

Archives of Nephrology

Research Article

Predictors of dialysis adequacy in elderly renal patients with acute kidney injury

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Received: 11 September 2018; Accepted: 3 December 2018; Published: 25 February 2019.

Citation of this article: Diallo K, Adeyemi Z, Achebe A (2019) Predictors of dialysis adequacy in elderly renal patients with acute kidney injury. Arch Nephrol, 2(1): 01-06. DOI: [10.5281/zenodo.22812960](https://doi.org/10.5281/zenodo.22812960)

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Abstract

Background: Dialysis-requiring acute kidney injury (AKI) is common in elderly patients, yet the delivered-dose targets validated in chronic hemodialysis are not well characterized in this population [17,16].

Objective: To describe the proportion of elderly AKI patients achieving adequate dialysis by Kt/V-based criteria and to identify independent predictors of inadequate dialysis.

Methods: In a retrospective cohort of 318 patients aged 65 years or older with dialysis-requiring AKI, single-pool Kt/V and urea reduction ratio were calculated for 2,046 hemodialysis sessions, and predictors of overall inadequate dialysis were identified by multivariable logistic regression [15,14].

Findings: 38.7% of patients had overall inadequate dialysis; non-tunneled vascular access, intradialytic hypotension, hypoalbuminemia, and high ultrafiltration rate independently predicted inadequacy, while residual urine output was protective, and chronological age was not independently predictive [20,19,22].

Conclusions: Dialysis adequacy in elderly AKI patients is substantially modifiable through vascular access selection, hemodynamic tolerance, and individualized ultrafiltration targets, rather than being fixed by age itself.

Keywords: acute kidney injury; dialysis adequacy; elderly; Kt/V; renal replacement therapy

1. Introduction

Acute kidney injury (AKI) severe enough to require renal replacement therapy (RRT) is common in hospitalized older adults, and its incidence rises sharply with age as comorbidity burden and exposure to nephrotoxic insults accumulate [1,2,3]. Multinational cohorts have repeatedly shown that dialysis-requiring AKI carries excess in-hospital mortality and a substantial risk of incomplete renal recovery [4,5,6]. Elderly patients are disproportionately represented in these cohorts, yet the pivotal timing-of-initiation and dose-intensity trials that shaped modern AKI-RRT practice enrolled mixed-age intensive care populations without a dedicated focus on how adequately dialysis is actually delivered in the oldest patients [7,8,9,10,11,12]. The chronic hemodialysis literature established that dose delivered, not merely dose prescribed, determines outcome, most directly in the Hemodialysis (HEMO) Study's finding that neither a higher Kt/V target nor high-flux membranes improved survival once delivered-dose targets were met [13].

Dialysis adequacy, quantified for intermittent hemodialysis as the single-pool Kt/V urea (spKt/V) or the urea reduction ratio (URR), was developed and validated in chronic maintenance hemodialysis through the National Cooperative Dialysis Study [14,15] and later codified in the KDOQI adequacy guidelines [16]. Whether the same delivered-dose targets translate to elderly AKI patients, who differ in urea distribution volume, hemodynamic reserve, vascular access, and residual native kidney function, is far less established; the KDIGO guideline recommends individualizing dialysis dose in AKI rather than extrapolating chronic-dialysis targets directly [17,18].

Several factors specific to AKI and older age plausibly interfere with achieving prescribed dose. Intradialytic hypotension, more frequent in elderly and critically ill patients, truncates effective treatment time and reduces clearance [19]. Vascular access in AKI is dictated by acuity,

so temporary non-tunneled catheters carry a higher risk of recirculation and inadequate flow than a tunneled catheter [20,21]. Residual native kidney function can meaningfully supplement clearance and mask an otherwise inadequate prescription [22], and comorbidity burden and nutritional status, both unfavorable in elderly AKI patients, have independently predicted poor dialysis tolerance in adjacent literatures [23,24,25].

We conducted a retrospective cohort study of elderly patients (aged 65 years or older) with AKI requiring RRT, to describe the proportion achieving adequate dialysis by spKt/V and URR thresholds and to identify factors that independently predict inadequate dialysis in this population.

