Hemodialysis Calculator

Instructions for Use and References
Version 1.0

Description

The online HD (Hemodialysis) Calculator is a tool for use by healthcare professionals for modeling the dialysis dose (Kt/V) for different dialysis prescription options.

For users in **countries in the region of Europe, Middle East and Africa (EMEA),** the HD Calculator is for simulation, education, and training purposes only. It must not be used in a clinical setting and/or to calculate doses for the treatment of specific patients. This educational tool provides clinicians with the ability to familiarize themselves with different therapy options by modeling the dialysis dose for different prescription options based on generalized formulas and assumptions derived from patient population.

Modeling a HD 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. The algorithms are not designed for simulation, education and training on modeling the dialysis dose for pediatric patients or patients with amputations.

The HD calculator is not intended to replace the judgment or experience of the prescribing healthcare provider. The HD prescription is the sole responsibility of the prescriber.

Important Information

The HD Calculator cannot address the full range of topics related to a HD prescription that are critical for the overall management and ongoing monitoring of a HD patient. This tool must never be used as a substitute for physician judgment.

The HD Calculator requires anthropomorphic (age, gender, height, weight) and clinical (transport status, residual kidney function) data to model a HD prescription. The algorithms used in the HD calculator are based upon published literature (see HD Calculator Formulas and References section).

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

Support

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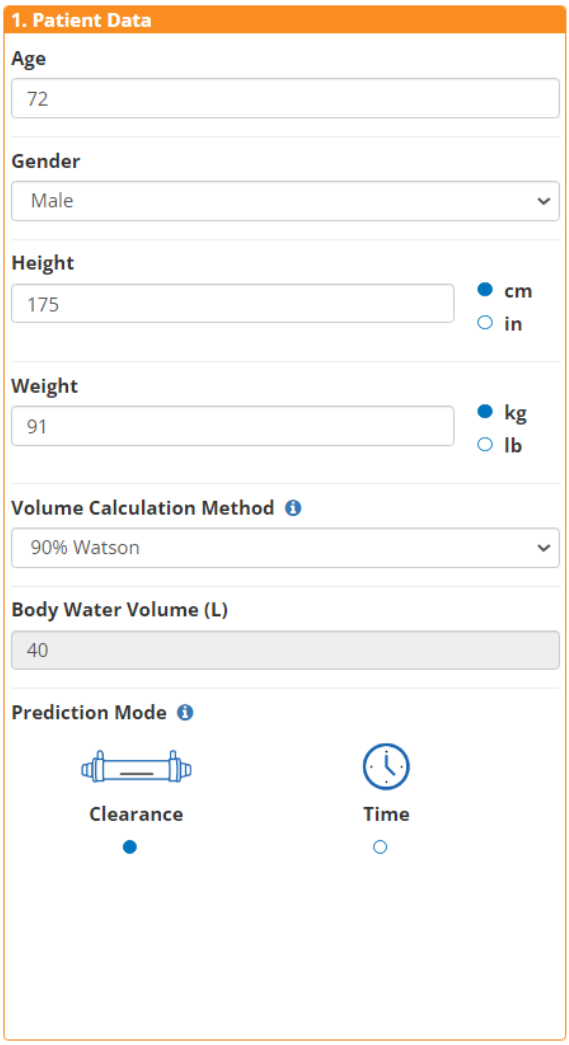
Minimum System Requirements

Internet Explorer 11, Firefox 56, Google Chrome 62, Safari 11, Android Google Chrome, iOS Safari

