Educational Home Hemodialysis Calculator

Instructions for Use and References

Intended Use

The online Home Hemodialysis (HHD) Calculator is intended for use by clinicians for modeling the dialysis dose (Kt/V) for different low-volume hemodialysis prescription options. Modeling an HHD dose is based on generalized formulas and assumptions derived from patient populations. The output of a modeled prescription is limited in its accuracy and cannot account for the variability seen in individual patients. It is essential that the physician adjusts the prescription according to the individual patient's clinical parameters to ensure the adequacy of the HHD prescription.

The calculator is not intended to replace the judgment or experience of the attending physician. The hemodialysis treatment prescription is the sole responsibility of the attending physician.

The HHD Calculator is not intended to be used for pediatric patients or amputees.

Important Information

The HHD Calculator cannot address the full range of topics related to an HHD prescription that are critical for the overall management and ongoing monitoring of an HHD patient. This tool should never be used as a substitute for physician judgement. It is the responsibility of the healthcare provider to independently review the results provided by the HHD Calculator and not rely solely on this tool when making clinical treatment decisions for patients.

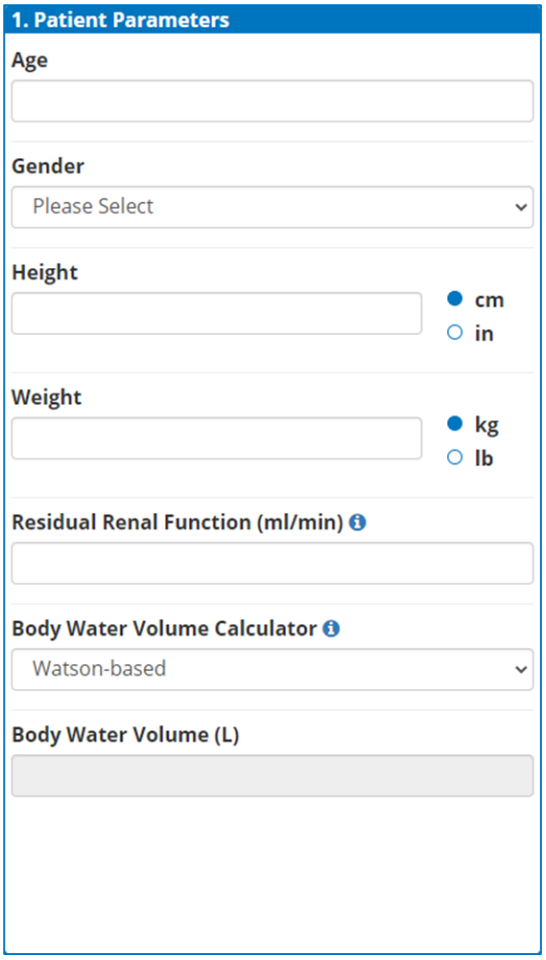
The HHD Calculator requires patient-specific input information (age, gender, height, weight, and residual renal function) for predicting Kt/V of a modeled prescription. It is the responsibility of the user to ensure the accuracy of the patient parameters. Incorrect patient data may result in the over- or under-estimation of the predicted Kt/V.

The HHD Calculator utilizes the formulas and algorithms provided in the HHD Calculator Formulas and References section. It is the physician's responsibility to confirm that these formulas are appropriate for and applicable to their particular patient.

The Fresenius Medical Care Renal Therapies Group has made every reasonable effort to ensure the accuracy of the calculations provided by the HHD Calculator. In no event will FMCNA be liable for any losses or damages arising from or relating to your use of the HHD Calculator, whether direct, indirect, incidental, or consequential.

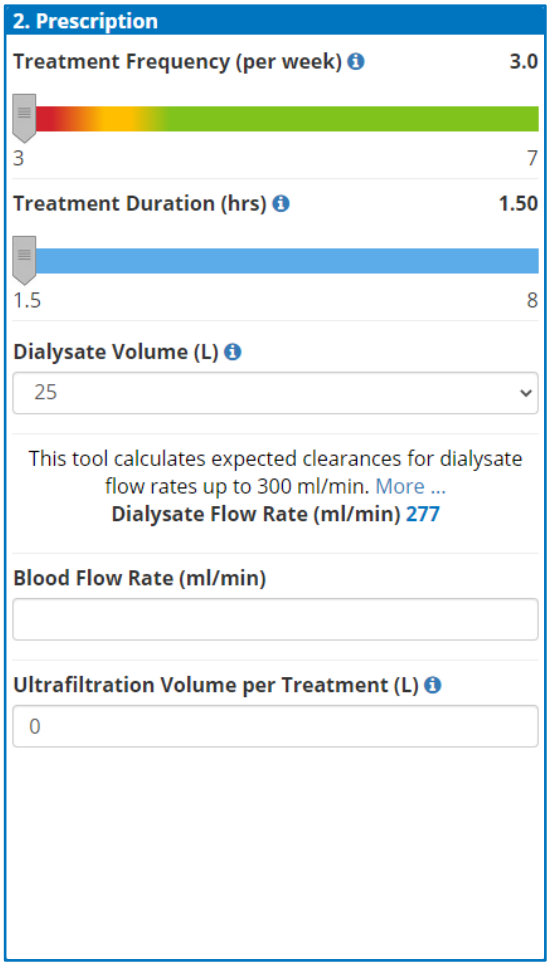
Instructions for Using the HHD Calculator