2. Methods

We performed a retrospective cohort study of consecutive patients aged 65 or older who developed KDIGO stage 2 or 3 AKI and received intermittent hemodialysis or sustained low-efficiency dialysis at a tertiary referral center over 30 months [17,26,27]. Patients receiving fewer than three RRT sessions, on chronic maintenance dialysis before admission, or with no established baseline creatinine were excluded. AKI stage used KDIGO serum creatinine and urine output criteria against the lowest available pre-admission creatinine [17].

Adequacy for each session was quantified as spKt/V from pre- and post-dialysis blood urea nitrogen, ultrafiltration volume, and post-dialysis weight, using the Daugirdas second-generation formula, cross-checked against URR [15,14]. A session was adequate if spKt/V was 1.2 or greater, the delivered-dose threshold recommended for thrice-weekly hemodialysis by KDOQI, applied here as KDIGO advises, as an individualized target rather than a directly transposed chronic-dialysis standard [16,17]. Patients were classified as having overall inadequate dialysis if fewer than two-thirds of sessions in the first two weeks met this threshold.

Candidate predictors, selected a priori, included age, sex, Charlson comorbidity index [23], vascular access type (tunneled internal jugular versus non-tunneled femoral or subclavian catheter) [20,21], intradialytic hypotension (systolic fall of 20 mmHg or more, or need for saline bolus or vasopressor) [19], prescribed ultrafiltration rate normalized to weight, residual urine output (>500 mL/24h versus oliguric) [22], baseline serum albumin, and RRT modality. Frailty was estimated retrospectively from admission documentation using a modified Fried phenotype proxy where direct measures were unavailable [24]. Groups were compared with t-tests or Mann-Whitney U tests and chi-square tests as appropriate, and independent predictors of inadequate dialysis were identified by multivariable logistic regression with backward elimination, retaining variables significant at $p < 0.10$ on univariable analysis; significance was set at $p < 0.05$. The protocol was approved by the institutional ethics committee, with a waiver of consent for retrospective, de-identified data.

3. Results

Three hundred eighteen elderly patients met inclusion criteria, contributing 2,046 hemodialysis sessions with paired urea measurements. Mean age was 74.8 ± 6.3 years, 56.9% were male, and mean Charlson index was 5.4 ± 2.1 . Sepsis (41.2%) and cardiac surgery-associated AKI (18.6%) were the leading precipitants. Vascular access was non-tunneled in 61.9% and tunneled in 38.1% of patients. Baseline characteristics are summarized in Table 1; non-tunneled patients were more often oliguric at RRT initiation and had a higher Charlson index.

Overall, 61.5% of sessions achieved $\text{spKt/V} \geq 1.2$ (mean 1.19 ± 0.28), and 123 of 318 patients (38.7%) had overall inadequate dialysis. Delivered spKt/V was lower with non-tunneled than tunneled access (1.10 ± 0.26 versus 1.32 ± 0.24 , $p < 0.001$), consistent with access-related clearance differences described in the sustained low-efficiency dialysis literature [20,21]. Intradialytic

hypotension occurred in 34.6% of sessions and was more frequent among patients with overall inadequate dialysis (49.6% versus 25.8% of sessions, $p < 0.001$), consistent with the truncated treatment time previously linked to hypotension elsewhere [19]. Figure 1 summarizes delivered spKt/V by access type and hypotension status.

Table 1: Baseline characteristics of elderly patients with acute kidney injury requiring renal replacement therapy, by vascular access type [23,17].

Characteristic	Non-tunneled access (n=197)	Tunneled access (n=121)
Mean age (years)	75.6 ± 6.1	73.5 ± 6.4
Male sex	58.4%	54.5%
Charlson comorbidity index	5.8 ± 2.0	4.7 ± 2.1
Oliguric at RRT initiation	66.5%	48.8%
Sepsis as AKI precipitant	46.7%	32.2%

Table 2: Independent predictors of overall inadequate dialysis on multivariable logistic regression [15,16,22].