Instructions for Using the HD Calculator

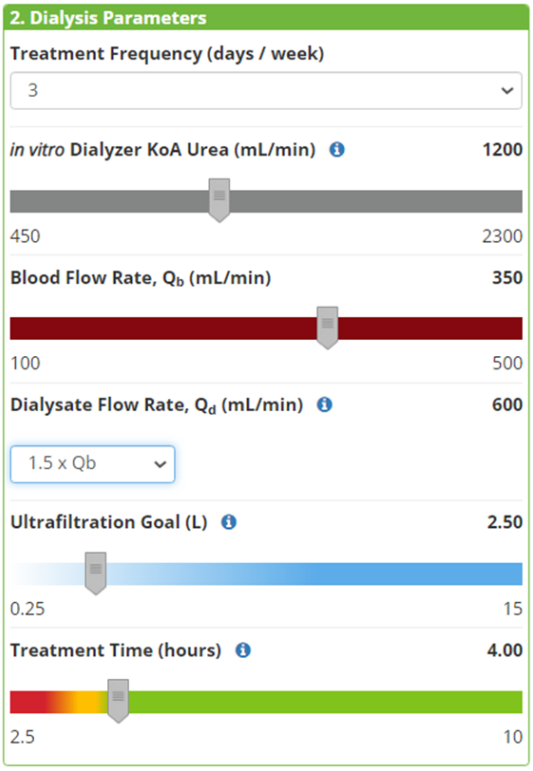
1. Enter patient data and modeling parameters in the Patient Data section.



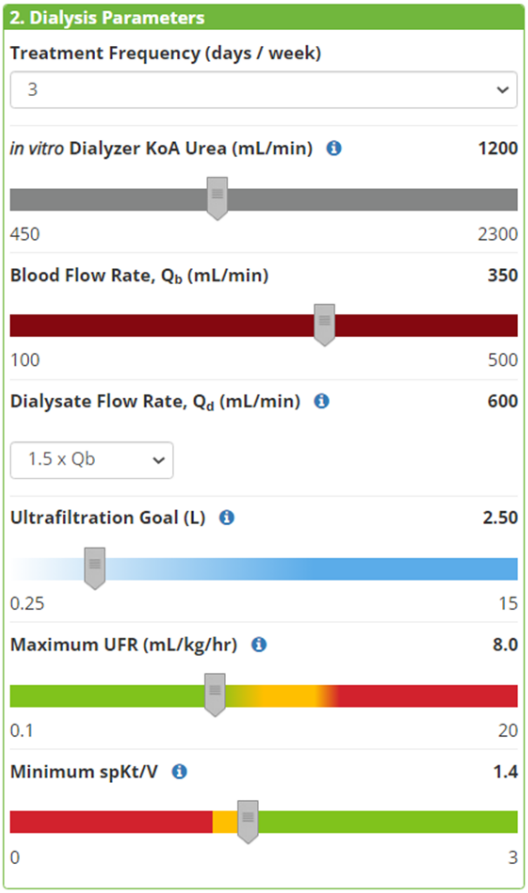
- Age: Enter patient's age. Age must be a whole number from 18 – 120.
- Gender: Select Male or Female from the drop-down menu
- Height: Enter the patient's height in cm (centimeters) or inch (inches). Choose the desired units from the dropdown. Height must be 124–213 cm (49–84 in), entered as a whole number.
- Weight: Enter the patient's weight in kg (kilograms) or lb (pounds). Choose the desired units from the radio buttons. Weight must be greater than 0 lb or kg
- Volume calculation: Select desired method to calculate the patient's urea distribution volume from the drop-down menu.
  - *Note: The determination of body water volume in a patient is an important part of estimating dialysis dose. Many methods for doing this exist. The HD Calculator can use three commonly used formulas. This volume is the urea distribution volume used in the calculation of Kt/V. Details on calculation methods can be found in the HD Calculator Formulas section.*
- Body Water Volume: The calculated total body water, in L, is displayed based on the selected method.
- Prediction mode: Select Clearance or Time from the drop-down menu
  - In Clearance mode, desired Treatment Time and ultrafiltration goal are entered under Dialysis Parameters, and Kt/V and URF are calculated in Predicted Outcomes
  - In Time mode, minimum spKt/V or weekly stdKt/V, ultrafiltration goal, and maximum UFR goal entered under Dialysis Parameters and Required Treatment Time is calculated in Predicted Outcomes

