Blood Urea Nitrogen Stability: A Feasibility Study for Home Hemodialysis Adequacy Testing Through Mail

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*U*rea *kinetic modeling measures the delivered dose of hemodialysis and is used to monitor dialysis adequacy. Obtaining samples for adequacy calculations is a challenge for home hemodialysis (HHD) patients. Ideally, the urea reduction ratio (URR) should be measured at a typical dialysis session; therefore, for HHD patients test specimens should be drawn at home and transferred to a clinical laboratory. Would blood urea nitrogen (BUN) remain stable if samples were mailed to the laboratory? To answer this question, BUN was measured in pre- and postdialysis samples from 20 patients over 8 days of laboratory storage. While BUN values varied among the patient population, neither pre- nor postdialysis values showed any significant variation during the 8-day storage time. These results suggest that BUN values are sufficiently stable for specimens to be drawn at home and mailed to a testing laboratory.*

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Key words

Hemodialysis adequacy, blood urea nitrogen stability, urea reduction ratio

Introduction

According to the National Kidney Foundation Dialysis Outcomes Quality Initiative guidelines [1], the prescribed hemodialysis dose should be routinely measured using urea kinetic modeling to monitor the delivered dose of hemodialysis. Mortality is lower [2], and the number of hospital days per patient per year also decreases [3] when a sufficient hemodialysis dose is delivered. Measuring hemodialysis dose presents a challenge for the home hemodialysis (HHD) patient. Ideally, Kt/V should be measured at a typical dialysis session; therefore, for HHD patients, test specimens should be drawn at home. It may be difficult to exactly reproduce all parameters of a home dialysis treatment when home patients come to an outpatient dialysis clinic for Kt/V determination. Specimens drawn at home may give a truer representation of the treatment, provided that the blood urea nitrogen (BUN) concentrations remain stable until measured in the laboratory.

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The purpose of this study was to determine if BUN values remained adequately stable to permit mailing from home to a testing laboratory.

Material and methods

Samples for this study were obtained from 20 patients dialyzed at a local clinic. Pre- and postdialysis blood samples were drawn for routine monthly evaluations. Postdialysis samples were obtained using a variation of the low-flow sampling technique [4]. At the completion of dialysis, the dialysate flow was turned off, blood flow was decreased to 80 mL/min, and, after a 20-second delay, the specimen was drawn from the arterial sampling port. Predialysis samples were drawn in serum separator tubes (SST Gel and Clot Activator, Vacutainer Systems, Becton Dickinson, Franklin Lakes, NJ, U.S.A.) and centrifuged for 20 minutes at 3000 revolutions per minute in a Clay Adams Dynac Model 420101 centrifuge (Becton Dickinson). Postdialysis samples were drawn into Vacutainer tubes containing lithium heparin. All samples were delivered to RenaLab, Inc., a local laboratory, on the same day they were drawn. The laboratory measured BUN values from both the pre- and postdialysis samples on each of 8 consecutive days. The samples were stored at room temperature throughout the study. Blood urea nitrogen measurements were done using Boehringer Mannheim's standard assay on a Hitachi 747-100 analyzer (Roche Diagnostics Corp., Indianapolis, IN, U.S.A.). Urea reduction ratios (URRs) were calculated using the formula

$$[(\text{predialysis urea} - \text{postdialysis urea})/\text{predialysis urea}] \times 100.$$

Results

Daily predialysis BUN values had a broad range of 43 – 83 mg/dL, due to patient-to-patient variations (Table I). Repeated values for individual patients were more consistent; differences from day 1 ranged between –2 and +4 mg/dL, corresponding to a maximum deviation of 2.3% of an individual patient's average BUN value for the entire testing period. Similarly, daily postdialysis BUN values for all patients ranged from 9 to 31 mg/dL; values for any individual varied by –2 to +5 mg/dL, corresponding to a maximum deviation of 10.7% of a patient's average value (Table II). Average day-to-day percent differences were well within acceptable testing standards according to the College of American Pathologists' accuracy-based evaluation criteria.

