Dry Weight Assessment: A Multi-Disciplinary Approach

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Disclosures

None: No financial support or conflict of interests to report

Objectives

- Discuss tools that can help to determine “dry weight” in our chronic dialysis patients
- Discuss fluid/Na^+ removal mechanisms & strategies in PD & HD patients
- Describe our multi-disciplinary approach to achieve dry weight in PD & HD
- Reveal “dry weight challenges” in 2 pediatric dialysis cases

Case Scenarios

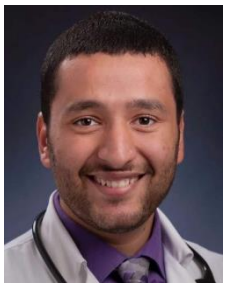
1. 6 yr old male on chronic PD with focal segmental glomerular sclerosis (FSGS)

2. 17 yr old male on chronic HD with ANCA vasculitis

It Takes a Village

Nephrologist

Dietitians



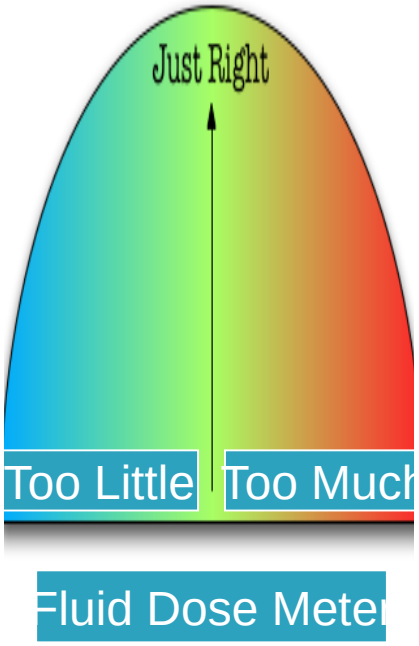
Fellows

Nurses

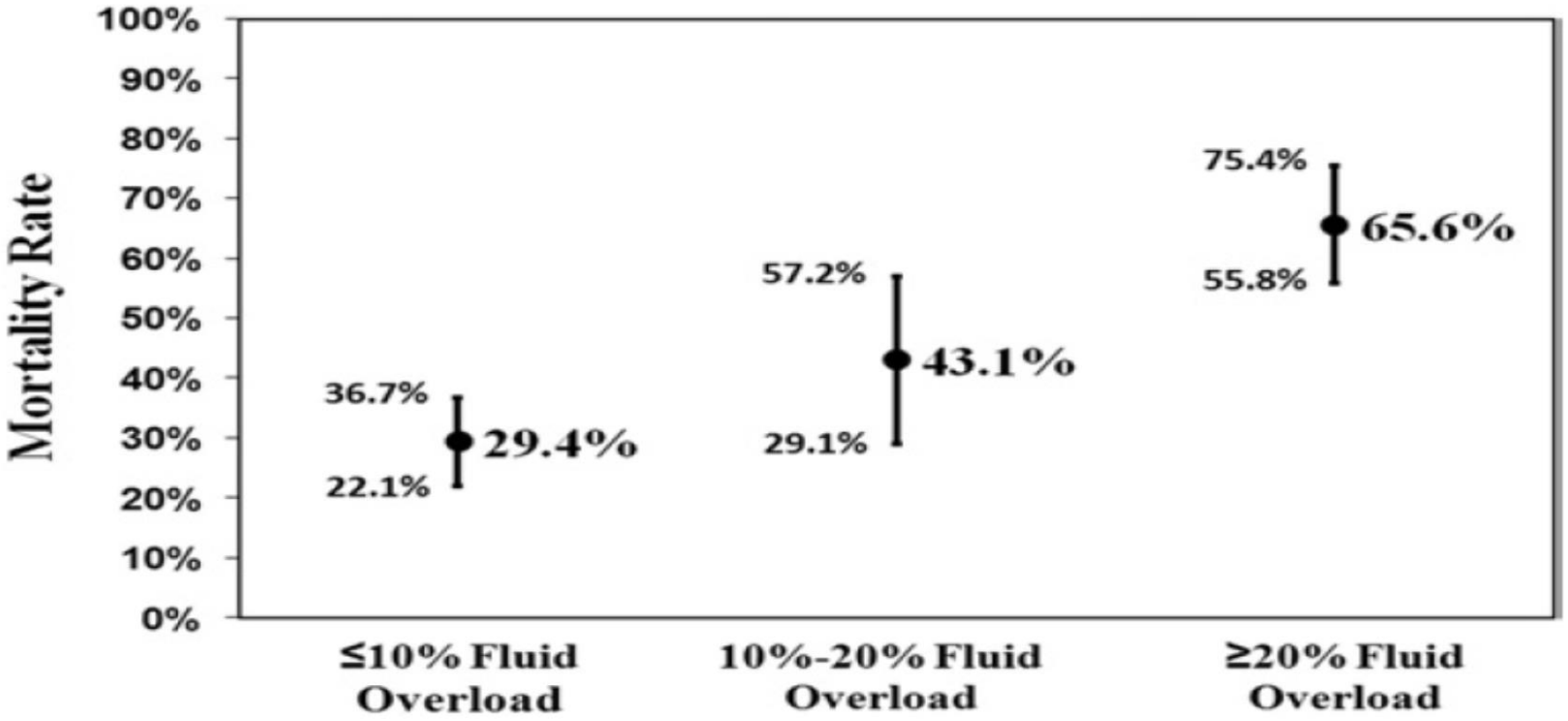
Definition of Dry Weight

- 1967 Thomson et al
  - Reduction of BP to hypotensive levels during ultrafiltration and unassociated with other obvious causes
- 1980 Hendersen et al
  - Weight obtained at the conclusion of regular dialysis treatment below which the patient more often than not will become symptomatic and go into shock
- 1996 Charra et al
  - Body weight at the end of dialysis at which the patient can remain normotensive until the next dialysis despite the retention of saline and ideally without the use of antihypertensive mediations
- 2005 Fishbach et al
  - Weight at termination of dialysis session below which the patient will become hypotensive
- 2008 Raimann et al
  - Flattening of baseline/instantaneous impedance ratio curve for at least 20 minutes in the presence of ongoing ultrafiltration
- 2009 Sinha and Agarwal
  - Lowest tolerated postdialysis weight achieved via gradual change in postdialysis weight at which there are minimal signs or symptoms of hypovolemia or hypervolemia

Our vision of “dry weight”



Consequences of fluid overload

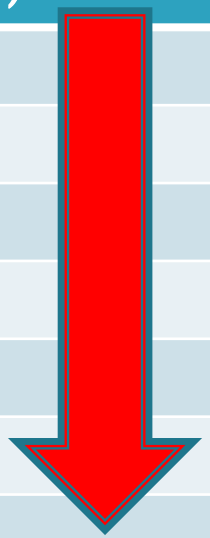


$$\%FO = \frac{\text{Sum of daily(fluid in} - \text{fluid out)}}{\text{ICU admission weight}} \times 100.$$

Sutherland S et al, Am J Kidney Dis, 2010

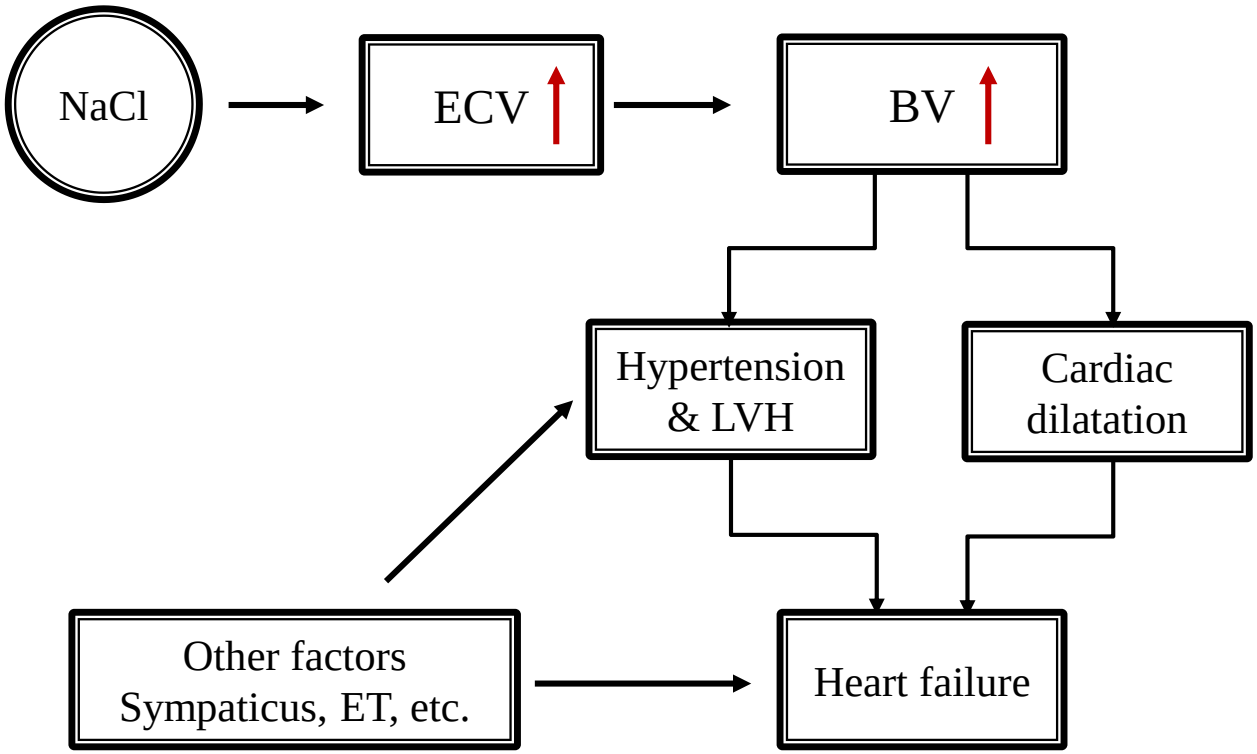
Dialysis patients don't excrete a lot of sodium!

GFR (ml/min)	Filtered Na (mmol/min)	Filtered Na (mmol/day)	Max excreted Na (g/day)
120	16.8	24.2	27.7
90	12.6	18.1	20.8
60	8.4	12.1	13.8
45	6.3	9.1	10.4
30	4.2	6.0	6.9
15	2.1	3.0	3.5
10	1.4	2.0	2.3



**assuming a max fractional sodium excretion of 5%

The consequences of sodium retention



(ECV: Extracellular volume, BV: Blood Volume, ET: Endothelin, LVH: Left Ventricular Hypertrophy)

HTN & cardiac abnormalities are common in pediatric dialysis

- NAPRTCS (2005): 57% of nearly 4000 patients on dialysis with BP >95thile
- European Ped RRT Registry: 35.5% of 851 PD patients had BP >95th%ile irrespective of the use of anti-hypertensive medications
- IPPN: LVH prevalence of 48.1% of 507 pediatric patients from 55 centers

Mitsefenes M, Am J Kidney Dis 2005
Kramer KI, Kidney Int 2011
Bakkaloglu SA CJASN 2011

Consequences of “underhydration”

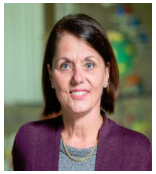
Inadequate nutrition & loss of weight
Patient/family fear of “probing” dry weight
Potential loss of residual renal function
Increased thirst

Fluid Overload

The barriers of finding goal weight

- “Goal weight” is a moving target!!!!!
- Goals of adequate nutrition often require supplementation (more fluid)
- Difficulties in patients restricting Na^+ and fluid
- Patients often feel “well” when overhydrated
- Difficulties in removing sodium and fluid with dialysis (PD vs HD), especially while on anti-hypertensive agents

Multidisciplinary Approach

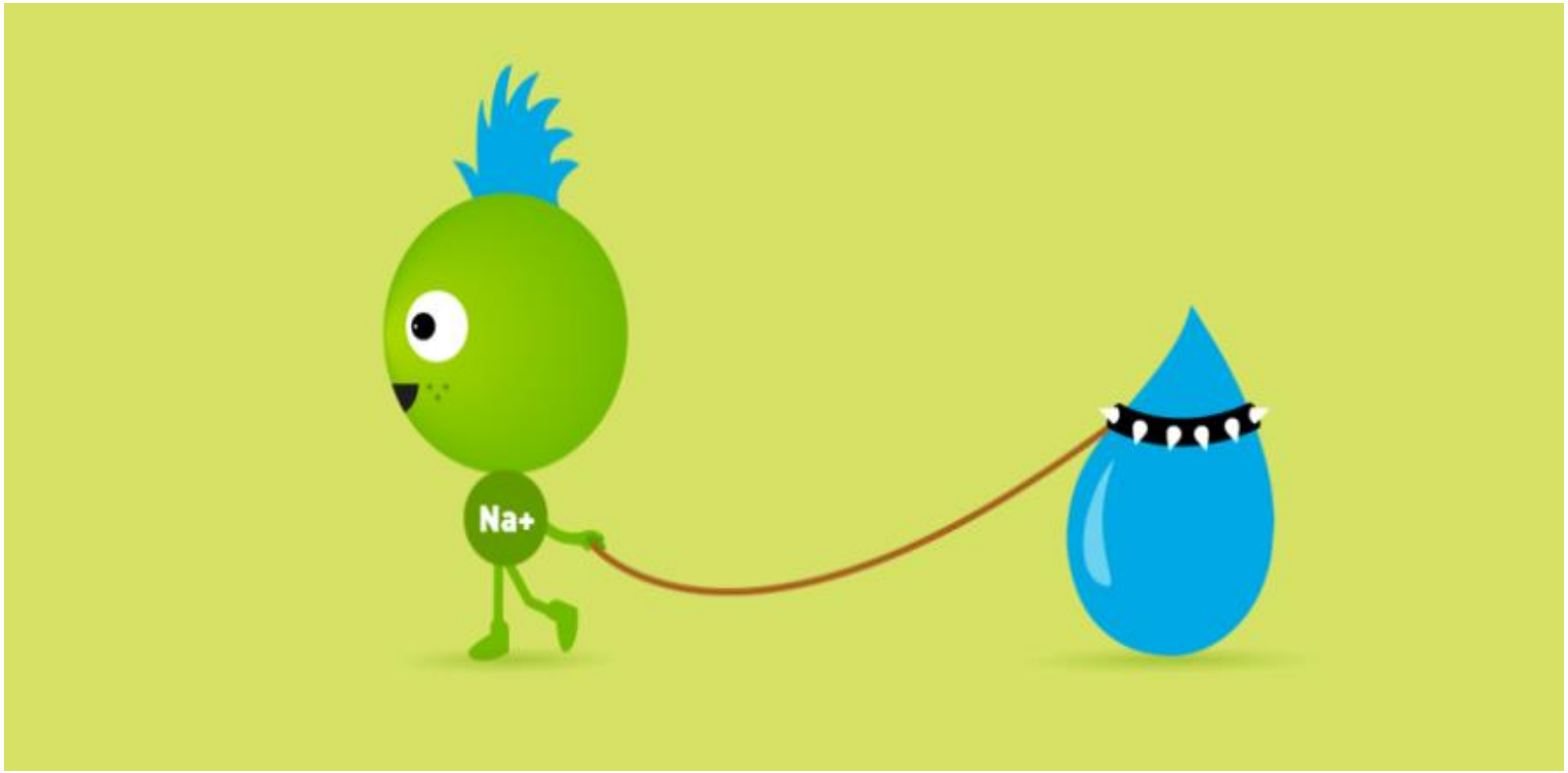


"We need to consider their sodium intake"
"Total fluid, free fluid, fluid on tray, flushes, TFI – are we speaking the same language"
"That rate of weight gain is higher then expected for age"
"Nutrition is part of overall medical therapy"

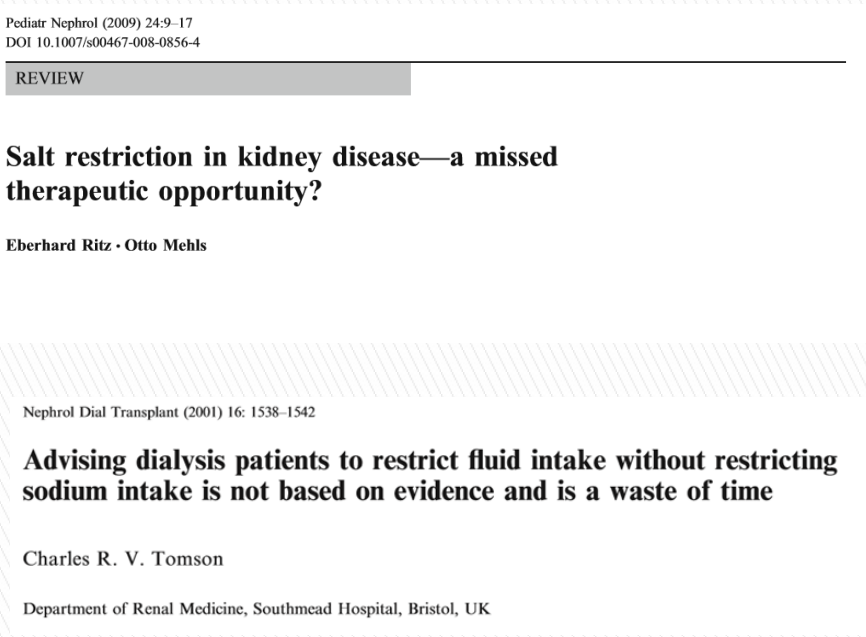
"What are their numbers (UF, weight, BP)?
"What solutions are they using?"
"Are any changes to voiding habits?"
"Any nausea, vomiting, headaches or dizziness?"
"Any issues with dialysis machine?"

"So what is the plan…."

Fluid and Sodium



Importance of Low Sodium Diet



Pediatr Nephrol (2009) 24:9–17
DOI 10.1007/s00467-008-0856-4

REVIEW

Salt restriction in kidney disease—a missed therapeutic opportunity?

Eberhard Ritz · Otto Mehls

Nephrol Dial Transplant (2001) 16: 1538–1542

Advising dialysis patients to restrict fluid intake without restricting sodium intake is not based on evidence and is a waste of time

Charles R. V. Tomson

Department of Renal Medicine, Southmead Hospital, Bristol, UK

"Advising dialysis patients to restrict fluid intake when they have not had advice on how to limit their salt intake is inhumane, because they are made to feel guilty and inadequate at being unable to restrict their fluid intake – and is a waste of time"

Tomson, Nephrol Dial Trans (2001)

So you just need to

The Sodium Assault

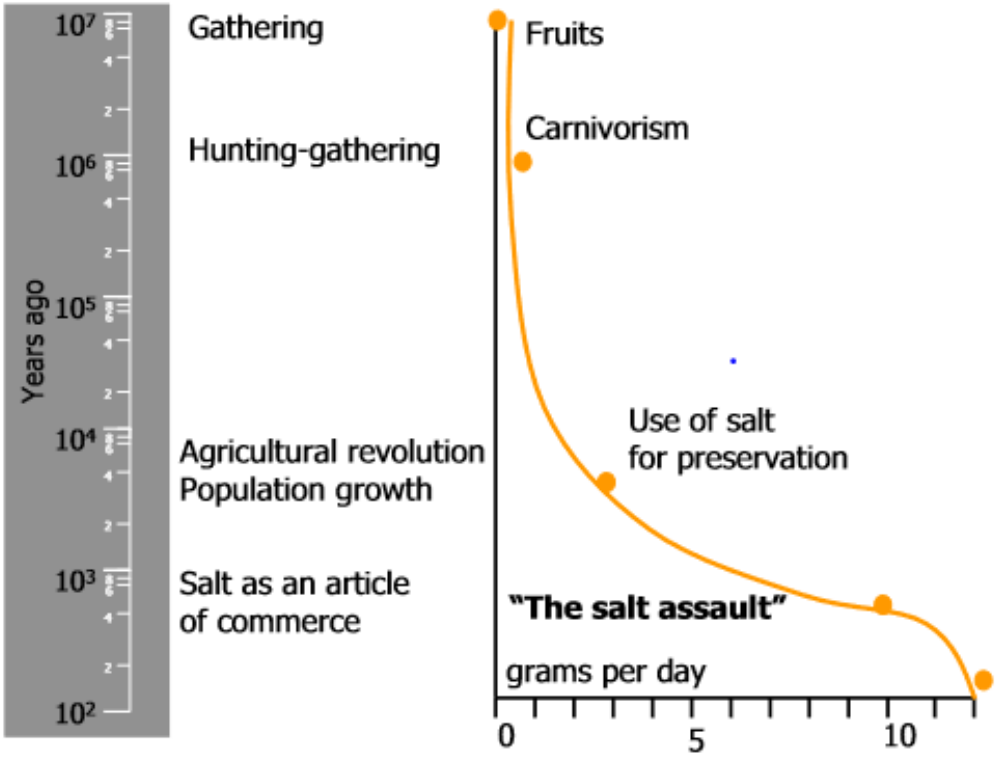
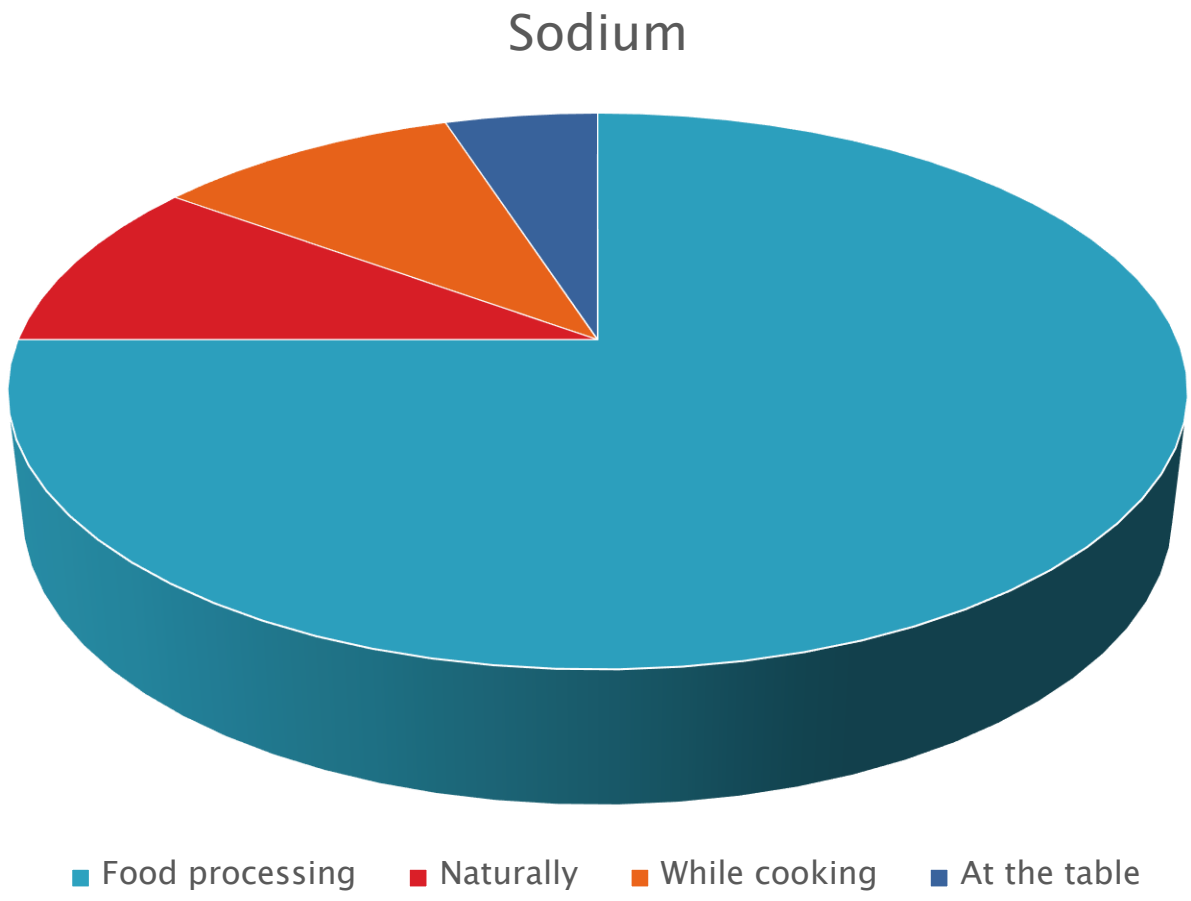


Fig. 2 Increase of salt intake during evolution. Courtesy of Dr. P. Ferrari, Department of Nephrology, Fremantle Hospital, Perth, Western Australia, Australia

Ritz et al. Pediatri Nephrol (2009)

Sources of dietary sodium



Recommended Sodium Intake vs Actual Sodium Intake

IOM & Health Canada

Age	AI (mg/d)	UL (mg/d)
1–3 y	1000	1500
4–8 y	1200	1900
9–13 y	1500	2200
14–18 y	1500	2300

NHANES 2011–12

Age	Sodium Intake (mg/d)
2–3 y	2154
4–6 y	2754
9–13 y	3126
14–18 y	3538

Quader, Z et al J Acad Nutr Diet (2017)

Sodium Consumption

United States (NHANES)

- Top 10 contributors made up 48% intake:
  - Pizza
  - Bread
  - Sandwiches
  - Cold cuts
  - Soups
  - Savoury snacks
  - Poultry
  - Mexican mixed dishes
  - Cheese
  - Plain milk

Quader, Z et al J Acad Nutr Diet (2017)

Canada (Health Canada)

- 72% of Canadian children between ages of 4 and 13 are consuming more than the recommended limits
- 77% of sodium consumed comes from processed food
- Canadians spend ~ 1/3 of their food budget on ready to eat and processed foods
- To contributors are bread, processed meats, cheese, soups and pizza

Health Canada, 2018

The problem continues..