2. Enter desired treatment conditions in the Dialysis Parameters section.

Clearance Mode



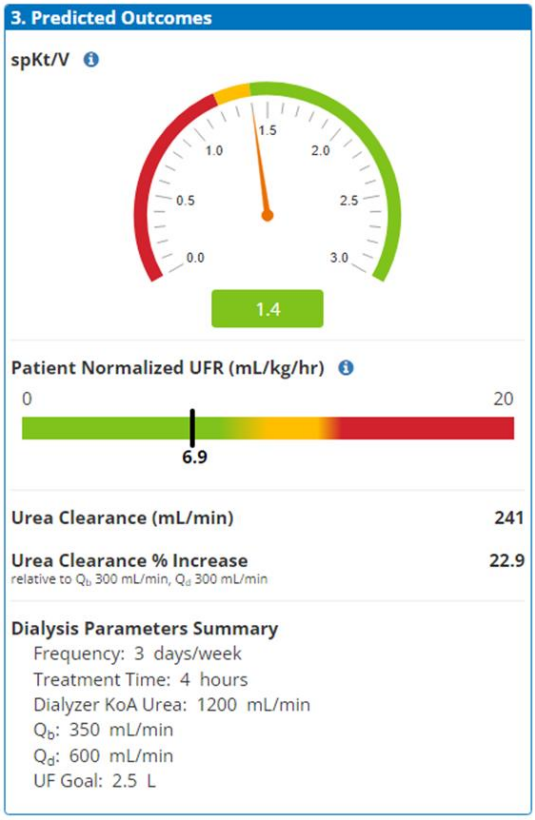
Time Mode



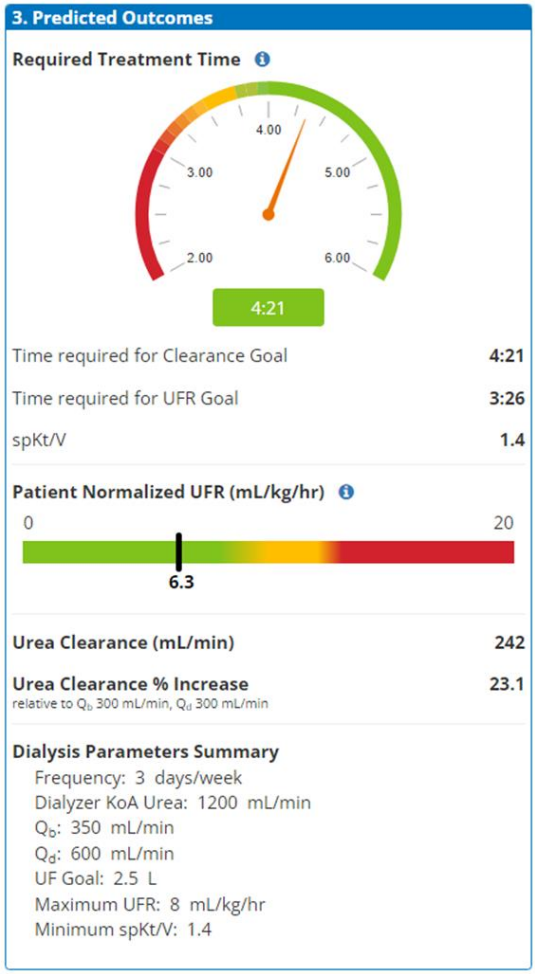
- Frequency: Enter the desired frequency for dialysis. Must be between 2 and 7 days/week.
- *in vitro* Dialyzer KoA Urea: Enter the published *in vitro* KoA Urea for a dialyzer.
  - The KoA Urea from *in vitro* studies (at a Q_b 300 and Q_d500) can be found on the package insert of most dialyzers. *Note: Manufacturer-published in vitro KoA values are reduced by 46% in calculations to account for in vivo clearance differences[1].*
- Blood Flow Rate, Q_b: Choose a desired blood flow rate. Value must be 100 – 800 mL/min.
- Dialysate Flow Rate, Q_d: Select method for dialysate flow rate from the drop down: a multiple of the Q_b or other.
  - If a multiple of the Q_b is chosen, the calculated Qd is displayed, rounded up to the next 100, up to a maximum of 800 mL/min. If other is chosen, use the slider to choose a desired Q_d. *Note: Many dialysis machines offer an option that automatically calculates the Q_d based on a factor of the Q_b. Ranges and options for individual machines vary and some flow rates are not available on all machines. Value must be 300 – 1,000 mL/min.*
- In Clearance Mode:
  - Ultrafiltration Goal: Enter the target ultrafiltration (UF) volume that will be removed during each treatment session, in Liters (L). Value must be 0.25 – 15.0 L.
    - *Note: 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.*
  - Treatment time: Enter the desired treatment time. Must be 2.5 – 10 hours.
    - *Note: Color-coded guidance for this parameter is only provided if dialysis frequency is 3 days/week.*
- In Time Mode:
  - Ultrafiltration Goal: Enter the target ultrafiltration (UF) volume that will be removed during each treatment session, in Liters (L). Value must be 0.25 – 15.0 L.
    - *Note: 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.*
  - Maximum UFR: Enter the maximum average patient normalized ultrafiltration rate for each treatment.
    - *Note: The Patient-normalized UFR is based on the patient weight, treatment duration, and UF volume. 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[2].*Minimum spKt/V or weekly stdKt/V: Enter the minimum spKt/V (if frequency is 3 days/week) or minimum weekly stdKt/V (if frequency is other than 3 days/week enter spKt/V target).