TABLE I   BUN values from predialysis samples during 8 days of storage

	BUN (mg/dL)									
Patient	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Average	SD
5760	73	76	77	73	74	74	76	77	75.0	1.69
5775	61	62	62	60	62	62	64	62	61.9	1.13
5734	53	55	53	52	53	53	56	55	53.8	1.39
5737	44	44	45	43	44	44	45	44	44.1	0.64
5777	69	70	71	68	69	69	71	70	69.6	1.06
5808	80	81	82	79	79	79	83	81	80.5	1.51
5710	73	74	74	71	72	72	75	75	73.3	1.49
5748	68	69	69	67	68	68	70	70	68.6	1.06
5741	54	54	55	53	54	54	56	56	54.5	1.07
5724	65	67	68	64	65	65	68	67	66.1	1.55
5717	78	81	80	78	79	79	83	82	80.0	1.85
5716	46	47	47	45	46	46	48	48	46.6	1.06
5689	75	77	77	74	74	74	76	77	75.5	1.41
5688	61	61	63	60	62	62	65	64	62.3	1.67
5727	63	64	64	62	63	63	65	65	63.6	1.06
5686	60	63	63	60	61	61	63	62	61.6	1.30
5740	62	65	64	61	63	63	64	65	63.4	1.41
5712	58	59	60	58	59	59	60	59	59.0	0.76
5748	68	69	69	67	68	68	70	70	68.6	1.06
5720	72	75	75	72	73	73	76	75	73.9	1.55
Average	64.2	65.7	65.9	63.4	64.4	64.4	66.7	66.2		
SD	9.7	10.2	10.1	9.8	9.6	9.6	10.1	10.1		

BUN = blood urea nitrogen; SD = standard deviation.

TABLE II   BUN values from postdialysis samples during 8 days of storage

	BUN (mg/dL)									
Patient	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Average	SD
5760	16	17	17	16	17	17	18	19	17.1	0.99
5775	15	16	16	15	17	17	19	20	16.9	1.81
5734	15	15	14	14	15	15	16	15	14.9	0.64
5737	12	12	12	12	13	13	13	13	12.5	0.53
5777	13	12	13	13	13	13	13	13	12.9	0.35
5808	16	16	16	15	16	16	17	17	16.1	0.64
5710	17	17	17	17	18	18	18	18	17.5	0.53
5748	18	18	18	17	18	18	18	19	18.0	0.53
5741	17	18	18	17	17	17	19	19	17.8	0.89
5724	20	20	20	20	20	20	20	21	20.1	0.35
5717	29	29	28	28	28	29	31	29	28.9	0.99
5716	10	10	10	10	10	9	11	11	10.1	0.64
5689	20	21	21	20	21	21	21	21	20.8	0.46
5688	23	23	23	21	22	22	22	22	22.3	0.71
5727	16	17	16	15	16	16	16	17	16.1	0.64
5686	20	20	20	19	20	20	20	20	19.9	0.35
5740	19	19	19	18	19	19	19	20	19.0	0.53
5712	14	15	14	14	15	15	15	17	14.9	0.99
5748	18	18	18	17	18	18	18	19	18.0	0.53
5720	26	27	27	26	27	27	31	28	27.4	1.60
Average	17.3	17.6	17.4	16.8	17.6	17.6	18.3	18.4		
SD	4.55	4.65	4.56	4.36	4.34	4.57	5.02	4.39		

BUN = blood urea nitrogen; SD = standard deviation.

Comparison of average pre- and postdialysis values for each patient revealed URRs ranging from 59.2% to 82.9% (Table III). Table IV presents the differences in URRs between day 1 and subsequent days. The ratios are essentially unchanged until day 6. The maximum deviation from day 1 did not exceed –2.8 or +2.7. The differences between day 1 and days 7 and 8 were higher, with an average difference of 1.1 and maximum deviations ranging from –7.7 at day 8 to +

TABLE III   Urea reduction ratios calculated from urea values shown in Tables I and II

Patient	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Average	SD
5760	78.1	77.6	77.9	78.1	77.0	77.0	76.3	75.3	77.2	0.97
5775	75.4	74.2	74.2	75.0	72.6	72.6	70.3	67.7	72.8	2.60
5734	71.7	72.7	73.6	73.1	71.7	71.7	71.4	72.7	72.3	0.80
5737	72.7	72.7	73.6	73.1	71.7	71.7	71.4	72.7	72.5	0.76
5777	72.7	72.7	73.3	72.1	70.5	70.5	71.1	70.5	71.7	1.19
5808	81.2	82.9	81.7	80.9	81.2	81.2	81.7	81.4	81.5	0.62
5710	80.0	80.2	80.5	81.0	79.7	79.7	79.5	79.0	80.0	0.62
5748	76.7	77.0	77.0	76.1	75.0	75.0	76.0	76.0	76.1	0.80
5741	73.5	73.9	73.9	74.6	73.5	73.5	74.3	72.9	73.8	0.54
5724	68.5	66.7	67.3	67.9	68.5	68.5	66.1	66.1	67.4	1.08
5717	69.2	70.1	70.6	68.8	69.2	69.2	70.6	68.7	69.6	0.78
5716	78.3	78.7	78.7	77.8	78.3	80.4	77.1	77.1	78.3	1.08
5689	73.3	72.7	72.7	73.0	71.6	71.6	72.4	72.7	72.5	0.61
5688	62.3	62.3	63.5	65.0	64.5	64.5	66.2	65.6	64.2	1.44
5727	74.6	73.4	75.0	75.8	74.6	74.6	75.4	73.8	74.7	0.77
5686	66.7	68.3	68.3	68.3	67.2	67.2	68.3	67.7	67.7	0.64
5740	69.4	70.8	70.3	70.5	69.8	69.8	70.3	69.2	70.0	0.55
5712	75.9	74.6	76.7	75.9	74.6	74.6	75.0	71.2	74.8	1.65
5748	73.5	73.9	73.9	74.6	73.5	73.5	74.3	72.9	73.8	0.54
5720	63.9	64.0	64.0	63.9	63.0	63.0	59.2	62.7	63.0	1.61
Average	72.9	73.0	73.3	73.3	72.4	72.5	72.3	71.8		
SD	5.06	5.12	4.94	4.75	4.70	4.86	5.11	4.69		