- Children enter CKD without having adopted a low sodium diet

Estimated daily sodium intake

Age/years	#Recommended maximum total daily intake	All participants
1–3 (N=39)	1500	2180 (1690, 2805)
4–8 (N=164)	1900	2873 (2118, 4048)
9–13 (N=235)	2200	2937 (2244, 3678)
14–18 (N=220)	2300	3884 (2854, 5150)

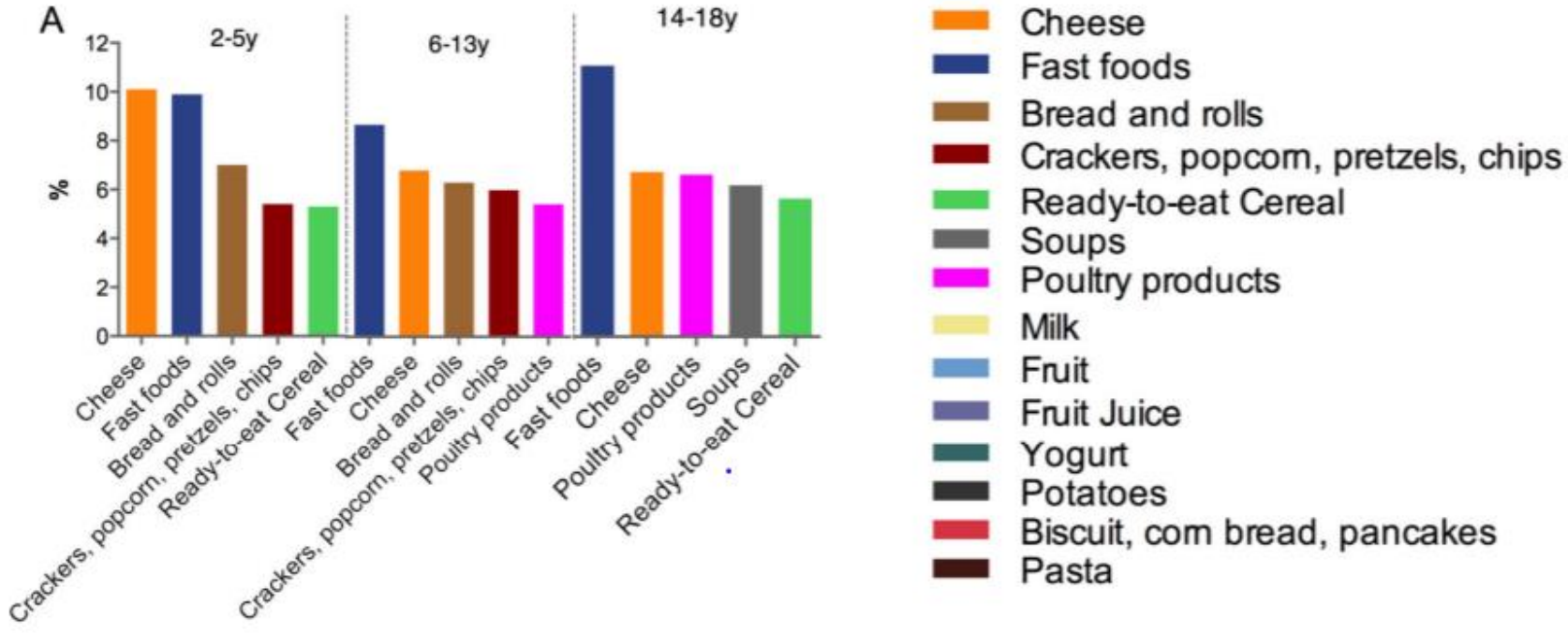
Hiu, Pediatr Nephrol (2017)

Sodium Intake (mg/d)
2154
2754
3126
3538

Quader, Z et al J Acad Nutr Diet (2017)

More than 25% of adolescents consumed > 5150 mg sodium daily

Sodium Intake CKD



Chen et al, Pediatr Nephrol, (2017)

Sodium from medications

Sodium Polystyrene
1 g of powder =
100 mg of Na (4.1 mEq)

Sodium Bicarbonate
1 g of powder =
275 mg of Na (12 mEq)

Sodium content from formula

	kcal	mmol	mg
Liquids	Kcal	Na	
Breast milk	100	1.1	25 mg
Nepro® Carb Steady	100	2.6	60 mg
NovaSource® Renal	100	2.1	48 mg
Suplena® Carb Steady	100	2.0	46 mg
Powders	Kcal	Na	
Nephea Kid Powder/g (4.5 g/scoop)	100	1.6	36 mg

Whole milk 67 mg per 100 calories

Reported Challenges with Sodium Modified Diet

1. Lack of control of sodium content of meals eaten away from home
2. Complex and time consuming nature of interpreting nutrition labels
3. Difficulty identifying suitable snacks

Nutrition Facts
Valeur nutritive

Per 1 oz (29 g)
pour 4 (29 g)

Amount / Teneur	% DV* / % VQ*
Calories / Calories 100	
Fat / Lipides 10 g	**15** %
Saturated / saturés 6 g + Trans / trans 1 g	**33** %
Cholesterol / Cholestérol 30 mg	
Sodium / Sodium 105 mg	**4** %
Carbohydrate / Glucides 1 g	**0** %
Fibre / Fibres 0 g	**0** %
Sugars / Sucres 1 g	
Protein / Protéines 2 g	
Vitamin A / Vitamine A	10 %
Vitamin C / Vitamine C	0 %
Calcium / Calcium	2 %
Iron / Fer	0 %

* DV = Daily Value
* VQ = valeur quotidienne

Lofthouse, Appetite, 2016

Sodium teaching at BCCH

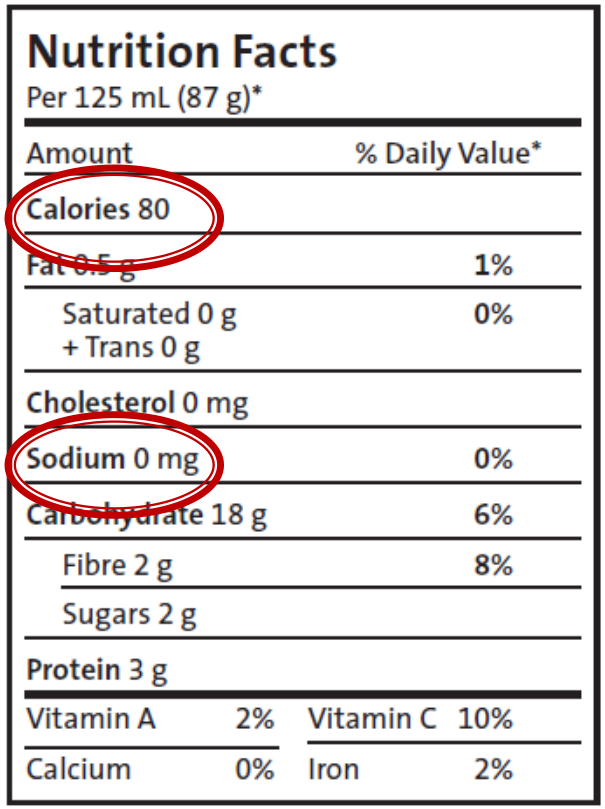
BCCH

Weight (kg)	Intake	
	Boys	Girls
10 – 19	800	800
20 – 29	1300	1300
30 – 39	1600	1400
40 – 49	1700	1600
50 – 59	2000	1700
60 – 69	2300	1800
70 and >	2400	1900

IOM & Health Canada

Age	AI (mg/d)	UL (mg/d)
1–3 y	1000	1500
4–8 y	1200	1900
9–13 y	1500	2200
14–18 y	1500	2300

Sodium: A Resource

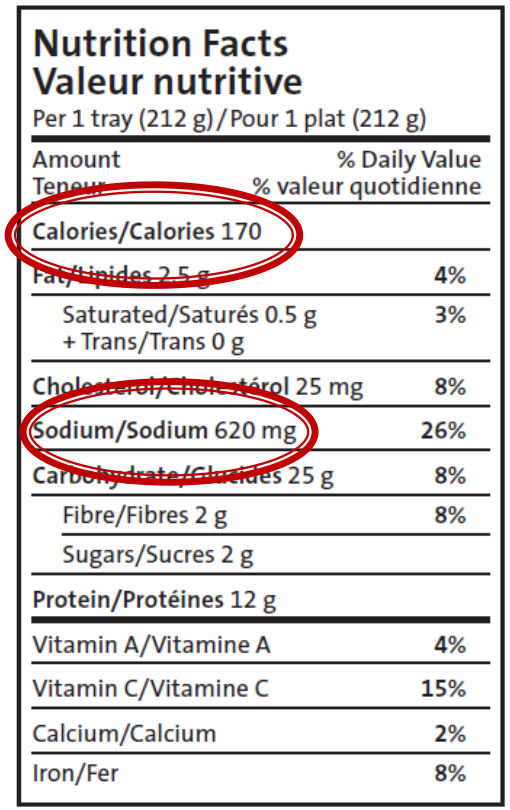


Nutrition Facts

Per 125 mL (87 g)*

Amount	% Daily Value*
Calories 80	
Fat 0.5 g	1%
Saturated 0 g + Trans 0 g	0%
Cholesterol 0 mg	
Sodium 0 mg	0%
Carbohydrate 18 g	6%
Fibre 2 g	8%
Sugars 2 g	
Protein 3 g	

Vitamin A	2%	Vitamin C	10%
Calcium	0%	Iron	2%



Nutrition Facts
Valeur nutritive

Per 1 tray (212 g) / Pour 1 plat (212 g)

Amount Teneur	% Daily Value % valeur quotidienne
Calories/Calories 170	
Fat/Lipides 2.5 g	4%
Saturated/Saturés 0.5 g + Trans/Trans 0 g	3%
Cholesterol/Cholestérol 25 mg	8%
Sodium/Sodium 620 mg	26%
Carbohydrate/Glucides 25 g	8%
Fibre/Fibres 2 g	8%
Sugars/Sucres 2 g	
Protein/Protéines 12 g	
Vitamin A/Vitamine A	4%
Vitamin C/Vitamine C	15%
Calcium/Calcium	2%
Iron/Fer	8%

Choose food items that have LESS sodium mg than calories

Reported Challenges with Sodium Modified Diet

1. Lack of control of sodium content of meals eaten away from home
2. Complex and time consuming nature of interpreting nutrition labels
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Nutrition Facts
Valeur nutritive

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Vitamin A / Vitamine A	10 %
Vitamin C / Vitamine C	0 %
Calcium / Calcium	2 %
Iron / Fer	0 %

* DV = Daily Value
* VQ = valeur quotidienne

Lofthouse, Appetite, 2016

Just takes time…

Am J Clin Nutr. 1982 Dec;36(6):1134-44.

Long-term reduction in dietary sodium alters the taste of salt.

Bertino M, Beauchamp GK, Engelman K.

- Preferred level of salt in food is dependent of the level of salt consumed
- Preferred level can be lowered after a reduction in sodium intake

European Journal of Nutrition (2018) 57 (Suppl 3):S43–S51
https://doi.org/10.1007/s00394-018-1745-7

REVIEW

Challenges in the assessment of total fluid intake in children and adolescents: a discussion paper

Janet Warren[1] · Isabelle Guelinckx[2] · Barbara Livingstone[3] · Nancy Potischman[4] · Michael Nelson[5] · Emma Foster[6] · Bridget Holmes[2]

Table 1 Considerations for measuring total fluid intake, by age range [18, 23, 24]

Consideration	Toddlers 1–2 years	Pre-school 2–4 years	Young children 5–8 years	Older children 9–12 years	Adolescents 13–18 years
Breastfeeding[a]/formula feeding to be assessed	Yes/no	No	No	No	No
High frequency of consumption	Yes	Yes	Yes	No	No
Need to consider regurgitation/drooling	Yes	No	No	No	No
Large amounts of wastage	Yes	Yes	Yes	Yes/no	Yes/no
Structured consumption habits	Yes	Yes	Yes/no	Yes/no	No
Ability to complete questionnaires on their own	No	No	No	Yes/no	Yes
Ability to recall information	No	No	No	Yes/no	Yes
Concept of time	No	No	No	Yes/no	Yes
Knowledge of food/drink, preparation	No	No	No	Yes	Yes
Ability to assess portion size	No	No	No	Yes/no	Yes
Multiple caregivers or locations	Yes	Yes	Yes	Yes	Yes
High amount of in-home consumption	Yes	Yes	Yes/no	Yes/no	Yes/no
Responsible for own consumption choice	No	No	Yes/no	Yes/no	Yes

[a]Exact age at which breastfeeding ceases depends on feeding habits of the child

How do you measure fluid intake?

Table 2 Level of appropriateness of dietary assessment methods to assess total fluid intake, by age group [18, 23, 24]

Group	Age (years)	Prospective				Retrospective				
		Test weighing	Weighed diet diary	Estimated diet diary	Checklist/diary	Single 24-h recall	Repeated 24-h recall	FFQ long	FFQ short	Diet history
Toddlers[a]	1–2	+	+	+++	+	+	++	+	+	+
Pre-school	2–4	–	+	+++	+	+	++	+	+	+
Young children	5–8	–	+	+++	+	+	++	+	+	+
Older children	9–12	–	+	+++	++	+	++	+	+	+
Adolescents	13–18	–	+	+++[b]	++	+	+++[b]	+	+	+

+++ very suitable, ++ moderately suitable, + limited suitability, – not suitable

[a]Exact age at which breastfeeding ceases depends on feeding habits of the child

[b]Methods weighted equally

Do you count fluid from food?

- Food Moisture (FM)
  - European Food Safety Authority FM contributes 20%–30% total water intake
  - Institute of Medicine assumes FM contributes 20% total water intake
  - FM estimated to be 40% in China where the consumption of soups and liquid based meals is higher (Ozen et al, J Hum Nutr Diet)

Dialysis


I'LL TELL THE DOC I WAS SWIMMING, AND I STARTED TO DROWN, AND I SWALLOWED HALF THE LAKE FIGHTING TO SURVIVE, AND I MANAGED TO STRUGGLE TO SHORE, AND...
YOU DRANK TOO MUCH FLUID
FLUID OKAY
YOU'RE A QUART LOW
D.K.
Lori James-Hartwell

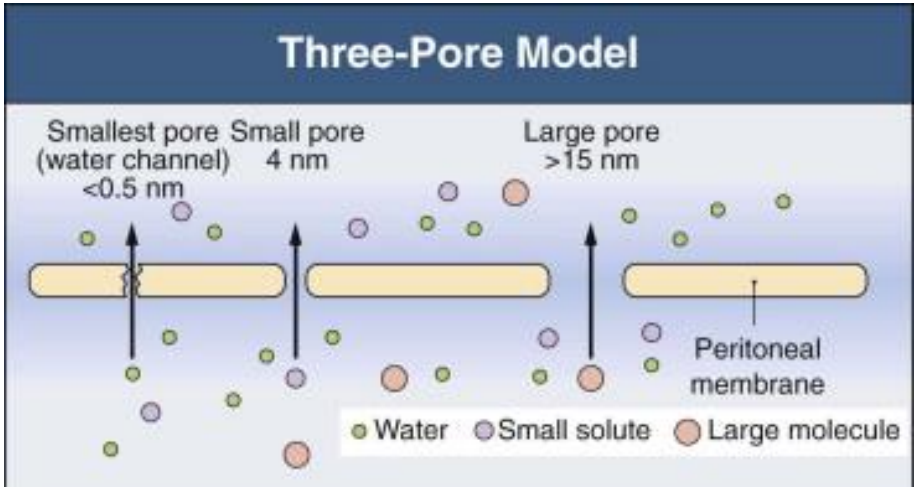
Infant on Automated PD

- Special scenario as intake is primarily formula with low Na^+ content
- Let's guess that APD removes 80 mmol Na^+/L of ultrafiltrate
- Example: 5 kg anuric infant with 300ml/day UF
  - 5 mmol/kg/day of Na loss
  - 500 ml of formula = Na intake of 3-10 mmoL
- Therefore, Na supplementation is <u>often</u> necessary
  - Especially in infants with low or normal BP
  - Especially infants with significant residual urine output

Dialysis and Fluid/Na^+ Removal

- Important to think of water (ultrafiltration) and Na^+ removal separately
- Na^+ removal is removed both by convection (solute moving with water) and diffusion (transport across a concentration gradient)
  - Convective loss > Diffusive loss
- Different mechanisms in PD & HD

PD and Fluid/Na^+ Removal



Water and sodium transport across the peritoneal membrane

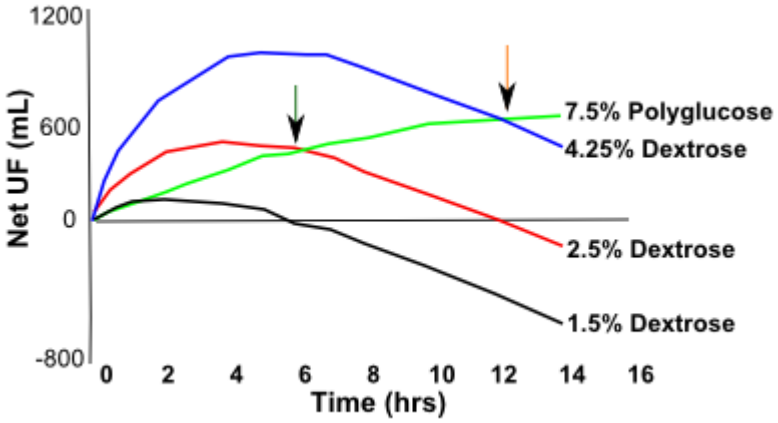
Ultrafiltration
(AQP-1 and small pores)

1. AQP-1 (40% to 50%), solute-free water transport, by osmotic gradient
2. Small pores (50% to 60%), solute-coupled water transport, by osmotic and hydrostatic pressure gradient

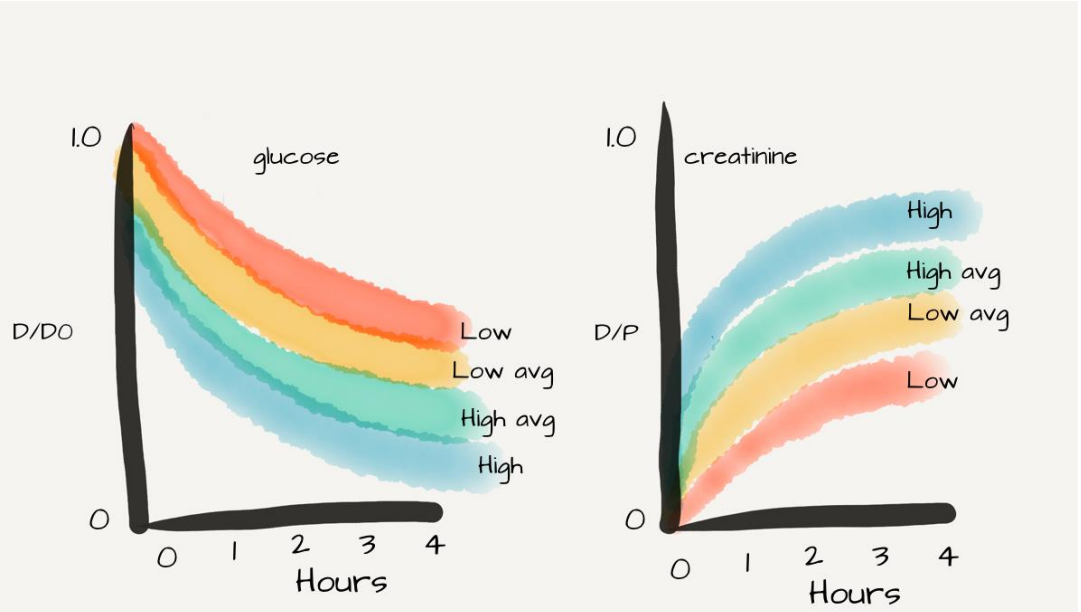
Sodium transport
(Small pores)

1. Convective mass transport (coupled water)
2. Diffusive mass transport (determined by diffusion gradient, volume, and time)
3. Peritoneal absorption (fluid and solutes absorbed to interstitial tissue and lymphatics)

PD and Fluid/Na^+ removal



↑ dextrose concentration improves ultrafiltration

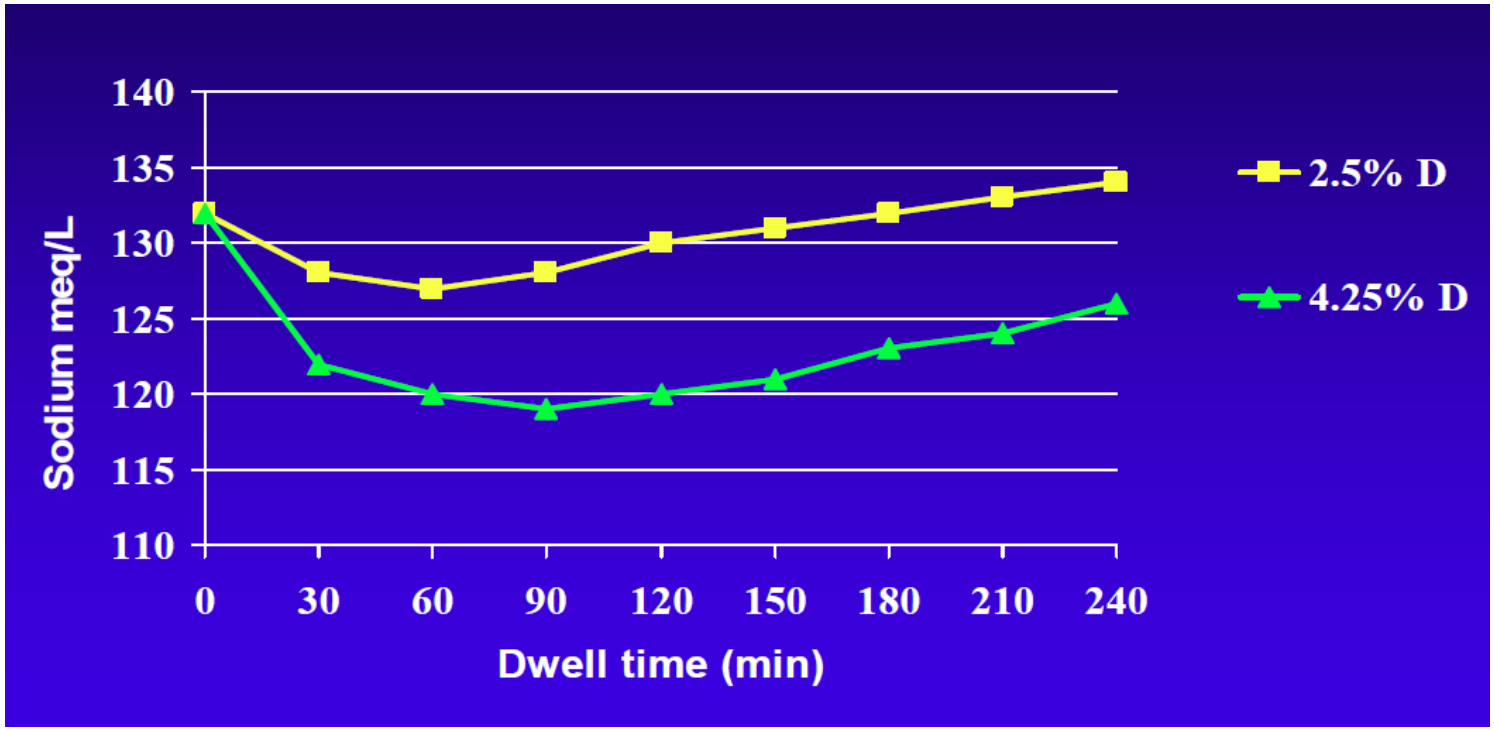


Peritoneal Equilibration Test (PET) determines membrane status.

