Global dialysis perspective: Korea

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Incidence and Prevalence of ESRD

According to Korean end stage renal disease (ESRD) registry (1), in 2018, there were 17,621 incident ESRD patients in Korea. The unadjusted incidence rate was 340.0 per million population (PMP) (Table 1a). The number of incident ESRD patients has continued to increase until 2006, then, it plateaued between 2007 and 2009, but, it rose again from 2010 (Figure 1a). This trend in rising ESRD incidence rate implies increasing burden of chronic kidney disease which is attributable to the aging Korean population and high rate of DM and hypertension.

On December 31, 2018, there were 103,984 prevalent ESRD patients in Korea, representing 271% increase since 2000. The unadjusted prevalence rate was 2006.4 PMP (Table 1b), which ranked high in the world (2). Prevalence rate of ESRD has steadily increased year after year (Figure 1b).

Treatment Modality

Hemodialysis (HD) was the predominant form of ESRD treatment modality in all years in both incident and prevalent ESRD patients. The number of incident peritoneal dialysis (PD) patients rapidly increased from late 1990s and peaked at 2006 (2,568), then declined every year until 2018 (735, decrease by 71.4%)(Table 1a, Figure1a). The ratio of HD to PD gradually changed from 68.9:31.1 in 2006 to 95.3:4.7 in 2018 in incipient ESRD patients, and changed from 78.4:21.6 in 2006 to 92.5:7.5 in 2018 in prevalent ESRD patients (Table 1b, Figure 1b). There are several potential reasons for the increasing HD use and decreasing PD use. First, the number of HD units increased continuously and rapidly since 2000 (304 in 2000, 487 in 2005, 631 in 2010, 846 in 2015, and 983 in 2018) probably due to higher dialysis facility revenues from HD than from PD. The high number of HD units provided the dialysis patients easy access to HD units in most areas. Second, because of low dialysis facility revenues, only university hospitals (9.8% of all dialysis units) and a few general hospitals offer PD facilities. Third, since the number of PD patients decreased significantly, many nephrologists do not have sufficient
knowledge, training, clinical experience, or confidence managing PD patients, which makes them to prefer HD as a dialysis modality. Doctor’s preference may affect the patient’s decision about dialysis modality. Public policies need to be developed to reboot PD use (3, 4). All HD patients have received in-center HD, because home HD is not available yet due to lack of reimbursement and systematic support. The number of kidney transplantation (KT) rose from 2006, which was partly ascribed to increase in deceased-donor KT, and plateaued from 2016. Analysis of transplantation registry data revealed potential reasons for plateau of KT number since 2016. First, the number of transplantation center reached almost plateau since 2016 (103 in 2016 and 107 in 2018). Second, deceased-donor KT also reached plateau from 2015 (263 in 2006, 680 in 2011, 901 in 2015, 1,059 in 2016, 903 in 2017, and 807 in 2018). The number of KT in 2018 was 2,107, which was 208% increase since 2000. On December 31, 2018, 74.6% of prevalent ESRD patients were receiving HD therapy, 6.0% were treated with PD, and 19.3% had a functioning kidney transplant (Table 1b).

Dialysis Units

On December 31, there were 983 dialysis units and 28,355 HD machines in Korea. The number of dialysis units and HD machines has increased by 223% and 444%, respectively since 2000. Mean number of HD machine was 29 in a dialysis unit. All dialysis units are for-profit, 45.1% freestanding, and 54.9% hospital-based units including 9.8% university hospital. Generally, patients receive HD treatment in a dialysis unit which is close to their home or work, because the quality of care and the dialysis cost are not different between freestanding and hospital-based units. However, university hospitals care fragile patients who have more co-morbidities and need to be cared specifically in multiple departments. PD patients have been cared only in university hospitals and a few general hospitals. A dialysis unit staff is simply composed of nephrologists and registered nurses. Technicians, nurse practitioners, or
physician’s assistants have not been established in Korea. All cannulation procedures are performed by nurses. The nurse to patient ratio is 1:8.3. A nephrologist who is in charge of dialysis unit rounds everyday on the dialysis patients, and nephrology fellows in the university hospitals take care of the patients under the supervision of the professors.

