**National Quality Forum—Evidence (subcriterion 1a)**

**Measure Number** (*if previously endorsed*)**:** Click here to enter NQF number

**Measure Title**: **Avoidance of Utilization of High Ultrafiltration Rate (>=13 ml/kg/hour)**

**IF the measure is a component in a composite performance measure, provide the title of the Composite Measure here:** Click here to enter composite measure #/ title

**Date of Submission**: **10/27/2020**

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| **Instructions**  *Complete 1a.1 and 1a.2 for all measures. If instrument-based measure, complete 1a.3.*  *Complete* ***EITHER 1a.2, 1a.3 or 1a.4*** *as applicable for the type of measure and evidence.*  *For composite performance measures:*  *A separate evidence form is required for each component measure unless several components were studied together.*  *If a component measure is submitted as an individual performance measure, attach the evidence form to the individual measure submission.*   * All information needed to demonstrate meeting the evidence subcriterion (1a) must be in this form. An appendix of *supplemental* materials may be submitted, but there is no guarantee it will be reviewed. * If you are unable to check a box, please highlight or shade the box for your response. * Contact NQF staff regarding questions. Check for resources at [Submitting Standards webpage](http://www.qualityforum.org/Measuring_Performance/Submitting_Standards.aspx). |

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| **Note: The information provided in this form is intended to aid the Standing Committee and other stakeholders in understanding to what degree the evidence for this measure meets NQF’s evaluation criteria.**   1a. Evidence to Support the Measure Focus The measure focus is evidence-based, demonstrated as follows:   * Outcome: [**3**](#Note3) Empirical data demonstrate a relationship between the outcome and at least one healthcare structure, process, intervention, or service. If not available, wide variation in performance can be used as evidence, assuming the data are from a robust number of providers and results are not subject to systematic bias. * Intermediate clinical outcome: a systematic assessment and grading of the quantity, quality, and consistency of the body of evidence [**4**](#Note4)that the measured intermediate clinical outcome leads to a desired health outcome. * Process: [**5**](#Note5) a systematic assessment and grading of the quantity, quality, and consistency of the body of evidence [**4**](#Note4) that the measured process leads to a desired health outcome. * Structure: a systematic assessment and grading of the quantity, quality, and consistency of the body of evidence [**4**](#Note4) that the measured structure leads to a desired health outcome. * Efficiency: [**6**](#Note6) evidence not required for the resource use component. * For measures derived from patient reports, evidence should demonstrate that the target population values the measured outcome, process, or structure and finds it meaningful. * Process measures incorporating Appropriate Use Criteria: See NQF’s guidance for evidence for measures, in general; guidance for measures specifically based on clinical practice guidelines apply as well.   **Notes**  **3.** Generally, rare event outcomes do not provide adequate information for improvement or discrimination; however, serious reportable events that are compared to zero are appropriate outcomes for public reporting and quality improvement.  **4.** The preferred systems for grading the evidence are the Grading of Recommendations, Assessment, Development and Evaluation [(GRADE) guidelines](http://www.gradeworkinggroup.org) and/or modified GRADE.  **5.** Clinical care processes typically include multiple steps: assess → identify problem/potential problem → choose/plan intervention (with patient input) → provide intervention → evaluate impact on health status. If the measure focus is one step in such a multistep process, the step with the strongest evidence for the link to the desired outcome should be selected as the focus of measurement. Note: A measure focused only on collecting PROM data is not a PRO-PM.  **6.** Measures of efficiency combine the concepts of resource use and quality (see NQF’s [Measurement Framework: Evaluating Efficiency Across Episodes of Care](http://www.qualityforum.org/Publications/2010/01/Measurement_Framework__Evaluating_Efficiency_Across_Patient-Focused_Episodes_of_Care.aspx); [AQA Principles of Efficiency Measures](http://www.aqaalliance.org/files/PrinciplesofEfficiencyMeasurementApril2006.doc)). |

