



A Novel Online Calculator for Total Body Water Calculation in the Pediatric Dialysis Population

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Total body water (TBW): clinical relevance

- Pharmacokinetics
- Nutritional assessments
- Dialysis dose

$$Kt/V_{\text{urea}}$$

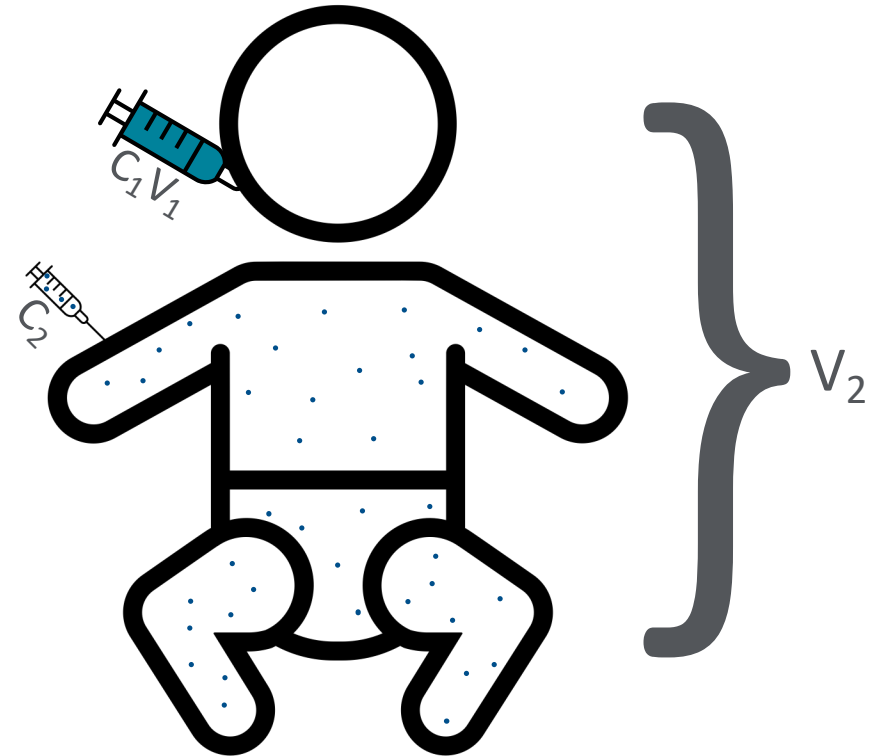
$$V_{\text{urea}} \approx \text{TBW}$$

Total body water (TBW): measurement

Gold standard: isotope dilution

1. Measure baseline concentration of isotope
2. Add known quantity of isotope
3. Allow time for equilibration
4. Measure new concentration of isotope
5. Calculate volume of pool

$$C_1V_1 = C_2V_2$$
$$V_2 = C_1V_1 / C_2$$



Total body water (TBW): measurement

Clinical alternatives to isotope dilution

1. Urea kinetic modeling (in HD)
2. Bioelectrical impedance analysis (BIA)
3. Anthropomorphic estimates

Total body water (TBW): anthropomorphic estimate milestones

Pediatric

Adult

1970: Mellits-Cheek

2002: Morgenstern
Mahoney & Warady

2006: Morgenstern, et al

1971: Hume-Weyers

1980: Watson,
Watson & Batt

Equation(s)	Demographics	Ages	Disease states?
Hume-Weyers (1971)	30 females 30 males	33-84 y	Healthy
Watson (1980)	265 females 458 males	17-86 y	Mostly healthy, some mild conditions
Mellits-Cheek (1970)	83 females 168 males	1 mo – 34 y	Healthy
Morgenstern (2002)	104 females 201 males	0-21 y	Healthy
Morgenstern (2006)	25 females 39 males	1.5 mo – 23 y	PD

Mellits-Cheek (1970): *Am J Physiol* 218:R100-R104
 Hume-Weyers (1971): *Am J Physiol* 221:R100-R104
 Watson (1980): *Am J Physiol* 248:R100-R104
 Watson & Batt (1980): *Am J Physiol* 248:R100-R104
 Morgenstern (2002): *Am J Physiol* 283:R100-R104
 Morgenstern et al (2006): *Am J Physiol* 291:R100-R104