Predictor	Adjusted odds ratio	95% CI	p-value
Non-tunneled vascular access	2.24	1.38-3.64	0.001
Intradialytic hypotension	2.71	1.69-4.34	<0.001
Serum albumin <2.5 g/dL	2.05	1.24-3.39	0.005
Ultrafiltration rate >13 mL/kg/h	1.86	1.14-3.03	0.012
Residual urine output >500 mL/24h	0.52	0.31-0.87	0.013

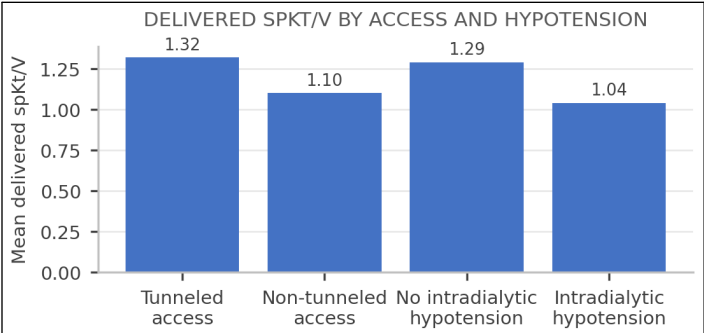


Figure 1: Mean delivered single-pool Kt/V by vascular access type and by presence or absence of intradialytic hypotension, both associated with reduced clearance in the wider dialysis-access and hemodynamic-tolerance literature [20,19].

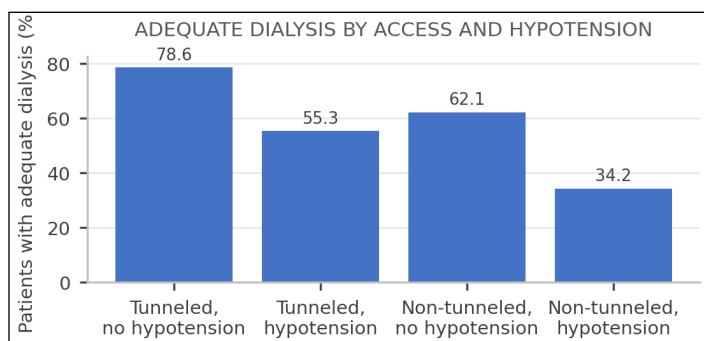


Figure 2: Proportion of patients achieving overall adequate dialysis stratified jointly by vascular access type and intradialytic hypotension status, showing a compounding effect of the two factors on delivered dialysis dose [21,19].

Residual urine output above 500 mL/24h, present in 28.6% of the cohort, was associated with a higher proportion of adequate sessions, consistent with residual native clearance supplementing dialytic clearance in the incremental-hemodialysis literature [22]. Serum albumin was lower in patients with inadequate dialysis (2.6 ± 0.5 versus 3.1 ± 0.6 g/dL, $p < 0.001$), and ultrafiltration rate above 13 mL/kg/h was more common in this group (44.7% versus 21.5%, $p < 0.001$). Table 2 presents the multivariable regression for overall inadequate dialysis. After adjustment, independent predictors were non-tunneled access (adjusted odds ratio [aOR] 2.24, 95% CI 1.38-3.64), intradialytic hypotension (aOR 2.71, 95% CI 1.69-4.34), albumin < 2.5 g/dL (aOR 2.05, 95% CI 1.24-3.39), and ultrafiltration rate > 13 mL/kg/h (aOR 1.86, 95% CI 1.14-3.03), while residual urine output was protective (aOR 0.52, 95% CI 0.31-0.87). Age was not independently predictive (aOR 1.02 per year, 95% CI 0.99-1.05), and Charlson tertile approached but did not reach significance (aOR 1.61, 95% CI 0.97-2.67, highest versus lowest tertile). Figure 2 shows adequate dialysis stratified jointly by access type and hypotension status, illustrating their compounding effect.

4. Discussion

More than a third of this elderly AKI cohort failed to achieve adequate dialysis, and the independent predictors of inadequacy were predominantly modifiable features of

dialysis delivery rather than fixed patient characteristics. Vascular access, intradialytic hypotension, ultrafiltration rate, and hypoalbuminemia accounted for most of the variance, while age and comorbidity burden contributed little once these process variables were adjusted for, consistent with the broader literature that dose delivered in practice, not dose prescribed, determines measured adequacy [14,16].