**1a.1.This is a measure of**: (*should be consistent with type of measure entered in De.1*)

Outcome

Outcome: Click here to name the health outcome

Patient-reported outcome (PRO): Click here to name the PRO

*PROs include HRQoL/functional status, symptom/symptom burden, experience with care, health-related behaviors.* (*A PRO-based performance measure is not a survey instrument. Data may be collected using a survey instrument to construct a PRO measure.)*

Intermediate clinical outcome (*e.g., lab value*): Click here to name the intermediate outcome

Process: **Avoidance of use of ultrafiltration rate (UFR) >=13 ml/kg/hour AND/OR dialysis session time <240 minutes.** (NOTE: Success for the measure can be achieved by employing either or both of two approaches: 1) Dialyzing patients at an average UFR <13 ml/kg/hour; AND/OR 2) Dialyzing patients for an average of >=240 minutes per session during the reporting period.)

Appropriate use measure: Click here to name what is being measured

Structure: Click here to name the structure

Composite: Click here to name what is being measured

**1a.2** **LOGIC MODEL** Diagram or briefly describe the steps between the healthcare structures and processes (e.g., interventions, or services) and the patient’s health outcome(s). The relationships in the diagram should be easily understood by general, non-technical audiences. Indicate the structure, process or outcome being measured.

**Process Being Measured:** Avoidance of use of ultrafiltration rate (UFR) >=13 ml/kg/hour and/or dialysis session time <240 minutes.

**Logic Diagram:** Potential mechanisms underlying the association between high UFR and adverse outcomes:

**Diagram

Description automatically generated**

**Rationale:** Ultrafiltration rate (UFR) is determined by the amount of fluid that must be removed from the patient and dialysis session length. As treatment time decreases, UFR tends to increase and vice versa. Both high UFR (>=13 ml/kg/hour) and abbreviated session duration (<240 minutes) are associated with a greater risk of all-cause and cardiovascular mortality in hemodialysis patients, with research suggesting that dialysis session length >=240 minutes is independently associated with a significantly reduced relative risk of mortality.

The intent of this measure is thus to generally foster the use of slower, gentler dialysis sessions to reduce hemodialysis-related mortality. The measure criteria can be met by employing either or both of two approaches: 1) dialyzing patients at an average UFR <13 ml/kg/hour; and/or 2) dialyzing patients for an average of >=240 minutes per session during the reporting period. Adherence to these conventions will help attenuate the rapid fluctuations in fluid balance and blood pressure that contribute to cardiovascular morbidity and mortality in hemodialysis patients.

**1a.3** **Value and Meaningfulness:**  **IF** this measure is derived from patient report, provide evidence that the target population values the measured ***outcome, process, or structure*** and finds it meaningful. (Describe how and from whom their input was obtained.)

Not applicable.

**\*\*RESPOND TO ONLY ONE SECTION BELOW -EITHER 1a.2, 1a.3 or 1a.4) \*\***

**1a.2** **FOR OUTCOME MEASURES including PATIENT REPORTED OUTCOMES - Provide empirical data demonstrating the relationship between the outcome (or PRO) to at least one healthcare structure, process, intervention, or service.**

Not applicable.

**1a.3.****SYSTEMATIC REVIEW(SR) OF THE EVIDENCE (for intermediate outcome, PROCESS, or STRUCTURE PERFORMANCE measures, including those that are instrument-based) If the evidence is not based on a systematic review go to section 1a.4) If you wish to include more than one systematic review, add additional tables.**

**What is the source of the systematic review of the body of evidence that supports the performance measure? A systematic review is a scientific investigation that focuses on a specific question and uses explicit, prespecified scientific methods to identify, select, assess, and summarize the findings of similar but separate studies. It may include a quantitative synthesis (meta-analysis), depending on the available data. (IOM)**

Clinical Practice Guideline recommendation (with evidence review)

☐ US Preventive Services Task Force Recommendation

Other systematic review and grading of the body of evidence (*e.g., Cochrane Collaboration, AHRQ Evidence Practice Center*)