1. Enter patient data in the Patient Parameters Section



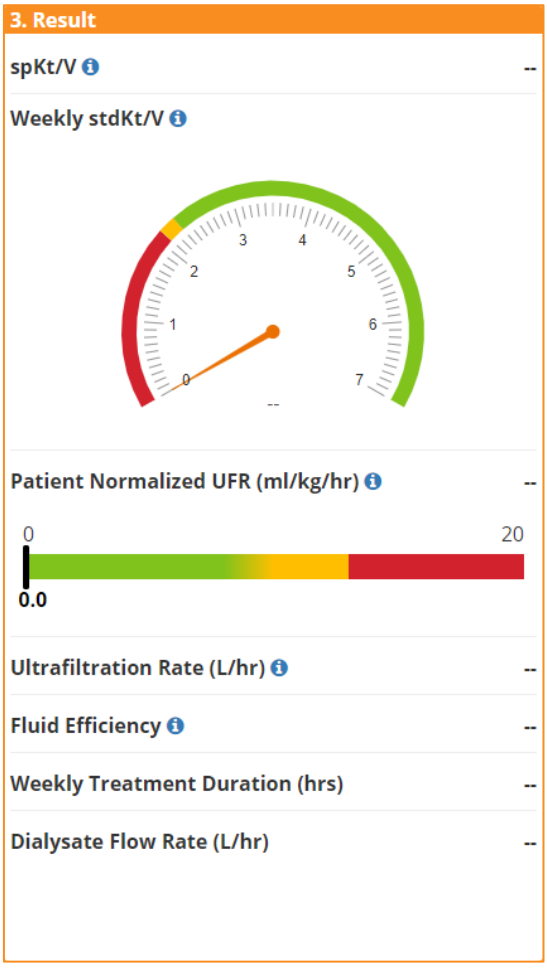
- Age: Enter the patient's age in years. Age must be a whole number from 18–120
- Gender: Select Male or Female from the drop-down menu
- Height: Enter the patient's height in cm (centimeters) or inch (inches). Choose the correct units from the radio buttons. Height must be 124–213 cm (49–84 in), entered as a whole number.
- Weight: Enter the patient's weight in kg (kilograms) or lb (pounds). Choose the correct units from the radio buttons. Weight must be greater than 0 lb or kg, and a whole number.
- Residual Renal Function (RRF): Enter the patient's RRF as Renal Urea Clearance (mL/min). RRF must be a whole number from 0–20 ml/min.
  - A patient's residual renal function (RRF) can be considered when modeling an HHD prescription. However, it is important to ensure that all clinical values are current. Incorrectly entering RRF can lead to over- or under-estimation of Kt/V. The RRF can be entered as renal (residual) Kt/V or renal urea clearance (mL/min). If you do not want to include RRF in modeling predictions, this can be left at 0.
- Body Water Volume Calculator: From the drop-down select Waston-based or Direct Entry. If Waston-based is selected, body water volume will be calculated based on Age, Gender, Height, and Weight and will display in the Body Water Volume field. If Direct-Entry is selected, enter the desired volume in the Body Water Volume field.
  - The determination of body water volume in the patient is an important part of estimating dialysis dose. Many methods for doing this exist. The HHD Calculator allows the use of the common Watson Body Water Calculator (slightly modified)[1,2], or direct entry of a body water volume. This volume is the urea distribution volume used in the calculation of Kt/V.
- Body Water Volume (L): The Watson-based calculation of Body Water Volume is displayed. Or, if Direct Entry is selected above, enter the body water desired volume.