The association between non-tunneled access and inadequate dialysis reflects a long-recognized limitation of AKI-RRT delivery: access placement is dictated by acuity, so femoral and subclavian catheters, more prone to kinking and recirculation, are disproportionately used in the sickest patients least able to tolerate a prolonged session to compensate [20]. Comparative RRT literature similarly finds that achieved clearance depends heavily on access performance and treatment time rather than modality choice alone [21,28]. Residual urine output being protective mirrors the incremental-hemodialysis literature, where preserved native clearance offsets a lower dialytic dose, suggesting adequacy targets might reasonably be individualized downward in patients who retain substantial urine output [22].

Intradialytic hypotension was among the strongest independent predictors, consistent mechanistically with truncated effective treatment time and reduced clearance regardless of prescribed blood flow, an association previously described in broader dialysis populations [19]. Elderly, often vasopressor-dependent AKI patients are particularly susceptible, so hemodynamic tolerance during the session, not just the prescribed parameters, deserves attention as a modifiable determinant of delivered dose. Hypoalbuminemia's association with inadequacy likely reflects both illness severity and a genuine contribution to altered urea distribution volume, consistent with prior work linking comorbidity and physiologic reserve to dialysis tolerance [23,25,24].

That chronological age was not independently predictive

once process-of-care variables were included suggests the excess morbidity long observed with AKI-RRT in elderly patients [29,30,31] may be driven substantially by how dialysis is delivered rather than by unmodifiable age-related physiology, consistent with the shift in AKI-RRT trials toward individualized, physiology-guided prescription rather than age-stratified dosing [17,7,8,9,10]. Whether closer attention to access selection, hemodynamic tolerance, and ultrafiltration pacing would narrow this gap is a reasonable hypothesis for prospective study, informed by literature showing gentler, more frequent sessions can improve delivered dose and tolerance simultaneously [32,33].

This single-center retrospective study has limitations. Frailty was estimated from documentation rather than measured directly. Adequacy metrics could not be applied uniformly to patients who transitioned to sustained low-efficiency dialysis, a modality decision itself potentially confounded with the hypotension predictor [20]. Generalizability is limited given known variation in AKI epidemiology and RRT practice across centers [1,4], and this analysis addresses delivered dose as an intermediate outcome rather than hard endpoints such as recovery or survival, which the larger trial literature has addressed more directly [7,8,34,6].

5. Conclusion

In this cohort of elderly patients with dialysis-requiring acute kidney injury, more than one in three did not achieve adequate dialysis by Kt/V-based criteria, and inadequacy was independently predicted by non-tunneled vascular access, intradialytic hypotension, high ultrafiltration rate, and hypoalbuminemia, while residual urine output was protective. Chronological age was not independently predictive once these variables were accounted for, suggesting the adequacy gap in elderly AKI patients is substantially modifiable. Attention to vascular access selection, hemodynamic tolerance, and individualized ultrafiltration targets represents a practical

opportunity to improve delivered dialysis dose in this population, and prospective studies linking these process measures to renal recovery and survival are warranted.

6. Declarations

Acknowledgements: The authors thank the nephrology and dialysis nursing staff for assistance with data verification. **Funding:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. **Conflict of Interest:** The authors declare no conflict of interest. **Author Contributions:** K.D. conceived the study, supervised data collection, and drafted the manuscript; Z.A. performed the chart review and statistical analysis; A.A. contributed to study design, data interpretation, and critical revision of the manuscript; all authors approved the final manuscript.