Causes of ESRD

Primary causes of ESRD in incident patients in 2018 were DM 48.8%, hypertension 19.8%, chronic glomerulonephritis 7.7% (kidney biopsy-proven 3.3%, pathology unknown 4.4%), cystic kidney disease 1.6%, interstitial nephritis 0.5%, lupus nephritis 0.5%, hereditary nephropathy 0.3%, kidney tumor 0.3%, toxic nephropathy 0.2%, gouty nephropathy 0.2%, other 4.5%, and unknown 15.7%. The number of diabetic ESRD patients rapidly increased from early 1990s, became a leading primary cause of ESRD from 1994, and plateaued from 2012 (Figure 2). Korea is one of the countries that DM is listed as the primary cause of ESRD (2).

Trends in Gender, Age, Duration of Dialysis Therapy, and Dialysis Therapy

In 2018, male to female ratio was 60:40 in HD, and 57:43 in PD. The ratio remained same during last 10 years. Mean age of prevalent dialysis patients has continued to increase, and was 62.3±14.4 years old in 2018, which was 10 years older than mean age of the patients in 2000 (52.3±13.6 years old). Elderly patients (≥65 years old) comprised 46.5% of all dialysis patients. HD patients (63.2±14.1 years old) were older than PD patients (54.8±14.3 years old) in 2018.

Duration of dialysis therapy has been prolonged in both HD and PD. In 2018, proportion of the patients who have been maintained on dialysis >5 years was 48% in HD, and 53% in PD.
In 2018, 92.3% of HD patients were receiving HD 3 times a week. Some HD patients having good amount of residual renal function or being treated in combination with PD, were receiving HD once or twice a week. In PD patients, use of APD has been increased since 2006, comprising 39% of PD patients in 2018. The typical HD treatment time is 4 h per session, and blood flow rate is 250-300 ml/min in most patients. Use of high-flux dialyzers is the standard care of HD. In 2019, high-flux dialyzers were used in 84.4% of all HD sessions.

Clinical parameters

In December 2017, the majority (63.3%) of HD patients had hemoglobin (Hgb) levels from 10 to <12 g/dL, while 6.8% had Hgb ≥12 g/dL, 21.4% had Hgb from 9 to <10 g/dL, and 8.5% had Hgb <9 g/dL. The mean Hgb was 10.4 g/dL. In December 2017, the majority (52.5%) of PD patients had Hgb levels from 10 to <12 g/dL, while 8.3% had Hgb ≥12 g/dL, 24.1% had Hgb from 9 to <10 g/dL, and 15.0% had Hgb <9 g/dL. The mean Hgb was 10.3 g/dL. As of 2018, erythropoiesis-stimulating agents (ESAs) were prescribed to 86% of HD patients and 84% of PD patients.

Regarding dialysis adequacy in 2018, mean single pool Kt/Vurea was 1.58±0.30 in prevalent HD patients, which was higher in female (1.75±0.30) than in male (1.46±0.25). Mean urea reduction ratio was 72.5±6.8% (female 76.1±6.2%, male 70.0±6.2%). Mean normalized protein catabolic rate was 0.98±0.28 g/kg/day (male 0.94±0.26 g/kg/day, female 1.05±0.30 g/kg/day).

In 2018, mean serum calcium levels were 8.76±0.94 mg/dl and 8.65±0.99 mg/dl in HD and PD patients, respectively. Mean serum phosphorus levels were 4.99±1.66 mg/dl and 5.38±1.67 mg/dl in HD and PD patients, respectively.

The proportion of patients taking calcium-based phosphate binder decreased from 67% in 2012 to 43% in 2018, while patients taking sevelamer or lanthanum increased from 12% in
In 2018, 47% of PD patients had a job (full time 36%, part time 11%), whereas 33% of HD patients had a job (full time 23%, part time 10%). Dialysis patients belong to the severe disabled. The Ministry of Employment and Labor enacted a law providing for the employment of the disabled. All workplaces having more than 100 staffs are mandated to employ certain number of the disabled (3.1%-3.4% of all staffs) according to the law. Government imposes a fine if they do not employ the disabled, and provides a financial incentive if they do. In addition, the disabled are financially and systematically supported by the law when they go into independent business. This law supports high employment rate in dialysis patients.

Insurance and Reimbursement

The National Health Insurance Service (NHIS) serves as the insurer, and makes the reimbursement policies. It is compulsory in Korea for an individual to take out medical insurance. Since January 2010, a dialysis patient pays 10% of medical costs including dialysis and interventional procedures for dialysis access while the remainder of 90% is borne by NHIS. Some low income patients (≈21% of all dialysis patients) are exempt from 10% payment of medical cost. NHIS is a unique medical insurance system. All medical services including dialysis should be government funded, and private medical insurance system is banned by law in Korea.