☐ Other

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| **Source of Systematic Review:**   * **Title:** * **Author:** * **Date:** * **Citation, including page number:** * **URL:** | **Title:** Kidney Disease Outcomes Quality Initiative (KDOQI). Clinical Practice Guideline for Hemodialysis Adequacy  **Author:** National Kidney Foundation  **Date:** 2015  **Citation:** National Kidney Foundation. Kidney Disease Outcomes Quality Initiative (KDOQI). Clinical Practice Guideline for Hemodialysis Adequacy: 2015 Update. *Am J Kidney Dis.* 2015;66(5):884-930.  **Relevant Pages:** 913-916.  **URL:** <https://www.ajkd.org/action/showPdf?pii=S0272-6386%2815%2901019-7>  **NOTE:** The relevant KDOQI Guidelines have been updated since the measure was endorsed in 2015. This endorsement maintenance submission cites these most recent recommendations; the original submission relied on the 2006 Guidelines. |
| Quote the guideline or recommendation verbatim about the process, structure or intermediate outcome being measured. If not a guideline, summarize the conclusions from the SR. | **Guideline 4: Volume and Blood Pressure Control: Treatment Time and Ultrafiltration Rate**  **4.1** We recommend that patients with low residual kidney function (<2 mL/min) undergoing thrice weekly hemodialysis be prescribed a bare minimum of 3 hours per session. (1D)   * **4.1.1** Consider additional hemodialysis sessions or longer hemodialysis treatment times for patients with large weight gains, high ultrafiltration rates, poorly controlled blood pressure, difficulty achieving dry weight, or poor metabolic control (such as hyperphosphatemia, metabolic acidosis, and/or hyperkalemia). (Not Graded)   **4.2**We recommend both reducing dietary sodium intake as well as adequate sodium/water removal with hemodialysis to manage hypertension, hypervolemia, and left ventricular hypertrophy. (1B)   * **4.2.1** Prescribe an ultrafiltration rate for each hemodialysis session that allows for an optimal balance among achieving euvolemia, adequate blood pressure control and solute clearance, while minimizing hemodynamic instability and intradialytic symptoms. (Not Graded) |
| Grade assigned to the **evidence** associated with the recommendation with the definition of the grade | Appraisal of the quality of the evidence and the strength of recommendations followed the Grading of Recommendation Assessment, Development, and Evaluation (GRADE) approach.  **Recommendation 4.1 Evidence Grade: D**   * Evidence Grade D is defined as “very low quality of evidence” for which “the estimate of effect is very uncertain and often will be far from the truth.”   **Recommendation 4.2 Evidence Grade: B**   * Evidence Grade B is defined as “moderate quality of evidence,” with “the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.”   **Recommendations 4.1.1. and 4.2.1: Not Graded**   * “Not Graded” was used typically “to provide guidance based on common sense or where the topic does not allow adequate application of evidence. The ungraded recommendations are generally written as simple declarative statements, but are not meant to be interpreted as being stronger recommendations than Level 1 or 2 recommendations.” |
| Provide all other grades and definitions from the evidence grading system | Other evidence grades in the grading system:   * **Evidence Grade A:** High quality of evidence for which KDOQI is “confident that the true effect lies close to that of the estimate of the effect.” * **Evidence Grade C:** Low quality of evidence for which “the true effect may be substantially different from the estimate of the effect.” |