High/high avg transporters have hardest time with optimal ultrafiltration

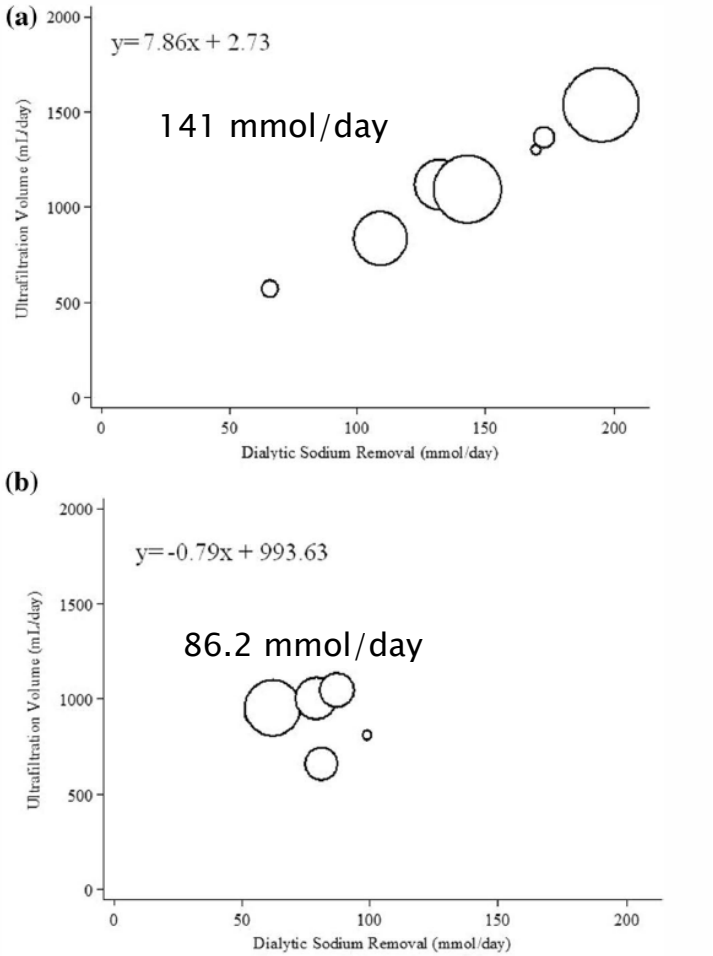
PD and Fluid/Na^+ Removal

- Sodium Sieving



Early part of dwell dominated by free water transport (AQP-1) & latter part includes diffusive Na transport

Na^+ Removal: CAPD > APD



Continuous Ambulatory PD (CAPD)

Automated PD (APD)

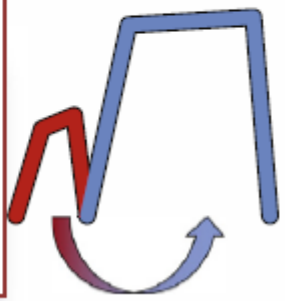
Borrelli S, Journal of Nephrology, 2018

Adapted Peritoneal Dialysis

The concept of adapted APD small/short exchange followed by large/long exchange to optimize dialytic sodium removal

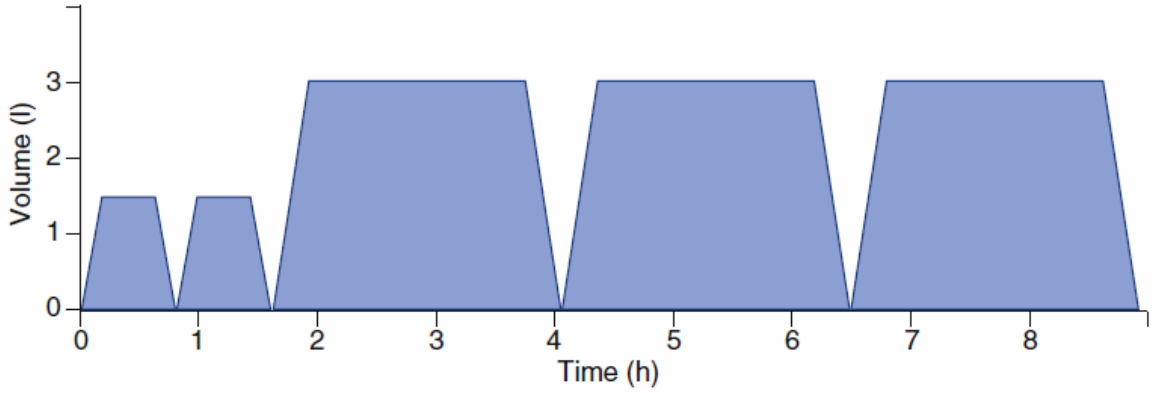
Exchange favoring UF

Short/small cycle
(Free water transfer via AQP-1)
- Hemoconcentration
- Incomplete drainage (low IPP)
- Low NaD



Exchange favoring dialytic Na removal

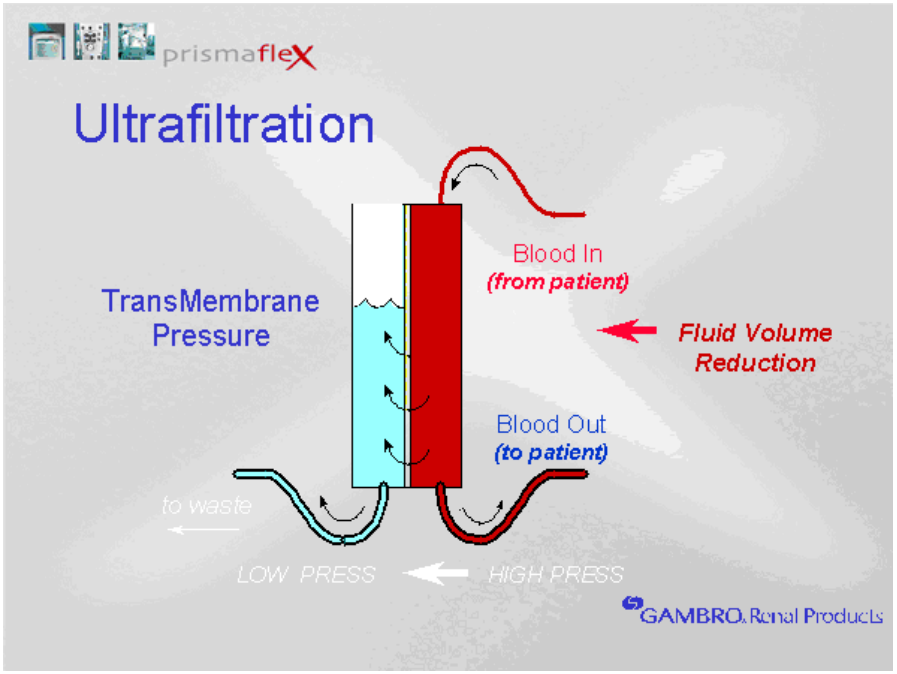
Long/large cycle
(Small pore recruitment)
- Na-coupled water transport
- Long diffusion time
- High diffusion gradient (NaPl/NaD)



Fischbach M Kidney Int 2016

HD and Fluid/Na^+ Removal

- Ultrafiltration (UF) amount set by the operator
- UF is driven by a pressure gradient between blood and dialysate compartments

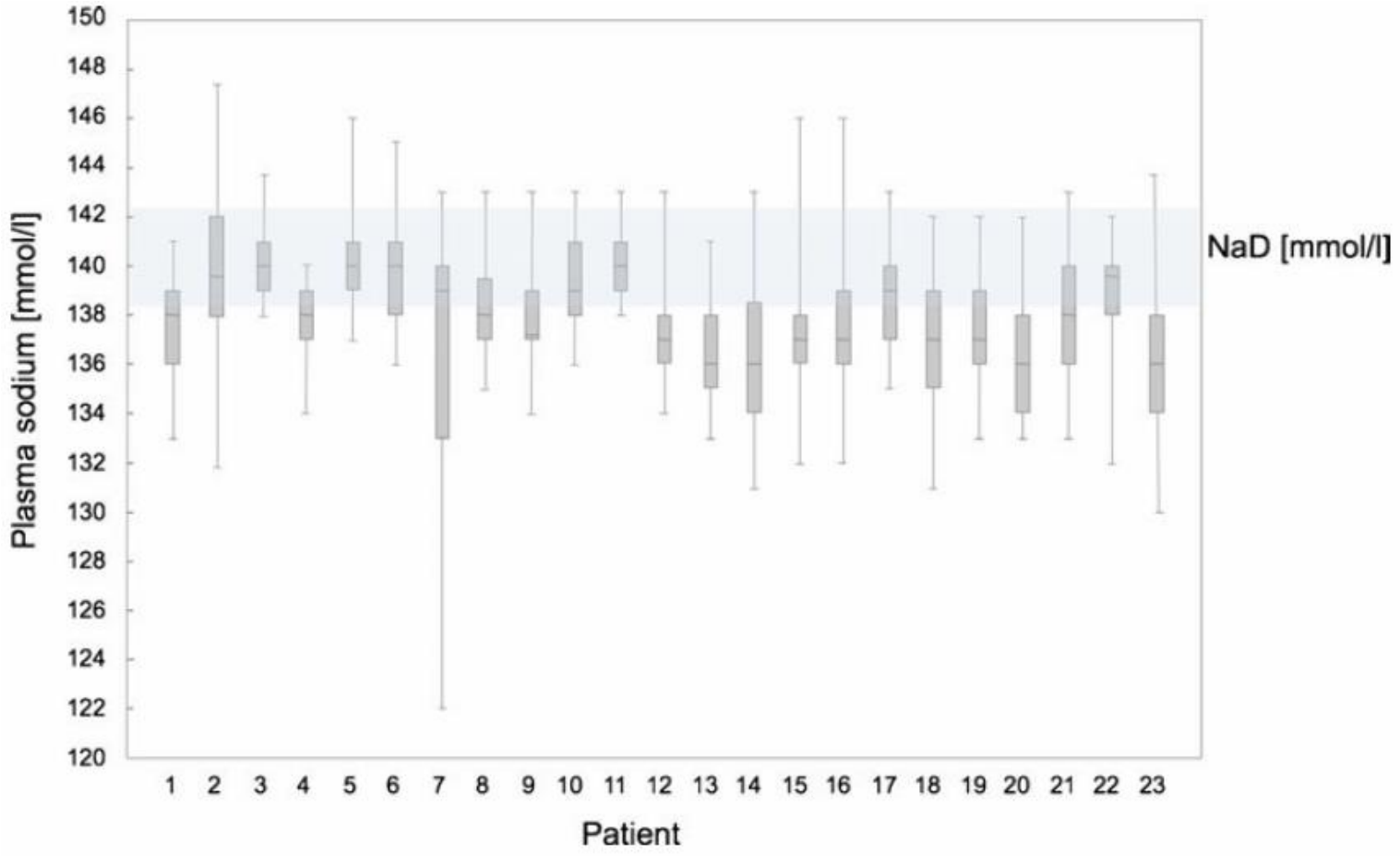


HD and Na^+ Removal

- For intermittent HD, Na^+ removal dependent more on *convective (80%) vs diffusive (20%)*
- Dialysate Na [ ] typically set at 140 mmol/L
- Pt post HD Na > pre HD Na by 2-4 mmol/L
- Adult strategies:
  - Lower dialysate Na to 134-138 mmol/L to optimize diffusive loss
  - Lower dialysate Na to 2 mmol/L lower than serum
- 1 pediatric study (450 HD sessions in 5 kids)
  - ↓ dialysate Na from 140→138 lowered inter-dialytic weight gain and systolic/diastolic BP.

Marcenic O Hemodial Int 2016

Intra & interpatient pre HD Na^+ variability



Zaloszyc A Pediatr Nephrol 2013

Challenges with HD & Fluid Removal

- **We only have 3-4 hrs per HD session, often done only 3x/week**
- Consequences of large interdialytic weight gain (IDWG)
  - Challenging to reach dry weight
  - Often hypertensive requiring multiple agents
    - Cardiac changes (LVH)
  - Patient intolerance (nausea, vomiting, cramps)
    - Resistance from patient/family to remove more fluid
  - Ischemic effects on heart, brain, and kidneys
    - Eg: Myocardial Stunning
      - 1 pediatric HD study (age 2-17) showing 11/12 had cardiac stunning during conventional 4 hour HD

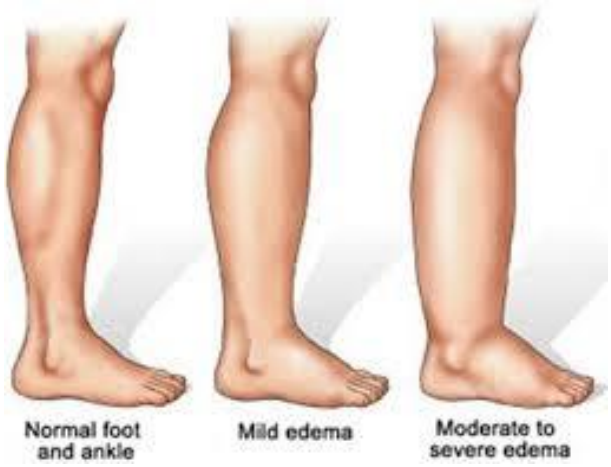
Hothi DK, CJASN 2009

Dry Weight Assessment Tools

1. Physical Exam (Edema & elevated BP)
2. Lab Results (Sodium, Hemoglobin, Albumin)
3. Weight Analysis & nPCR
4. Bioimpedance Analysis (PD & HD)
5. Plasma Volume Monitoring/Crit line monitoring (HD)

Physical Exam (Edema)

- Location: Face (periorbital), limb edema
- Often hard to detect in chronic dialysis patients
- Have to have at least 10% of excess on board to manifest edema



Physical Exam (Blood Pressure)

- Often measured in PD & HD patients
- Elevated BP often denotes ECV expansion
- If elevated:
  - Look at recent trends
  - Was the patients "relaxed"?
  - Ensure correct cuff size
    - Too small a cuff overestimates BP
    - Too large a cuff underestimates BP
  - If done by automated method, confirm manually

- If concerned about "white coat" HTN, can do a 24 hour ambulatory BP monitor in older kids

How do we define HTN in kids?

Table 3 Blood pressure values by age and height percentile for boys and girls

A Boys

Age (y)	Blood Pressure Percentile	Systolic Blood Pressure (mmHg) Height Percentile or Measured Height							Diastolic Blood Pressure (mmHg) Height Percentile or Measured Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1	Height (in)	30.4	30.8	31.6	32.4	33.3	34.1	34.6	30.4	30.8	31.6	32.4	33.3	34.1	34.6
	Height (cm)	77.2	78.3	80.2	82.4	84.6	86.7	87.9	77.2	78.3	80.2	82.4	84.6	86.7	87.9
	50th	85	85	86	86	87	88	88	40	40	40	41	41	42	42
	90th	98	99	99	100	100	101	101	52	52	53	53	54	54	54
	95th	102	102	103	103	104	105	105	54	54	55	55	56	57	57
	95th + 12 mmHg	114	114	115	115	116	117	117	66	66	67	67	68	69	69
2	Height (in)	33.9	34.4	35.3	36.3	37.3	38.2	38.8	33.9	34.4	35.3	36.3	37.3	38.2	38.8
	Height (cm)	86.1	87.4	89.6	92.1	94.7	97.1	98.5	86.1	87.4	89.6	92.1	94.7	97.1	98.5
	50th	87	87	88	89	89	90	91	43	43	44	44	45	46	46
	90th	100	100	101	102	103	103	104	55	55	56	56	57	58	58
	95th	104	105	105	106	107	107	108	57	58	58	59	60	61	61
	95th + 12 mmHg	116	117	117	118	119	119	120	69	70	70	71	72	73	73
3	Height (in)	36.4	37	37.9	39	40.1	41.1	41.7	36.4	37	37.9	39	40.1	41.1	41.7
	Height (cm)	92.5	93.9	96.3	99	101.8	104.3	105.8	92.5	93.9	96.3	99	101.8	104.3	105.8
	50th	88	89	89	90	91	92	92	45	46	46	47	48	49	49
	90th	101	102	102	103	104	105	105	58	58	59	59	60	61	61
	95th	106	106	107	107	108	109	109	60	61	61	62	63	64	64
	95th + 12 mmHg	118	118	119	119	120	121	121	72	73	73	74	75	76	76
4	Height (in)	38.8	39.4	40.5	41.7	42.9	43.9	44.5	38.8	39.4	40.5	41.7	42.9	43.9	44.5
	Height (cm)	98.5	100.2	102.9	105.9	108.9	111.5	113.2	98.5	100.2	102.9	105.9	108.9	111.5	113.2
	50th	90	90	91	92	93	94	94	48	49	49	50	51	52	52
	90th	102	103	104	105	105	106	107	60	61	62	62	63	64	64
	95th	107	107	108	108	109	110	110	63	64	65	66	67	67	68
	95th + 12 mmHg	119	119	120	120	121	122	122	75	76	77	78	79	79	80
5	Height (in)	41.1	41.8	43.0	44.3	45.5	46.7	47.4	41.1	41.8	43.0	44.3	45.5	46.7	47.4
	Height (cm)	104.4	106.2	109.1	112.4	115.7	118.6	120.3	104.4	106.2	109.1	112.4	115.7	118.6	120.3
	50th	91	92	93	94	95	96	96	51	51	52	53	54	55	55
	90th	103	104	105	106	107	108	108	63	64	65	65	66	67	67
	95th	107	108	109	109	110	111	112	66	67	68	69	70	70	71
	95th + 12 mmHg	119	120	121	121	122	123	124	78	79	80	81	82	82	83
6	Height (in)	43.4	44.2	45.4	46.8	48.2	49.4	50.2	43.4	44.2	45.4	46.8	48.2	49.4	50.2
	Height (cm)	110.3	112.2	115.3	118.9	122.4	125.6	127.5	110.3	112.2	115.3	118.9	122.4	125.6	127.5
	50th	93	93	94	95	96	97	98	54	54	55	56	57	57	58
	90th	105	105	106	107	109	110	110	66	66	67	68	68	69	69
	95th	108	109	110	111	112	113	114	69	70	70	71	72	72	73
	95th + 12 mmHg	120	121	122	123	124	125	126	81	82	82	83	84	84	85

≥95th%ile for sex, age & height

≥130/90 for ≥13 yrs of age

2017 Academy of Pediatrics
&
Dionne, Curr Hyperten Rep, 2017

Weight Analysis

1. Plot weight on growth chart; electronic
2. WHO before 2; CDC after
3. Look at trends; changes in z-score
    - Q. Represent nutritional weight gain?
    - Q. Represent overhydration?
4. Example: Gain of 200 grams

6 week old	~ 1 week
7 year old	~ 1 month
14 year old	~ 2- 3 weeks

Phases of Growth & Nutrition

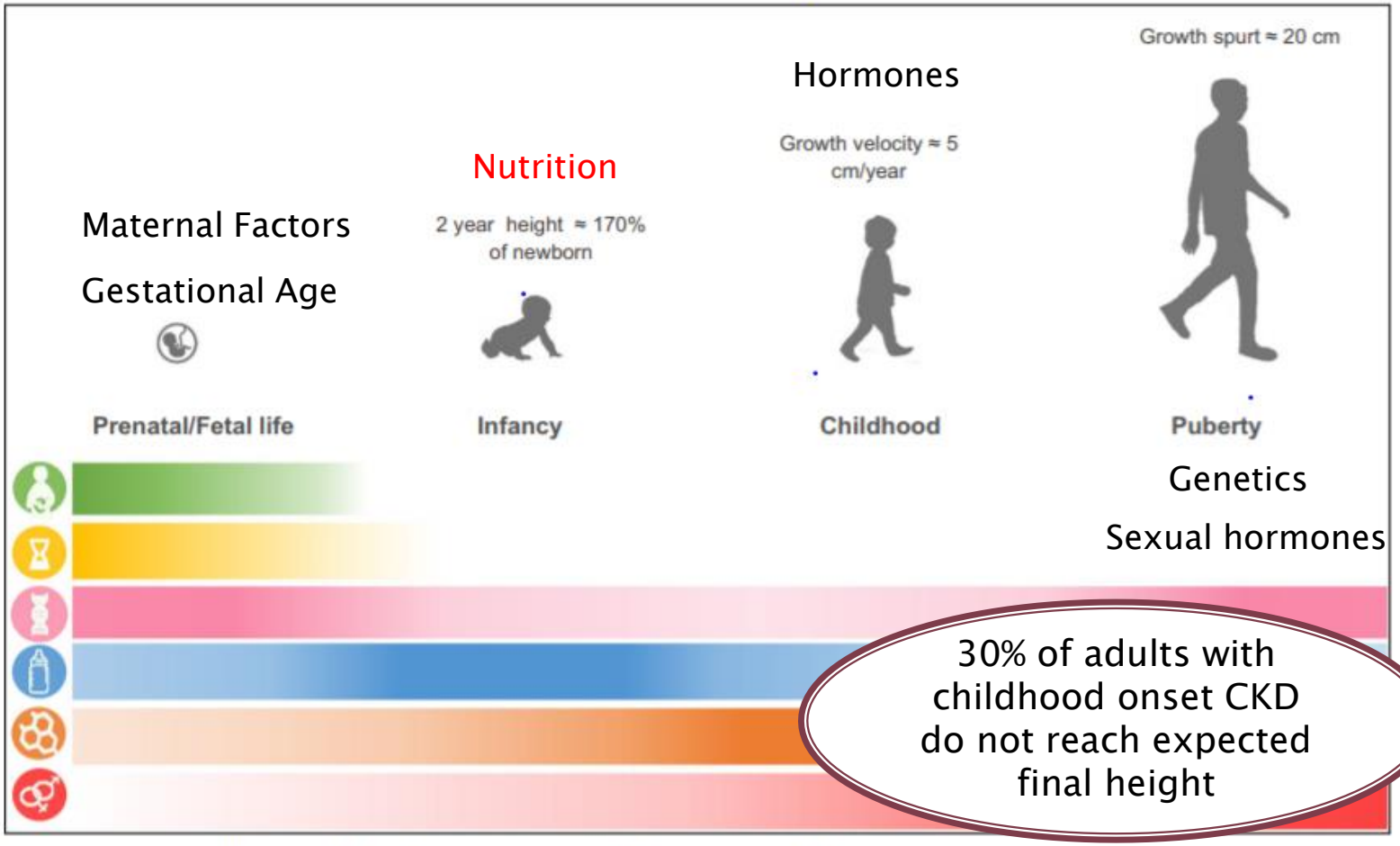


Fig. 1 Phases of normal growth and regulating factors. Color legend: green, maternal factors; yellow, gestational age; pink, genetics; blue, nutrition; orange, hormones; red, sexual differences. Color intensity determines the importance of the factor for each phase of growth

