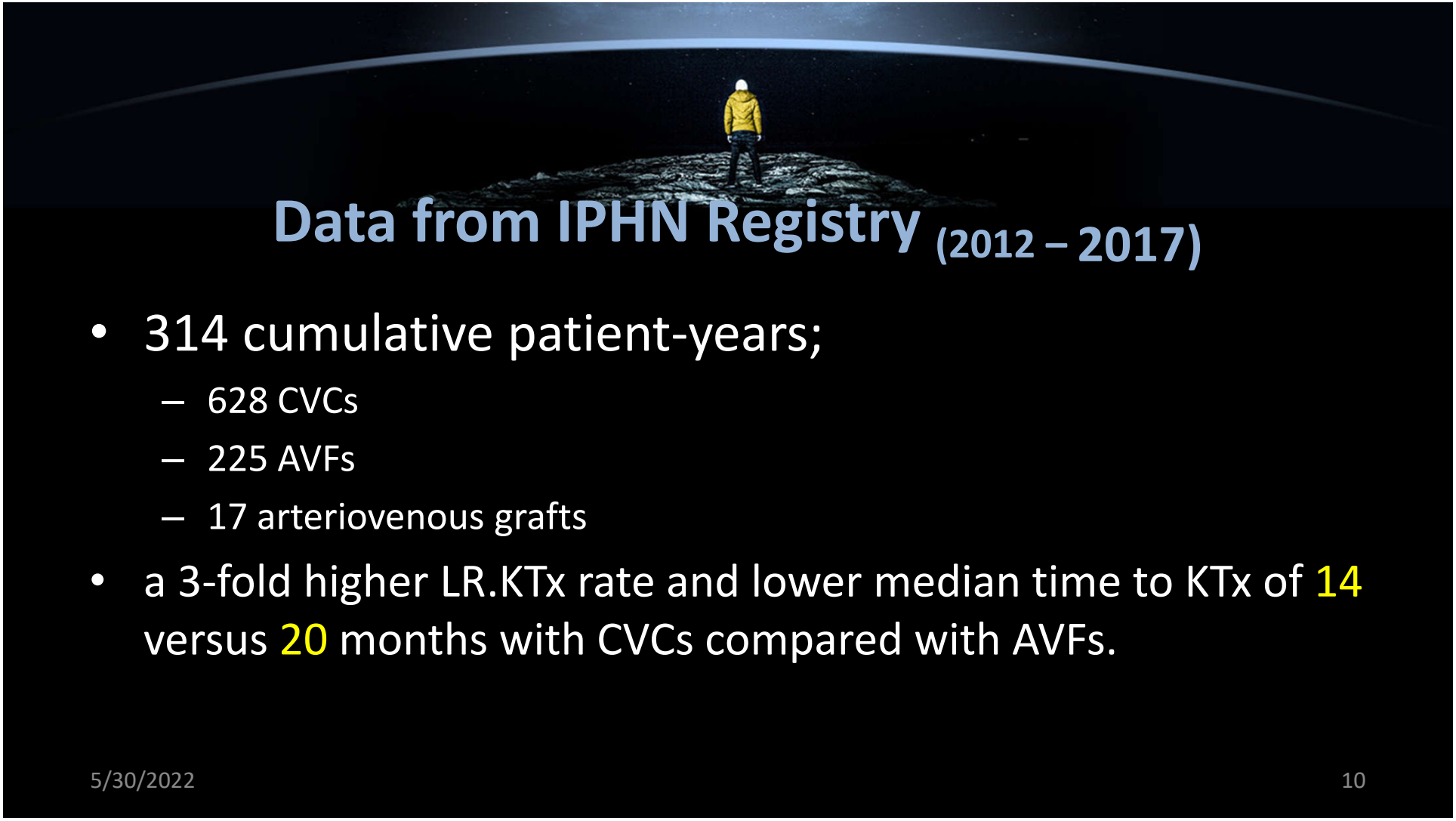
Think before you stick!!!