Ethics Statement: The study protocol was reviewed and approved by the institutional ethics committee and conducted in accordance with the Declaration of Helsinki; the requirement for individual informed consent was waived given the retrospective, de-identified nature of the data. **Data Availability:** The de-identified dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

7. References

1. Hoste, E.A.J., Bagshaw, S.M., Bellomo, R., Cely, C.M., Colman, R., Cruz, D.N., et al. (2015) Epidemiology of acute kidney injury in critically ill patients: the multinational AKI-EPI study. *Intensive Care Medicine*, 41(8): 1411-1423. DOI: [10.1007/s00134-015-3934-7](https://doi.org/10.1007/s00134-015-3934-7)
2. Susantitaphong, P., Cruz, D.N., Cerda, J., Abulfaraj, M., Alqahtani, F., Koulouridis, I., et al. (2013) World incidence of AKI: a meta-analysis. *Clinical Journal of the American Society of Nephrology*, 8(9): 1482-1493. DOI: [10.2215/CJN.00710113](https://doi.org/10.2215/CJN.00710113)
3. Hoste, E.A.J., Kellum, J.A., Selby, N.M., Zarbock, A., Palevsky, P.M., Bellomo, R., et al. (2018) Global epidemiology and

- outcomes of acute kidney injury. Nature Reviews Nephrology, 14(10): 607-625. DOI: [10.1038/s41581-018-0052-0](https://doi.org/10.1038/s41581-018-0052-0)
4. Uchino, S., Kellum, J.A., Bellomo, R., Doig, G.S., Morimatsu, H., Morgera, S., et al. (2005) Acute renal failure in critically ill patients: a multinational, multicenter study. JAMA, 294(7): 813-818. DOI: [10.1001/jama.294.7.813](https://doi.org/10.1001/jama.294.7.813)
5. Chertow, G.M., Burdick, E., Honour, M., Bonventre, J.V., Bates, D.W. (2005) Acute kidney injury, mortality, length of stay, and costs in hospitalized patients. Journal of the American Society of Nephrology, 16(11): 3365-3370. DOI: [10.1681/ASN.2004090740](https://doi.org/10.1681/ASN.2004090740)
6. Coca, S.G., Yusuf, B., Shlipak, M.G., Garg, A.X., Parikh, C.R. (2009) Long-term risk of mortality and other adverse outcomes after acute kidney injury: a systematic review and meta-analysis. American Journal of Kidney Diseases, 53(6): 961-973. DOI: [10.1053/j.ajkd.2008.11.034](https://doi.org/10.1053/j.ajkd.2008.11.034)
7. Palevsky, P.M., Zhang, J.H., O'Connor, T.Z., Chertow, G.M., Crowley, S.T., Choudhury, D., et al. (2008) Intensity of renal support in critically ill patients with acute kidney injury. New England Journal of Medicine, 359(1): 7-20. DOI: [10.1056/NEJMoa0802639](https://doi.org/10.1056/NEJMoa0802639)
8. RENAL Replacement Therapy Study Investigators, Bellomo, R., Cass, A., Cole, L., Finfer, S., Gallagher, M., et al. (2009) Intensity of continuous renal-replacement therapy in critically ill patients. New England Journal of Medicine, 361(17): 1627-1638. DOI: [10.1056/NEJMoa0902413](https://doi.org/10.1056/NEJMoa0902413)