| Grade assigned to the **recommendation** with definition of the grade | **Recommendation 4.1 Grade: 1**   * Recommendation Grade Level 1 is defined as a “strong recommendation” for which “most patients should receive the recommended course of action” and “the recommendation can be adopted as policy for most situations.”   **Recommendation 4.2 Grade: 1**   * Recommendation Grade Level 1 (see above).   **Recommendations 4.1.1. and 4.2.1: Not Graded**   * “Not Graded” was used typically “to provide guidance based on common sense or where the topic does not allow adequate application of evidence. The ungraded recommendations are generally written as simple declarative statements, but are not meant to be interpreted as being stronger recommendations than Level 1 or 2 recommendations.” |
| Provide all other grades and definitions from the recommendation grading system | Other recommendation grades include:   * **Recommendation Level 2:** Conditional recommendation for which “different choices will be appropriate for different patients” and “the recommendation is likely to require substantial debate and involvement of stakeholders before policy can be determined.” |
| Body of evidence:   * Quantity – how many studies? * Quality – what type of studies? | **Quantity:** A total of 39 studies were cited by KDOQI as evidence supporting Guideline 4.2.  **Quality:** The 2015 KDOQI update included a review of clinical trials and observational studies published between 2000 and March 2014 on topics including high-frequency hemodialysis and risks; prescription flexibility in initiation timing, frequency, duration, and ultrafiltration rate; and volume and blood pressure control. |
| Estimates of benefit and consistency across studies | **Recommendation 4.1:**  “The estimate of effect is very uncertain and often will be far from the truth.”  **Recommendation 4.2:** “The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.”  **Recommendations 4.1.1 and 4.2.1:**  “Guidance based on common sense or where the topic does not allow adequate application of evidence.”  The publication did not provide an estimate of consistency across the cited studies. |
| What harms were identified? | No harms were cited for the recommendation; the supporting body of evidence validates the recommendations’ premises—failure to prescribe an appropriate hemodialysis UFR and session duration to achieve euvolemia and minimize hemodynamic instability is associated with adverse outcomes ranging from cardiovascular events and mortality to hypotensive seizures.  Nevertheless, potential harms stemming from the process of setting UFR to achieve a set target (“dry”) weight post-dialysis were noted. While this has been the accepted method of maintaining a consistent volume state, the inaccuracy of estimation is widely appreciated. Both over- and underestimation are common, with the former contributing to hypertension and left ventricular hypertrophy, and the latter accelerating the loss of residual kidney function and perhaps risking myocardial stunning. |
| Identify any new studies conducted since the SR. Do the new studies change the conclusions from the SR? | Numerous studies addressing UFR and dialysis treatment time have been published since this guideline was released in 2015 (see 1a.4.1 and 1a.4.2 below for details and citations); none were identified that contradict the KDOQI recommendation, which does not identify an absolute threshold for UFR and establishes a “bare minimum” treatment time. |