- 1- Avoid the non-dominant arm all together.
- 2- Avoid the cephalic veins in both arms, but never use the cephalic vein in non-dominant arm.
- 3- A single stick in the cephalic vein can occlude it permanently.
- 4- Inserting a single lumen catheter in SCV precludes forever the use of extremity for HD access.


LCNF
*
SBRN
RSP
ASB
DIM
LCNF
*
##
CV
SBRN
RSP
ASB
#
DIM
MV
b
*
2.6±1.0 cm
##
0
8
5.8±1.2 cm

Arteriovenous sites

Artery	Vein	Fistula
Radial	Cephalic	Wrist
Brachial	Cephalic	Antecubital
Brachial	Basilic	Forearm
Brachial	Basilic	Upper arm/ transposed
Femoral	Saphenous	Thigh



Data from IPHN Registry (2012 – 2017)

- 314 cumulative patient-years;
  - 628 CVCs
  - 225 AVFs
  - 17 arteriovenous grafts
- a 3-fold higher LR.KTx rate and lower median time to KTx of 14 versus 20 months with CVCs compared with AVFs.

Maturation time & cannulation

- Low dose Aspirin to prevent thrombosis??
- Maturation time 1-6 months
- Educating both Child and Family
- The first few treatments using 17- gauge needle
- Cannulation of arterial portion and using CVC for venous return for the first times
- Child life specialist??????

Dialysis prescription

- **Dialysis/ Filter Size**
  - KOA (urea clearance coefficient): 350-500ml/h
  - Filter surface area: 0.3-0.8 m^2
  - Filling Volume 20-50 ml
  - Synthetic filter

DIALYSIS PRESCRIPTION

Filter	Surface area	UF Coefficient
F3	o.4	1.7
F4	0.7	2.8
F5	1.0	4
F6	1.3	5.5
F7	1.6	6.4
F8	1.8	7.5

Dialysis prescription

Filter	Surface area	UF Coefficient
PS10	1.0	34
PS12	1.2	42
PS15	1.5	50

Dialysis prescription

- **Which dialyzer membrane to "choose"**
  - synthetic membrane, low flux, capillary configuration
  - high-flux membrane use: requires use of ultrapure dialysate
  - removal of urea and other uremic toxins dialytic should be considered, especially in chronic, long-term dialysis

Dialysis prescription

- **Blood Flow**
  - Initial clearance for significant uremia:
    - 30% on the first day
    - 30% → 50% → 70%: to avoid disequilibrium
    - Using mannitol through the dialysis circuit
  - BFR: 6-8 ml/kg/min (limited to 25-50 in most dialysis machines)

Dialysis prescription

- **Dialysate Flow**
  - At least 1.5-2 times the BFR to provide optimal countercurrent gradient
  - Set at a minimum 300-500
  - Keep warm blood lines and dialysate to avoid hypothermia

Dialysis prescription

- **Dialysate:**
  - bicarbonate buffered
  - low calcium level (1.25 mmol L^{-1}) becomes the standard
  - glucose concentration at physiological level
  - dialysate quality control (germs and endotoxins) is required

Dialysis prescription

- **Anticoagulation**
  - Most centers prefer to use unfractionated heparin (UFH): inexpensive and easy to handle
  - LMWH: better predictability

Dialysis prescription

- **Anticoagulation:**
  - UFH:
    - It consists of a large series of glycosaminoglycans which interact with antithrombin and effectively reduces coagulation cascade activation
    - It activates directly PLTs and results in micro thrombi deposits on the dialyzer wall

Dialysis prescription

- **Anticoagulation:**
  - UFH:
    - Loading dose: 25-50 IU/Kg (300-1000 IU/m^2)
    - Maintenance: 10-30 IU/kg/h
    - Infusion is stopped 30 min before ending session
    - Monitoring by ACT or PTT