One session of HD costs approximately $135 USD. AVF creation costs $658 USD, AVG creation $640 USD, AVF or AVG angiography $345 USD, PTA $1,050 USD, mechanical thrombectomy $1,141 USD, tunneled HD catheter insertion with fluoroscopy $152 USD.

Vascular access and Establishment of Interventional Nephrology

The type of HD vascular access remained same during last 5 years (arteriovenous fistulas 77%, arteriovenous grafts 15%, central venous catheters 8% in 2018). PD catheter was mostly
inserted surgically (67%), and swan neck straight tip PD catheter was the most commonly used (48%). Vascular access has been created by surgeons (vascular surgeons ≈60%). Tunneled central venous HD catheter insertion and endovascular intervention such as percutaneous transluminal angioplasty (PTA) and thrombectomy have been mostly performed by radiologists (≈70%) (5).

Since the nephrologists became interested in and trained in interventional nephrology, they began to play roles in vascular access management since 2010. Tunneled hemodialysis catheter insertion and endovascular intervention by nephrologists have slowly but consistently increased.

Recently, the number of central venous HD catheter insertion has decreased (303.8 catheters/1,000 HD patients/year in 2010, 260.9 catheters/1,000 HD patients/year in 2016), and tunneled HD catheter has been inserted more than non-tunneled hemodialysis catheter, indicating that vascular access has been created timely and the vascular access team has been educated about and following international guidelines (5).

**Cause of Death**

Cardiovascular disease accounted for 45.2% of known causes of death (cardiac 33.7%, vascular 11.5%) among dialysis patients followed by infectious disease (22.6%). Analysis of the mortality hazard ratio showed that low BMI, low hemoglobin, low serum albumin, low phosphorus, and low URR were associated with a significantly increased mortality risk (6). Five year survival rate was significantly lower in diabetic HD patients compared with non-diabetic HD patients (7).

**Summary**

The characteristics of dialysis therapy in Korea can be summarized as high incidence and prevalence rates of ESRD patients, decreasing PD use, increasing proportion of elderly
patients, high rate of diabetic patients, sufficient number of HD units providing easy access to them, unique insurance system enabling patients to pay small for dialysis, high rate of adequate dialysis, and high rate of arteriovenous fistulas as an HD vascular access (Table 2). Public policy to increase in PD use will be a big challenge we have to rise to in near future.
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**Figure legend**

Figure1. (a) Trends in the annual number of incident ESRD patients by modality in the Korean population, 2000-2018; (b) Trends in the annual number of prevalent ESRD patients by modality in the Korean population, 2000-2018

Figure2. Trends in three leading causes of ESRD. Abbreviation: DM, diabetes mellitus; HTN, hypertension; CGN, chronic glomerulonephritis
Table 1. (a) Trends in annual number of incident ESRD patients and incidence rates of ESRD in the Korean population, 2000-2018