2. Enter treatment parameters into the Prescription Section



- Treatment Frequency (per week): Move the slider to select the how many days per week the patient will do treatments.
  - Treatment frequency is the number of treatments the patient will do each week. The frequency of 3.5 is used in the weekly standard Kt/V calculation to model every other day therapy.
- Treatment Duration: Move the slider to select how long (in hours) each treatment will be.
  - Treatment Duration is the total amount of time the patient spends receiving dialysis each treatment. If the Treatment Frequency is 5 and the Treatment Duration is 3 hr, this would mean the patient would dialyze 15 hours per week. Best practices suggest a minimum of 12-15 hours per week; some benefits may occur with >15 hours/week[3].
- Dialysate Volume: The volume of dialysate used during a single treatment. Select a volume from the drop-down list for modeling.
  - Dialysate Volume is the amount of fluid used per treatment by the patient. Dialysate for HHD is typically available in 5-liter bags or produced in batches of 40, 50, or 60-liters.
- Dialysate Flow Rate (DFR) is calculated from Treatment Duration and Dialysate Volume. The calculator uses these parameters to calculate and immediately display a DFR.
  - This tool calculates expected clearances for dialysate flow rates up to 300 ml/min. If the dialysate flow rate is above 300 ml/min, the Dialysate Volume must be lowered or Treatment Duration must be increased.
- Blood Flow Rate: Blood flow rate used during dialysis in ml/min.
- Ultrafiltration Volume per Treatment: The expected ultrafiltration (UF) volume that will be removed during each treatment. This volume will be applied to every treatment.
  - Ultrafiltration (UF) Volume is the amount of excess fluid that is to be removed from the patient each session. In actual practice, UF volume will vary each treatment, but for modeling purposes an expected amount is required. Keep in mind that even if no UF volume is needed in a treatment, the equipment will put fluid on at the end of the treatment when it rinses back the blood.

3. Review the results



- Single Pool Kt/V (spKt/V): Predicted spKt/V based on patient parameters and entered prescription.
  - spKt/V is a measurement of dialysis dose expressed as the product of dialyzer urea clearance (K) and treatment time (t), divided by the urea distribution volume (V) in the patient. It is called the Single Pool Kt/V because it treats the presence of urea in the body as if it were in a single compartment (pool). However, urea is not contained in a single compartment and spKt/V does not account for the rebound effect. As such, it overestimates the urea cleared in a single dialysis session[4].
- Weekly stdKt/V: Predicted weekly standard Kt/V based on patient parameters and entered prescription.
  - Weekly Standard Kt/V adjusts the dialysis dose based on the frequency of treatments. For hemodialysis schedules other than thrice weekly, the KDOQI guidelines suggest targeting a stdKt/V of 2.3 with a minimum delivered dose of 2.1[5].
- Patient-Normalized UFR (ml/kg/hr): Calculated ultrafiltration rate (UFR) normalized to the entered patient weight.
  - The Patient-normalized UFR is calculated based on the patient weight, treatment duration, and UF volume in the calculator inputs. The calculator assumes that the UF volume will be removed over the entire duration of the treatment, i.e. as slowly as possible. Literature suggests that slower Patient-Normalized UFRs are associated with better survival[6].
- Weekly Treatment Duration: The total dialysis treatment time expected per week.
  - Weekly Treatment Duration is the product of the Treatment Duration and Treatment Frequency. Data has shown that increasing Weekly Treatment Duration may improve outcomes. Best practices suggest a minimum of 12-15 hrs/week; some benefits may occur with >15 hours/week[6].
- Dialysate Flow Rate (L/hr): The calculated dialysate flow rate for each treatment.
- Ultrafiltration Rate (L/hr): Calculated UFR
  - The UFR is calculated based on the treatment duration and UF volume in the calculator inputs. The calculator assumes that the UF volume will be removed over the entire duration of the treatment, i.e. as slowly as possible. Literature suggests that slower UF rates are associated with better survival[6].
- Fluid Efficiency: calculated percentage of prepared or bagged dialysate that is used each treatment.
  - The generation of dialysate fluid in the home is one of the key logistical and cost challenges for the therapy. For that reason, using dialysate fluid as efficiently as possible may be desirable. Fluid efficiency has no effect on therapy or patient outcome.

Support

In the United States, contact the Fresenius Medical Care Renal Therapies Group Medical Information and Communications Office. Phone: 855-616-2309 Email: Medical.Information@fmc-na.com

HHD Calculator Formulas and References

The formulas and modeling algorithms used in the HHD Calculator are as follows and are based upon the cited references.