Dialysis prescription

- **Anticoagulation:**
  - Side effects of prolonged use of UFH:
    - Allergic reaction (derived from bovine intestine)
    - Osteoporosis
    - Exacerbate hyperkalemia(antagonizing aldosterone)
    - Alopecia
    - Abnormality in LFT

Dialysis prescription

- **Ultrafiltration:**
  - Should be limited to no more than 5% of the infant's dry weight
  - Should not exceed 100 ml/h
  - Treatment time may be extended beyond that required for clearance

Assessment of fluid overload in children

- 1- Bioimpedance analysis (BIA)
- 2- Inferior vena cava collapsibility index
- 3- Relative blood volume monitoring
- 4- N-terminal pro-brain natriuretic peptide (NT-proBNP)
- 5- Lung ultrasound

Post-dialytic Dry Weight Assessment

- Particularly difficult to define in growing children
- No “unique” optimum method, importance of a clinical “pediatric” experience
- Need for regular assessment in a growing child
- Close collaboration with pediatric renal dietician

Post-dialytic Dry Weight Assessment

- Clinical criteria used to assess hydration status are important but not always reliable.
- Assessment of total body water by bioelectrical impedance analysis
  - In BIA, a weak electric current flows through the body and the voltage is measured in order to calculate impedance (resistance) of the body.
- Continuous measurement of hematocrit variations

Post-dialytic Dry Weight Assessment

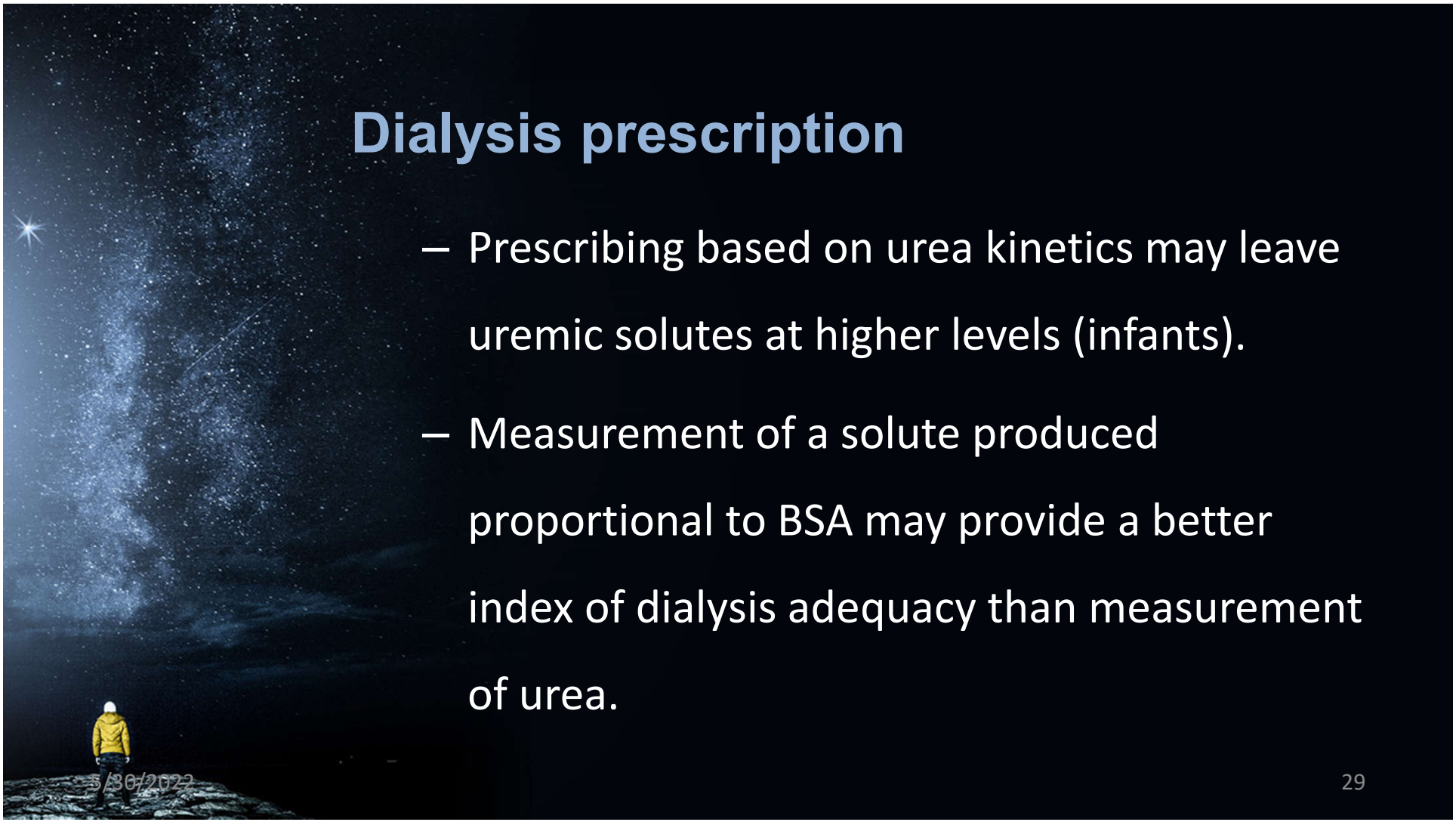
- Plasma atrial natriuretic peptide
- Cyclic guanosine monophosphate
- Echography of the inferior vena cava
- Measurement of the diameter of the IVC by ultrasound:
  - Expressed as an index to body surface-area in mm m^{-2}, and the decrease on deep inspiration, called the collapse index