| Year | Hemodialysis | Peritoneal Dialysis | Transplant Recipients | All ESRD |
|------|--------------|---------------------|-----------------------|---------|
|      | Number of patients | Unadjusted rate (per million population) | % Change from previous year | Number of patients | Unadjusted rate (per million population) | % Change from previous year | Number of patients | Unadjusted rate (per million population) | % Change from previous year |
|      |               |                     |                        |               |                     |                        |               |                     |                        |
| 2000 | 2,736         | 57.0                | N/A                   | 1,021         | 21.3                | N/A                   | 683            | 14.2                | N/A                   |
| 2001 | 3,373         | 69.9                | 22.6                  | 1,279         | 26.5                | 24.4                  | 848            | 17.6                | 23.9                  |
| 2002 | 3,878         | 79.9                | 14.3                  | 1,666         | 34.3                | 29.4                  | 739            | 15.2                | -13.6                 |
| 2003 | 4,769         | 97.7                | 22.2                  | 1,866         | 38.2                | 11.4                  | 806            | 16.5                | 8.6                   |
| 2004 | 5,279         | 107.6               | 10.1                  | 2,246         | 45.8                | 19.9                  | 853            | 17.4                | 5.5                   |
| 2005 | 5,400         | 109.6               | 1.9                   | 2,381         | 48.3                | 5.5                   | 762            | 15.5                | -10.9                 |
| 2006 | 5,694         | 114.7               | 4.7                   | 2,568         | 51.7                | 7.0                   | 935            | 18.8                | 21.3                  |
| 2007 | 6,193         | 123.8               | 7.9                   | 2,062         | 41.2                | -20.3                 | 928            | 18.5                | -1.6                  |
| 2008 | 6,415         | 127.3               | 2.8                   | 1,619         | 32.1                | -22.1                 | 1,145          | 22.7                | 22.7                  |
| 2009 | 6,540         | 129.1               | 1.4                   | 1,125         | 22.2                | -30.8                 | 1,241          | 24.5                | 7.9                   |
| 2010 | 7,204         | 140.1               | 8.5                   | 867           | 16.9                | -23.9                 | 1,264          | 24.6                | 0.4                   |
| 2011 | 8,057         | 155.8               | 11.2                  | 920           | 17.8                | 5.3                   | 1,639          | 31.7                | 28.9                  |
| Year | Per Capita Income | Unemployment Rate | Unemployment Insurance Payments | Medicare Premium Income | Medicare Premium Rate | Total Income | Total Employment | Total Employment Rate |
|------|-------------------|-------------------|---------------------------------|------------------------|----------------------|---------------|-----------------|---------------------|
| 2012 | 8,811             | 169.8             | 9.0                             | 923                    | 17.8                 | 0.0           | 1,738           | 33.5                | 5.7                  | 11,472 | 221.1           | 7.7 |
| 2013 | 9,543             | 183.3             | 8.0                             | 884                    | 17.0                 | -4.5          | 1,756           | 33.7                | 0.6                  | 12,183 | 234.0           | 5.8 |
| 2014 | 10,594            | 206.4             | 12.6                            | 867                    | 16.9                 | -0.6          | 1,680           | 32.7                | -3.0                 | 13,141 | 256.0           | 9.4 |
| 2015 | 12,011            | 233.1             | 12.9                            | 854                    | 16.6                 | -1.8          | 1,891           | 36.7                | 12.2                 | 14,756 | 286.4           | 11.9 |
| 2016 | 13,049            | 252.4             | 8.3                             | 786                    | 15.2                 | -8.4          | 2,233           | 43.2                | 17.7                 | 16,068 | 310.8           | 8.5 |
| 2017 | 13,754            | 265.6             | 5.2                             | 742                    | 14.3                 | -5.9          | 2,163           | 41.8                | -3.2                 | 16,659 | 321.7           | 3.5 |
| 2018 | 14,779            | 285.2             | 7.4                             | 735                    | 14.2                 | -0.7          | 2,107           | 40.7                | -2.6                 | 17,621 | 340.0           | 5.7 |

Abbreviations: ESRD, end-stage renal disease; N/A, not applicable
Table 1. (b) Trends in annual number of prevalent ESRD patients and prevalence rates of ESRD in the Korean population, 2000-2018