Fernandez-Iglesias, A et al Ped Neprol (2018)

Weight analysis continued

1. Think about normal weight for height
2. How many times changed dry weight?
3. When found dry weight that should be reference point

Normalized Protein Catabolic Rate (nPCR)

- Primarily used in HD
- Based on pre and post urea and weights
- Measures protein intake as g/kg/day
- Potential advantage to determine dry vs fluid weight
- Monitor trends
- Patients with significant residual renal function a 24 hour urine collection needed
- Think about real weight gain, fluid weight gain, weight loss and catabolic state

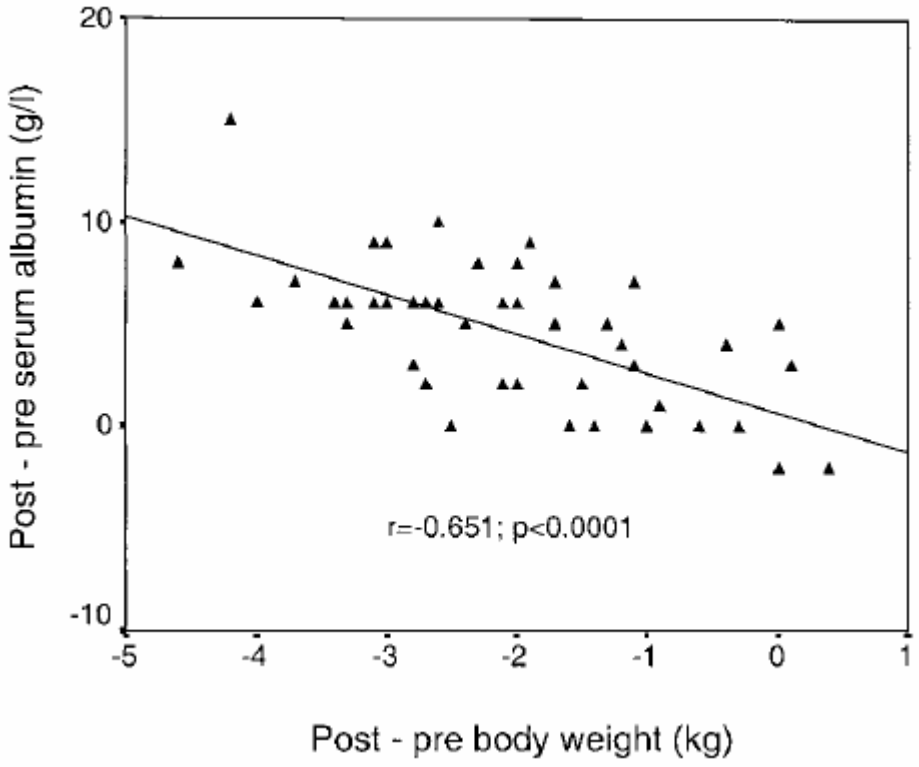
	Real weight gain	Fluid weight gain	Weight loss	Catabolic state
nPCR	adequate	↓	↓	↑
Kt/V	↓	↓	↔	↔
Weight	↑	↑	↓	↓

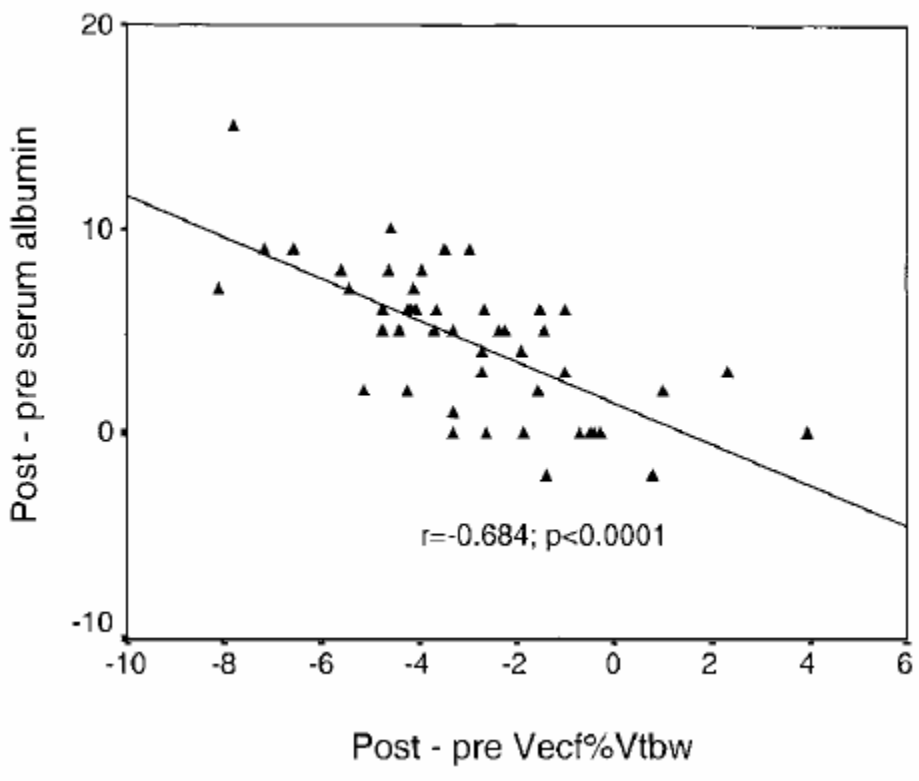
Lab Results (Overhydration)

- Serum sodium
  - Hyponatremia (Na <135) often signifies free water excess ("dilutional")
  - Does not mean the patient needs more Na^+
- Hemoglobin
  - Often low in dialysis patients (eg: EPO deficiency)
  - Unexplained drop in Hb may signify hemodilution
- Albumin
  - Can be low in malnutrition, and inflammatory states
  - In a stable patient, decrease in albumin may also signify hemodilution

Serum albumin and fluid status

49 adult HD pts: Pre vs Post HD albumin 36.8 g/L vs 41.4 g/L





Jones CH J Ren Nutr 2002

Case: NR

- Diagnosed with NS in at 2 yrs of age
- Renal biopsy FSGS
- G-tube and VAD inserted at 5 yrs of age
- HD started at 5 yrs of age
- Transitioned to PD at 6 yrs of age

Clinic Visit

N.R (7 yrs old)	December 3, 2018
Dialysis PD: High Transporter	10 cycles, 12 hrs UF 300 ml mix of 1.5 and 2.5% UF 600 ml 2.5% 2.5% Dianeal used 3 last 4 weeks 800 ml fill; last fill Extraneal
Fluid/Diet	**Total: 800 ml** *+thirsty 300 ml homo milk + 56 scoops of Nephea Kid with water to 700 ml 100 ml oral fluids 60 ml HBTF; Oral intake unchanged, minimal
Output	Unchanged; 15 ml urine
Growth (kg) Goal Wt	20.8 (- 0.59) Goal Wt 18.3-18.6

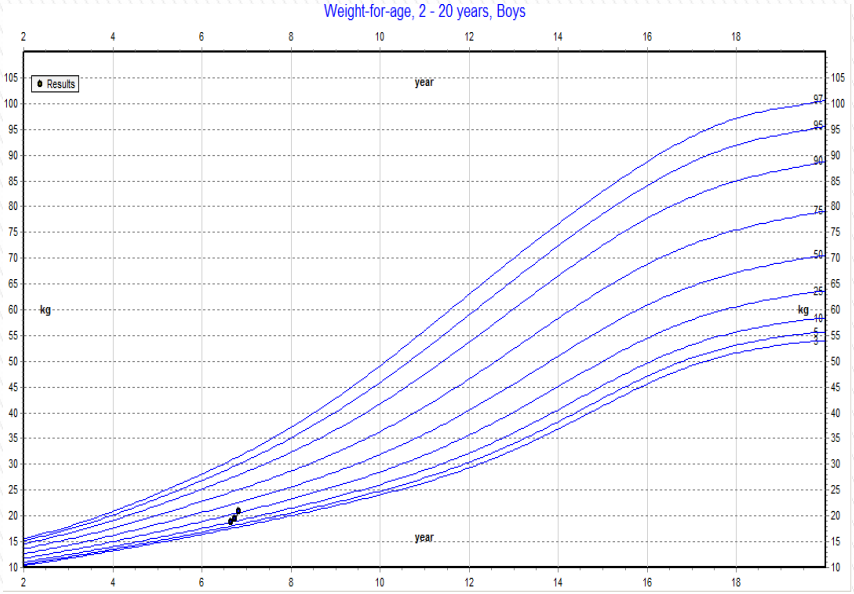
Trends Past Clinic Visits

	Oct 1	Oct 29	Dec 3
Blood Pressure	110/78	↑119/78	↑124/88
Albumin	39 g/L	38 g/L	41 g/L
Hemoglobin	101 g/L	109 g/L	119 g/L
Sodium	140 mmol/L	134 mmol/L	137 mmol/L
Meds	None	None	Amlodipine 5 mg
BCM (absolute) OH/ECW %	-0.7 -16.6%	-0.6 -14.5%	-0.7 -16.5%

Admitted to hospital for 4 weeks in September with peritonitis and pneumonia
Received suboptimal dialysis and nutrition

Growth Parameters

Weight



01-Oct-2018	6 years	18.74 kg	9.94	-1.28
29-Oct-2018	6 years	19.40 kg	14.29	-1.07
03-Dec-2018	6 years	20.80 kg	27.90	-0.59

Feeds

Formula Order:	300 ml homo milk + 56 scoops of Nephea Kid with water to 700 ml														
				Macronutrients			Water	Electrolytes		Minerals				Fat soluble vitamins	
			kcal	g	g	g	mL	mmol	mmol	mg	mg	mg	mg	IU	IU
Powders	Scoops	Grams	Kcal	Pro	Fat	Cho	Water	Na	K	Ca	P04	Mg	Iron	Vit A	Vit D
Nephea Kid Powder/g (4.5 g/scoop)	56.0	252.0	1230	16.4	60	151		20.2	1.3	378	66	88.2	8.8	839	1008
Other Liquids	Conc	Vol	Kcal	Pro	Fat	Cho	Water	Na	K	Ca	P04	Mg	Iron	Vit A	Vit D
Homo milk		3.00	186	10.0	10	14	273	5.4	11.3	350	282	30.9	0.1	289	131
Total Volume (mL)	700														
Kcal/mL	2.02														
Weight (kg)	18.6														
Total Intake			1415	26	71	165	273	26	13	728	347	119	9	1128	1139
% Kcals				7	45	47									
Intake/kg			76	1.42	3.8	8.9	15	1.4	0.7	39	19	6.4	0.5	61	61
Recommended Intake: KDOQI				1.35						≤2000	≤400				
Recommended Intake: DRI/AI			1385	0.95						1000	500			1333	600
Upper Limit										2500				3000	

Calories from dialysis ~200 kcals

Physical Exam

September 2018

December 2018

Is this patient overhydrated or not?

Assessment

Overhydrated

- Mild hypertension
- ? Faster then expected rate of wt gain
- Thirst ? going over fluid restriction

Not Overhydrated

- No overt edema
- ? Wt gain explained by 2.5% dialysate; excessive calories; catch up growth after admission
- ? Thirst caused by 2.5% dialysate
- Albumin WNL
- Reported fluid intake WNL
- BCM trends; showing underhydrated
- Minimal sodium intake
- Optimal dialysis

What did we decide?????

Not Overhydrated

1. Decreased calories by 15%
2. Increased dry weight 20.6-21 kg
3. Changed dialysis combination 1.5 and 2.5% (from all 2.5%)
4. Increased Amlodipine

Clinic Visit

N.R	2 months later
Dialysis PD:	8 cycles, 10 hrs UF 196-440ml Mix 1.5/2.5% 800 ml fill; last fill Extraneal 500 ml
Fluid/Diet	**Total: 700 – 800 ml** 250 ml homo milk + 48 scoops of Nephea Kid with water to 600 ml 100 ml additional water
Output	unchanged
Growth (kg) Goal weight	21.9 (-0.4 from -0.59) 21.5-22

Trends Past Clinic Visits

	Dec 3	Jan 14	Feb 11
Blood Pressure	↑ 124/88	↑128/86	↑ 132/88
Albumin	41 g/L	38 g/L	36 g/L
Hemoglobin	119 g/L	122 g/L	105 g/L
Sodium	137 mmol/L	137 mmol/L	137 mmol/L
Meds	Amlodipine 5mg	Amlodipine 7.5mg	Amlodipine 10mg Enalapril 7.5 mg
BCM absolute OH/ECW %	-0.7 -16.5%	-0.3 -5.9%	-0.4 -8.8%
Other			Mild LVH

Feeds

Formula Order:	250 ml Homo Milk + 48 scoops Nephea Kid with water to 600 ml														
				Macronutrients			Water	Electrolytes		Minerals				Fat soluble vitamins	
			kcal	g	g	g	mL	mmol	mmol	mg	mg	mg	mg	IU	IU
Powders	Scoops	Grams	Kcal	Pro	Fat	Cho	Water	Na	K	Ca	P04	Mg	Iron	Vit A	Vit D
Nephea Kid Powder/g (4.5 g/scoop)	48.0	216.0	1054	14.0	52	130		17.3	1.1	324	56	75.6	7.6	719	864
Other Liquids	Conc	Vol	Kcal	Pro	Fat	Cho	Water	Na	K	Ca	P04	Mg	Iron	Vit A	Vit D
Homo milk		2.50	155	8.3	8	12	228	4.5	9.5	291	235	25.8	0.1	241	109
Total Volume (mL)	600														
Kcal/mL	2.01														
Weight (kg)	21.0														
Total Intake			1209	22	60	141	228	22	11	615	291	101	8	960	973
% Kcals				7	45	47									
Intake/kg			58	1.06	2.9	6.7	11	1.0	0.5	29	14	4.8	0.4	46	46
Recommended Intake: KDOQI				1.35						≤2000	≤400				
Recommended Intake: DRI/AI			1422	0.95						1000	500			1333	600
Upper Limit										2500				3000	
**ND= Not determined*															

Physical Exam

December 2019

February 2019

Is this patient overhydrated or not?

Assessment

Overhydrated

- More Hypertensive
  - Mild LVH
- Edematous
- BCM increasing
- Albumin decreasing

The Plan

- Increase Enalapril
- Decrease total fluid 500 ml
- Decrease dry weight – find lowest wt tolerated

December Wt: 20.8 kg

February Wt: 21.9 kg

March Wt: 19.1kg

Dr C. Mammen Dry Weight Definition

Dry weight is when you have reached a point where you feel like crap

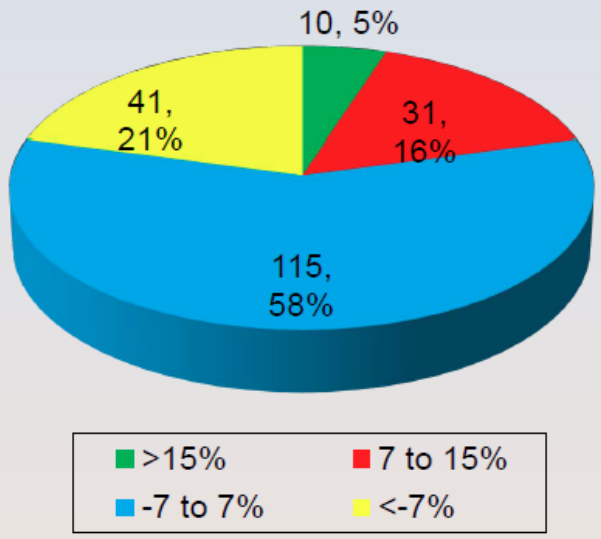
Visit last week

	Mar 11
Dialysis PD	8 cycles, 10 hrs UF 196–440ml Mix 1.5/2.5% 800 ml fill; last fill Extraneal 500 ml
Fluid/Diet	400 ml Novasource 100 ml water
Output	unchanged
Growth (kg) Goal wt	19.8 (–1.25) 19.4–19.7
Blood Pres	108/76
Albumin	43 g/L
Hemoglobin	84 g/L
Sodium	139 mmol/L
Meds	Enalapril 7.5 mg
BCM absolute OH/ECW %	–0.9 –24.1%

Our Local BCM Experience (PD)

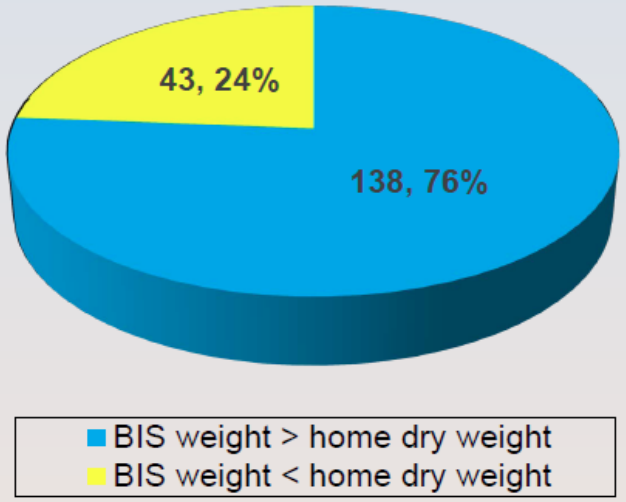
17 chronic PD patients from 2013-2018, median age 13 yrs (range 6-17)

Figure 1: OH/ECW (%) readings (n=197)



➢ Presence of OH was not related to transporter status, presence of daytime dwell, or residual urine output (p>0.05).

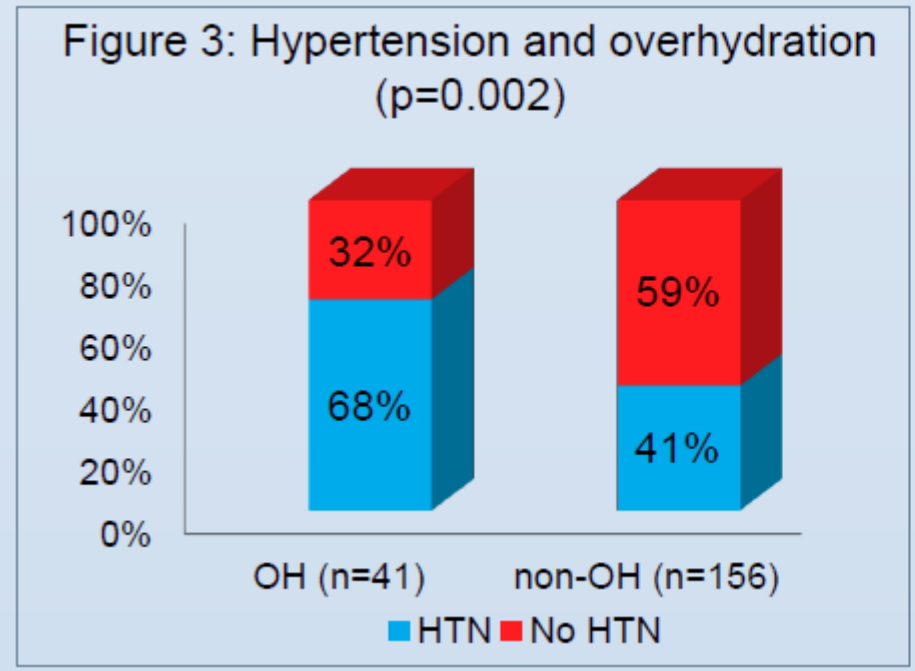
Figure 2: BIS weight vs Home dry weight (n=197)

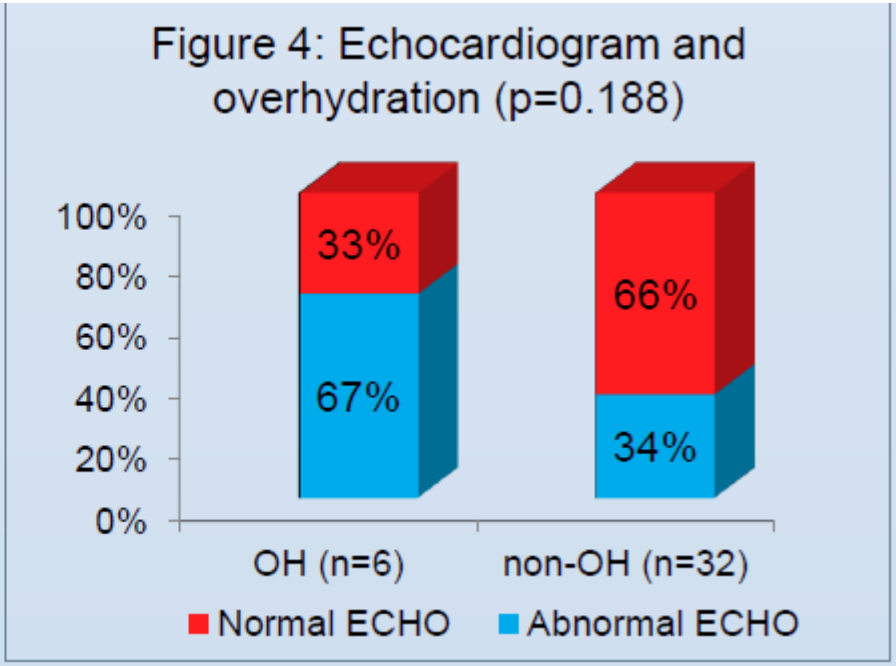


➢ BIS defined dry weight exceeded the lowest recorded home weight by median weight of **1.6 kg** (range 0.1-4.9 kg)

2019 ADC Poster: Kadam P et al

Our Local BCM Experience (PD)





- 48% of clinic BP readings were >95th%ile (BP index >1)
- Positive relationship between BP index and OH (r=+0.23, p=0.001)
- Patients were on at least 1 BP med 96% of the time when labelled as OH vs 81% of the time without OH (p<0.05)

Take Home Points

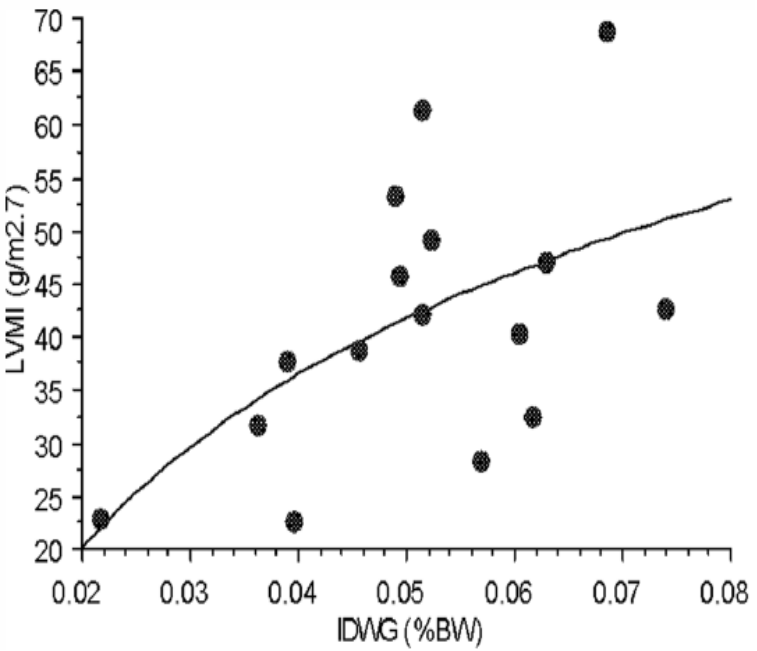
1. BCM can be misleading
   - Always had a negative BCM (underhydration)
2. Pay close attention to blood pressure trends and hypertension
3. Serial pictures can be helpful in assessing for edema
4. “Sometimes you just need to dry them out”