9. Gaudry, S., Hajage, D., Schortgen, F., Martin-Lefevre, L., Pons, B., Boulet, E., et al. (2016) Initiation strategies for renal-replacement therapy in the intensive care unit. New England Journal of Medicine, 375(2): 122-133. DOI: [10.1056/NEJMoa1603017](https://doi.org/10.1056/NEJMoa1603017)
10. STARRT-AKI Investigators, Bagshaw, S.M., Wald, R., Adhikari, N.K.J., Bellomo, R., da Costa, B.R., et al. (2020) Timing of initiation of renal-replacement therapy in acute kidney injury. New England Journal of Medicine, 383(3): 240-251. DOI: [10.1056/NEJMoa2000741](https://doi.org/10.1056/NEJMoa2000741)
11. Zarbock, A., Kellum, J.A., Schmidt, C., Van Aken, H., Wempe, C., Pavenstadt, H., et al. (2016) Effect of early vs delayed initiation of renal replacement therapy on mortality in critically ill patients with acute kidney injury: the ELAIN randomized clinical trial. JAMA, 315(20): 2190-2199. DOI: [10.1001/jama.2016.5828](https://doi.org/10.1001/jama.2016.5828)
12. Barbar, S.D., Clere-Jehl, R., Bourredjem, A., Hernu, R., Montini, F., Bruyere, R., et al. (2018) Timing of renal-replacement therapy in patients with acute kidney injury and sepsis. New England Journal of Medicine, 379(15): 1431-1442. DOI: [10.1056/NEJMoa1803213](https://doi.org/10.1056/NEJMoa1803213)
13. Eknoyan, G., Beck, G.J., Cheung, A.K., Daugirdas, J.T., Greene, T., Kusek, J.W., et al. (2002) Effect of dialysis dose and membrane flux in maintenance hemodialysis. New England Journal of Medicine, 347(25): 2010-2019. DOI: [10.1056/NEJMoa021583](https://doi.org/10.1056/NEJMoa021583)
14. Gotch, F.A., Sargent, J.A. (1985) A mechanistic analysis of the National Cooperative Dialysis Study (NCDS). Kidney International, 28(3): 526-534. DOI: [10.1038/ki.1985.160](https://doi.org/10.1038/ki.1985.160)
15. Daugirdas, J.T. (1993) Second generation logarithmic estimates of single-pool variable volume Kt/V: an analysis of error. Journal of the American Society of Nephrology, 4(5): 1205-1213. DOI: [10.1681/ASN.V451205](https://doi.org/10.1681/ASN.V451205)
16. National Kidney Foundation (2015) KDOQI Clinical Practice Guideline for Hemodialysis Adequacy: 2015 update. American Journal of Kidney Diseases, 66(5): 884-930. DOI: [10.1053/j.ajkd.2015.07.015](https://doi.org/10.1053/j.ajkd.2015.07.015)
17. KDIGO AKI Work Group (2012) KDIGO Clinical Practice Guideline for Acute Kidney Injury. Kidney International Supplements, 2(1): 1-138. DOI: [10.1038/kisup.2012.1](https://doi.org/10.1038/kisup.2012.1)
18. Kellum, J.A., Lameire, N., KDIGO AKI Guideline Work Group (2013) Diagnosis, evaluation, and management of acute kidney injury: a KDIGO summary. Critical Care, 17(1): 204. DOI: [10.1186/cc11454](https://doi.org/10.1186/cc11454)