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| **Source of Systematic Review:**   * **Title** * **Author** * **Date** * **Citation, including page number** * **URL** | **Title:** Clinical Practice Guideline on Haemodialysis  **Author:** UK Renal Association  **Date:** 2019  **Citation:** UK Renal Association. Clinical Practice Guideline on Haemodialysis. *BMC Nephrology.* 2019;20:379-415*.*  **Relevant Pages:** 3-4 (382-383).  **URL:** <https://bmcnephrol.biomedcentral.com/track/pdf/10.1186/s12882-019-1527-3>.  **NOTE:** The UK Renal Association Guidelines have been updated since 2701 was endorsed in 2015. This endorsement maintenance submission cites the most recent recommendations; the original submission referenced the 2009 Guidelines. |
| Quote the guideline or recommendation verbatim about the process, structure or intermediate outcome being measured. If not a guideline, summarize the conclusions from the SR. | **Guideline 4.1: Fluid Assessment and Management in Adults**  We recommend avoiding excessive UFRs by addressing fluid gains, accepting staged achievement of target weight, or using an augmented schedule, as necessary. [1B]  **NOTE:** This recommendation, wherein an absolute UFR threshold is not identified, represents a change from the 2009 iteration in which a maximum rate of 10 ml/kg/hour was recommended. |
| Grade assigned to the **evidence** associated with the recommendation with the definition of the grade | Appraisal of the quality of the evidence and the strength of recommendations followed a modified Grading of Recommendation Assessment, Development, and Evaluation (GRADE) approach.  **Guideline 4.1 Evidence Grade: B**   * Evidence Grade B is defined as “moderate-quality evidence from randomized trials that suffer from serious flaws in conduct, inconsistency, indirectness, imprecise estimates, reporting bias, or some combination of these limitations, or from other study designs with special strength.” |
| Provide all other grades and definitions from the evidence grading system | Other evidence grades in the grading system include:   * **Evidence Grade A:** “High-quality evidence that comes from consistent results from well-performed randomized controlled trials, or overwhelming evidence of some other sort (such as well-executed observational studies with very strong effects).” * **Evidence Grade C:** “Low-quality evidence from observational studies, or from controlled trials with several very serious limitations.” * **Evidence Grade D:** “Evidence is based only on case studies or expert opinion.” |
| Grade assigned to the **recommendation** with definition of the grade | **Guideline 4.1 Recommendation Grade: 1**   * Recommendation Grade 1 is a strong recommendation to do (or not do) something, where the benefits clearly outweigh the risks (or vice versa) for most, if not all patients. |
| Provide all other grades and definitions from the recommendation grading system | Other recommendation grades in the grading system include:   * **Recommendation Grade 2:** “A weaker recommendation, where the risks and benefits are more closely balanced or are more uncertain.” |
| Body of evidence:   * Quantity – how many studies? * Quality – what type of studies? | **Quantity:** A total of 15 studies were cited as evidence supporting Guideline 4.1.  **Quality:** The guideline is an update of a previous version written in 2009 and included systematic literature searches of clinical trials and observational studies undertaken by lead authors to identify all relevant evidence published up until the end of June 2018. |
| Estimates of benefit and consistency across studies | The publication did not provide an estimate of benefit or consistency across the cited studies. |
| What harms were identified? | As with the KDOQI guidelines, the cited body of evidence support the premise of the recommendation—failure to appropriately address fluid gains through achievement of target weights and/or use of augmented schedules to avoid excessive UFR is associated with mortality and adverse cardiovascular-related outcomes.  Nevertheless, it was noted that potential harms might stem from the process of setting UFR to achieve a set target (“dry”) weight post-dialysis, for which the inaccuracy of estimation is widely appreciated. Both over- and underestimation are common, with the former contributing to hypertension and left ventricular hypertrophy, and the latter accelerating the loss of residual kidney function and perhaps risking myocardial stunning. |
| Identify any new studies conducted since the SR. Do the new studies change the conclusions from the SR? | Few studies addressing UFR have been published since this guideline was released in 2019 (see 1a.4.1 and 1a.4.2 below for details and citations); none were identified that contradict the UK recommendation, which does not identify an absolute threshold for UFR. |