Take Home Messages

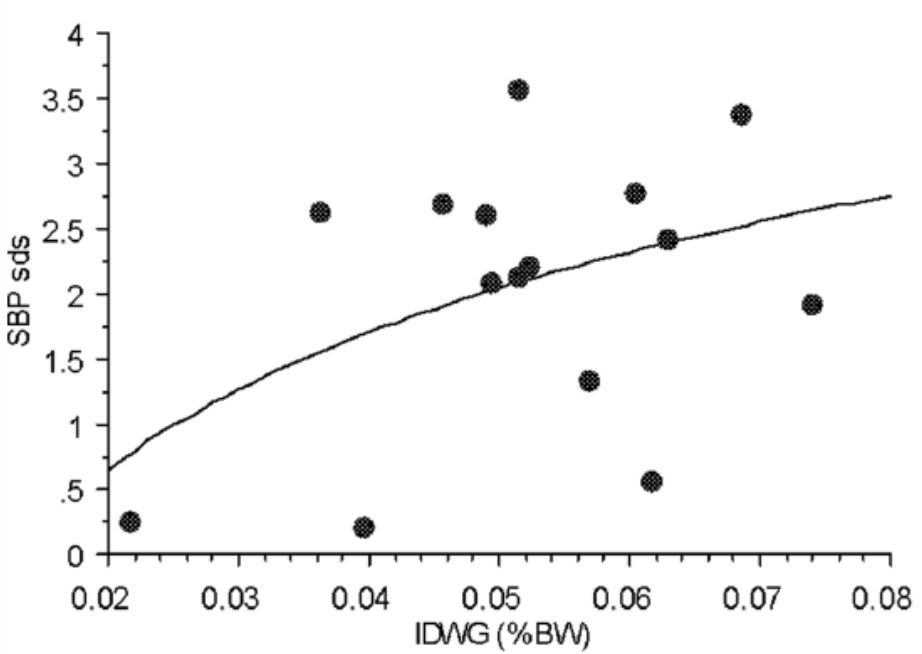
- Fluid balance is one of the most challenging issues for dialysis patients, families and the health care team
- A team approach is essential in understanding the multifaceted approach to fluid assessment and management in the pediatric dialysis population

Questions

Consequences of ↑ IDWG



Left ventricular mass index



Systolic BP SDS

IDWG >4% associated with left ventricular hypertrophy (LVH)

Pagliolonga F Pediatr Nephrol 2015

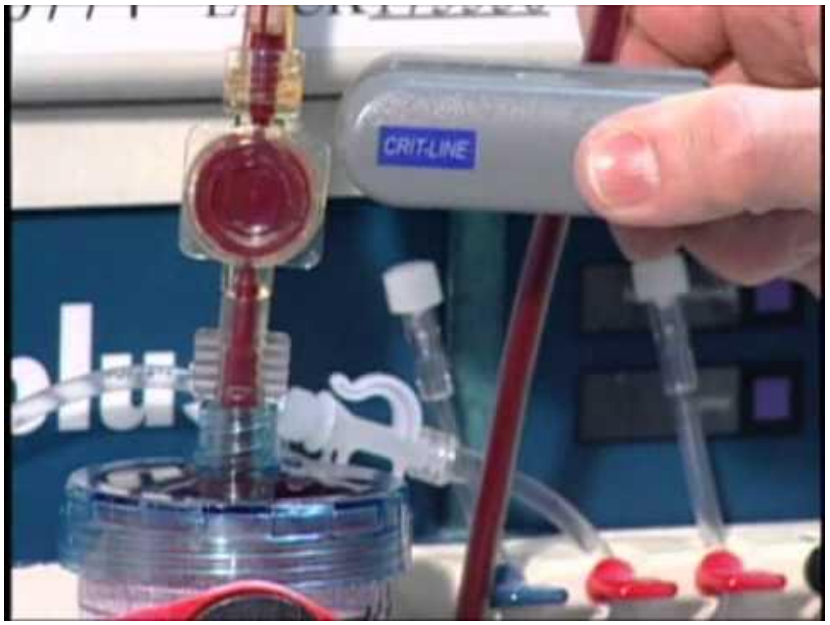
HD strategies for safe UF

- Try & limit UF to 5% of weight/session
  - Edematous may tolerate UF up to 10% of wt
  - Adults:<13 ml/kg/hr (cardiac stunning risk)
- If >5% IDWG, extend HD or run on extra day
- If patient not tolerating fluid removal, can try
  - Ultrafiltration profiling
    - Eg: Taking 50% of UF in the 1st hour, and the remaining in the next 2-3 hours
  - Sodium profiling
    - Eg: Increasing dialysate Na [ ] above pt Na temporarily
- Blood volume monitoring

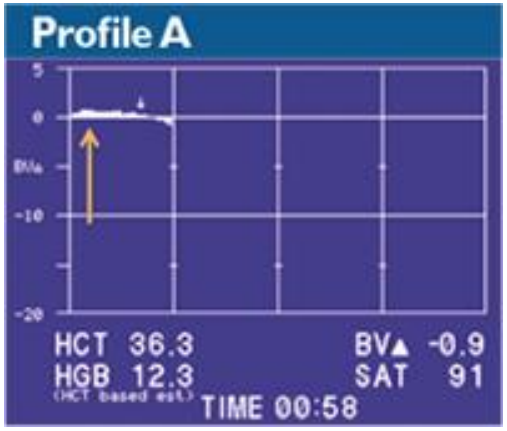
Blood volume monitoring in HD

- Non-invasive technology that measures blood volume (BV) in real time & continuously during HD
- Measures relative change in hematocrit in response to UF
- Relative BV decreases with UF (inverse of HCT)
- Slope of the BV curve determined by
  - 1) rate of fluid removal (UFR)
  - 2) ability to refill the vascular space

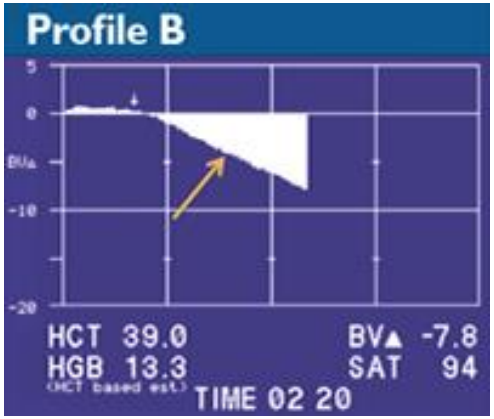
CritLine Monitor (Fresenius)



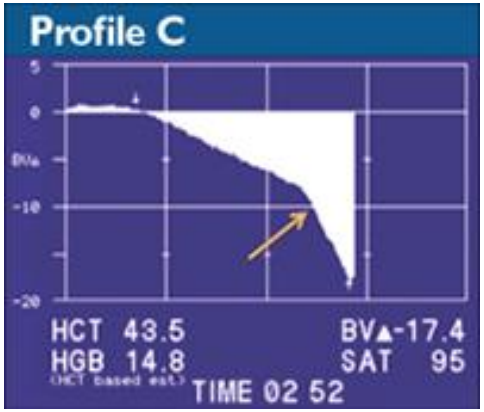
Example of BVM profile during HD



No change in BV



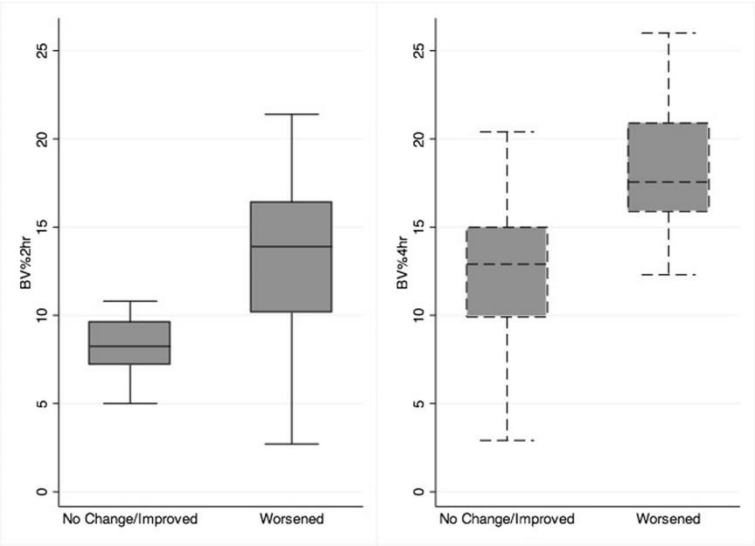
Gradual ↓ in BV



Steep ↓ in BV

Safe BVM changes in children

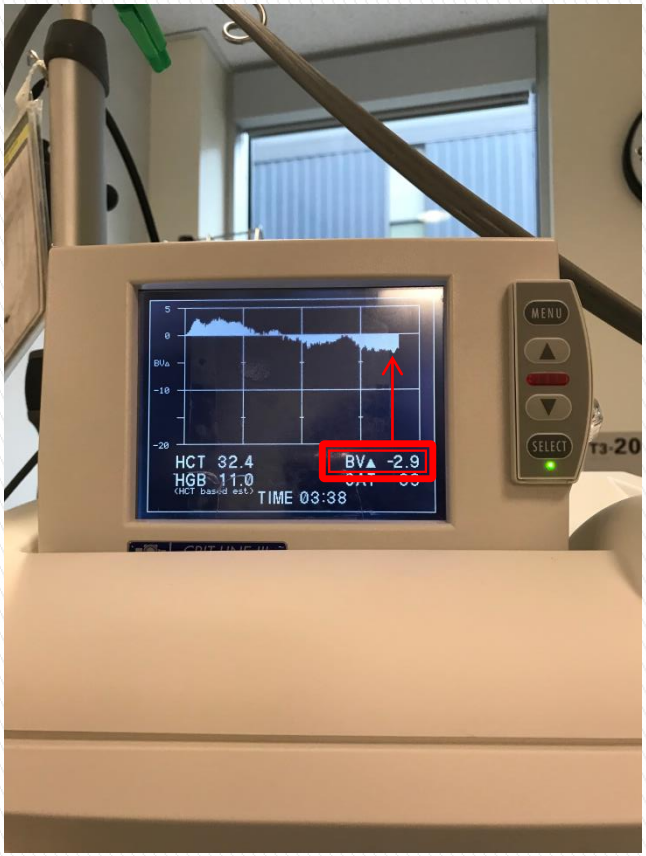
- *Safe UF rate defined by BV change of <8% per hour in 1st 90 min and <4% after with no more than a 12% net RBV change per dialysis session (based on intradialytic events)*



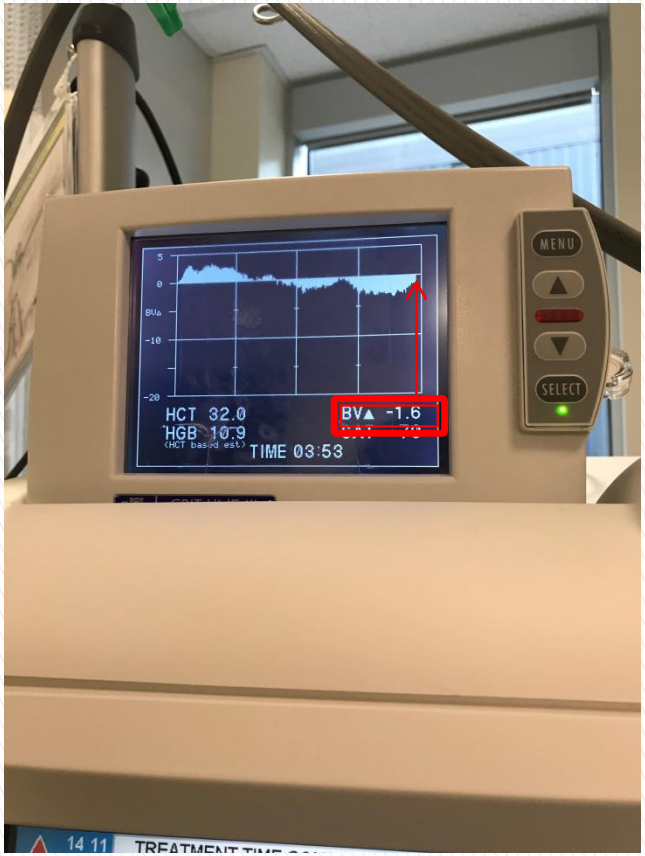
Cardiac Index changes at
2 hrs and 4 hrs into HD

Jain SR Pediatr Nephrol 2001
Geer J Pediatr Nephrol 2017

Finding Dry Weight with Crit Line Monitoring (HD)



Nurse places patient into a mimimum UF profile (0.1L/hr) with 15 min remaining on the HD run



Then look at the BV change after. If BV ↑ (ie refilling occurs), then there is more fluid to remove

The Year in Review: Recent Research and Practical Applications for Nutrition Care

Christina L. Nelms, MS RDN LMNT

Annual Dialysis Conference

March 7, 2021

Objectives

- Review key articles from the last year that have provided significant updates in standards of pediatric renal nutrition practice
- Summarize take-home points from the literature that may be important to keep pediatric renal nutrition clinicians up-to-date
- Discuss practical, tangible ways that the recent literature can be pursued in individual practice
- Review updates from the newest Clinical Practice Recommendations

Disclaimer: This grouping of research is by no means comprehensive or meeting the scope of all influential research compiled in the last year!!

Vitamins and Minerals

Joyce T, Rasmussen P, Melhem N, Clothier J, Booth C, Sinha MD. Vitamin and trace element concentrations in infants and children with chronic kidney disease. *Pediatr Nephrol*. 2020 Aug;35(8):1463-1470.

Key Messages

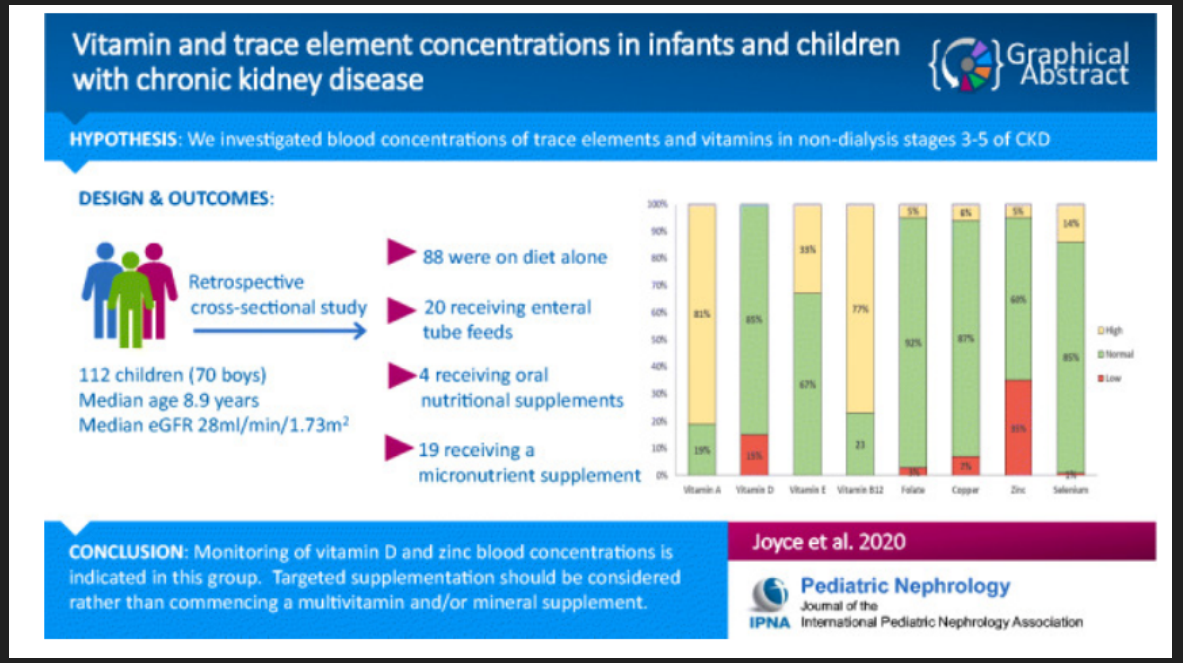
- Vitamin A
  - WNL 19%
  - 81% elevated
- Vitamin B12
  - WNL 23%
  - 77% elevated
- Vitamin E
  - WNL 67%
  - 33% elevated
- Vitamin D
  - WNL 85%
  - 15% depressed
- Folate
  - WNL 92%
  - 5% elevated
  - 3% depressed
- Zinc
  - WNL 60%
  - 5% elevated
  - 35% depressed
- Selenium
  - WNL 85%
  - 14% elevated
  - 1% depressed
- Copper
  - WNL 87%
  - 6% elevated
  - 7% depressed

Manichkavasagar B, McArdle AJ, Yadav P et al. Hypervitaminosis A is prevalent in children with CKD and contributes to hypercalcemia. *Pediatr Nephrol.* 2015;30:317-25.

Joyce T, Court Brown F, Wallace D, Reid CJD, Sinha MD. Trace element and vitamin concentrations in paediatric dialysis patients. *Pediatr Nephrol.* 2018;33:159-65.
5) Kriley M and Warady

Applications for Practice

- Vitamin and mineral levels are off – even before dialysis
- Vitamin D and zinc may need supplemented even early in CKD
- Avoid supplementing vitamin A and E
- Enteral/oral supplements and vitamin supplements increase levels
- Zinc low despite supplementation in some, other causes of zinc loss?
- Ala carte supplementation vs. pill burden



Kennedy SS, Perilloux A, Pereira RC, Handelman G, Wesseling-Perry K, Salusky IB. Vitamin C overload may contribute to systemic oxalosis in children receiving dialysis. *Pediatr Nephrol.* 2020 Aug 9.

Key Messages

- Thirteen young children evaluated
- Two index cases showing significant bone deformities, fractures and oxalate crystallization in the bone marrow – significantly elevated calcium and vitamin C
- Formula and vitamin supplements significant contributors of vitamin C
- Dialysis vintage contributing factor
- 145-847% age specific DRI for vitamin C consumed
- Limitations: small sample size, no official association between vitamin C intake, ascorbic acid levels and oxalate, no measure of amounts in urine or UF

Applications for Practice

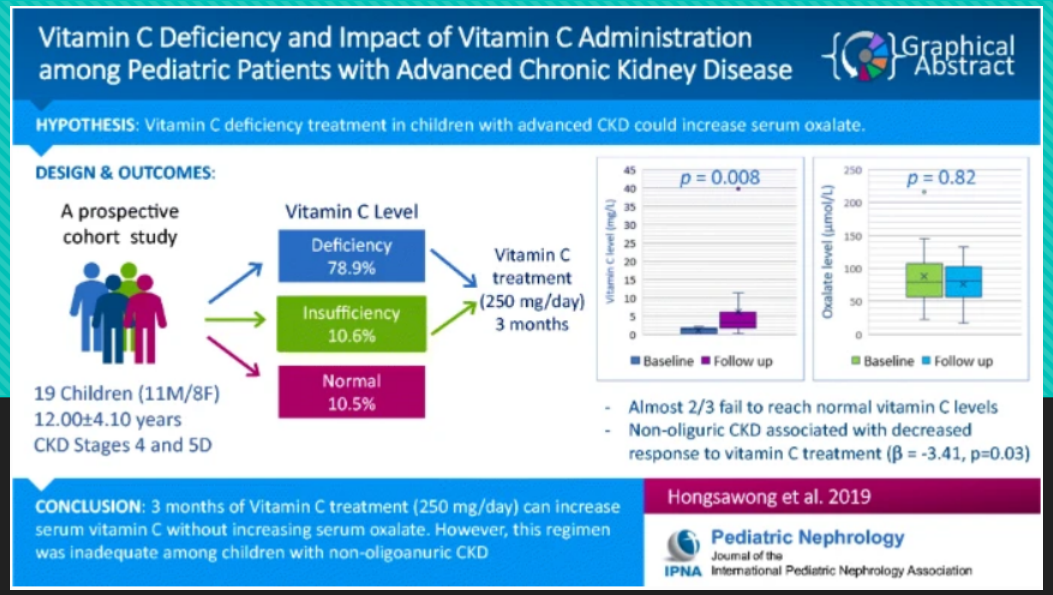
Age	Male	Female
0–6 months	40 mg*	40 mg*
7–12 months	50 mg*	50 mg*
1–3 years	15 mg	15 mg
4–8 years	25 mg	25 mg

- Carefully evaluate diet before making multivitamin recommendations (all patients should have an initial dietary evaluation)
- There are studies in favor of more vitamin C, some in favor of less – careful assessment and balance must be considered with each patient

El Mashad GM, ElSayed HM, Nosair NA. Effect of vitamin C supplementation on lipid profile, serum uric acid, and ascorbic acid in children on hemodialysis. Saudi J Kidney Dis Transpl 2016;27:1148-54.

Hongsawong N, Chawprang N, Kittisakmontri K, Vittayananan P, Srisuwan K, Chartapisak W. Vitamin C deficiency and impact of vitamin C administration among pediatric patients with advanced chronic kidney disease. *Pediatr Nephrol.* 2021 Feb;36(2):397-408. [Epub ahead of print.]

Key Messages



- 19 patients – 11% with vitamin C insufficiency; 79% deficiency
- Vitamin C, 250 mg, given for repletion; oxalate levels weren't increased
- 63% still failed to achieve normal serum vitamin C levels
- Dietary intake did not appear to influence sufficiency
- Difficult to achieve sufficiency

Applications for Practice

- Vitamin C needs are controversial
- It appears that moderate amounts of vitamin C may at least improve serum vitamin C levels
- Must monitor for oxalate excesses, however, it seems that moderate amounts may not increase oxalate
- This protocol might not be appropriate for young children

Protein Energy Wasting/Malnutrition

Iyengar A, Raj JM, Vasudevan A. Protein Energy Wasting in Children With Chronic Kidney Disease and End-Stage Kidney Disease: An Observational Study. *J Ren Nutr.* 2020 Sep 18:S1051-2276(20)30202-8.

Key Messages

- Appetite and anthropometry more useful than biochemical measures for diagnosis
- Inflammation more common in ESKD
- Reduced appetite, low mid-upper arm circumference and low BMI index for height most useful
- Duration and severity of disease associated with higher PEW incidence

Abraham AG, Mak RH, Mitsnefes M, et al. Protein energy wasting in children with chronic kidney disease. *Pediatric nephrology*. 2014;29(7):1231-1238.

Applications for Practice

- This appears to be the first study in ESKD in addition to CKD; even higher prevalence in ESKD
- Focus on tools of anthropometry and appetite for evaluation

Hogan J, Schneider MF, Pai R. Grip strength in children with chronic kidney disease. *Pediatr Nephrol*. 2020 May;35(5):891-899.