19. Flythe, J.E., Kimmel, S.E., Brunelli, S.M. (2011) Rapid fluid removal during dialysis is associated with cardiovascular morbidity and mortality. *Kidney International*, 79(2): 250-257. DOI: [10.1038/ki.2010.383](https://doi.org/10.1038/ki.2010.383)
20. Marshall, M.R., Golper, T.A., Shaver, M.J., Alam, M.G., Chatoth, D.K. (2001) Sustained low-efficiency dialysis for critically ill patients requiring renal replacement therapy. *Kidney International*, 60(2): 777-785. DOI: [10.1046/j.1523-1755.2001.060002777.x](https://doi.org/10.1046/j.1523-1755.2001.060002777.x)
21. Uehlinger, D.E., Jakob, S.M., Ferrari, P., Eichelberger, M., Huynh-Do, U., Marti, H.P., et al. (2005) Comparison of continuous and intermittent renal replacement therapy for acute renal failure. *Nephrology Dialysis Transplantation*, 20(8): 1630-1637. DOI: [10.1093/ndt/gfh880](https://doi.org/10.1093/ndt/gfh880)
22. Vilar, E., Wellsted, D., Chandna, S.M., Greenwood, R.N., Farrington, K. (2009) Residual renal function improves outcome in incremental haemodialysis despite reduced dialysis dose. *Nephrology Dialysis Transplantation*, 24(8): 2502-2510. DOI: [10.1093/ndt/gfp071](https://doi.org/10.1093/ndt/gfp071)
23. Charlson, M.E., Pompei, P., Ales, K.L., MacKenzie, C.R. (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *Journal of Chronic Diseases*, 40(5): 373-383. DOI: [10.1016/0021-9681\(87\)90171-8](https://doi.org/10.1016/0021-9681(87)90171-8)
24. Fried, L.P., Tangen, C.M., Walston, J., Newman, A.B., Hirsch, C., Gottdiener, J., et al. (2001) Frailty in older adults: evidence for a phenotype. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 56(3): M146-M156. DOI: [10.1093/gerona/56.3.m146](https://doi.org/10.1093/gerona/56.3.m146)
25. Metnitz, P.G.H., Krenn, C.G., Steltzer, H., Lang, T., Ploder, J., Lenz, K., et al. (2002) Effect of acute renal failure requiring renal replacement therapy on outcome in critically ill patients. *Critical Care Medicine*, 30(9): 2051-2058. DOI: [10.1097/00003246-200209000-00016](https://doi.org/10.1097/00003246-200209000-00016)
26. Bellomo, R., Ronco, C., Kellum, J.A., Mehta, R.L., Palevsky, P. (2004) Acute renal failure - definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. *Critical Care*, 8(4): R204-212. DOI: [10.1186/cc2872](https://doi.org/10.1186/cc2872)
27. Mehta, R.L., Kellum, J.A., Shah, S.V., Molitoris, B.A., Ronco, C., Warnock, D.G., et al. (2007) Acute Kidney Injury Network: report of an initiative to improve outcomes in acute kidney injury. *Critical Care*, 11(2): R31. DOI: [10.1186/cc5713](https://doi.org/10.1186/cc5713)
28. Vinsonneau, C., Camus, C., Combes, A., Costa de Beauregard, M.A., Klouche, K., Boulain, T., et al. (2006) Continuous venovenous haemodiafiltration versus intermittent haemodialysis for acute renal failure in patients with multiple-organ dysfunction syndrome. *Lancet*, 368(9533): 379-385. DOI: [10.1016/S0140-6736\(06\)69111-3](https://doi.org/10.1016/S0140-6736(06)69111-3)
29. Kurella, M., Covinsky, K.E., Collins, A.J., Chertow, G.M. (2007) Octogenarians and nonagenarians starting dialysis in the United States. *Annals of Internal Medicine*, 146(3): 177-183. DOI: [10.7326/0003-4819-146-3-200702060-00006](https://doi.org/10.7326/0003-4819-146-3-200702060-00006)
30. Kurella Tamura, M., Covinsky, K.E., Chertow, G.M., Yaffe, K., Landefeld, C.S., McCulloch, C.E. (2009) Functional status of elderly adults before and after initiation of dialysis. *New England Journal of Medicine*, 361(16): 1539-1547. DOI: [10.1056/NEJMoa0904655](https://doi.org/10.1056/NEJMoa0904655)
31. Wald, R., Quinn, R.R., Luo, J., Li, P., Scales, D.C., Mamdani, M.M., et al. (2009) Chronic dialysis and death among survivors of acute kidney injury requiring dialysis. *JAMA*, 302(11): 1179-1185. DOI: [10.1001/jama.2009.1322](https://doi.org/10.1001/jama.2009.1322)
32. Schiff, H., Lang, S.M., Fischer, R. (2002) Daily hemodialysis and the outcome of acute renal failure. *New England Journal of Medicine*, 346(5): 305-310. DOI: [10.1056/NEJMoa010877](https://doi.org/10.1056/NEJMoa010877)
33. Ronco, C., Bellomo, R., Homel, P., Brendolan, A., Dan, M., Piccinni, P., et al. (2000) Effects of different doses in continuous veno-venous haemofiltration on outcomes of acute renal failure: a prospective randomised trial. *Lancet*, 356(9223): 26-30. DOI: [10.1016/S0140-6736\(00\)02430-2](https://doi.org/10.1016/S0140-6736(00)02430-2)

Citation: Diallo K, Adeyemi Z, Achebe A (2019) Predictors of dialysis adequacy in elderly renal patients with acute kidney injury. Arch Nephrol, 2(1): 01-06.

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34. Hsu, R.K., Hsu, C.Y. (2016) The role of acute kidney injury in chronic kidney disease. Seminars in Nephrology, 36(4): 283-292. DOI: [10.1016/j.semnephrol.2016.05.005](https://doi.org/10.1016/j.semnephrol.2016.05.005)