3. Review the results in the Predicted Outcomes section.

Clearance Mode



Time Mode



- Clearance Mode:
  - spKt/V: Predicted single pool (sp) Kt/V based on patient parameters and entered prescription.
    - *Note: spKt/V measures the dialysis dose of a single treatment, expressed as the product of dialyzer urea clearance (K) and treatment time (t), divided by the urea distribution volume (V) of the patient. The spKt/V is recommended as the main target parameter only if frequency is 3 days/week. The KDOQI guidelines suggest targeting a spKt/V of 1.4 per hemodialysis session, with a minimum delivered spKt/V of 1.2[3].*
  - Weekly stdKt/V: Predicted weekly standard (std) Kt/V based on patient parameters and entered prescription.
    - *Note: Weekly stdKt/V measures the dialysis dose of all treatments within one week, expressed as the product of dialyzer urea clearance (K) and treatment time (t), divided by the urea distribution volume (V) of the patient and an adjustment accounting for the treatment frequency. The stdKt/V is recommended as the main target parameter only for hemodialysis schedules other than thrice weekly. The KDOQI guidelines suggest targeting a weekly stdKt/V of 2.3, with a minimum delivered dose of 2.1[3].*
- Time Mode:
  - Required Treatment Time: The Required Treatment Time to achieve both the spKt/V or weekly stdKt/V, and UFR Goals entered in the Dialysis Parameters Section.
    - *Note: Color-coded guidance is only provided if dialysis frequency is 3 days/week.*
- Patient Normalized Ultrafiltration Rate (UFR): Calculated or entered ultrafiltration rate (UFR) normalized to the entered patient weight.
  - Note: 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[2].
- Urea Clearance: Calculated urea clearance (mL/min) for a single dialysis session with specified Dialysis Parameters.
- Urea Clearance %Change: Percent increase in urea clearance of specified Dialysis Parameters relative to Dialysis Parameters of Q_b and Q_d of 300 mL/min.
- Dialysis Parameters Summary: Displays a summary of the dialysis parameters that were using in the modeling.