Urea Distribution Volume[1,2]

$$V = \begin{cases} \text{Male: } (2.447 - 0.09516A + 0.1074H + 0.3362W) \times 0.9 \\ \text{Female: } (-2.097 + 0.1069H + 0.2466W) \times 0.9 \end{cases}$$

V = body water volume (liters)
A = age (years)
H = height (cm)
W = weight (kg)

Urea Clearance[4,7–9]

$$K_u = \frac{Q_e\left(e^{K_oA\frac{\left(1-\frac{Q_e}{Q_d}\right)}{Q_e}} - 1\right)}{e^{K_oA\frac{\left(1-\frac{Q_e}{Q_d}\right)}{Q_e}} - \frac{Q_e}{Q_d}}\left(1 - \frac{Q_f}{Q_e}\right) + Qf$$

$K_oA_{in\ vivo} = 472.7 + 0.35 \times Q_d$

(DFR 200–300 ml/min)

$K_oA_{in\ vivo} = 62 + 2.4 \times Q_d$

(DFR < 200 ml/min)

$Q_e = 0.86 \times Q_b$

K_u = urea clearance (ml/min)
K_oA_{invivo} = estimated in vivo K_oA (dialyzer mass transfer area coefficient) (ml/min)
Q_e = equilibrated blood flow rate (ml/min)
Q_d = dialysate flow rate (ml/min)
Q_b = blood flow rate (ml/min)
Q_f = ultrafiltration rate (ml/min)

Weekly Standard Kt/V[5]

$$stdKt/V = \frac{10{,}080\,\frac{1 - e^{-eKt/V}}{t}}{\frac{1 - e^{-eKt/V}}{eKt/V} + \frac{10{,}080}{Nt} - 1} + K_r\frac{10{,}080}{V}}{1 - \frac{0.74}{F}\left[\frac{U_f}{V}\right]}$$

$$eKt/V = spKt/V(t/(t+30))$$

Where:

- stdKt/V = standard Kt/V
- spKt/V = single pool Kt/V
- eKt/V = equilibrated Kt/V
- V = body water volume (liters)
- F = N = number of treatments per week
- 10,080 = number of minutes in a week
- t = treatment duration (minutes)
- U_f = weekly ultrafiltration volume (liters)
- K_r = residual renal function (ml/min)

References:

1. Watson PE, Watson ID, Batt RD. Total body water volumes for adult males and females estimated from simple anthropometric measurements. *Am J Clin Nutr*. 1980;33(1):27-39. http://www.ncbi.nlm.nih.gov/pubmed/6986753.
2. Daugirdas JT, Depner TA, Greene T, et al. Standard Kt/Vurea: a method of calculation that includes effects of fluid removal and residual kidney clearance. *Kidney Int*. 2010;77(7):637-644. http://www.ncbi.nlm.nih.gov/pubmed/20107428.
3. Kjellstrand C, Buoncristiani U, Ting G, et al. Survival with short-daily hemodialysis: Association of time, site, and dose of dialysis. *Hemodial Int*. 2010;14(4):464-470. https://pubmed.ncbi.nlm.nih.gov/20854330/.
4. Daugirdas JT. Physiologic Principles and Urea Kinetic Modeling. In: Daugirdas JT, Blake PG, Ing TS, eds. *Handbook of Dialysis*. 5th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2015:34-65.
5. Daugirdas JT, Depner TA, Inrig J, et al. KDOQI Clinical Practice Guideline for Hemodialysis Adequacy: 2015 Update. *Am J Kidney Dis*. 2015;66(5):884-930. http://www.ncbi.nlm.nih.gov/pubmed/26498416.
6. Assimon MM, Wenger JB, Wang L, Flythe JE. Ultrafiltration Rate and Mortality in Maintenance Hemodialysis Patients. *Am J Kidney Dis*. 2016;68(6):911-922. http://www.ncbi.nlm.nih.gov/pubmed/27575009.
7. Daugirdas JT, Depner TA, Greene T, Silisteanu P. Solute-Solver: A Web-Based Tool for Modeling Urea Kinetics for a Broad Range of Hemodialysis Schedules in Multiple Patients. *Am J Kidney Dis*. 2009;54(5):798-809. https://pubmed.ncbi.nlm.nih.gov/19853198/.
8. Leypoldt JK, Kamerath CD, Gilson JF, Friederichs G. Dialyzer clearances and mass transfer-area coefficients for small solutes at low dialysate flow rates. *ASAIO J*. 2006;52(4):404-409. https://pubmed.ncbi.nlm.nih.gov/16883120/.
9. Leypoldt JK, Weinhandl ED, Collins AJ. Volume of urea cleared as a therapy dosing guide for more frequent hemodialysis. *Hemodial Int*. 2019;23(1):42-49. https://pubmed.ncbi.nlm.nih.gov/30255600/.

P/N 104479-02 Rev. A 11/2020

FRESENIUS MEDICAL CARE
RENAL THERAPIES GROUP