Female TBW nomogram

a		Height (cm)															
Weight (kg)	50	54	58	62	66	70	74	78	82	86	90	94	98	102	106	110	114
2	2.0	2.1	2.2	2.4													
3	2.4	2.6	2.8	2.9													
4	2.8	3.0	3.2	3.4	3.6												
5	3.1	3.3	3.5	3.8	4.0												
6	3.3	3.6	3.8	4.1	4.3	4.6	4.8										
7	3.5	3.8	4.1	4.4	4.8	4.9	5.2	5.5	5.7								
8	3.7	4.0	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4	6.6						
9				4.9	5.2	5.5	5.8	6.1	6.4	6.7	7.0	7.3	7.6				
10				5.1	5.4	5.8	6.1	6.4	6.8	7.1	7.4	7.7	8.0	8.3	8.6		
11				5.3	5.6	6.0	6.4	6.7	7.1	7.4	7.7	8.1	8.4	8.7	9.0	9.3	9.6
12				5.4	5.8	6.2	6.6	7.0	7.3	7.7	8.0	8.4	8.7	9.1	9.4	9.7	10.0
13								7.2	7.6	8.0	8.3	8.7	9.1	9.4	9.8	10.1	10.4
14								7.4	7.8	8.2	8.6	9.0	9.4	9.7	10.1	10.5	10.8
15								7.6	8.0	8.5	8.9	9.3	9.7	10.0	10.4	10.8	11.2
16								7.8	8.3	8.7	9.1	9.5	9.9	10.3	10.7	11.1	11.5
17											9.3	9.8	10.2	10.6	11.0	11.4	11.8
18											9.6	10.0	10.5	10.9	11.3	11.7	12.2
19											9.8	10.2	10.7	11.1	11.6	12.0	12.5
20											10.0	10.4	10.9	11.4	11.8	12.3	12.7