Key Messages

- Compared to NHANES controls, children with CKD have poorer grip strength
- Longer CKD vintage, pre-pubertal status, delayed puberty, neuopsychiatric conditions, need for feeding support, alkali therapy and low hemoglobin level associated with poorer hand grip strength
- Low grip strength associated with less exercise and less intensity
- Overweight and obese patients with improved grip strength

Applications for Practice

- Exercise is beneficial to prioritize
- Consider screening for muscle strength, physical activity, weight loss and measures of frailty so that interventions can be considered
- Benefits despite previous research showing exercise may not affect muscle mass

Foster BJ, Kalkwarf HJ, Shults J, Zemel BS, Wetzsteon RJ, Thayu M, Foerster DL, Leonard MB. Association of chronic kidney disease with muscle deficits in children. J Am Soc Nephrol. 2011 Feb;22(2):377-86.

El-Serw HES, Bassiouni DARH, Al-Wakeil AA, El-Masry RSAI, Bakr AMAEB. Efficacy of intradialytic amino acids on nutritional status in children with stage 5 chronic kidney disease. *Pediatr Nephrol.* 2020 Nov 18.[Epub ahead of print.]

Key Messages

- 50 patients, 25 controls received IDPN, 25 received saline as controls
- At 9 months, the patients with the intervention had improvement in height Z-scores, lean tissue mass and albumin

Juarez MD. Intradialytic Parenteral Nutrition in Pediatrics. Front Pediatr. 2018 Oct 4;6:267. doi: 10.3389/fped.2018.00267.

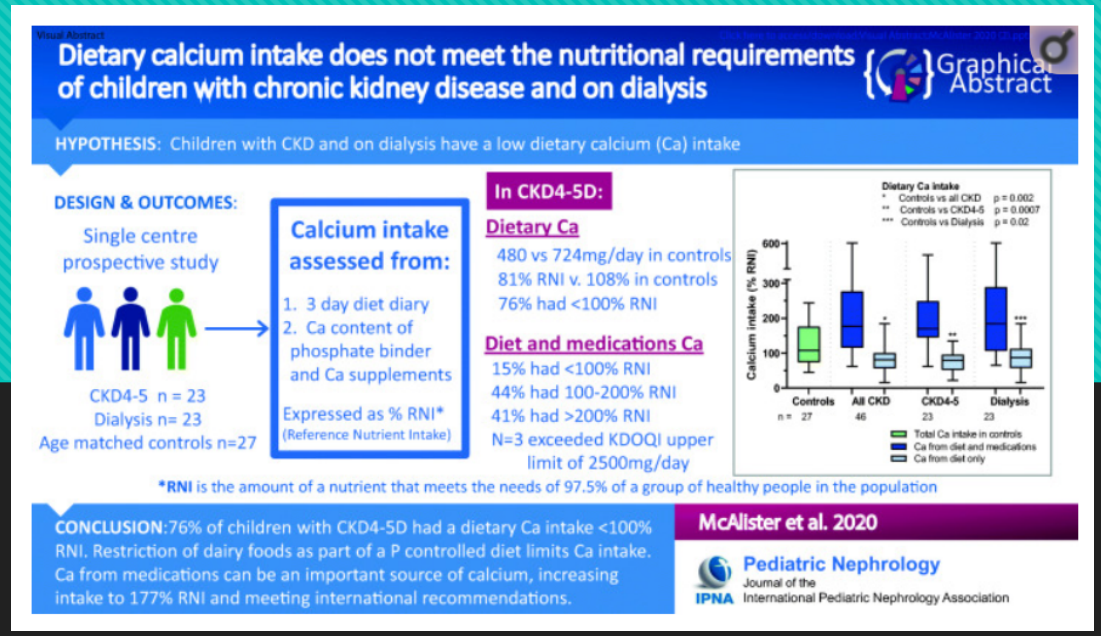
Applications for Practice

- Good nutrition can improve linear growth
- IDPN may improve lean mass – something difficult to increase in dialysis patients
- IDPN is another option if tube feeding is not

Bone Mineral

McAlister L, Silva S, Shaw V, Shroff R. Dietary calcium intake does not meet the nutritional requirements of children with chronic kidney disease and on dialysis. *Pediatr Nephrol.* 2020 Oct;35(10):1915-1923.

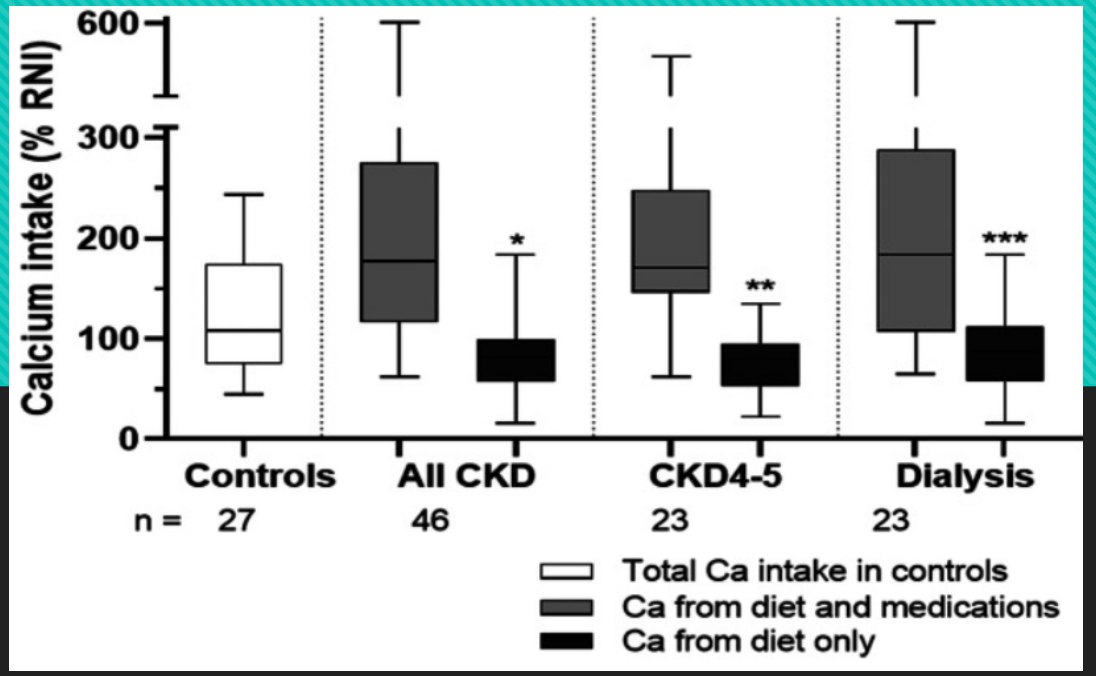
Key Messages



- High fracture risk
- Calcium intake below RNI (British study) in 67% of children with CKD stages 4-5D
- Calcium needed to meet goal of 100-200% of recommended through diet or medication
- Less dairy intake

McAlister L, Pugh P, Greenbaum L, Haffner D, Rees L, Anderson C, Desloovere A, Nelms C, Oosterveld M, Paglialonga F, Polderman N, Qizalbash L, Renken-Terhaerdt J, Tuokkola J, Warady B, Walle JV, Shaw V, Shroff R. The dietary management of calcium and phosphate in children with CKD stages 2-5 and on dialysis-clinical practice recommendation from the Pediatric Renal Nutrition Taskforce. Pediatr Nephrol. 2020 Mar;35(3):501-518.

Applications for Practice



- Evaluate diet and calcium based medications carefully
- Bedtime calcium may help achieve calcium needs and help determine more definitely how much calcium is being consumed

Enteral Feeding

Khweir S, McAlister L, Marks SD. Feeding patterns and outcomes of enterally tube fed paediatric kidney transplant recipients. *Pediatr Nephrol.* 2020 Dec;35(12):2361-2367.

Key Messages

- Seventy percent of children transitioned to oral feeding, off TF by 6 weeks of age
- Twenty percent needed a feeding and eating disorder team at around 20 months post transplant
- Positive BMI associated with shorter transition

Samaan S, Secker D. Oral feeding challenges in infants with chronic kidney disease. *Infant Child Adolesc Nutr.* (2014) 6:164–71.

Applications for Practice

- Most patients transition quickly after transplant off tube feedings; can be aggressive post-transplant, but a smaller group may need long term therapy to get there
- Dietetic time devoted pre-transplant and post-transplant for weaning strategies, is beneficial

Acidosis

Brown DD, Roem J, Ng DK. Low Serum Bicarbonate and CKD Progression in Children. *Clin J Am Soc Nephrol*. 2020 Jun 8;15(6):755-765.

Key Messages

- Children, especially those with glomerular disease, have more rapid progression of CKD with lower CO2
- Only half of children received alkali supplements
- We don't know why these patients weren't treated (GI side effects?, medication burden?) so alternative forms of treating acidosis may be needed

Applications for Practice

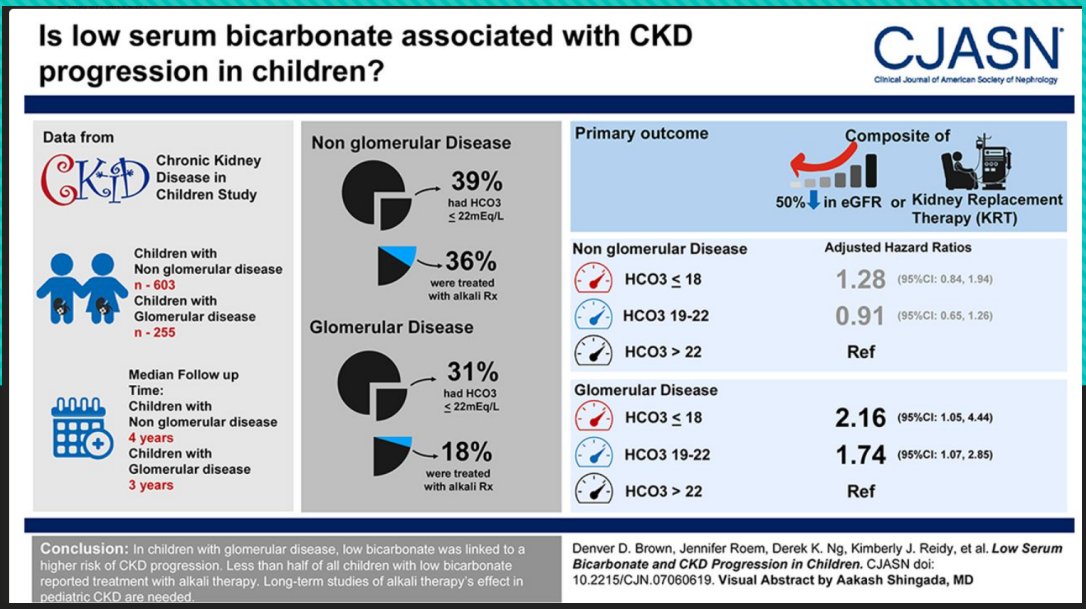
- Change formula or increase fruits and vegetable intake to reduce incidence of acidosis
- Ensure your patients are on alkali supplements

López M, Moreno G, Lugo G, Marcano G. Dietary acid load in children with chronic kidney disease. *Eur J Clin Nutr*. 2020 Aug;74(Suppl 1):57-62.

Key Messages

- Dietary protein load elevated in 79% of patients (PRAL – potential renal acid load estimated)
- Average vegetable intake was 0.4 servings and fruit 1.5 servings per day; high PRAL associated with low vegetable intake

Applications for Practice



- Consider dietary interventions for management of acidosis
- Fruits and vegetables has a critical role in prevention of CKD prevention
- Current evidence showing acidosis a risk for progression of CKD

Additional references:

Brown DD, Roem J, Ng DK, Reidy KJ, Kumar J, Abramowitz MK, Mak RH, Furth SL, Schwartz GJ, Warady BA, Kaskel FJ, Melamed ML. Low Serum Bicarbonate and CKD Progression in Children. *Clin J Am Soc Nephrol.* 2020 Jun 8;15(6):755-765.

Furth SL, Abraham AG, Jerry-Fluker J, Schwartz GJ, Benfield M, Kaskel F, Wong C, Mak RH, Moxey-Mims M, Warady BA. Metabolic abnormalities, cardiovascular disease risk factors, and GFR decline in children with chronic kidney disease. *Clin J Am Soc Nephrol.* 2011 Sep;6(9):2132-40.

Harambat J, Kunzmann K, Azukaitis K, Bayazit AK, Canpolat N, Doyon A, Duzova A, Niemirska A, Sözeri B, Thurn-Valsassina D, Anarat A, Bessenay L, Candan C, Peco-Antic A, Yilmaz A, Tschumi S, Testa S, Jankauskiene A, Erdogan H, Rosales A, Alpay H, Lugani F, Arbeiter K, Mencarelli F, Kiyak A, Dönmez O, Drozdz D, Melk A, Querfeld U, Schaefer F; 4C Study Consortium. Metabolic acidosis is common and associates with disease progression in children with chronic kidney disease. *Kidney Int.* 2017 Dec;92(6):1507-1514.

Other

Trace SL, Collinson A, Searle AJ, Lithander FE. Using videoconsultations to deliver dietary advice to children with chronic kidney disease: a qualitative study of parent and child perspectives. *J Hum Nutr Diet*. 2020 Apr 2.

Key Messages

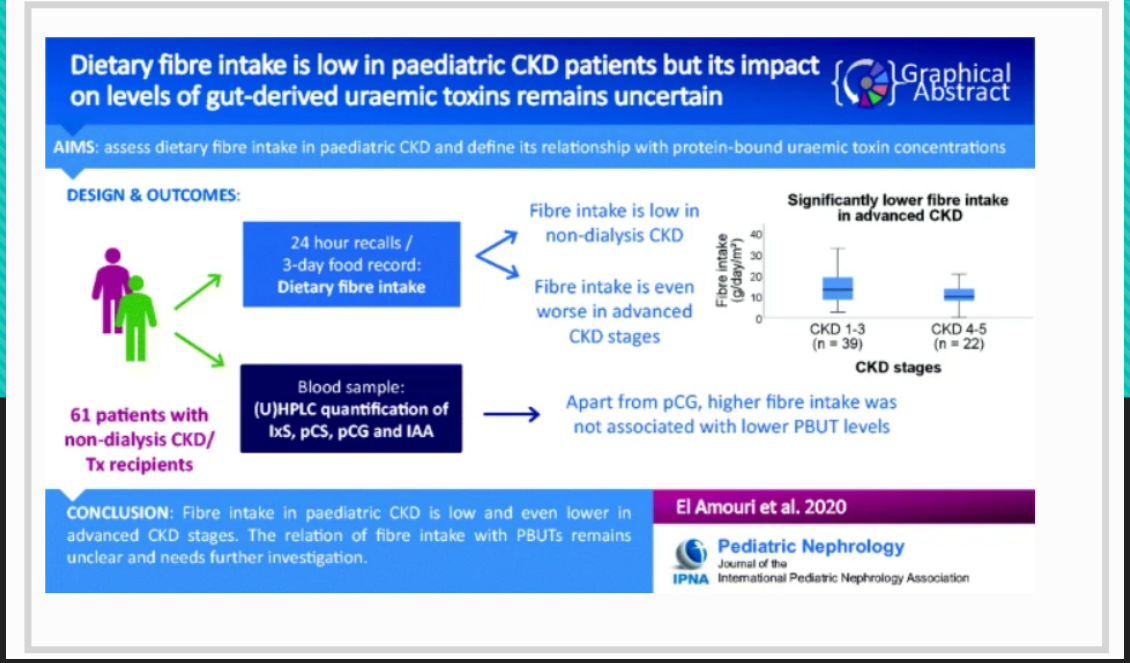
- Parents and especially patients liked the video conferencing with screen sharing
- Parents requested it as a tool to supplement care
- Families reported improved access to dietetic care
- Parents reported increased privacy, efficiency, minimal technological issues, ability to show food items, etc.

Applications for Practice

- Especially in age of COVID, having video conferencing/screen sharing is important
- RDN time is limited, sometimes does not coincide with families appointments
- Centers that reach rural populations/large areas may utilize this tool
- VC could aid in earlier and more frequent contacts

El Amouri A, Snauwaert E, Foulon A, Vande Moortel C, Van Dyck M, Van Hoeck K, Godefroid N, Glorieux G, Van Biesen W, Vande Walle J, Raes A, Eloot S. Dietary fibre intake is low in paediatric chronic kidney disease patients but its impact on levels of gut-derived uraemic toxins remains uncertain. *Pediatr Nephrol*. 2021 Jan 2. [Epub ahead of print.]

Key Messages



- Low fiber intake in children with CKD, especially as CKD advanced (average of 10 g/day in stages 4-5, 14 grams in stages 1-3)
- Lower uremic toxins in those with higher fiber intake
- 23% met goal fiber intake; 39% in early CKD, 9% in late CKD
- 3 patients (formula fed) no fiber at all

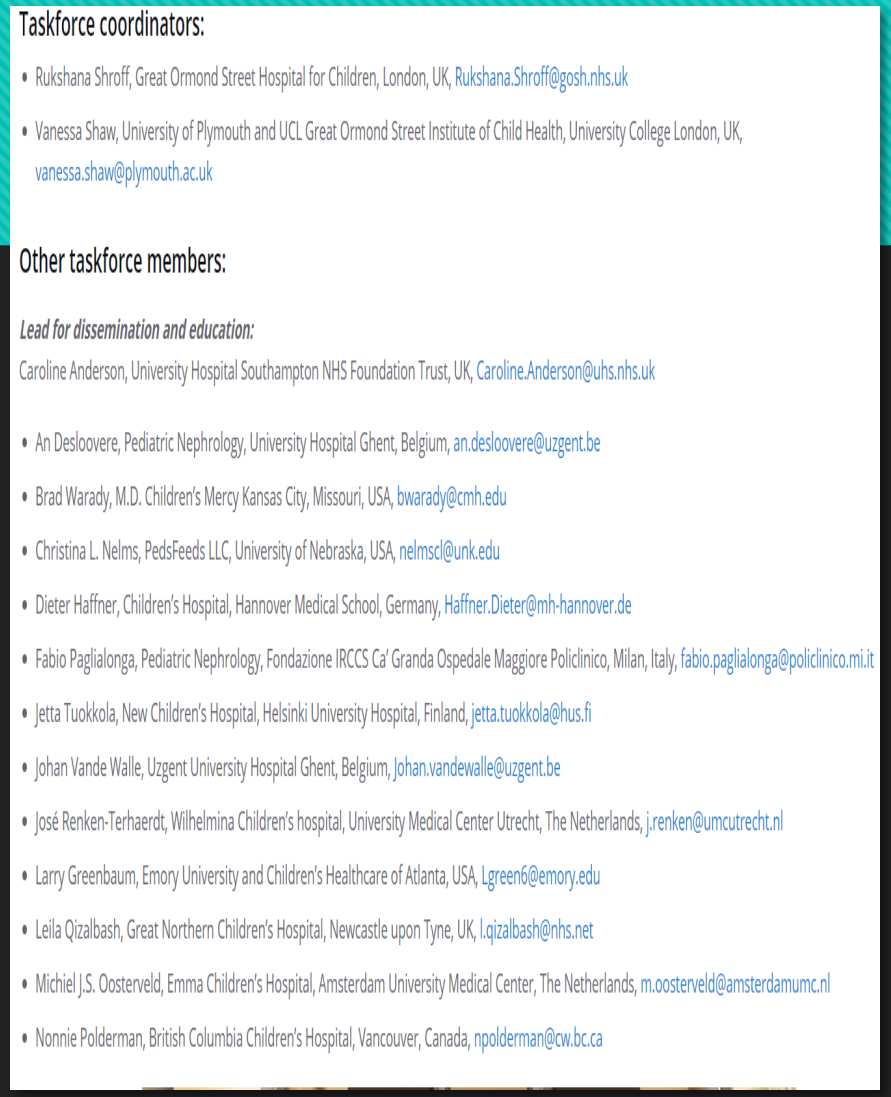
Crespo-Salgado J, Vehaskari VM, Stewart T. et al. Intestinal microbiota in pediatric patients with end stage renal disease: a Midwest Pediatric Nephrology Consortium study. *Microbiome*. 2016;4:50 (open access)

Applications for Practice

- Encourage low potassium fruits and vegetables
- More evidence for movement toward plant based diet!
- Consider fiber supplementation, as tolerated, in formula/tube fed children
- Could nutrition have a role in slowing progression to dialysis!?
- Can good nutrition have an impact on uremia and alleviate patient symptoms?!

Update on the Clinical Practice Recommendations from the Pediatric Renal Nutrition Taskforce

The Pediatric Renal Nutrition Taskforce (PRNT) is an international team of pediatric renal dietitians and pediatric nephrologists, who develop clinical practice recommendations (CPRs) for the nutritional management of various aspects of renal disease management in children.



Taskforce coordinators:

- Rukshana Shroff, Great Ormond Street Hospital for Children, London, UK, Rukshana.Shroff@gosh.nhs.uk
- Vanessa Shaw, University of Plymouth and UCL Great Ormond Street Institute of Child Health, University College London, UK, vanessa.shaw@plymouth.ac.uk

Other taskforce members:

Lead for dissemination and education:

Caroline Anderson, University Hospital Southampton NHS Foundation Trust, UK, Caroline.Anderson@uhs.nhs.uk

- An Desloovere, Pediatric Nephrology, University Hospital Ghent, Belgium, an.desloovere@uzgent.be
- Brad Warady, M.D. Children's Mercy Kansas City, Missouri, USA, bwarady@cmh.edu
- Christina L. Nelms, PedsFeeds LLC, University of Nebraska, USA, nelmscl@unk.edu
- Dieter Haffner, Children's Hospital, Hannover Medical School, Germany, Haffner.Dieter@mh-hannover.de
- Fabio Paglialonga, Pediatric Nephrology, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy, fabio.paglialonga@policlinico.mi.it
- Jetta Tuokkola, New Children's Hospital, Helsinki University Hospital, Finland, jetta.tuokkola@hus.fi
- Johan Vande Walle, Uzgent University Hospital Ghent, Belgium, Johan.vandewalle@uzgent.be
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- Larry Greenbaum, Emory University and Children's Healthcare of Atlanta, USA, Lgreen6@emory.edu
- Leila Qizalbash, Great Northern Children's Hospital, Newcastle upon Tyne, UK, l.qizalbash@nhs.net
- Michiel J.S. Oosterveld, Emma Children's Hospital, Amsterdam University Medical Center, The Netherlands, m.oosterveld@amsterdamumc.nl
- Nonnie Polderman, British Columbia Children's Hospital, Vancouver, Canada, npolderman@cw.bc.ca

THE CURRENT TEAM

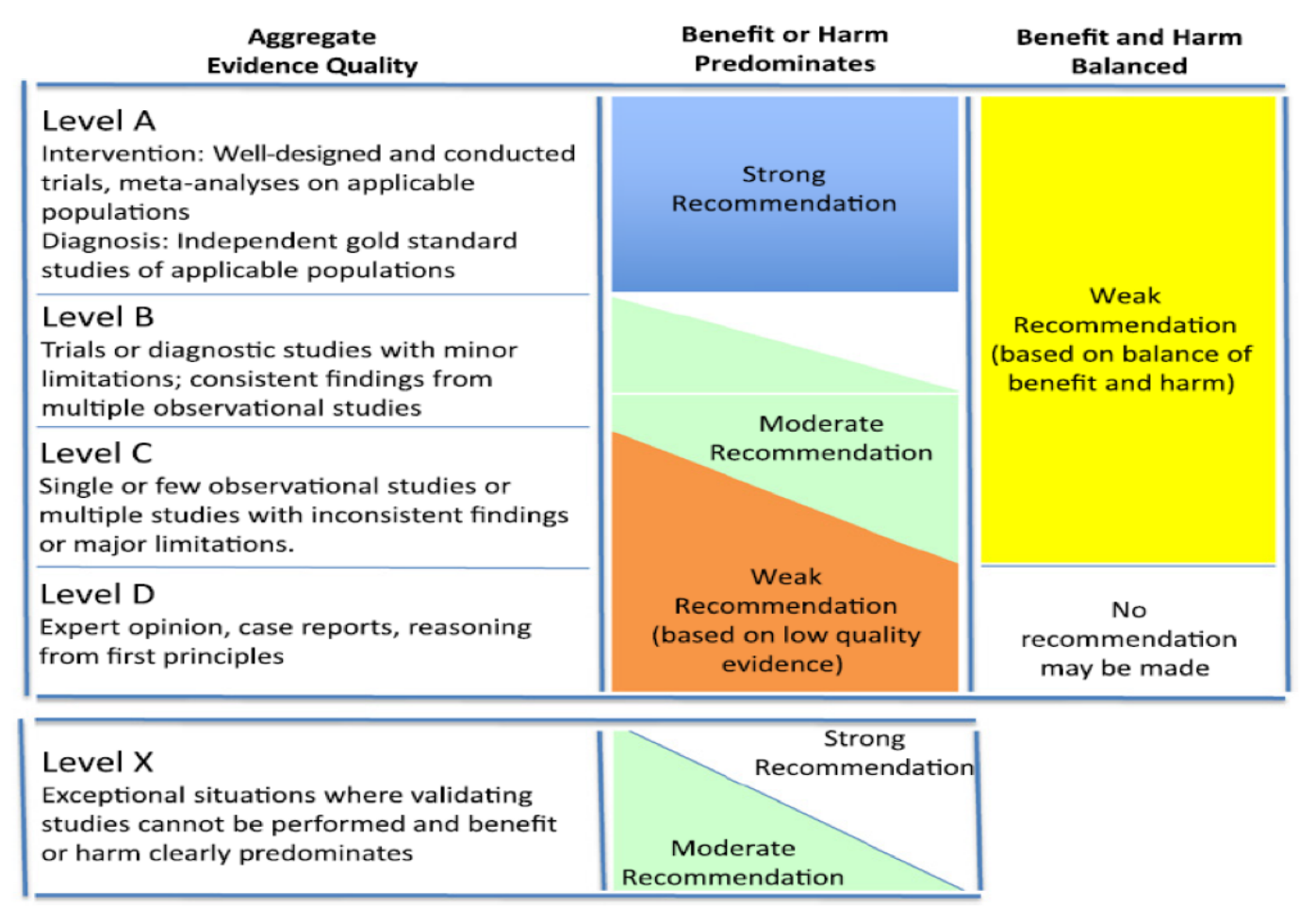
From: The dietary management of calcium and phosphate in children with CKD stages 2-5 and on dialysis – clinical practice recommendation from the Pediatric Renal Nutrition Taskforce, *Pediatr Nephrol*. In press

Goals of PRNT

- To update / complement the KDOQI guidelines, by reviewing and incorporating the newest literature; focus on practicality
- Ongoing project; goals to:
  - keep recommendations current and relevant
  - serve all areas of the world
- Joint European and North American project
- 14 primary members (7 RDs, 7 MDs) with content experts invited based on topic
- Clinical Practice Recommendations (CPRs) vetted via use of:

PICO question foundation	AAP grading matrix
Evidence tables	Delphi review of 70% agreement

American Academy of Pediatrics (AAP) Grading Matrix



ESPN main website

The Paediatric Renal Nutrition Taskforce comprises paediatric renal dietitians and paediatric nephrologists from 8 countries across Europe and North America who are dedicated to improving the nutritional care of children with kidney diseases.
The taskforce is endorsed by ESPN and IPNA.