TABLE IV   Differences in urea reduction ratios between day 1 and subsequent days

Patient	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Average	SD
5760	0.0	−0.5	−0.2	0.0	−1.1	−1.1	−1.8	−2.8	−0.9	0.97
5775	0.0	−1.2	−1.2	−0.4	−2.8	−2.8	−5.1	−7.7	−2.7	2.60
5734	0.0	1.0	1.9	1.4	0.0	0.0	−0.3	1.0	0.6	0.80
5737	0.0	0.0	0.6	−0.6	−2.3	−2.3	−1.6	−2.3	−1.1	1.19
5777	0.0	1.7	0.5	−0.3	0.0	0.0	0.5	0.3	0.3	0.62
5808	0.0	0.2	0.5	1.0	−0.3	−0.3	−0.5	−1.0	−0.0	0.62
5710	0.0	0.3	0.3	−0.7	−1.7	−1.7	−0.7	−0.7	−0.6	0.80
5748	0.0	−1.9	−1.2	−0.6	0.0	0.0	−2.4	−2.4	−1.1	1.08
5741	0.0	−1.9	−1.2	−0.6	0.0	0.0	−2.4	−2.4	−1.1	1.08
5724	0.0	0.9	1.4	−0.5	0.0	0.0	1.4	−0.6	0.3	0.78
5717	0.0	1.4	2.2	1.3	1.7	0.5	−0.2	1.8	1.1	0.88
5716	0.0	0.5	0.5	−0.5	0.0	2.2	−1.2	−1.2	0.0	1.08
5689	0.0	−0.6	−0.6	−0.4	−1.7	−1.7	−1.0	−0.6	−0.8	0.61
5688	0.0	0.0	1.2	2.7	2.2	2.2	3.9	3.3	1.9	1.44
5727	0.0	−1.2	0.4	1.2	0.0	0.0	0.8	−0.8	0.1	0.77
5686	0.0	1.6	1.6	1.7	0.5	0.5	1.6	1.1	1.1	0.64
5740	0.0	1.4	1.0	1.1	0.5	0.5	1.0	−0.1	0.7	0.55
5712	0.0	−1.3	0.8	0.0	−1.3	−1.3	−0.9	−4.7	−1.1	1.65
5748	0.0	0.4	0.4	1.1	0.0	0.0	0.8	−0.7	0.2	0.54
5720	0.0	0.1	0.1	0.0	−0.9	−0.9	−4.7	−1.2	−0.9	1.61
Average	0.0	0.1	0.4	0.3	−0.4	−0.3	−0.6	−1.1		
SD	0.0	1.1	1.0	1.0	1.2	1.2	2.0	2.3		

3.9 at day 7. Even at days 7 and 8, where the differences were clinically important in some patients, these differences were not statistically significant.

Discussion

Typically, HHD patients come into the center to dialyze when adequacy testing is done. Ideally, adequacy testing should be measured at a typical dialysis session; therefore, for HHD patients test specimens should be drawn at home. Specimens drawn during a HHD session may give a truer representation of the treatment. Before implementing adequacy testing at home for HHD patients, we needed to assure that BUN levels are stable if samples are to be mailed to the laboratory. Blood specimens drawn in a dialysis clinic are typically tested within

24 hours. It was reasonable to assume that specimens mailed from home would arrive at a testing laboratory within 3 to 5 days. Therefore, we chose to study BUN stability over 8 days of storage. Pre- and postdialysis samples from 20 different patients were sent to our local testing laboratory and were stored at room temperature; BUN was determined on each of 8 consecutive days.

The resulting data demonstrated that pre- and postdialysis BUN values were essentially stable for 6 days of storage. Urea reduction ratios calculated from these values did not differ on days 1 – 6. Urea reduction ratios on days 7 and 8 were only minimally lower. Clinically, these changes were not significant, except for 2 patients on day 7, where the maximal deviations from day 1 were –4.7 and –5.1, and 2 patients with deviations of –4.7 and –7.7 on day 8.

In conclusion, BUN values from blood delivered to the laboratory and spun on the same day are stable at room temperature over the 3 to 5 days of estimated mailing time. Further studies are in progress to address the effect of actual mailing and to assess patient compliance with correct protocol.

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