b		Height (cm)																					
Weight (kg)	106	110	114	118	122	126	130	134	138	142	146	150	154	158	162	166	170	174	178	182	186	190	
20	11.8	12.3	12.7	13.2	13.6	14.0	14.5	14.9	15.3	15.7	16.1	16.5											
22	12.3	12.8	13.3	13.7	14.2	14.7	15.1	15.6	16.0	16.4	16.9	17.3											
24	12.8	13.3	13.8	14.3	14.8	15.2	15.7	16.2	16.7	17.1	17.6	18.0	18.5	18.9	19.4								
26	13.2	13.7	14.2	14.8	15.3	15.8	16.3	16.8	17.3	17.8	18.3	18.7	19.2	19.7	20.1								
28	13.6	14.1	14.7	15.2	15.8	16.3	16.8	17.3	17.9	18.4	18.9	19.4	19.9	20.4	20.9	21.3	21.8						
30	13.9	14.5	15.1	15.7	16.2	16.8	17.3	17.9	18.4	18.9	19.5	20.0	20.5	21.0	21.5	22.0	22.5						
32	14.3	14.9	15.5	16.1	16.6	17.2	17.8	18.4	18.9	19.5	20.0	20.6	21.1	21.7	22.2	22.7	23.2	23.7	24.3				
34	14.6	15.2	15.8	16.4	17.0	17.7	18.2	18.8	19.4	20.0	20.6	21.1	21.7	22.3	22.8	23.4	23.9	24.4	25.0				
36	14.8	15.5	16.2	16.8	17.4	18.1	18.7	19.3	19.9	20.5	21.1	21.7	22.3	22.8	23.4	24.0	24.5	25.1	25.6	26.2	26.7		
38	15.1	15.8	16.5	17.1	17.8	18.4	19.1	19.7	20.3	21.0	21.6	22.2	22.8	23.4	24.0	24.6	25.1	25.7	26.3	26.9	27.4		
40			16.8	17.4	18.1	18.8	19.5	20.1	20.7	21.4	22.0	22.7	23.3	23.9	24.5	25.1	25.7	26.3	26.9	27.5	28.1	28.6	
42			17.0	17.7	18.4	19.1	19.8	20.5	21.1	21.8	22.5	23.1	23.8	24.4	25.0	25.7	26.3	26.9	27.5	28.1	28.7	29.3	
44			17.3	18.0	18.7	19.5	20.2	20.9	21.5	22.2	22.9	23.6	24.2	24.9	25.5	26.2	26.8	27.4	28.1	28.7	29.3	29.9	
46			17.5	18.3	19.0	19.8	20.5	21.2	21.9	22.6	23.3	24.0	24.7	25.3	26.0	26.7	27.3	28.0	28.6	29.3	29.9	30.5	
48			17.8	18.5	19.3	20.0	20.8	21.5	22.3	23.0	23.7	24.4	25.1	25.8	26.5	27.2	27.8	28.5	29.2	29.8	30.5	31.1	
50			18.0	18.8	19.6	20.3	21.1	21.8	22.6	23.3	24.1	24.8	25.5	26.2	26.9	27.6	28.3	29.0	29.7	30.4	31.0	31.7	
52						20.6	21.4	22.1	22.9	23.7	24.4	25.2	25.9	26.6	27.4	28.1	28.8	29.5	30.2	30.9	31.6	32.2	
54						20.8	21.6	22.4	23.2	24.0	24.8	25.5	26.3	27.0	27.8	28.5	29.2	29.9	30.7	31.4	32.1	32.8	
56						21.1	21.9	22.7	23.5	24.3	25.1	25.9	26.6	27.4	28.2	28.9	29.7	30.4	31.1	31.9	32.6	33.3	
58						21.3	22.1	23.0	23.8	24.6	25.4	26.2	27.0	27.8	28.5	29.3	30.1	30.8	31.6	32.3	33.1	33.8	
60						21.5	22.4	23.2	24.1	24.9	25.7	26.5	27.3	28.1	28.9	29.7	30.5	31.3	32.0	32.8	33.5	34.3	
62						21.7	22.6	23.4	24.3	25.2	26.0	26.8	27.7	28.5	29.3	30.1	30.9	31.7	32.4	33.2	34.0	34.8	
64						21.9	22.8	23.7	24.6	25.4	26.3	27.1	28.0	28.8	29.6	30.4	31.3	32.1	32.9	33.6	34.4	35.2	
66									24.8	25.7	26.5	27.4	28.3	29.1	30.0	30.8	31.6	32.4	33.2	34.1	34.9	35.7	
68									25.0	25.9	26.8	27.7	28.6	29.4	30.3	31.1	32.0	32.8	33.6	34.5	35.3	36.1	
70									25.2	26.1	27.0	27.9	28.8	29.7	30.6	31.5	32.3	33.2	34.0	34.9	35.7	36.5	
72									25.4	26.4	27.3	28.2	29.1	30.0	30.9	31.8	32.7	33.5	34.4	35.2	36.1	36.9	
74									25.6	26.6	27.5	28.4	29.4	30.3	31.2	32.1	33.0	33.9	34.7	35.6	36.5	37.3	
76									25.8	26.8	27.7	28.7	29.6	30.6	31.5	32.4	33.3	34.2	35.1	36.0	36.8	37.3	
78									26.0	27.0	27.9	28.9	29.9	30.8	31.7	32.7	33.6	34.5	35.4	36.3	37.2	38.1	
80									26.2	27.2	28.1	29.1	30.1	31.1	32.0	33.0	33.9	34.8	35.7	36.7	37.6	38.5	

Morgenstern (2006)

Boys:

$$TBW = 0.10 \times (HtWt)^{0.68} - 0.37 \times \text{weight}$$

Girls:

$$TBW = 0.14 \times (HtWt)^{0.64} - 0.35 \times \text{weight}$$

- Nomograms
- Calculators...?

Online calculator: <https://kidney.wiki/tbw>

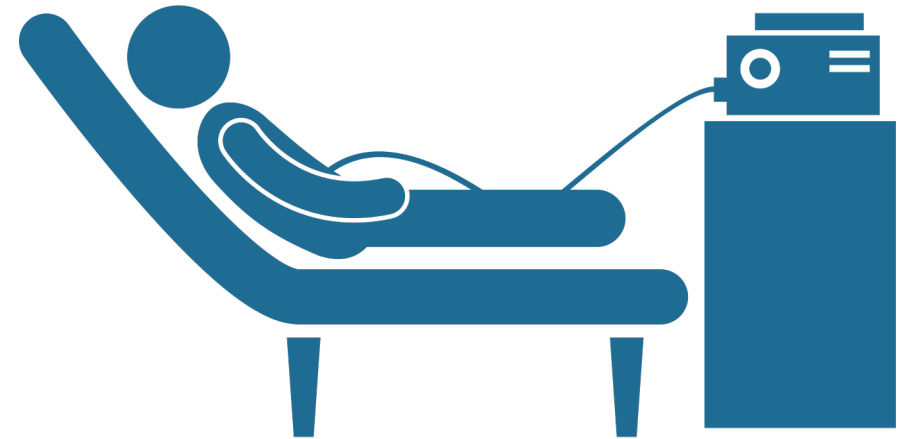
1. Easy-to-use interface
2. Mobile friendly
3. Accounts for fluid overload
4. Also calculates BSA
5. Built-in guidance
6. Hosted on a larger library of pediatric nephrology knowledge