PAEDIATRIC RENAL NUTRITION TASKFORCE

ANNOUNCEMENT: The management of childhood kidney diseases – pre-conference meeting on 16 September at ESPN 2020 in Ljubljana. **Unfortunately, due to the coronavirus pandemic, meeting has been cancelled along with the main ESPN conference.**

Why was the Paediatric Renal Nutrition Taskforce created?

The taskforce was set up in December 2017, prompted by the challenges and inconsistencies in the nutritional management of children with kidney diseases globally. Many renal centres do not have trained dietitians and the importance of nutrition in patient care is not always addressed in medical education.

Our vision:

To ensure best practice in the nutritional management of children with kidney diseases

Our mission:

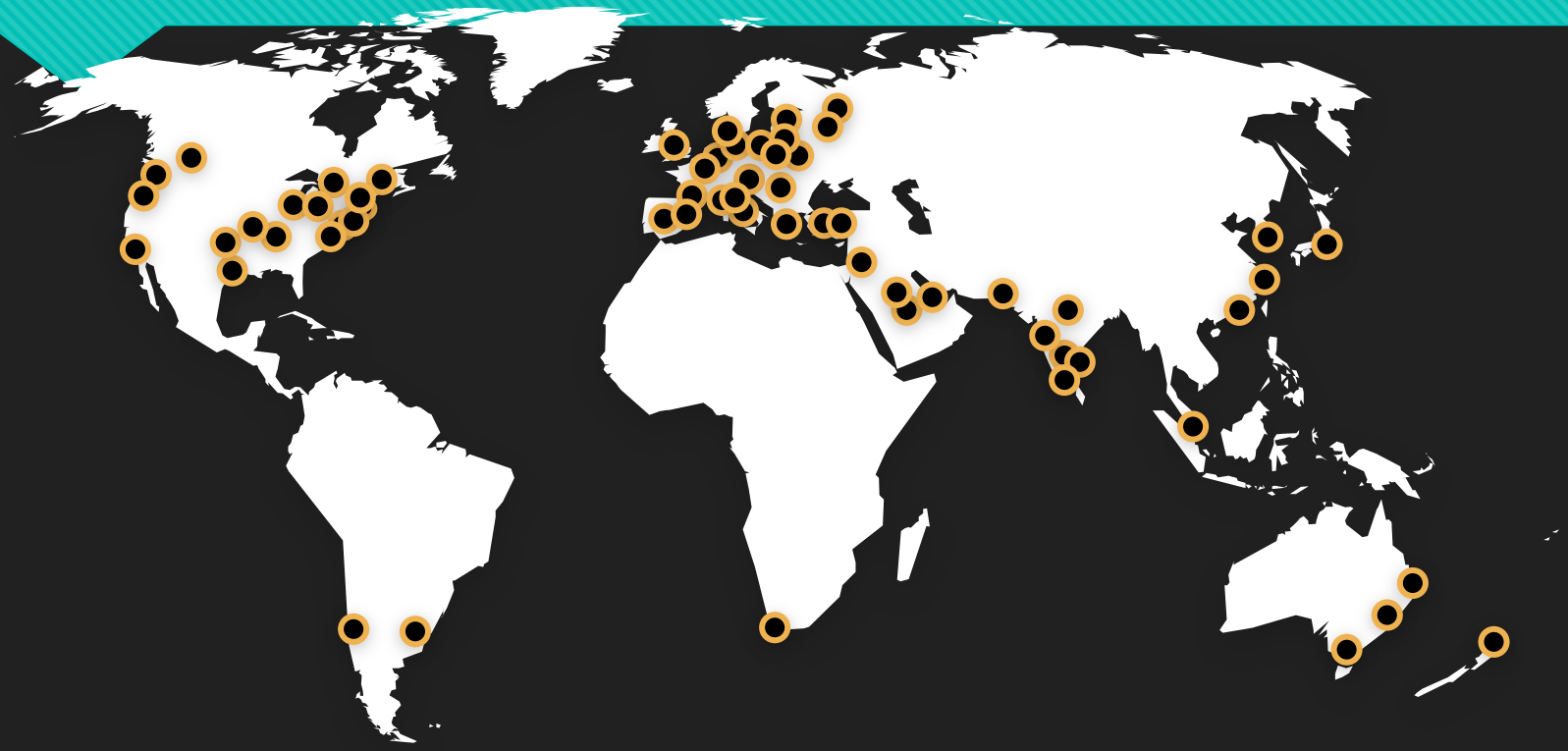
- To formulate clinical practice recommendations to enable best practice
- To provide education and training resources for healthcare professionals caring for children with kidney diseases
- To devise resources which offer practical support to children with kidney disease and their families
- To promote research to expand the evidence base for nutritional intervention in paediatric kidney diseases

Our values:

Our work will be guided by our commitment to open and transparent discussion amongst our members who strive to produce quality recommendations, based on the evidence base where possible. We will work inclusively with external experts and stakeholders and respect their opinion in developing and disseminating best practice for the benefit of children with kidney diseases.

PRNT members globally

First of 4 Delphi Surveys - participants



CPRs published to date:

- Assessment
- Energy/Protein
- Calcium /Phosphorus
- Delivery
- Potassium

PAEDIATRIC RENAL NUTRITION TASK FORCE

Assessment Highlights

- Anthropometric
  - Standard anthropometric tools still best for assessment
  - Use appropriate growth charts; z-scores complementary
  - Use surrogate measures if needed
  - Mid parental height and prematurity guidelines
- Dietary
  - Evaluate appetite
  - 3 or more day food records ideal, recalls also acceptable, any information helpful,
- Biochemical
  - Albumin only useful in the absence of other factors; consider trending other labs as secondary measures

Nelms CL, Shaw V, Greenbaum LA, Anderson C, Desloovere A, Haffner D, Oosterveld MJS, Paglialonga F, Polderman N, Qizalbash L, Rees L, Renken-Terhaerdt J, Tuokkola J, Vande Walle J, Shroff R, Warady BA. Assessment of nutritional status in children with kidney diseases-clinical practice recommendations from the Pediatric Renal Nutrition Taskforce. Pediatr Nephrol. 2020 Dec 14..

Energy/Protein Highlights

- Energy needs similar to healthy children
- Protein needs within range of healthy children (SDI), adjusting up for dialysis and on the lower end for CKD
- Nutrition prescription encourages breastfeeding, fortification of feeds to meet kcal needs, solid food introduction per age appropriate guidelines, oral food preference, fast intervention needed when centiles decline

Shaw V, Polderman N, Renken-Terhaerdt J, Paglialonga F, Oosterveld M, Tuokkola J, Anderson C, Desloovere A, Greenbaum L, Haffner D, Nelms C, Qizalbash L, Vande Walle J, Warady B, Shroff R, Rees L. Energy and protein requirements for children with CKD stages 2-5 and on dialysis-clinical practice recommendations from the Pediatric Renal Nutrition Taskforce. Pediatr Nephrol. 2020 Mar;35(3):519-531.

Calcium/Phosphorus Highlights

- Review of sources of calcium and phosphorus
- Discuss methods for evaluation of calcium and phosphorus and sources to consider
- Requirements for calcium and phosphorus similar to healthy children, with adjustments up or down based on labs
- Management involves trending labs, very high or low labs indicate adjusting calcium or phosphorus intake above or below the norms; special emphasis on managing hypercalcemia

McAlister L, Pugh P, Greenbaum L, Haffner D, Rees L, Anderson C, Desloovere A, Nelms C, Oosterveld M, Paglialonga F, Polderman N, Qizalbash L, Renken-Terhaerdt J, Tuokkola J, Warady B, Walle JV, Shaw V, Shroff R. The dietary management of calcium and phosphate in children with CKD stages 2-5 and on dialysis-clinical practice recommendation from the Pediatric Renal Nutrition Taskforce. Pediatr Nephrol. 2020 Mar;35(3):501-518.

Delivery Highlights

- Early intervention; use tube feeding when oral needs not able to be met
- NG best for short term; g-tube for long term
- Guidance on surgical techniques, prevention of peritonitis
- Guidance on rate/timing to start feeds
- If vomiting, evaluate for GERD and treat; consider fundo
- Encourage oral intake, while watching growth

Rees L, Shaw V, Qizalbash L, Anderson C, Desloovere A, Greenbaum L, Haffner D, Nelms C, Oosterveld M, Paglialonga F, Polderman N, Renken-Terhaerdt J, Tuokkola J, Warady B, Walle JV, Shroff R; Pediatric Renal Nutrition Taskforce. Delivery of a nutritional prescription by enteral tube feeding in children with chronic kidney disease stages 2-5 and on dialysis-clinical practice recommendations from the Pediatric Renal Nutrition Taskforce. Pediatr Nephrol. 2021 Jan;36(1):187-204.

Potassium Highlights

- Identification of sources of potassium
- Evaluation of potassium in those with altered K+, 24 recalls can be used
- Management infants with hyperkalemia
- Evaluation of non-dietary causes
- Management of hyperkalemia urgently, discussion of alteration of feeds, possible use of resins for management
- Hypokalemia also medically urgent, discussion of adjustment of meds, etc.

Desloovere et al, 2021 pending

Future CPR Goals

- Obesity and Metabolic Syndrome
- Transplant (position paper only)
- Vitamin and Mineral Needs
- Fiber and Gut Health
- Acute Kidney Injury

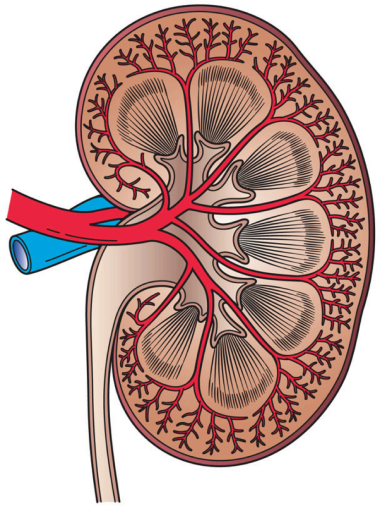
PAEDIATRIC RENAL NUTRITION TASK FORCE

Future Taskforce

- Will continue to meet bi-annually
- Terms are 3 years, can reapply once for a total of 6 years
- New representatives can soon apply

Thanks for Your Interest!

Questions?



The Renal Diet Paradigm Shift

PRESENTED BY: KATHRYN J RAPPOLT, MS, RD

SATURDAY, MARCH 6TH, 2021

5-6PM CENTRAL TIME

Conflict of Interest

- Nothing to disclose.

Learning Objectives

At the conclusion of this presentation, participants will be able to:

1. Define the composition of a “plant-based diet”
2. Describe the risks and benefits of following a plant-based diet in the pediatric dialysis population
3. Evaluate the nutritional status of the pediatric dialysis patient and develop individualized, dietary modifications and recommendations to promote optimal health and well-being

Nutritional Goals for the Pediatric Dialysis Patient

- To promote optimal nutritional status, growth, and development
- To control the biochemical and metabolic consequences associated with kidney disease
- To help prepare children with end stage renal disease (ESRD) for kidney transplant readiness and candidacy

Medical Nutrition Therapy in Pediatric vs Adult Dialysis Patients

- Growth
- Bone Development
- Meeting developmental milestones in feeding
- Establishing initial relationships with food and nurturing that relationship through chronic illness
- Supporting autonomy with feeding
- Advocating for liberalization when clinically feasible

Barriers to Achieving Optimal Growth and Nutritional Status

- Malnutrition
  - Poor appetite
  - Malabsorption
  - Changes in acid base balance (e.g. metabolic acidosis)
- Gastrointestinal disturbances
  - Reflex, delayed gastric emptying, emesis, early satiety, constipation, diarrhea
- Metabolic bone and mineral abnormalities

Barriers to Achieving Optimal Growth and Nutritional Status

- Hormonal abnormalities
  - Chronic growth deficits, especially linear growth
- Psychosocial issues
  - Difficulty concentrating
  - Decreased ability to learn new knowledge (e.g. diet education)
  - Negative self-image
  - Relationship and behavior problems
- Developmental issues
  - Delayed language and motor skill development
  - Oral aversion

Classic Renal Diet on Dialysis

Typically:

- High protein
- Low potassium
- Low phosphorus
- Low sodium
- Fluid restriction, if needed

Restrictions typically made pre-emptively or in response to clinical or laboratory findings

Classic Renal Diet on Dialysis

- Common observations

High Protein	Low Potassium	Low Phosphorus	Low Sodium	Fluid restriction
• ↑ intake animal protein	• ↓ intake of fruit, vegetables, beans, lentils, nuts, and seeds	• ↑ intake of refined grains • ↓ intake of whole-grains	• ↑ intake of blander tasting food	• ↓ water intake • ↓ intake of fruit and vegetables with higher water content • ↑ risk of constipation

Classic Renal Diet on Dialysis

- Fruit and vegetable intake is typically low across the CKD spectrum and unnecessary restriction may risk vitamin and mineral insufficiencies[1]
- Individual nutrient modifications often results in complex nutritional messages that are confusing, inconsistent, and constraining[2,3]
  - Conflicting priorities often result in poor compliance
  - Lack of autonomy
- Patients with CKD report dietary interventions to be burdensome leading to overall poor adherence and can compromise the overall quality of the diet and be detrimental to one's health[2,4]
  - Restriction in dietary phosphorus intake was associated with poorer nutritional status and higher mortality in adult patients on HD, suggesting that constraining phosphorus intake resulted in unintended reductions in beneficial macronutrients (7 in references of Clegg 2019)
- Limited evidence to support the efficacy of single-nutrient restriction[2,5]

[1]Luis et al., 2016
[2] Kelly et al., 2017
[3]Lambert et al., 2018
[4]St-Jules et al., March 2016
[5]Carrero et al., 2020

Poll Question #1

From your own personal clinical experience, what is the **most common** food type that is often blamed for causing hyperkalemia?

A) Fruit and/or vegetables

B) Dairy

C) Whole Grains

D) Legumes

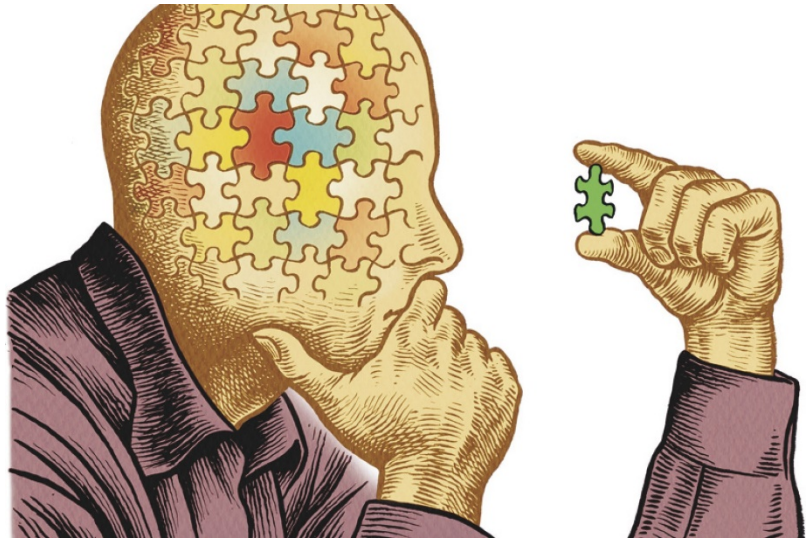
E) Nuts and/or seeds

F) Animal protein (Beef, chicken, seafood, eggs, etc)

What is a “Paradigm Shift”?

Defined by the Merriam-Webster Dictionary:

- **An important change that happens when the usual way of thinking about or doing something is replaced by a new and different way**



What is a "Plant-Based Diet"?

- There is **no single** definition of a plant-based diet
- In general, can be defined as:
  - *A dietary pattern that focuses on maximizing the consumption of whole, plant foods such as fruit, vegetables, legumes, whole grains, nuts, and seeds*
- Plant-based eaters aim to minimize the intake of animal-based foods (meat, egg, seafood, poultry, dairy), heavily processed, and refined foods (pastries, soda)

Table I. Classification of dietary patterns

Dietary patterns	Definition	Beef	Poultry	Fish	Dairy/eggs
Nonvegetarian	Eat red meat, poultry, fish, milk, and eggs more than once a week	Yes (++)	Yes (++)	Yes (++)	Yes
Semivegetarian	Eat red meat, poultry, and fish less than once per week and more than once per month	Yes (+)	Yes (+)	Yes (+)	Yes
Vegetarians					
Pescatarian (pesco)	Eat fish, milk, and eggs but no red meat nor poultry	No	No	Yes	Yes
Lacto-ovo	Eat milk and eggs but no red meat, poultry nor fish	No	No	No	Yes
Vegan	Eat no red meat, poultry, fish, dairy, and eggs	No	No	No	No

Carrero et al., 2020
Table: Ferrara et al., 2017

Plant-Based Diet: The Research

General adult population:

- Commonly studied plant-based dietary patterns[1,2]:
  - Dietary Approaches to Stop Hypertension (DASH) diet
  - Mediterranean diet
  - Vegetarian diets
- Observational studies suggest that plant-based dietary patterns may be superior to single-nutrient interventions due to the cumulative effects of multiple nutrients consumed through the diet[1,2]
  - High intake of fruit, vegetables, fish and omega 3 fatty acids, legumes, whole-grains, and nuts
  - Naturally lower in sodium, red meat, saturated fat, and phosphate additives
  - Naturally higher in fiber

[1]Carrero et al., 2020
[2] Clegg et al., 2019

Plant-Based Diet: The Research

General adult population cont:

- Plant-based diets have long-standing associations with reduced cardiovascular incidence and mortality in non-CKD, adult populations[1-3]
- Some evidence of a negative association between vegetarian diets and prevalence of CKD, proposing possible protective factors[4]
- Some evidence of decreased production of uremic toxins, inflammatory status, and oxidative stress among individuals following a plant-based diet[4-7]

[1]Estruch et al., 2013
[2] Rees et al., 2013
[3]Trichopoulou et al., 2009
[4]Liu et al., 2019
[5]Patel et al., 2012
[6]Haghighatdoost et al., 2017
[7]Kim et al., 2012

Plant-Based Diet: The Research

Adult chronic kidney disease (CKD) population (non-dialysis)

- Heavily researched
- Plant-based diets are associated with reduced renal-related mortality, decreased cardiovascular disease risk, reducing systemic inflammation, reducing microalbuminuria, and slower progression to ESRD[1,2]
- Plant-based diets also limit the bioavailability of dietary phosphorus compared higher animal protein diets[3] thereby decreasing the absorption due to the presence of phytate [4,5]
- Increased intake of dietary acid load (associated with increased meat and cheese intake and reduced fruit and vegetable intake) is associated with significantly increased risk of progressing to ESRD[6]
- Increased intake of fruit and vegetables is associated with decreased blood pressure, improved metabolic acidosis, and slowed eGFR compared with control patients [7,8]
  - Alkali-rich foods include, but not limited to: apples, apricots, oranges, peaches, pears, raisins, strawberries, carrots, cauliflower, eggplant, lettuce, potatoes, spinach, tomatoes, and zucchini[7]

[1]Kelly et al., 2017
[2] Clegg et al., 2019
[3]Moe et al., 2011
[4]Calvo et al., 2013
[5]Banerjee et al., 2016
[6]Banerjee et al., 2015
[7]Goraya et al., 2014
[8]Goraya et al., 2013

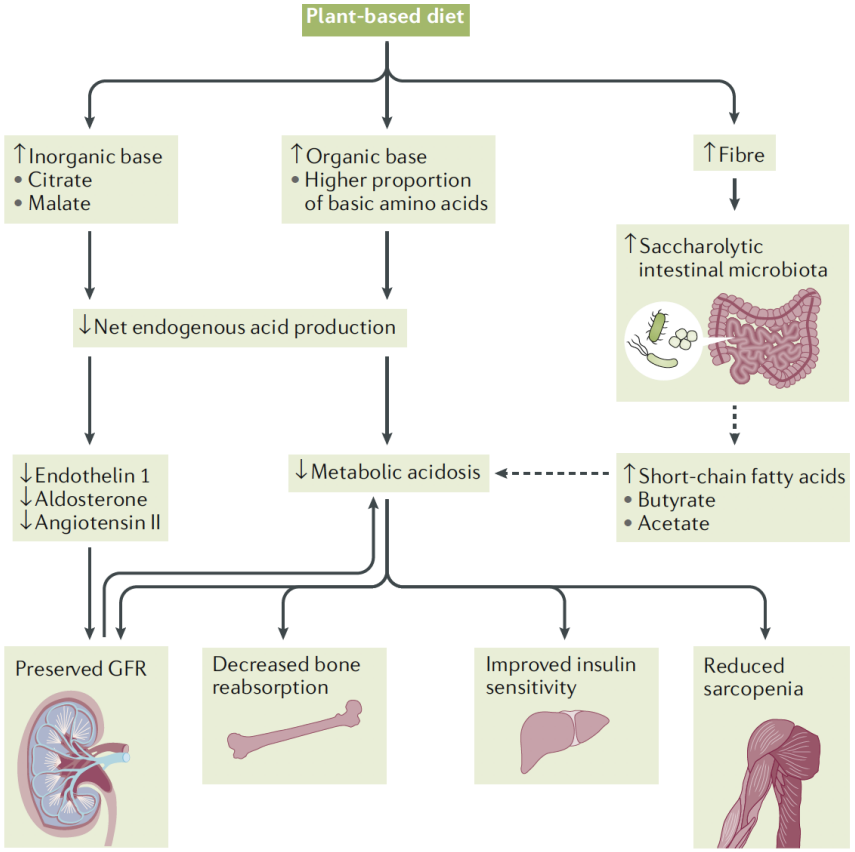


Fig. 2 | **Plant food intake and acid-base homeostasis in people with low glomerular filtration rate.** In people with normal kidney function, high net endogenous acid production and low short-chain amino acid production will not result in metabolic acidosis because the kidney has excess capacity to excrete acid. When glomerular filtration rate (GFR) is low, however, there is a tendency towards metabolic acidosis, which is worsened by high net endogenous acid production and low short-chain fatty acid production. A plant-based diet might mitigate this effect by reducing net endogenous acid production (as a result of increased alkali intake) and enabling increased metabolism of fibre by the microbiota, which results in increased translocation of short-chain fatty acids into the circulation. Improved control of metabolic acidosis has subsequent positive effects on end organ metabolism, including preservation of kidney function and muscle mass[78,79,84]. Dashed arrows represent proposed mechanisms for which limited evidence is available[82–85].