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**1a.4 OTHER SOURCE OF EVIDENCE**

*If source of evidence is NOT from a clinical practice guideline, USPSTF, or systematic review, please describe the evidence on which you are basing the performance measure.*

**1a.4.1** **Briefly SYNTHESIZE the evidence that supports the measure.** A list of references without a summary is not acceptable.

UFR is recognized as an important and modifiable risk factor for morbidity and mortality among patients receiving maintenance hemodialysis, yet identifying a specific UFR target and determining the appropriate amount of fluid to remove during dialysis remains a clinical challenge. Both volume overload with excessive interdialytic weight gain (IDWG) and recurrent episodes of intradialytic hypotension associated with the use of higher UFRs are recognized as important predictors of morbidity and mortality.[[1]](#footnote-1),[[2]](#footnote-2),[[3]](#footnote-3)

Numerous observational studies in recent years have assessed outcomes associated with UFR:[[4]](#footnote-4),[[5]](#footnote-5)

* The first included 22,000 prevalent hemodialysis patients from seven countries in the Dialysis Outcomes and Practice Patterns Study (DOPPS). Saran et al. found that UFR >10 ml/kg/hour was associated with both intradialytic hypotension (OR = 1.3, p = 0.045) and all-cause mortality (adjusted HR 1.09, p = 0.02).[[6]](#footnote-6)
* Another prospective cohort study of 287 prevalent hemodialysis patients in Italy demonstrated that for every 1 ml/kg/hour increase in UFR there was a 22% increase in mortality risk (p <0.01). In secondary analyses, the authors identified a UFR of 12.4 ml/kg/hour as the most discriminatory cut-point for predicting two-year mortality.[[7]](#footnote-7) Notably, the study was also restricted to patients with a urine output of 150 ml/day or less, offering compelling evidence for the association absent confounding from residual kidney function, typically associated with better clinical outcomes.[[8]](#footnote-8)
* An analysis of the Hemodialysis (HEMO) Study, a randomized controlled trial of 1,846 patients followed prospectively for 7 years, found that UFRs >13 ml/kg/hour were associated with a 59% increased risk of all-cause mortality (HR 1.59, 1.29-1.96) and a 71% increased risk of cardiovascular mortality (HR 1.71, 1.23-2.38 after adjustment (p <0.001 for both). In spline analyses, risk increased sharply after 10 ml/kg/hour.[[9]](#footnote-9)
* An observational study of 118,394 hemodialysis patients in a large dialysis organization between 2008 and 2012 dichotomized mean UFR over a 30-day period as <= or >10 and <= or >13 ml/kg/hour. Here again, UFRs >10 and >13 were both associated with higher all-cause mortality compared to their respective references (adjusted HRs 1.22 [1.20-1.24] and 1.31 [1.28-1.34]). The association was more pronounced in blacks, non-Hispanics, patients with longer dialysis vintage, longer session duration, and patients with higher BMI. When UFR was treated as a continuous variable, each 1 ml/kg/hour increase was associated with 3% increased risk for mortality.[[10]](#footnote-10)
* The preceding studies included markers of health such as albumin, blood pressure, and comorbidities, but did not fully account for potential residual confounders like patient resiliency or frailty. Shorter dialysis sessions may, for instance, be prescribed to frailer patients due to dialysis intolerance or a lower body weight. Flythe et al. offered some clarity on this issue by assessing treatment time and outcomes in a national cohort of patients from a large dialysis organization undergoing thrice weekly in-center hemodialysis. Patients prescribed dialysis sessions > and <240 minutes were pair-matched on post-dialysis weight, age, gender, and vascular access type. Session length <240 minutes was significantly associated with increased all-cause mortality (adjusted HR 1.26, 1.07–1.48; p = 0.005), with a dose-response between prescribed session length and survival.[[11]](#footnote-11) The study did not directly address UFR, but suggests that the slower fluid removal facilitated by longer treatment times may be advantageous, independent of body weight.[[12]](#footnote-12)

The near-linear association between high UFR and adverse outcomes illustrated in these landmark studies highlights a considerable opportunity to improve care and outcomes for dialysis patients—and offers a compelling framework upon which a performance metric can be constructed to address this vitally important aspect of dialysis care. Yet while the literature provides persuasive evidence supporting the use of UFR between 10 and 13—with more recent publications[[13]](#footnote-13) suggesting that even lower rates may prove beneficial—KCQA is cognizant of the fact that imposing too restrictive a limitation would not be without consequence, increasing risk for pervasive failures of target weight achievement and volume expansion over time.[[14]](#footnote-14)

KCQA recognizes that any effective fluid management measure must provide for clinical judgement, allowing physicians ample room to respond appropriately to varying clinical presentations in a manner that also meets the needs and preferences of their patients. KCQA and the larger renal community thus selected the <13 ml/kg/hour parameter not only because it carries the greatest consensus among experts, but because we believe it also offers a balanced, feasible approach to prevent the deleterious consequences of excessive UFR.

**1a.4.2 What process was used to identify the evidence?**

The process used to identify the evidence supporting NQF 2701 consisted of an extensive literature review, the clinical experience and expert consensus of KCQA members and the KCQA Feasibility/Testing Workgroup, and a retrospective review of pertinent database data from three large dialysis organizations with a correlation to existing measures of adverse outcomes (i.e., hospitalization and mortality) over the same time period. Relevant peer-reviewed publications since the measure was endorsed have been incorporated into this maintenance review submission.