| Year | Hemodialysis | Peritoneal Dialysis | Functioning Kidney Transplant | All ESRD |
|------|--------------|---------------------|-------------------------------|----------|
|      | Number of patients | Unadjusted rate (per million population) | % Change from previous year | Number of patients | Unadjusted rate (per million population) | % Change from previous year | Number of patients | Unadjusted rate (per million population) | % Change from previous year |
| 2000 | 15,853 | 330.4 | N/A | 4,671 | 97.4 | N/A | 7,522 | 156.8 | N/A | 28,046 | 584.5 | N/A |
| 2001 | 17,568 | 363.8 | 10.1 | 5,489 | 113.7 | 16.7 | 7,957 | 164.8 | 5.1 | 31,014 | 642.3 | 9.9 |
| 2002 | 20,010 | 412.4 | 13.4 | 5,712 | 117.7 | 3.5 | 8,271 | 170.5 | 3.5 | 33,993 | 700.6 | 9.1 |
| 2003 | 23,348 | 478.2 | 16.0 | 6,807 | 139.4 | 18.4 | 8,635 | 176.9 | 3.8 | 38,790 | 794.5 | 13.4 |
| 2004 | 25,335 | 516.5 | 8.0 | 7,569 | 154.3 | 10.7 | 8,987 | 183.2 | 3.6 | 41,891 | 854.0 | 7.5 |
| 2005 | 27,246 | 553.0 | 7.1 | 7,816 | 158.6 | 2.8 | 9,271 | 188.2 | 2.7 | 44,333 | 899.8 | 5.4 |
| 2006 | 29,031 | 585.0 | 5.8 | 7,990 | 161.0 | 1.5 | 9,709 | 195.7 | 4.0 | 46,730 | 941.7 | 4.7 |
| 2007 | 30,907 | 617.7 | 5.6 | 7,649 | 152.9 | -5.3 | 10,119 | 202.2 | 3.3 | 48,675 | 972.8 | 3.3 |
| 2008 | 33,427 | 663.3 | 7.4 | 7,840 | 155.6 | 1.8 | 10,722 | 212.8 | 5.2 | 51,989 | 1,031.6 | 6.0 |
| 2009 | 37,391 | 738.3 | 11.3 | 7,618 | 150.4 | -3.3 | 11,387 | 224.8 | 5.6 | 56,396 | 1,113.5 | 7.9 |
| 2010 | 39,509 | 768.1 | 4.0 | 7,309 | 142.1 | -5.5 | 12,042 | 234.1 | 4.1 | 58,860 | 1,144.4 | 2.8 |
| Year | Unique Patients | ESRD-EU Enrollees | ESRD-CAM Enrollees | ESRD-N EURO Enrollees | Total Access | Utilization | ESRD N/P Ratio | Other ESRD | N/A | N/A |
|------|----------------|------------------|------------------|----------------------|-------------|------------|----------------|-----------|-----|-----|
| 2011 | 42,596         | 823.6            | 7.2              | 7,694                | 148.8       | 4.7        | 13,051         | 252.4     | 7.8 | 63,341 | 1,224.8 | 7.0 |
| 2012 | 48,531         | 935.4            | 13.6             | 7,552                | 145.6       | -2.2       | 14,128         | 272.3     | 7.9 | 70,211 | 1,353.3 | 10.5 |
| 2013 | 52,378         | 1,006.1          | 7.6              | 7,540                | 144.8       | -0.5       | 15,124         | 290.5     | 6.7 | 75,042 | 1,441.5 | 6.5 |
| 2014 | 57,256         | 1,115.3          | 10.9             | 7,423                | 144.6       | -0.1       | 15,995         | 311.6     | 7.3 | 80,674 | 1,571.5 | 9.0 |
| 2015 | 62,634         | 1,215.5          | 9.0              | 7,352                | 142.7       | -1.3       | 17,028         | 330.5     | 6.1 | 87,014 | 1,688.6 | 7.5 |
| 2016 | 68,853         | 1,331.9          | 9.6              | 6,842                | 132.4       | -7.2       | 18,189         | 351.8     | 6.4 | 93,884 | 1,816.1 | 7.6 |
| 2017 | 73,059         | 1,411.0          | 5.9              | 6,475                | 125.1       | -5.5       | 19,212         | 371.0     | 5.5 | 98,746 | 1,907.1 | 5.0 |
| 2018 | 77,617         | 1,497.6          | 6.1              | 6,248                | 120.6       | -3.6       | 20,119         | 388.2     | 4.6 | 103,984 | 2,006.4 | 5.2 |

Abbreviations: ESRD, end-stage renal disease; N/A, not applicable
| Characteristics                                      | Details                                                                 |
|-----------------------------------------------------|-------------------------------------------------------------------------|
| Number of dialysis patients                         | 83,865, 1618.2 per million population (December 31, 2018)              |
| Percent of patients on home dialysis                | 7.5% (December 31, 2018)                                               |
| Dialysis session covered by insurance               | 90% of total cost, patient pays 10% of cost                             |
| Dialysis units: hospital-based vs. freestanding     | Hospital-based 54.9% vs. Freestanding 45.1%                             |
| Dialysis units: for-profit or non-profit            | For-profit                                                              |
| Reimbursement per dialysis session                  | $135 USD                                                               |
| Staffs who deliver dialysis: nurses or technicians  | Nurses                                                                  |
| The nurse to patient ratio                          | 1:8.3                                                                  |
| Average length of a dialysis session                | 4 h                                                                    |
| Frequency that patients are seen by nephrologists   | Every dialysis session                                                 |
| Type of vascular access                             | arteriovenous fistulas 77%, arteriovenous grafts 15%, central venous catheters 8% |
Figure 1 (a)

The graph illustrates the number of patients in different categories over a period from 2000 to 2018. The categories include:

- All ESRD
- Hemodialysis
- Peritoneal Dialysis
- