Clinical characteristics of end stage renal disease patients at hemodialysis initiation

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- **ABSTRACT** -

Clinical characteristics of end stage renal disease patients at hemodialysis initiation

The starting time of renal replacement therapy (RRT) is a complicated issue, which is based on multiple factors including clinical, social and laboratory parameters. To help make decision on when to start hemodialysis in impending end stage renal disease (ESRD) patients, we investigated the clinical features of ESRD patients at the start of hemodialysis at a university hospital center in Korea. We retrospectively analyzed 409 ESRD patients who were newly started on hemodialysis treatment between January 2010 and December 2012. The most common cause of ESRD was diabetic nephropathy (48.7%), followed by biopsy-proven glomerulonephritis (11.7%). The mean eGFR at the start of hemodialysis, ranging between 5.59 – 7.82 ml/min/1.73m^2 (except Nankivell equation), were significantly different according to different equations. The modified Cockcroft-Gault, the MDRD and the CKD-EPI equations showed significant correlations with all categories of chronic kidney disease complications. The main reasons to start hemodialysis were fluid overload (38.4%) and uremic symptoms (35.0%). DM patents were older and started dialysis at higher eGFR levels than non-DM patients (mean eGFR by the MDRD equation, 6.92 ± 3.63 vs 5.41 ± 2.91, $p < 0.001$). Hemodialysis was started in 59.2% patents through outpatient clinic or admission after outpatient clinic (OPD group), and in the remaining 40.8% patients via emergency department (ER group). In the ER group, hyperkalemia and metabolic acidosis were significantly more severe than the OPD group. We hope our study will provide valuable information on the clinical and laboratory characteristics of the patients at the time of hemodialysis initiation in our current practices.

Keyword : End stage renal disease, hemodialysis, estimated glomerular filtration rate

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I. Introduction

Dialysis treatment has long been accepted as a life-saving treatment in end stage renal disease (ESRD), and now offers life-sustaining treatment to approximately two million ESRD patients around the world(1). European Renal Best Practice Guidelines recommend that dialysis should be started whenever an estimated glomerular filtration rate (eGFR) is < 15 ml/min and there are clinical indications such as symptoms or signs of uremia, inability to control hydration status or blood pressure, or a progressive deterioration in nutritional status. In any case, dialysis should be started before the eGFR falls to 6 ml/min/1.73 m^2, even if optimal pre-dialysis care has been provided and there are no symptoms(2). National Kidney Foundation Kidney Disease Quality Outcomes Initiative (KDOQI) clinical practice guidelines recommend that when the eGFR falls below 15 ml/min/1.73 m^2, nephrologists should evaluate the benefits, risks and disadvantages of beginning kidney replacement therapy. The KDOQI guidelines state that there are theoretical considerations to support the initiation of dialysis therapy at a GFR of approximately 10 mL/min/1.73 m^2, and even when the eGFR is above 15 ml/min/1.73m^2, certain signs and symptoms may justify the initiation of dialysis. In addition, the guidelines suggest that earlier dialysis initiation can be associated with a lower risk of death(3).

However, in current clinical practice, only a small number of Korean patients are starting dialysis according to these recommendations, mainly because most of them want to delay the initiation of dialysis as much as possible. Decision making of the optimal time to start renal replacement therapy (RRT) is a complicated issue, which is entangled with multiple factors including clinical, social and laboratory parameters. In the present study, we aim to investigate clinical features of ESRD patients at the start of hemodialysis at a tertiary care university hospital in Korea. We hope our study will provide valuable information on the clinical and laboratory characteristics of the patients at the time of hemodialysis initiation in our current practices, thus helping to make decision on when to start hemodialysis in impending ESRD patients.

II. Methods

A. Patients

In our retrospective study, we analyzed ESRD patients who were newly started on hemodialysis treatment between January 2010 and December 2012. Inclusion criteria were age ≥ 18 years and starting hemodialysis for the first time. Data regarding clinical and demographic characteristics including age, gender, height, weight, systolic and diastolic blood pressures, causes of ESRD, and comorbidities including diabetes mellitus (DM) and hypertension, were collected. DM was defined based on the presence of documented or self-reported history of diabetes or diabetic retinopathy, or the presence of diabetic medication(s) in patients' prescription records. Hypertension was defined in the same way as in diabetes.

B. Laboratory data

Blood urea nitrogen (BUN), creatinine, bone mineral markers (intact parathyroid hormone, phosphorus, and total calcium), a nutritional marker (albumin), metabolic acidosis markers (total CO_2 content) and anemia markers (hemoglobin, hematocrit) were collected. All laboratory data except intact parathyroid hormone (iPTH) were obtained within one day prior to the start of hemodialysis. Intact PTH levels were obtained within 3 months before the start of hemodialysis or within 3 days after the start of hemodialysis.

C. *Estimated glomerular filtration rate*

A great number of mathematical equations have been developed over the years in order to provide physicians with the best GFR estimate possible. To estimate GFR, we used several equations. These five equations are as follows:

(1) Cockcroft-Gault equation(4)

(140-age[years]) x (weight[kg]) x (0.85 if female) / (72 x Cr[mg/dl])

(2) Modified Cockcroft-Gault equation

Creatinine clearance by Cockroft-Gault equation adjusted for BSA(m^2)

(140-age[years]) x (weight[kg]) x (0.85 if female) / (72 x Cr[mg/dl]) x 1.73/BSA(m^2)

(3) Four-variable Modification of Diet in Renal Disease (MDRD) equation(5)

186.3 x (serum creatinine[mg/dl])$^{-1.154}$ x (age[years])$^{-0.203}$ x (0.742 if female)

(4) CKD-EPI equation(6)

141 X min(Scr[mg/dl]/κ,1)$^{\alpha}$ x max(Scr[mg/dl]/κ,1)$^{-1.209}$ x $0.993^{Age[years]}$ x 1.018 [if female] x 1.159 [if black]

Where κ is 0.7 for females and 0.9 for males, α is –0.329 for females and –0.411 for males, min indicates the minimum of Scr/κ or 1, and max indicates the maximum of Scr/κ or 1

(5) Nankivell equation(7)

(6.7/serum creatinine[mmol/L]) + (weight[kg]/4) – (serum urea[mmol/L]/2) – (100/height[m^2]) + (35 if males and 25 if females)

D. Statistical analysis

Continuous variables were described as means with standard deviation (SD) and categorical variables as proportions. Differences between the subgroups were assessed using chi-square tests for categorical variables and Student's t-tests for continuous variables. The means of eGFR equations were compared using paired t-tests. The coefficient of variation (CV) was calculated as the percent ratio of the standard deviation to the mean. Values of $P < 0.05$ were considered statistically significant. Correlations between variables were assessed by Pearson correlation tests. The correlation coefficient γ measures the strength of the relationship between eGFR and CKD complications. The analyses were performed using the Statistical Package for Social Sciences (SPSS for Windows 18.0, SPSS Inc., Chicago, IL).

III. Results

A total of 1,369 patients received hemodialysis for the first time at Ajou University Hospital between January 2010 and December 2012. Of these, 660 patients were excluded because they had started hemodialysis previously in other centers. Other excluded patients were 240 who received hemodialysis for management of acute kidney injury, 17 who received preemptive hemodialysis for preparation of kidney transplantation, 11 who returned to hemodialysis following renal allograft failure, and 23 who switched to hemodialysis from peritoneal dialysis. Finally, 409 patients who started maintenance hemodialysis for management of ESRD were included in the present analysis. Table 1 summarizes the patients' demographics and the causes of ESRD. The mean age was 58.58 ± 14.57 years, and 52.6 % of the patients were male. Comorbidities were common, particularly hypertension (81.9 %) and DM (52.8 %). 28.9 % of patients were referred to the nephrologist < 3 months before the start of hemodialysis. The most common cause of ESRD was diabetic nephropathy (48.7 %), similar to the 2012 data of Korean Society of Nephrology (50.6 %) (8), followed by biopsy-proven glomerulonephritis (11.7 %). Clinically suspicious but not biopsy-confirmed chronic glomerulonephritis cases were classified as "unknown". Polycystic kidney diseases accounted for 3.2 % of the causes.

The laboratory and clinical characteristics at the start of hemodialysis are listed in Table 2. The mean systolic and diastolic blood pressures were 153.20 ± 25.43 mmHg, and 81.57 ± 16.24 mmHg, respectively and all of the patients were on antihypertensive treatment. Laboratory data showed the expected complications from CKD including anemia, hypocalcemia, hyperphosphatemia, metabolic acidosis and hyperparathyroidism. Nearly half (46.2 %) of patients had albumin levels ≤ 3.5 g/dl, which reflects poor nutritional status of the patients. The mean eGFR at the start of hemodialysis were significantly different according to different equations (Table 3). The highest mean eGFR was derived from the modified C-G equation (7.82 ± 3.60 ml/min/1.73m^2) followed by the C-G (7.67 ± 3.80 ml/min/1.73m^2), MDRD (6.22 ± 3.39 ml/min/1.73m^2), CKD-EPI

(5.59 ± 3.16 ml/min/1.73m^2) and lastly the Nankivell equation (0.10 ± 12.74 ml/min/1.73m^2). To evaluate the extent of variability in relation to mean eGFR, we calculated CV of each eGFR and the results showed that the CV of the modified C-G equation (46.0 %) was the smallest among the included equations, whereas the Nankivell equation showed the biggest CV (127.4 %) despite its lowest eGFR value (Table 3).

Next, we evaluated the correlation between each eGFR and CKD specific complications including hypertension, anemia, hyperkalemia, metabolic acidosis, hypocalcemia, hyperphosphatemia and hyperparathyroidism (Table 4). We found that the modified C-G, the MDRD and the CKD-EPI equations showed significant correlations with all categories of CKD complications, suggesting that these equations are better than the other ones in reflecting actual clinical status of the patients having the degree of renal functions requiring the start of dialysis treatment. In contrast, the eGFR from the Nankivell equation even showed a paradoxical relationship with hypertension as well as with serum calcium levels, suggesting that this equation, derived from kidney transplant recipients, poorly reflects the actual clinical status of the patients included in the present study.

The main reasons to start hemodialysis were shown in Figure 1. The most common reason was fluid overload (38.4 %) such as peripheral and pulmonary edema unresponsive to diuretics, followed by uremic symptoms (35.0 %) including anorexia, nausea, fatigue, anemia and pruritus. Other reasons were progressive azotemia (high BUN and creatinine), hyperkalemia, metabolic acidosis, uremic encephalopathy, and uremic pericarditis.

Next, we analyzed the data according to the presence of DM (Table 5). DM patients (216 patients, 52.8 %) were older than non-DM patients (193 patients, 47.2 %) at the time of hemodialysis initiation (age, 61.13 ± 11.52 vs 55.69 ± 17.02, $p < 0.001$). DM patients started dialysis at higher eGFR levels than non-DM patients (mean eGFR by MDRD equation, 6.923 ± 3.635 vs 5.411 ± 2.912, $p < 0.001$). DM patients showed lower albumin levels compared to non-DM patients, whereas DM patients were better in metabolic acidosis, hyperphosphatemia, and hyperparathyroidism.

Finally, we analyzed the data after sub-grouping the patients into outpatient department

(OPD) visits and emergency department (ER) visits. Among the 409 patients, 242 (59.2 %) patients started hemodialylsis through OPD or admission after OPD, and the remaining 167 (40.8 %) patients started hemodialysis via ER visits. There were significant differences in the causes to start hemodialysis between the two groups (Table 6): The most common causes for the ER group were fluid overload (48.5 %) and then uremic symptoms (31.9%), whereas they were uremic symptoms (40.5 %) followed by fluid overload (31.4%) for the OPD group. Hyperkalemia (serum potassium level, OPD group 4.99 ± 0.92 mg/dL vs. ER group 5.27 ± 1.24 mg/dL, $p = 0.014$) and metabolic acidosis (serum total bicarbonate level, OPD group 16.83 ± 4.15 mMol/L vs. ER group 14.37 ± 5.20 mMol/L, $p < 0.001$) were significantly more severe in the ER group compared to the OPD group.

IV. Discussions

In this study, we assessed the clinical characteristics of ESRD patients at hemodialysis start at a tertiary care university center in Korea. In clinical practice, eGFR is widely used in the evaluation of renal function and several such equations are available including the C-G, modified C-G, MDRD, CKD-EPI and Nankivell equations. In addition to collecting clinical and laboratory data, we calculated eGFR using these equations to know the timing of dialysis initiation in actual clinical practice. However, there is no consensus regarding their use when the residual renal function is minimal and renal replacement therapy is impending(9, 10). The best method to determine GFR in advanced renal failure is to calculate from a 24 hour urine collection and to normalize it to 1.73m^2. In reality, however, it is difficult to monitor renal function by repeatedly collecting 24 hour urine to estimate the time for RRT start, which prompted us to compare the various eGFR equations to determine the most suitable one to define the GFR at which the patients should not wait any longer to start dialysis. Many investigations have tried to determine the optimal timing of initiating dialysis by comparing clinical outcomes in patients with chronic renal failure starting dialysis at various pre-defined levels of GFR, only to produce mixed and inconclusive results(11-14). In our study, the mean eGFR calculated by the equations except Nankivell equation ranged between 5.59 and 7.82 ml/min/1.73m^2 immediately prior to the start of hemodialysis, indicating the delayed initiation of hemodialysis treatment in our clinical settings compared to the recommendations of existing guidelines, which is attributed to the fact that most of our patients want to delay the initiation of dialysis as long as they can in order to keep extra time free of dialysis. The next question is which equation we should use to define the eGFR value to start dialysis, and we found that the eGFRs at dialysis initiation have large dispersion (CV) indicating that the utility of the included eGFR equations for such purpose is hard to be validated, though we can suggest that the modified C-G may best fit for it given its good correlations with CKD complications and the smallest CV.

The retrospective analysis of the USRDS data have shown that the early initiation of dialysis is associated with the presence of DM(14), which is consistent with our data showing that the DM patients were more likely to be started on dialysis earlier than the non-DM patients. Previous data showed that, though this issue is beyond the scope of our study, patients who initiate dialysis at higher eGFR levels usually have a greater comorbidity burden and diabetes and are less able to tolerate uremic symptoms, which exert unfavorable effects on survival, thus culminating in the results showing higher mortality risks associated with early dialysis initiation(15).

In the present study, DM patients were different from the non-DM patients in some of the clinical features at the time of hemodialysis initiation. The most common cause of dialysis start in DM patients was fluid overload in contrast to uremic symptoms in non-DM patients, which reflects increased capillary permeability leading to increased edema in DM patients. DM patients started hemodialysis at a higher eGFR than non-DM patients though DM patients had less severe metabolic acidosis, hyperphosphatemia, and hyperparathyroidism than non-DM patients. It may be because DM patients were older, and more prone to have fluid overload compared to DM patients.

We compared the patients who presented to the ER with those who presented to OPD hypothesizing that the former may have lower eGFR than the latter, however, there were no differences in the mean eGFR between the two groups to the contrary to our expectation. The two groups were different in that the ER group started hemodialysis more commonly due to fluid overload, and developed more severe hyperkalemia and metabolic acidosis than the OPD group.

In summary, the mean eGFRs at hemodialysis start were between 5.59 and 7.82 ml/min/1.73m^2 by the C-G, modified C-G, MDRD and the CKD-EPI equations. The modified C-G, MDRD and the CKD-EPI equations were well correlated with all CKD specific complications and the modified C-G equation showed the smallest CV among all five equations. DM patients started hemodialysis at higher eGFR levels than non-DM patients which may be due to higher degree of fluid overload in DM patients. The patients who started hemodialysis in ER did not differ in eGFR compared to the OPD patients. We hope that our study may improve our understanding of the clinical

characteristics of the patients requiring immediate dialysis initiation, thus helping predict the timing of dialysis initiation in CKD patients. To better understand the utility of eGFR for such purpose, direct comparison of eGFR and measured GFR from 24 hour urine collection is warranted in the future studies.

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Fig1. Reasons to start hemodialysis. (N=409)

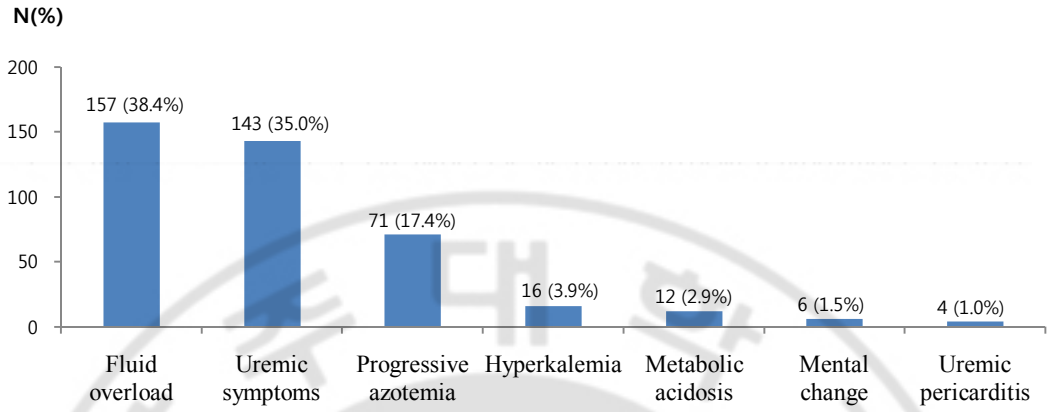

Table 1. Baseline Characteristics of the patients. (N=409)

	Mean (± SD) or N (%)
Gender	
Males	215 (52.6%)
Females	194 (46.4%)
Age (years)	58.58 ± 14.57
Height (cm)	162.47 ± 9.20
Weight (kg)	63.23 ± 12.68
BMI (kg/m^2)	24.30 ± 9.06
Comorbidities	
Hypertension	335 (81.9%)
Duration (years)	9.96 ± 8.56
Diabetes mellitus	216 (52.8%)
Duration (years)	16.34 ± 8.43
Follow up by nephrologists	
For < 3months	118 (28.9%)
For ≥ 3months	291 (71.1%)
Causes of renal failure	
Diabetic nephropathy	197 (48.2%)
Chronic glomerulonephritis[1]	48 (11.7%)
IgA nephropathy	29
Henoch Schoin Purpura	2
Focal Segmental Glomerulosclerosis	4
Membranoproliferative GN†	3
Membranous GN†	3
Minimal Change Disease	2
Diffuse Mesangial Proliferative GN†	1
ANCA associated vasculitis	4
Polycystic Kidney Disease	13 (3.2%)
Unknown[2]	130 (31.7%)
Miscellaneous	21 (5.1%)

[1]Included are biopsy-proven glomerulonephritis.
[2]Included are clinically suspected chronic glomerulonephritis without biopsy.
†GN: glomerulonephritis

Table 2. Laboratory & Clinical data at the start of hemodialysis. (N=409)

	Mean ± SD
Systolic BP (mmHg)	153.20 ± 25.43
Diastolic BP (mmHg)	81.57 ± 16.24
Hemoglobin (mg/dl)	8.52 ± 1.66
Hematocrit (mg/dl)	25.24 ± 5.01
BUN (mg/dl)	97.41 ± 67.67
Creatinine (mg/dl)	10.33 ± 5.06
Sodium (mMol/L)	136.74 ± 5.48
Potassium (mMol/L)	5.10 ± 1.07
Bicarbonate (mMol/L)	15.83 ± 4.75
Calcium (mg/dl)	7.52 ± 1.27
Phosphorus (mg/dl)	6.35 ± 2.18
Albumin (g/dl)	3.53 ± 0.57
Intact PTH (pg/dl, N=268)	237.89 ± 173.75

Table 3. Estimated GFR at the start of hemodialysis.

	Mean ± SD	CV(%)	Range (MIN~MAX)	P-values between eGFR equations				
				C-G	Modified C-G	MDRD	CKD-EPI	Nankivell
Cockcroft-Gault (ml/min)	7.67 ± 3.80	49.5	1.925~29.106		0.002	<0.001	<0.001	<0.001
Modified C-G (ml/min/1.73m^2)	7.82 ± 3.60	46.0	1.873~30.581			<0.001	<0.001	<0.001
MDRD (ml/min/1.73m^2)	6.22 ± 3.39	54.5	1.378~23.418				<0.001	<0.001
CKD-EPI (ml/min/1.73m^2)	5.59 ± 3.16	56.5	1.103~23.924					<0.001
Nankivell (ml/min/1.73m^2)	0.10 ± 12.74	127.4	-54.101~33.034					

Table 4. Relationships between eGFR and CKD specific complications.

	sBP	dBP	Hb	Hct	K	HCO3	Ca	P	iPTH
Cockcroft-Gault	-0.073	-0.070	0.161**	0.152**	-0.161**	0.300**	0.135**	-0.399**	-0.203**
Modified C-G	-0.115*	-0.110*	0.179**	0.173**	-0.182**	0.343**	0.187**	-0.461**	-0.221**
MDRD	-0.133**	-0.201**	0.204**	0.197**	-0.203**	0.375**	0.242**	-0.549**	-0.272**
CKD-EPI	-0.133**	-0.178**	0.198**	0.191**	-0.206**	0.375**	0.232**	-0.532**	-0.259**
Nankivell	0.091	0.039	0.161**	0.148**	-0.095	0.241**	-0.014	-0.368**	-0.188**

Pearson correlation coefficient * $p<0.05$, ** $p<0.01$

Table 5. Comparisons of clinical and laboratory characteristics at the start of hemodialysis according to the the presence of diabetes mellitus.

	DM (Mean±SD or N (%)) (N=216)	NonDM (Mean±SD or N (%)) (N=193)	p-value
Age	61.13 ± 11.52	55.69 ± 17.02	<0.001
Male gender	109 (50.5%)	105 (55.0%)	0.363
Height (cm)	162.17 ± 8.78	162.76 ± 9.68	0.520
Weight (kg)	63.83 ± 11.05	62.34 ± 14.20	0.237
BMI (kg/m^2)	25.06 ± 11.87	23.39 ± 4.03	0.067
BSA (m^2)	1.69 ± 0.18	1.67 ± 0.22	0.377
Systolic BP (mmHg)	154.23 ± 24.05	151.85 ± 29.96	0.347
Diastolic BP (mmHg)	78.18 ± 15.04	85.42 ± 16.73	<0.001
Hemoglobin (mg/dl)	8.55 ± 1.57	8.50 ± 1.77	0.756
Hematocrit (%)	25.35 ± 4.77	25.12 ± 5.30	0.655
BUN (mg/dl)	93.00 ± 84.00	102.77 ± 42.25	0.147
Creatinine (mg/dl)	8.96 ± 3.71	11.92 ± 5.88	<0.001
Sodium (mg/dl)	136.59 ± 5.06	136.86 ± 5.93	0.626
Potassium (mg/dl)	5.10 ± 1.08	5.11 ± 1.06	0.913
Bicarbonate (mg/dl)	16.35 ± 4.41	15.23 ± 5.09	0.018
Calcium (mg/dl)	7.48 ± 1.07	7.57 ± 1.47	0.496
Phosphorus (mg/dl)	6.02 ± 1.92	6.72 ± 2.41	0.002
Albumin (g/dl)	3.44 ± 0.54	3.64 ± 0.57	<0.001
Intact PTH (pg/dl)	216.93 ± 157.50	260.15 ± 188.05	0.042
Estimated GFR			
Cockcroft-Gault	8.47 ± 4.21	6.69 ± 2.95	<0.001
Modified C-G	8.61 ± 4.00	6.90 ± 2.81	<0.001
MDRD	6.92 ± 3.63	5.41 ± 2.91	<0.001
CKD-EPI	6.24 ± 3.45	4.82 ± 2.59	<0.001
Nankivell	2.04 ± 11.90	-2.20 ± 13.25	0.001
Main reasons to start of hemodialysis			0.031
Fluid overload	97 (44.9%)	60 (31.4%)	
Uremic symptoms	69 (31.9%)	74 (38.7%)	
Progressive azotemia	29 (13.4%)	41 (21.5%)	
Hyperkalemia	11 (5.1%)	5 (2.6%)	
Metabolic acidosis	4 (1.9%)	7 (3.7%)	
Acute pericarditis	2 (0.9%)	2 (1.0%)	
Mental change	4 (1.9%)	2 (1.0%)	

Table 6. Comparisons of clinical and laboratory characteristics at the start of hemodialysis between the OPD and the ER groups.

	OPD (Mean±SD or N (%)) (N=242)	ER (Mean±SD or N (%)) (N=167)	p-value
Age	56.71 ± 14.30	61.29 ± 14.56	0.002
Male gender	123 (50.8%)	92 (55.1%)	0.396
Height (cm)	162.40 ± 8.89	162.56 ± 9.65	0.863
Weight (kg)	62.79 ± 11.52	63.85 ± 14.23	0.405
BMI (kg/m^2)	24.41 ± 11.15	24.13 ± 4.45	0.767
BSA (m^2)	1.68 ± 0.19	1.69 ± 0.21	0.398
DM	120 (49.8%)	96 (57.8%)	0.110
Systolic BP (mmHg)	151.09 ± 24.39	156.26 ± 26.62	0.043
Diastolic BP (mmHg)	81.77 ± 15.74	81.27 ± 16.97	0.758
Hemoglobin (mg/dl)	8.59 ± 1.62	8.43 ± 1.72	0.335
Hematocrit (%)	25.46 ± 4.93	24.92 ± 5.13	0.287
BUN (mg/dl)	92.53 ± 32.33	104.48 ± 98.25	0.131
Creatinine (mg/dl)	10.30 ± 4.65	10.38 ± 5.62	0.874
Sodium (mg/dl)	137.17 ± 5.16	136.11 ± 5.87	0.054
Potassium (mg/dl)	4.99 ± 0.92	5.27 ± 1.24	0.014
Bicarbonate (mg/dl)	16.83 ± 4.15	14.38 ± 5.19	<0.001
Calcium (mg/dl)	7.51 ± 1.09	7.53 ± 1.49	0.897
Phosphorus (mg/dl)	6.28 ± 1.95	6.44 ± 2.48	0.499
Albumin (g/dl)	3.55 ± 0.58	3.50 ± 0.54	0.472
Intact PTH (pg/dl)	239.66 ± 178.50	235.46 ± 167.77	0.845
Estimated GFR			
Cockcroft-Gault	7.72 ± 3.89	7.59 ± 3.66	0.728
Modified C-G	7.91 ± 3.74	7.69 ± 3.38	0.538
MDRD	6.16 ± 3.37	6.32 ± 3.43	0.640
CKD-EPI	5.57 ± 3.18	5.62 ± 3.13	0.880
Nankivell	0.13 ± 12.19	0.06 ± 13.57	0.956
Main reasons to start of hemodialysis			<0.001
Fluid overload	76 (31.4%)	81 (48.5%)	
Uremic symptoms	98 (40.5%)	45 (26.9%)	
Progressive azotemia	58 (24.0%)	13 (7.8%)	
Hyperkalemia	3 (1.2%)	13 (7.8%)	
Metabolic acidosis	2 (0.8%)	10 (6.0%)	
Mental change	4 (1.7%)	2 (1.2%)	
Acute pericarditis	1 (0.4%)	3 (1.8%)	

– 국문요약 –

혈액투석시작 시점에서의 말기신장질환 환자의 임상적 특징

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“신대체요법을 언제 시작해야 하는가?” 란 물음에 답하는 것은 어려운 일이다. 신대체요법이 임박한 말기신장질환 환자에서 언제 투석을 시작할지에 대한 결정을 돕기 위하여, 본 연구에서는 한국 3차 의료기관에서 혈액투석 시작 시점에서의 말기신장질환 환자의 임상적 특징을 분석하고자 한다. 2010년 1월부터 2012년 12월까지 처음 혈액투석을 시작한 409명의 환자를 후향적으로 분석하였다. 말기신부전의 가장 흔한 원인은 당뇨병성신증 (48.7%) 였으며, 두 번째로 흔한 원인은 조직검사로 증명된 사구체신염 (11.7%)이었다. 혈액투석 시작 시점에서의 사구체 여과율은 5.59 ~ 7.82 ml/min/1.73m^2 였다 (Nankivell equation 으로 계산한 사구체 여과율 제외). 이러한 사구체 여과율은 사구체 여과율 계산 공식을 어떤 것을 사용하는가에 따라 통계학적으로 유의한 차이가 있었다 ($p \leq 0.002$). 다섯 가지의 사구체 여과율 공식 중에서, Modified Cockcroft-Gault 식, MDRD 식과 CKD-EPI 식이 만성신부전 합병증과 유의한 상관관계를 보였다. 특히 Modified Cockcroft-Gault 식의 경우 변동 계수 (CV; coefficient of variation)가 가장 작았으며, 이는 이 식이 본 연구의 환자들의

eGFR 값을 가장 재현성 있게 나타낸다는 것을 의미한다. 혈액투석을 시작하게 된 주된 이유는 부종 (38.4%), 요독 증세 (35.0%) 였다. 당뇨 환자는 비당뇨 환자에 비하여 더 나이가 많고, 투석 시작시 높은 사구체 여과율을 보였다. 59.2% 의 환자는 외래를 경유하여 혈액투석을 시작하였고, 40.8% 의 환자는 응급실로 내원하여 혈액투석을 시작하였다. 응급실로 내원하여 투석을 시작한 경우, 고칼륨혈증 및 대사성 산증이 외래 내원하여 시작한 환자군에 비하여 더 심한 소견을 보였다. 현재 한국에서 행해지고 있는 혈액 투석 시작 시점에서의 말기신장질환 환자들의 임상적 특징 및 혈액검사 자료 등의 자료가 향후 투석 시작 시점을 결정하는데 유용한 정보가 되길 기대한다.