**1a.4.3.** **Provide the citation(s) for the evidence.**

1. Agarwal R, Weir MR. Dry-weight: A concept revisited in an effort to avoid medication-directed approaches for blood pressure control in hemodialysis patients.  *CJASN.* 2010;5:1255–1260.
2. Chou JA, Kalantar-Zadeh K. Volume balance and intradialytic ultrafiltration rate in the hemodialysis patient. *Curr Heart Fail Rep.* 2017;14(5):421-427.
3. Lopot F, Kotyk P, Blaha J, Forejt J. Use of continuous blood volume monitoring to detect inadequately high dry weight.  *International Journal of Artificial Organs.* 1996;19:411–414.
4. Slinlin Y, Babu M, Ishani A. Ultrafiltration rate in conventional hemodialysis: Where are the limits and what are the consequences? *Seminars in Dialysis.* 2018;31(6):544-550.
5. Assimon MM, Flythe JE. Rapid ultrafiltration rates and outcomes among hemodialysis patients: Re-examining the evidence base. *Curr Opin Nephrol Hypertens.* 2015;24(6):525-530.
6. Saran R, Bragg-Gresham JL, Levin NW, et al. Longer treatment time and slower ultrafiltration in hemodialysis: Associations with reduced mortality in the DOPPS. *Kidney Int.* 2006;69:1222-1228.
7. Movilli E, Gaggia P, Zubani R, et al. Association between high ultrafiltration rates and mortality in uraemic patients on regular haemodialysis. A 5-year prospective observational multicentre study. *Nephrol Dial Transplant.* 2007;22:3547–3552.
8. Vilar E, Farrington K. Emerging importance of residual renal function in endstage renal failure. *Semin Dial.* 2011; 24:487–494.
9. Flythe JE, Kimmel SE, Brunelli SM. Rapid fluid removal during dialysis is associated with cardiovascular morbidity and mortality. *Kidney Int.* 2011;79:250-257.
10. Assimon MM, Wenger JB, Wang L, Flythe JE. Ultrafiltration rate and mortality in maintenance hemodialysis patients. *Am J Kidney Dis.* 2016;68:911-922.
11. Flythe JE, Curhan GC, Brunelli SM. Shorter length dialysis sessions are associated with increased mortality, independent of body weight. *Kidney Int.* 2013; 83:104–113.
12. Assimon MM, Flythe JE. Rapid ultrafiltration rates and outcomes among hemodialysis patients: Re-examining the evidence base. *Curr Opin Nephrol Hypertens.* 2015;24(6):525-530.
13. Lee YJ et al. Ultrafiltration rate, residual kidney function, and survival among patients treated with reduced-frequency hemodialysis. *AJKD.* 2020;75(3):342-350.
14. Flythe JE. Ultrafiltration rate clinical performance measures: Ready for primetime? *Semin Dial.* 2016;29(6):425-434.
15. Sinha AD, Agawaral A. Opinion: The fallacy of low interdialytic weight gain and lower ultrafiltration rate: Lower is not always better. *Semin Dial.* 2014;27(1):11-13.
16. Flythe JE, Curhan GC, Brunelli SM. Disentangling the ultrafiltration rate-mortality association: The respective roles of session length and weight gain. *Clin J Am Soc Nephrol*. 2013;8(7):1151-1161.
17. Lindberg M, Pruetz KG, Lindberg P et al. Interdialytic weight gain and ultrafiltration rate in hemodialysis: Lessons about fluid adherence from a national registry of clinical practice. *Hemodial Int.* 2013;17(4):548-556.
18. Curatola G, Bolignano D, Rastelli S, et al. Ultrafiltration intensification in hemodialysis patients improves hypertension but increases AV fistula complications and cardiovascular events. *J Nephrol.* 2011;24(4):465-473.
19. Flythe JE, Brunelli SM. The risks of high ultrafiltration rate in chronic hemodialysis: Implications for patient care. *Semin Dial*. 2011;24(3):259-265.
20. London GM. Ultrafiltration intensification for achievement of dry weight and hypertension control is not always the therapeutic gold standard. *J Nephrol.* 2011;24(4)395-397.
21. Brunelli SM, Chertow GM, Ankers ED, et al. Shorter dialysis times are associated with higher mortality among incident hemodialysis patients. *Kidney Int.* 2010;77:630–636.
22. Burton JO, Jefferies HJ, Selby NM, and McIntyre CW. Hemodialysis-induced cardiac injury: Determinants and associated outcomes. *Clin J Am Soc Nephrol.* 2009;4:914–920.
23. Miller JE, Kovesdy CP, Nissenson AR, et al. Association of hemodialysis treatment time and dose with mortality and the role of race and sex. *Am J Kidney Dis.* 2010; 55:100–112.