Post-dialytic Dry Weight Assessment

- An IVCD between 8.0 - 11.5 mm m^{-2} and a collapse index between 40 and 75 % is considered as re-presenting normo – volemia.
- However, unlike body impedance, interstitial volume and sodium balance are not reflected by IVCD.

Dialysis prescription

- Prescribing based on urea kinetics may leave uremic solutes at higher levels (infants).
- Measurement of a solute produced proportional to BSA may provide a better index of dialysis adequacy than measurement of urea.



Dialysis dose and outcome

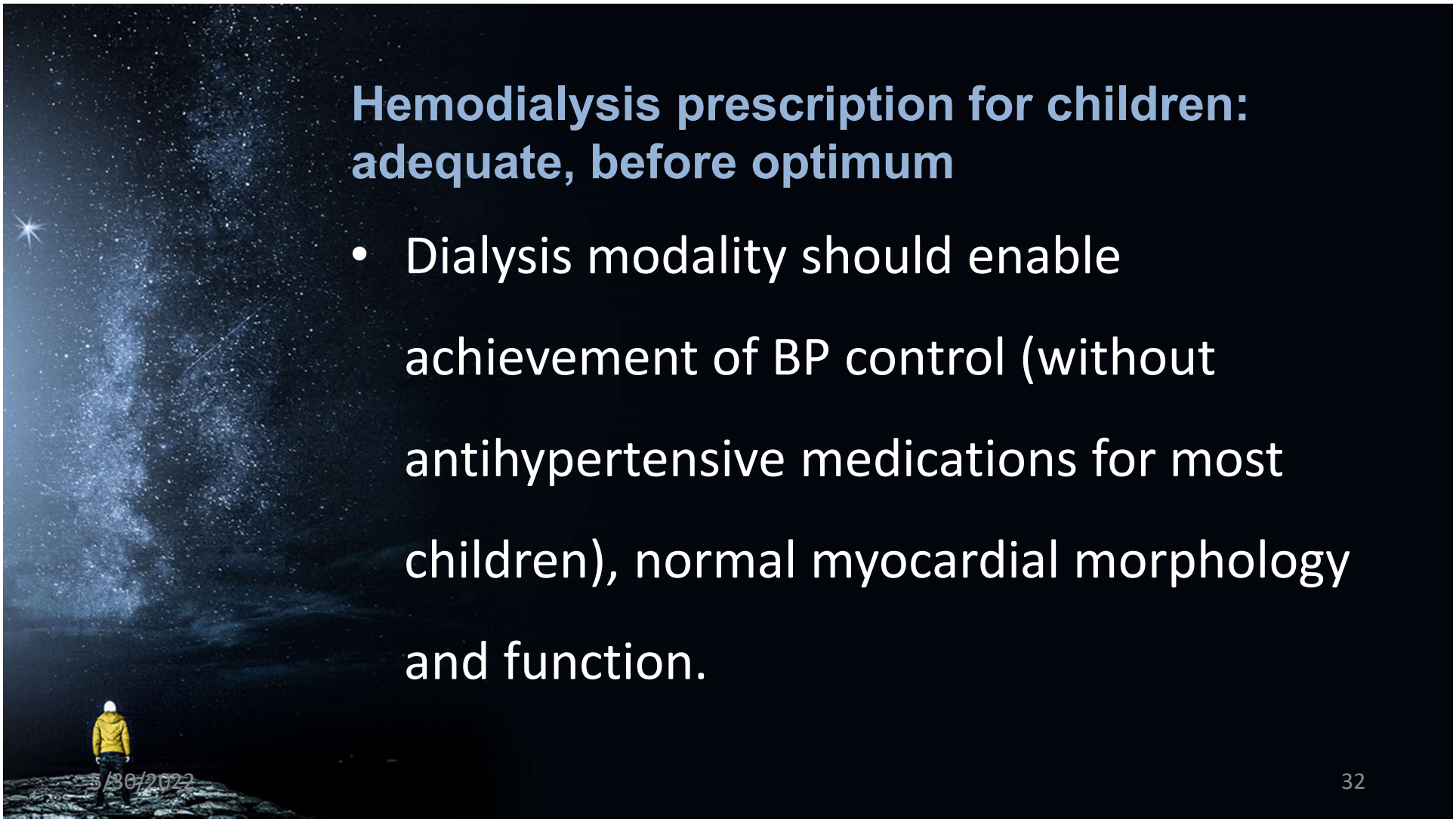
- Only “small solute urea clearance” prescription?
- A minimum Kt/V urea level of 1.2–1.4 is thought to be desirable
- Adequacy tests should be performed monthly
- Dialysis and residual renal small-solute clearance are not equivalent

Dialysis dose and outcome

- Dialysis prescription should be adequate before being optimum, not only a “urea dialysis dose”.
- As a rule of thumb, the total extracorporeal blood volume (needles, tubes, and dialyzer) should not exceed 10% of total patient blood volume.

Hemodialysis prescription for children: adequate, before optimum

- Dialysis modality should enable achievement of BP control (without antihypertensive medications for most children), normal myocardial morphology and function.



Hemodialysis prescription for children: adequate, before optimum

- Dialysis dose prescription should not only be an urea dialysis dose.
- Removal of the other uremic toxins should be considered, not only middle molecules but overall phosphate.

Hemodialysis prescription for children: adequate, before optimum

- Dialysis frequency and duration must be adjusted to the tolerance of ultrafiltration to reach the dry weight.
- Ultrafiltration rate should not exceed 1.5± 0.5% of BW/h (in theory no more than 5% BW loss per whole session).

Hemodialysis prescription for children: adequate, before optimum

- A regular diet survey is essential to maintain adequate protein and calorie intakes.
- Urea kinetic assessment enables not only urea dialysis dose calculation, i.e. Kt/V, but also estimation of protein intake by use of the PCRn calculation (protein catabolic rate).

Hemodialysis prescription for children: adequate, before optimum

- Too fast ultrafiltration can induce hypotension and cramps during dialysis, usually during the second half time session, and fatigue and/or hang over after dialysis.

Hemodialysis prescription for children: adequate, before optimum

- A small solute, e.g. urea, clearance which is too high is a factor of disequilibrium syndrome occurring during dialysis, 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

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