The screenshot shows the mobile interface of the kidney.wiki BSA & Total Body Water Calculator. The page title is "BSA & Total Body Water Calculator" and it includes an "Info" button. The main content area is titled "Cite This Calculator" and provides citation information: "Town RM. Body Surface Area & Total Body Water Calculator. kidney.wiki. Published August 18, 2022. Accessed February 23, 2023. <https://kidney.wiki/bsa-tbw-calculator/>". Below this is a section titled "How To Use This Calculator" with a dropdown menu set to "Total body water (TBW)". The "TBW calculation" section explains the Morgenstern (2006) equation and its application in pediatric patients on peritoneal dialysis, comparing it to the Mellits-Cheek formula. The "Fluid overload states" section provides an example calculation: "For patients with fluid overload, the edema fluid (i.e., 1000 mL per kg of weight attributed to fluid overload) should be added to the TBW calculated from their estimated edema-free ('dry') weight. Example: a 150 cm, 55 kg boy is estimated to have 10% fluid overload (estimated dry weight of 50 kg). Using the dry weight of 50 kg, the Morgenstern equation yields a TBW (dry) of 24656 mL; adding 5000 mL (1000 mL/kg * 5 kg of fluid weight) yields a TBW of 29.7 L. This result is >13% higher than if a body weight of 55 kg was used in the Morgenstern equation." At the bottom, there is a calculator interface with two input fields: "Excess fluid weight" set to 3 kg and "TBW (total)" set to 23949 mL.

How could using a calculator rather than a shorthand estimate (600 mL/kg) impact patient care?

Potential impacts on patient care: a brief quality assessment

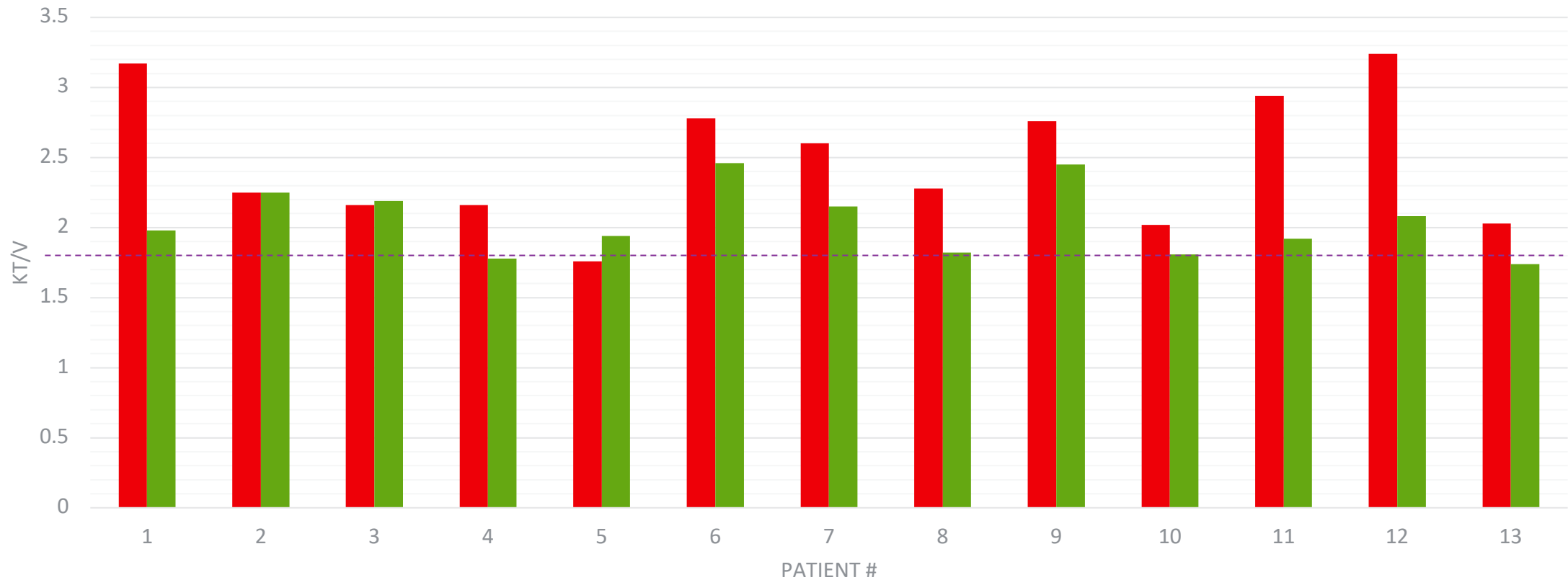
- Convenience sample of PD patients aged ≤ 2 years since 2020 ($n = 13$, aged < 1 wk–2 yrs)
- Initial “goal” fill volumes based on BSA
 - 700 mL/m² if aged 0-2 years
 - 1000 mL/m² if aged 2 years
- Hourly cycles
- Assume UF of 3% body weight/day
- Prescribed Kt/V of 1.8