1. Agarwal R, Weir MR. Dry-weight: A concept revisited in an effort to avoid medication-directed approaches for blood pressure control in hemodialysis patients.  *CJASN.* 2010;5:1255–1260.  [↑](#footnote-ref-1)
2. # Chou JA, Kalantar-Zadeh K. Volume balance and intradialytic ultrafiltration rate in the hemodialysis patient. *Curr Heart Fail Rep.* 2017;14(5):421-427.

   [↑](#footnote-ref-2)
3. Lopot F, Kotyk P, Blaha J, Forejt J. Use of continuous blood volume monitoring to detect inadequately high dry weight.  *International Journal of Artificial Organs.* 1996;19:411–414. [↑](#footnote-ref-3)
4. Slinlin Y, Babu M, Ishani A. Ultrafiltration rate in conventional hemodialysis: Where are the limits and what are the consequences? *Seminars in Dialysis.* 2018;31(6):544-550. [↑](#footnote-ref-4)
5. Assimon MM, Flythe JE. Rapid ultrafiltration rates and outcomes among hemodialysis patients: Re-examining the evidence base. *Curr Opin Nephrol Hypertens.* 2015;24(6):525-530. [↑](#footnote-ref-5)
6. Saran R, Bragg-Gresham JL, Levin NW, et al. Longer treatment time and slower ultrafiltration in hemodialysis: Associations with reduced mortality in the DOPPS. *Kidney Int.* 2006;69:1222-1228. [↑](#footnote-ref-6)
7. Movilli E, Gaggia P, Zubani R, et al. Association between high ultrafiltration rates and mortality in uraemic patients on regular haemodialysis. A 5-year prospective observational multicentre study. *Nephrol Dial Transplant.* 2007;22:3547–3552. [↑](#footnote-ref-7)
8. Vilar E, Farrington K. Emerging importance of residual renal function in endstage renal failure. *Semin Dial.* 2011; 24:487–494. [↑](#footnote-ref-8)
9. Flythe JE, Kimmel SE, Brunelli SM. Rapid fluid removal during dialysis is associated with cardiovascular morbidity and mortality. *Kidney Int.* 2011;79:250-257. [↑](#footnote-ref-9)
10. Assimon MM, Wenger JB, Wang L, Flythe JE. Ultrafiltration rate and mortality in maintenance hemodialysis patients. *Am J Kidney Dis.* 2016;68:911-922. [↑](#footnote-ref-10)
11. Flythe JE, Curhan GC, Brunelli SM. Shorter length dialysis sessions are associated with increased mortality, independent of body weight. *Kidney Int.* 2013; 83:104–113. [↑](#footnote-ref-11)
12. Assimon MM, Flythe JE. Rapid ultrafiltration rates and outcomes among hemodialysis patients: Re-examining the evidence base. *Curr Opin Nephrol Hypertens.* 2015;24(6):525-530. [↑](#footnote-ref-12)
13. Lee YJ et al. Ultrafiltration rate, residual kidney function, and survival among patients treated with reduced-frequency hemodialysis. *AJKD.* 2020;75(3):342-350. [↑](#footnote-ref-13)
14. Flythe JE. Ultrafiltration rate clinical performance measures: Ready for primetime? *Semin Dial.* 2016;29(6):425-434. [↑](#footnote-ref-14)