Figure: Carrero et al., 2020

Plant-Based Diet: The Research

Adult dialysis population

- Limited longitudinal research available
  - Increased fruit and vegetable intake does not necessarily translate into hyperkalemia[1-3]
  - Higher fiber intake can help prevent constipation in dialysis populations and facilitate fecal extraction of excess potassium , which can be up to 3.5x greater than that of the general population[3]
- Low dietary fiber intake associated with higher concentrations of inflammatory markers, myocardial hypertrophy, and arterial stiffness, and a higher risk of cardiovascular events and death [4-6]
- Increased fiber intake associated with reduced uremic toxin (Indoxyl sulphate)[7], improved lipid profile, oxidative status, and decreased systemic inflammation[8]
- More studies on the long-term safety and efficacy of increased fruit/vegetable intake in this population is needed before a plant-based diet can become routinely recommended[9]

[1]St-Jules et al., 2016
[2]Mathialahan et al., 2005
[3]Hayes et al., 1966
[4]Erthal et al., 2019
[5]Demirci., 2019
[6]Wang et al., 2019
[7]Sirich et al., 2014
[8]Xie et al., 2015
[9]Kelly et al., 2017

Plant-Based Diet: The Research

Pediatric CKD and dialysis populations

- No research
- Some available research on estimating the potential renal acid load (PRAL) and acid base status in CKD patients[1]
  - Positive correlation between PRAL and energy, protein, fat, dairy, meat, and cereal
  - No correlation between PRAL and fruit intake
  - **Negative correlation between PRAL and vegetable intake → potential effect on reducing metabolic acidosis?**

[1]López et al., 2020

Plant-Based Diet: The Research

General pediatric population:

- Plant-based diets deemed as “safe” by the Academy of Nutrition and Dietetics[1]
- The Northern American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) reports that:[2]
  - The inclusion of alternative, plant-based milks when used as an occasional beverage and not the primary milk source in a older child’s diet is acceptable within adoption of a carefully planned diet with alternative dietary sources of protein, calcium, iron, vitamin B12, and vitamin D.
    - These can be from animal or plant sources and may include use of nutritional supplements to ensure a complete and well-balanced diet for age

POSITION STATEMENT

It is the position of the Academy of Nutrition and Dietetics that appropriately planned vegetarian, including vegan, diets are healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of certain diseases. These diets are appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence, older adulthood, and for athletes. Plant-based diets are more environmentally sustainable than diets rich in animal products because they use fewer natural resources and are associated with much less environmental damage.

[1]Melina et al., 2016
[2]Merritt et al., 2020

Poll Question #2

What is your **primary** barrier to recommending a plant-based diet to your patient population?

A) Risk of hyperkalemia

B) Risk of hyperphosphatemia

C) Increased expense/cost

D) Not accessible to my patient (grocery access)

E) Lack of literature

F) Unconventional medical nutrition therapy for dialysis patients

G) None, I don’t have any barriers. I am or would recommend.

Plant-Based Diet: The Research

Byrne, et al. 2020 (Ireland)[1]

- Multicenter, pragmatic, parallel-arm, open-label RCT of a standard vs modified low phosphorus diet in adult HD patients
  - Modified diet = some pulses and nuts, increased use of whole grains, and increased focus on avoidance of phosphorus additives
  - Standard diet = restricts pulses, nuts, whole grains and other high phosphorus foods to control hyperphosphatemia
- N = 74 patients on HD with baseline hyperphosphatemia and normal potassium levels (≥18 y/o; median: 59.9 y/o in standard group and 61 y/o in modified group)
- Length of intervention = 1 month, used 2-day food records to record intake and patient questionnaire

Table 1. Summary of changes in modified diet sheet

Nutrient-based recommendations	Food-based recommendations
Inclusion of foods with reduced phosphorus bioavailability due to phytate content	Two of the daily allowances of high biological value protein exchanges (7 g protein/exchange) are replaced with plant-based vegetarian protein exchanges (e.g. replace 50 g of meat with 100 g of pulses and 25 g of unsalted peanuts). Whole grain breads and cereals are encouraged.
Focus on more accurate protein prescription of 1.1 g of protein/kg ideal body weight, thus avoiding overprescription of protein that carries an obligatory protein load, and include some focus on phosphorus-to-protein ratio.	Bread, cereals, and potatoes have been included in prescribed daily protein allowances. Target percentage of protein from high biological value changed from 70% to 50%–70%. Fish has been reduced to 25 g of fish per 7 g of protein exchange. Two portions of fruit and 2 portions of vegetable were counted as 4 g of protein. Phosphorus-to-protein ratio: Beef has lowest P:protein ratio (7 mg/g), with oily fish having the highest ratio (11 mg/g). However, the consensus reached was not to focus on the ratio in this food group, and to broadly follow healthy eating guidelines and to encourage variety, including consumption of fish twice a week. Dairy products are restricted to 1 portion per day P:protein ratio 20–30 mg/g. Egg whites, which have an extremely low ratio 1.1 mg P/g protein, are included
Full avoidance of phosphate additives from the European Union list of authorized phosphate additives in foods.	Check for phosphate E numbers E338, E339,E340, E341, E343, E450, E451, E452, and E541. We also advised to check for "phos" on ingredient lists, giving examples that we commonly encountered on labels, such as diphosphate, sodium polyphosphate, and calcium triphosphate.

P, phosphorus.

[1]Byrne et al., 2020

Plant-Based Diet: The Research

Byrne, et al. 2020 (Ireland)[1]

- Results:
  - Both diets were well-tolerated.
  - No significant difference in the change in serum phosphate levels between the standard and modified diets despite increased intake of phytate-bound dietary phosphorus in the modified diet group ($p<0.001$)
  - Dietary fiber intake was significantly higher ($p<0.003$) as was the percentage of patients reporting an increase in number of bowel movements while following the modified diet ($p=0.008$)
  - No significant difference in the change in serum potassium or in reported protein intake between the two groups
- In a randomized, cross-over trial of nine patients randomized to alternate between an animal-protein-heavy diet and a plant-protein-heavy diet, despite the diets having similar phosphorus content, patients phosphorus levels were significantly lower after the plant-protein-heavy diet vs animal-protein-heavy diet[2]

[1]Byrne et al., 2020
[2]Moe et al., 2011

Plant-Based Diet: The Research

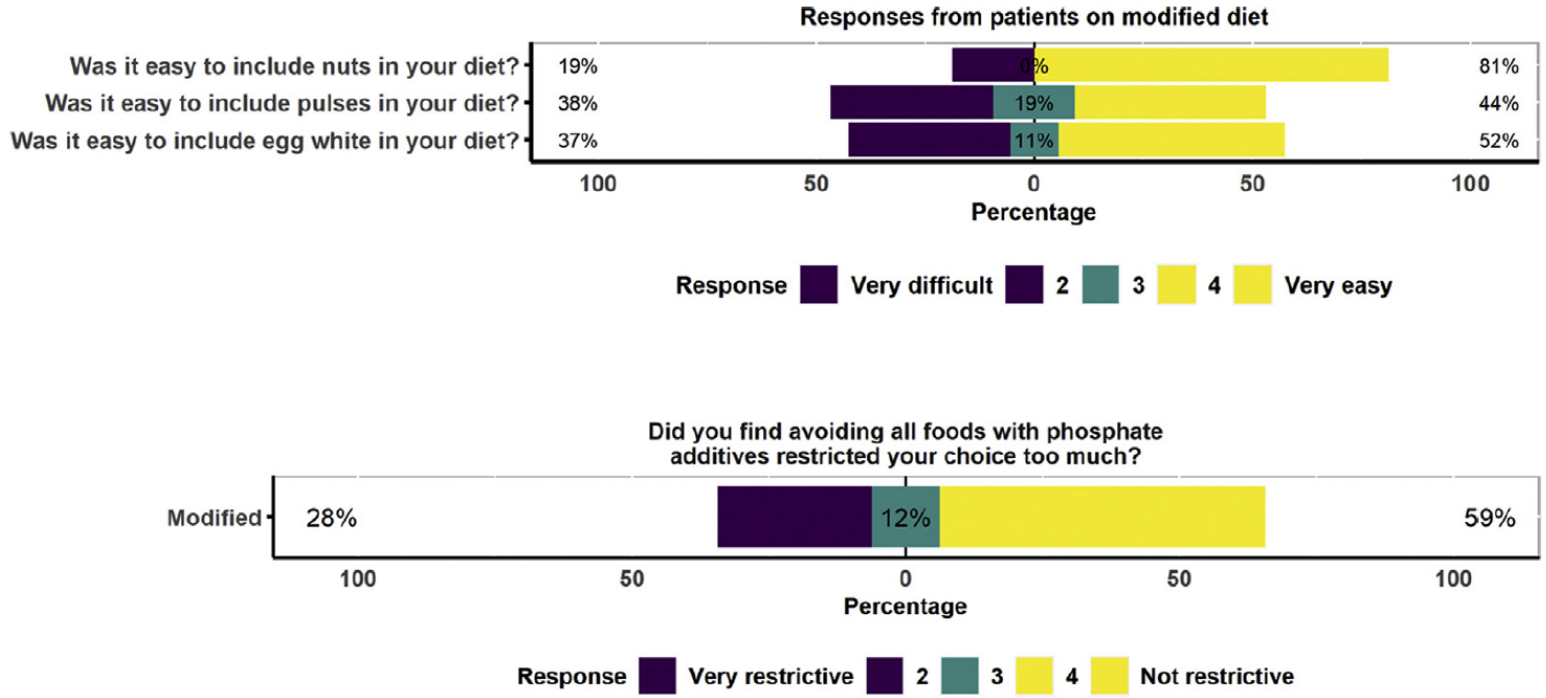


Figure 6. Tolerance data. Participants following the modified diet were ask about the ease of including new foods such as nuts, pulses, and egg whites and about how restrictive it was to avoid all foods with additives, and were asked to give a rating between 1 and 5.

[1]Byrne et al., 2020

Plant-Based Diet: The Research

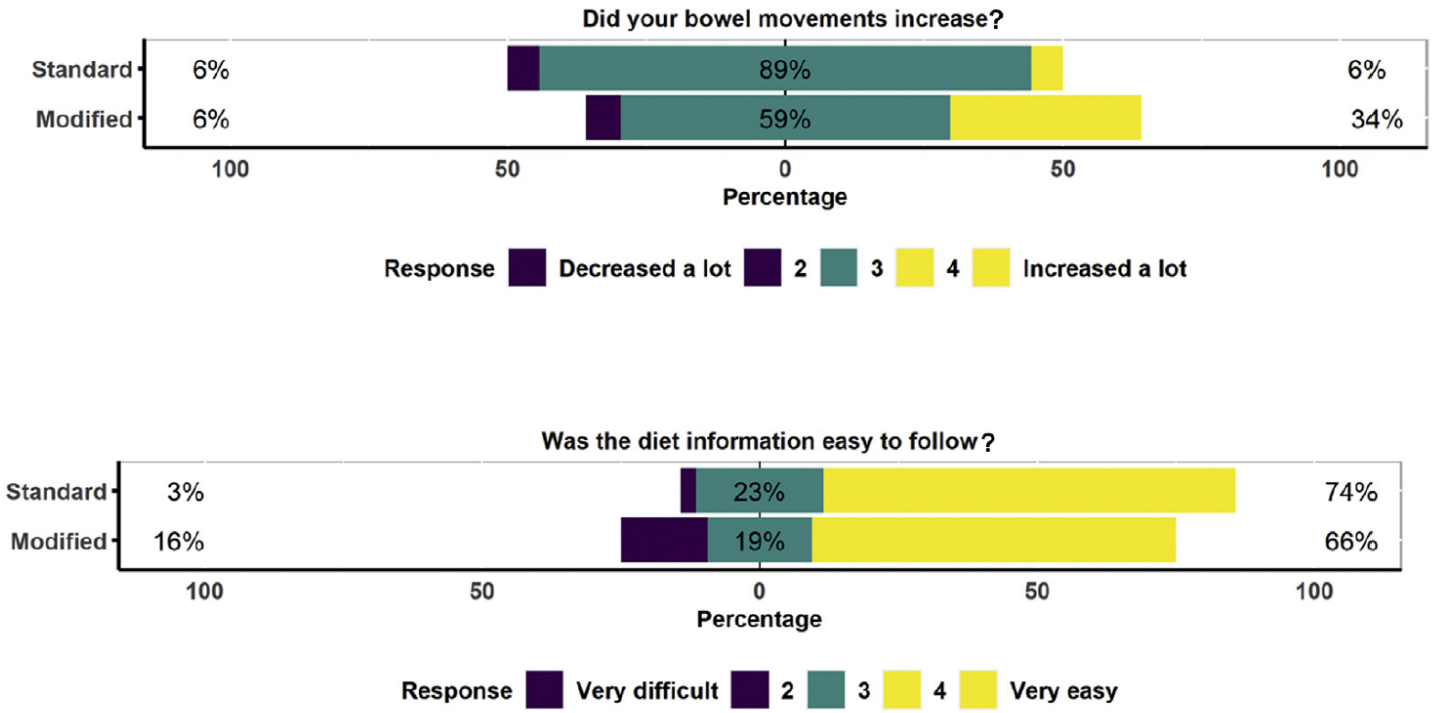


Figure 5. Tolerance data. Participants were asked about their bowel movements and ease of following the information, and were asked to give a rating between 1 and 5.

[1]Byrne et al., 2020

Food for Thought…

- Gut dysbiosis is commonly observed in kidney disease patients and is a major contributor to build-up of uremic toxins[1]
- The gut microbiota is able to be manipulated by plant-based dietary patterns.
  - Indoxyl sulphate (IS) and p-cresyl sulphate (PCS) are two uremic toxins produced by gut microbiome from protein metabolism in the gut and are associated with increased risk of cardiovascular disease[2]
  - Higher protein diets promote proteolytic (putrefaction) bacteria over saccharolytic (fermentation) bacteria, which results in dysbiosis.[3] A higher concentration of uremic toxins is increased by a high protein-to-fiber ratio in the diet[4]
  - The fermentation of fiber releases short chain fatty acids that favor healthy microbial activity to control dysbiosis[5]
  - A high fiber vegetarian diet has been shown to reduce the product of IS and PCS compared to a high meat diet in a healthy population[6]
- Summary:

  A plant-based dietary pattern which contains natural prebiotics and lower protein bioavailability may represent an important strategy for reducing uremic toxin production naturally[6]

[1]Kelly et al., 2017
[2] Rossi et al., 2014
[3]Evenepoel et al., 2009
[4]Rossi et al., 2015
[5]den Besten et al., 2013
[6]Patel et al., 2012

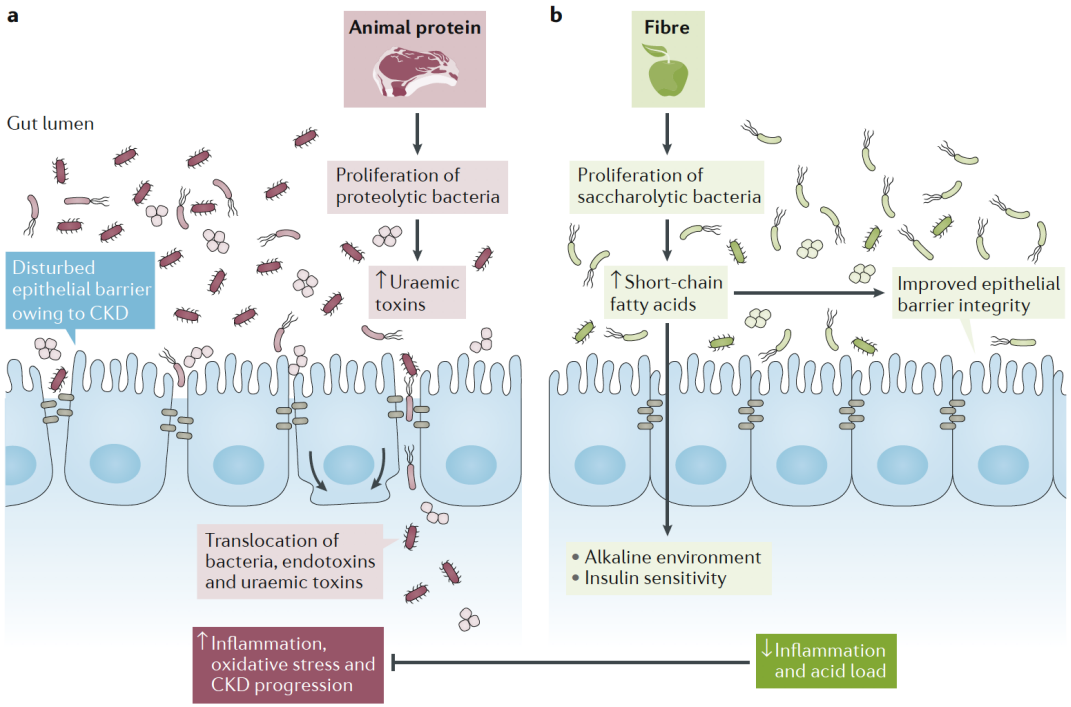


Fig. 1 | **The effects of animal proteins and fibre on the gut microbiota and uraemic milieu in chronic kidney disease.** **a** | A diet that is rich in animal proteins leads to the expansion of populations of proteolytic bacteria that ferment dietary protein and generate uraemic toxins such as indoxyl sulfate, indole-3 acetic acid, *p*-cresyl sulfate and trimethylamine *N*-oxide. These toxins are normally cleared by the kidneys but accumulate in the blood of patients with chronic kidney disease (CKD). The uraemic milieu of patients with advanced CKD leads to changes in the colonic environment that result in microbial dysbiosis and disturbances in the intestinal barrier. Intestinal excretion of nitrogen compounds (such as urea or uric acid) increases as glomerular filtration rate and tubular elimination declines. Furthermore, CKD-induced oedema of the intestinal mucosa alters its permeability, enabling translocation of bacteria and endotoxins through the intestinal barrier, which in turn stimulates monocytes and leads to increased synthesis of inflammatory cytokines. The nitrogen-rich environment further promotes the growth of proteolytic bacteria, which outcompete symbiotic saccharolytic bacteria. **b** | Consumption of fibre promotes the growth of saccharolytic bacteria, which compete with proteolytic bacteria and therefore mitigate the harmful effects of animal protein intake. In addition, fibre metabolism increases the generation of short-chain fatty acids in the gut, which promote gut-barrier integrity. Short-chain fatty acids can translocate into the blood and have been associated with improved insulin sensitivity and a more alkaline environment[59–61,232].

Figure: Carrero et al., 2020

What's the Shift?

- Shifting from single nutrient focus to → dietary patterns + portion modifications (if needed)
- Dietary patterns consider the cumulative effect and synergy between the combinations of foods and nutrients with less focus on classifying "bad" and "good" foods
- More focus on quality and diversity of the diet, particularly with liberalization of plant-based foods when able[1]

[1]Kelly et al., 2017

Key Take-Aways

- Adopting a whole-foods, plant-based diet approach that shifts focus onto foods (e.g whole grains, fruit, vegetables, etc) rather than single nutrients shows considerable promise in reaching overall health goals
- Potential for long-term benefits observed in the adult CKD populations
- May help manage metabolic acidosis and gut dysbiosis
- More diversified dietary pattern
- Less stress on “good” and “bad” foods that have the potential to initiate disordered eating/negative relationships with food and nutrition

Key Take-Aways cont.

- Potential for higher risk of hyperkalemia among some patients on dialysis remains valid, thus emphasizing the importance of individualized, medical nutrition therapy counseling is necessary to avoid depriving patients of the potential effects of a plant-based diet
  - Plants with lower potassium content provide choice for those who need to limit their potassium intake more conservatively
- More observational and RCTs are needed before universally recommending strict, plant-based diets in the pediatric and adult dialysis populations

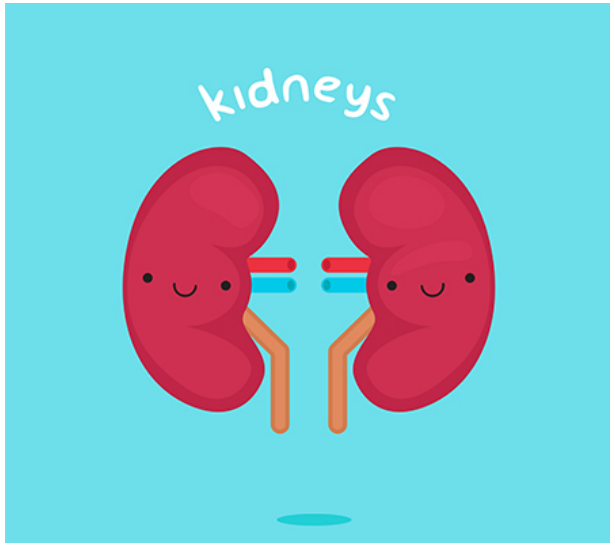
Our Role as Pediatric Renal Dietitians

- When there is room for liberalization… ALLOW IT!
- Modify portion sizes and frequency of intake, if needed, to still allow favorite healthy foods
- Advocate for inclusion of healthy food choices (whole grains, fruit, vegetables, legumes, nuts)
  - Create individualized medical nutrition therapy
    - No patient should ever be treated the exact same. Every patient is unique in their own way and responds differently to interventions
    - Closely monitor lab trends and tailor nutrition therapy recommendations accordingly to promote a more diverse intake

Our Role as Pediatric Renal Dietitians cont.

- Our universal goal is to strive to meet the DRI for ALL micronutrients, as permissible, to support optimal growth
- Utilize phosphorus binders with meals and/or snacks to help diversify diet
  - Use of phosphorus binders in adult dialysis patients was associated with a 14% risk reduction in mortality (8 in Clegg 2019)
  - Use of phosphorus binders may allow more relaxed dietary phosphorus restrictions leading to better nutritional intake and improved long-term survival
- Help our patients establish healthy relationships with food to prevent negative connotations with nutrition and to set them up for success before and after a future kidney transplant!

Questions?



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