Potential impacts on patient care: a brief quality assessment

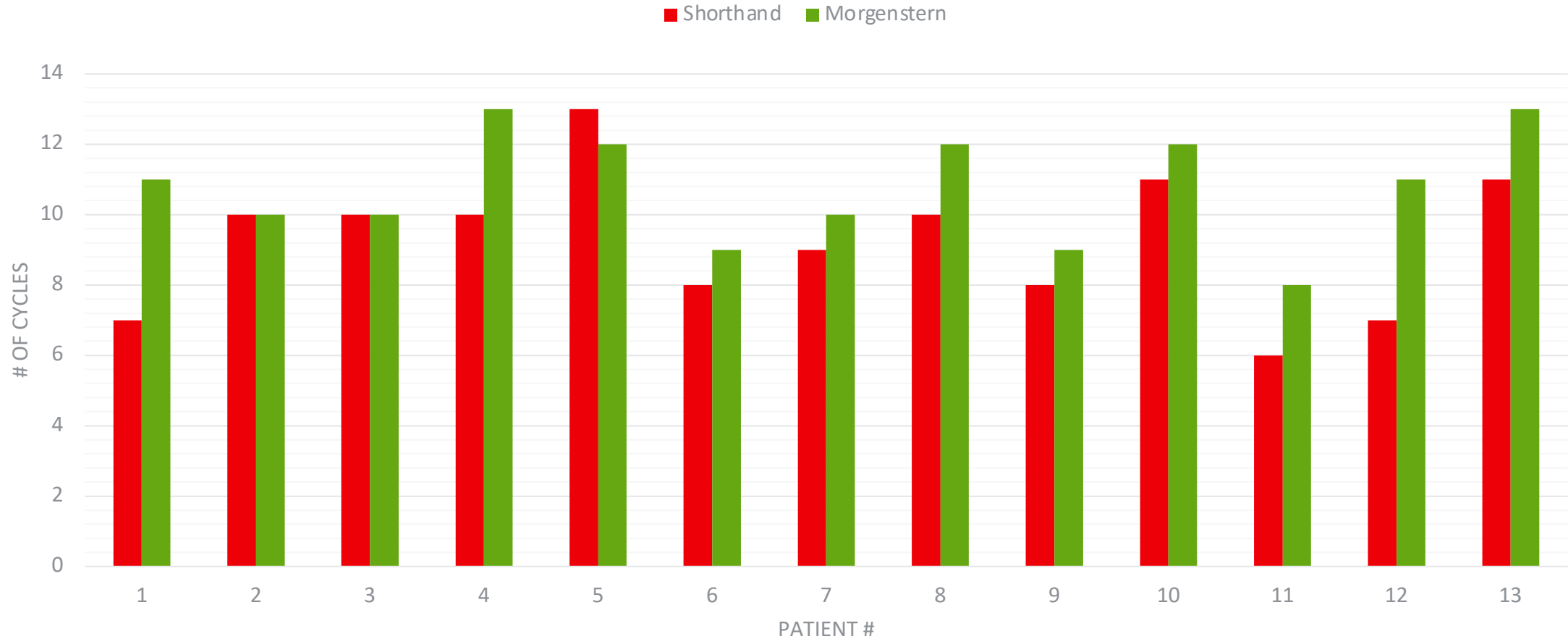
12 Cycles

■ Shorthand ■ Morgenstern



Potential impacts on patient care: a brief quality assessment

of cycles to achieve prescribed Kt/V of ≥ 1.8



Conclusion: using a TBW nomogram or a calculator is preferable to crude estimation and may impact management decisions

kidney.wiki/tbw



References

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