KIDNEY HEALTH INITIATIVE

DATA STANDARD	Quantification of Small Molecule Removal in a Single Hemodialysis Treatment using Single-Pool Urea Kt/V (spKt/V) and Equilibrated Urea Kt/V (eKt/V)
ALTERNATE NAME(S)	**Single-Pool Urea Kt/V for Hemodialysis** **spKt/V Method: Second Generation Ultrafiltration-Adjusted Estimation** **eKt/V Method: Patient Clearance Time Correction**
DESCRIPTION	The **single-pool urea Kt/V** for hemodialysis is a dimensionless measure of the adequacy of small molecule removal provided by a single dialysis treatment, where K is the dialyzer urea clearance, t is the treatment time, and V is the urea distribution volume for the patient. As discussed in the Rationale section below, spKt/V can be estimated from 5 parameters from a single hemodialysis treatment. This formula represents one such calculation, based on a second-generation ultrafiltration-adjusted estimate, which is commonly used today. Two related hemodialysis adequacy measures are derived from the spKt/V: • **Equilibrated Kt/V** or **double-pool Kt/V**, which accounts for the rebound in the blood urea nitrogen concentration after completion of the dialysis treatment. • **Standard weekly Kt/V**, which is a measure of total clearance per week, and as such, accounts for the number of treatments during the week Separate specifications and appropriate applications for those metrics are provided below.

The Kidney Health Initiative is a public-private partnership between the American Society of Nephrology, US Food and Drug Administration and over 100 companies and organizations in the kidney community. KHI leadership acknowledges and thanks the workgroup that developed these data standards to support research and development in kidney disease. To learn more about KHI or this project, please visit www.kidneyhealthinitiative.org.

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RATIONALE	An easily measured product of protein breakdown, urea has been an accepted marker for determination of small-molecule clearance in dialysis for over thirty years.[1-6] The Kt/V term arises from solution of a very simple time-dependent mass balance on urea nitrogen based on the following assumptions: • The human body acts as a single well-mixed reservoir in which urea is uniformly distributed. • The volume of that reservoir is constant during the dialysis treatment (i.e., ignore ultrafiltration) • The rate of change of urea concentration with time is proportional to the urea concentration. The urea distribution volume of a patient depends on body size, gender, and body composition. It is costly and impractical to measure each patient's urea distribution volume by indicator dilution. However, if the dialyzer clearance is known, then V can be calculated from the pre/post BUN, pre/post weight, and treatment time by iterative solution using formal urea kinetic modeling (UKM). UKM relies on an iterative method to determine the urea distribution volume. Given the challenges related to such an iterative process, various empirically derived equations have been developed for estimating spKt/V. In recent years, the so-called "Daugirdas II" Kt/V approximation has been in wide use. For example, the equation is one of the accepted dialysis dose methods acceptable to the U.S. Centers for Medicare and Medicaid Services (CMS) for claims and other reporting. First published in 1989, the original Daugirdas formula for estimating variable-volume spKt/V for a dialysis treatment frequency of 3x per week was found to overestimate Kt/V for values of Kt/V above.[1.3.4] The revised equation from 1993 provided more accurate Kt/V estimates at higher Kt/V's.[5] The following specifications are based on the second-generation equation.
DATA SOURCE(S)	• Hemodialysis treatment-level data • Laboratory results