HD Calculator Formulas

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

Body Water Volume

- Watson[4]:

$$V_{males} = 2.447 - 0.09516A + 0.1074H + 0.3362W$$

$$V_{females} = -2.097 + 0.1069H + 0.2466W$$

V: Volume (L), A: Age (years), H: Height (cm), W: Weight (kg)

- 90% Watson[5]:

$$V_{males} = 0.9\ x\ (2.447 - 0.09516A + 0.1074H + 0.3362W)$$

$$V_{females} = 0.9\ x\ (-2.097 + 0.1069H + 0.2466W)$$

V: Volume (L), A: Age (years), H: Height (cm), W: Weight (kg)

- Hume-Weyers[6]:

$$V_{males} = 0.194786H + 0.296785W - 14.012934$$

$$V_{females} = 0.34454H + 0.183809W - 35.270121$$

V: Volume (L), H: Height (cm), W: Weight (kg)

Urea Clearance, K_d[7]

$$K_d = \left(1 - \frac{\frac{UF\ x\ 1000}{TT}}{0.86\ x\ Qb}\right) x \left(\frac{0.86\ x\ Qb\ x\ \left(e^{\left(\frac{KoA}{0.86\ x\ Qb} x\ 1 - \left(\frac{0.86\ x\ Qb}{Qd}\right)\right)} - 1\right)}{e^{\left(\frac{KoA}{0.86\ x\ Qb} x\ 1 - \left(\frac{0.8\ x\ Qb}{Qd}\right)\right)} - \frac{0.86\ x\ Qb}{Qd}}\right) + \left(\frac{UF\ x\ 1000}{TT}\right)$$

K_d: Dialysis Clearance (mL/min), UF: Ultrafiltration (L), TT: treatment time (min), Qb: blood flow rate (mL/min), KoA: adjusted dialyzer urea KoA (mL/min),; Qd: dialysate flow rate (mL/min)

Single pool Kt/V (spKt/V)[8]

$$sp\ Kt/V = \frac{K_d\ x\ TT}{V * 1000}$$

K_d: Dialysis Clearance (mL/min), TT: treatment time (min), V: Body water volume (L)

Weekly Standard Kt/V[7]

$$std\ Kt/V = \frac{\frac{10{,}080\ x\ \frac{1 - e^{-\frac{eqKt}{V}}}{TT}}{\frac{1 - e^{-\frac{eqKt}{V}}}{\frac{eqKt}{V}} + \frac{10{,}080}{F\ x\ TT} - 1}}{1 - \frac{0.74}{F}\ x\ \frac{UF\ x\ F}{V}}$$

$$eq\ Kt/V = sp\ Kt/V\ x\ \frac{TT}{TT + 30.7}$$

eqKt/V: equilibrated Kt/V; TT: treatment time (min), V: Body water volume (L), UF: ultrafiltration per session (L), F: frequency (days/week)

Patient Normalized Ultrafiltration Rate (UFR)[2]

$$UFR = \frac{\frac{UF\ x\ 1{,}000}{W}}{TT}$$

UFR: Ultrafiltration Rate (mL/kg/hr), UF: ultrafiltration per session (L). W: weight (kg), TT: treatment Time (hours)

Urea Clearance %Change

$$\%Change = 100\ x\ \frac{K_d\ calculated - K_d 300}{K_d 300}$$

$K_d$calculated: Calculated K_d based on entered parameters
K_d300: K_d calculated at Qb 300 mL/min, Qd 300 mL/min

References

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2. 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. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27575009.
3. Rocco M, Daugirdas JT, Depner TA, et al. KDOQI Clinical Practice Guideline for Hemodialysis Adequacy: 2015 Update. *Am J Kidney Dis*. 2015;66(5):884-930. Available from: https://pubmed.ncbi.nlm.nih.gov/26498416/.
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5. 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. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20107428.
6. Hume R, Weyers E. Relationship between total body water and surface area in normal and obese subjects. *J Clin Pathol*. 1971;24(3):234-238. Available from: http://www.ncbi.nlm.nih.gov/pubmed/5573437.
7. Daugirdas J, Blake P, Ing T, eds. Appendix C: Urea Kinetic Modeling. In: *Handbook of Dialysis*. 5th ed. Walters Kluwer Health; 2015:795-795.
8. Daugirdas JT. Physiologic Principles and Urea Kinetic Modeling. In: Daugirdas JT, Blake PG, Ing TS, eds. *Handbook of Dialysis*. 5th ed. Lippincott Williams & Wilkins; 2015:34-65.

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