REQUIRED DATA ELEMENTS	• Pre-dialysis weight (PreWt, kg) • Post-dialysis weight (PostWt, kg). The weighing conditions should be comparable for the pre- and post-dialysis weight (e.g., the same scale, identical clothing worn, use of a wheelchair, etc.) • Pre-dialysis Blood Urea Nitrogen (PreBUN) concentration (mg/dL) • Post-dialysis Blood Urea Nitrogen (PostBUN) concentration (mg/dL). For accurate results, the "Stop Flow/Stop Pump" technique should be used, in which the blood flow rate is stopped prior to drawing blood for the PostBUN sample. • Delivered treatment time (t, minutes). The delivered treatment time reflects the total time of administered dialysis (i.e., excludes time for intermittent dialysis discontinuation if blood returned by setting the machine in bypass mode). It should also exclude any time during the procedure when the patient is not connected to the machine and receiving dialysis. For example, the treatment time should be adjusted if dialysis is temporarily interrupted (e.g., to allow the patient to use bathroom facilities).
CALCULATION METHOD	**Single Treatment spKt/V for HD using 2nd generation UFR-adjusted estimate**[5] $spKt/V = -\ln[(PostBUN/PreBUN) - (0.008 \times t/60)] + [4 - (3.5 \times PostBUN/PreBUN)] \times [(PostWt - PreWt)/PostWt]$ To address the impact of alternative treatment regimens, it has been proposed that the 0.008 constant be replaced by a g-factor (GFAC) to account for dialysis frequencies other than 3X per week.[6] **Single Treatment eKt/V for HD using patient clearance time concept**[7] **with modified clearance time constant**[7] $eKt/V = spKt/V \times t/(t + 30.7)$ **Alternative Single Treatment eKt/V for HD using multiple linear regression**[8] $eKt/V = spKt/V * [0.924 - 0.395 / (t/60)] + 0.056$ Both spKt/V and eKt/V for HD are typically rounded to the first decimal point (e.g., 1.34 rounds to 1.3 and 1.35 rounds to 1.4) since the BUNs are usually recorded with two significant digits (e.g., 65 mg/dL and 21 mg/dL). However, unrounded spKt/V values should be used in eKt/V calculations.

EXCLUSIONS	• Hemodialysis treatments without the required data elements • Pediatric patients
ADDITIONAL DESIRABLE DATA ELEMENTS FOR COLLECTION	• Method of Kt/V calculation • Specific hemodialysis modality: in-center hemodialysis, home hemodialysis, home nocturnal hemodialysis, or in-center nocturnal hemodialysis (i.e., >6-hour treatment time in-center).
NOTES	• If a researcher chooses to aggregate and calculate the average spKt/V HD for any time period (e.g., 30-days, 3 months, etc.), first calculate the spKt/V for each individual treatment and then calculate the average by summing the spKt/V's across treatments and dividing by the total number of treatments. • Where possible, conduct data cleaning of input values prior to Kt/V calculation. For example, remove atypically low PostBUN values that may represent blood draw errors. If that is not possible, consider removing atypically high Kt/V values and exercise particular caution when averaging values over long periods of time. • For the purposes of research, each individual data element and the calculated spKt/V HD should be collected. This allows identification of outlier input parameters such as a diluted post BUN or a weight change during dialysis that exceeds a clinically reasonable range. • Single pool Kt/V is generally used for thrice weekly hemodialysis whereas standardized Kt/V can be used to estimate clearance for any frequency of dialysis.
EXAMPLE MEASURE CALCULATION	The following is an example of how to calculate spKt/V for HD using the above equation: In-center hemodialysis modality, prescribed thrice weekly dialysis Pre-dialysis weight 73 kg, post-dialysis weight 70 kg, total treatment time 240 minutes Pre-dialysis BUN 60 mg/dL, Post-dialysis BUN 18 mg/dL spKt/V = -ln(18/80-0.008*240/60) + ((4 - 3.5*(18/80))*(3/70)) = 1.443, which rounds to 1.4 eKt/V = 1.443 x (240)/(240 + 30.7) = 1.279, which rounds to 1.3 or alternatively: eKt/V = 0.924 * 1.443 – 0.395 * 1.443/(240/60) + 0.056 = 1.247, which rounds to 1.2

ACRONYMS	spKt/V: Single pool Kt/V eKt/V: Equilibrated Kt/V HD: Hemodialysis
SYNONYMS	Daugirdas II Kt/V is used interchangeably with single pool Kt/V
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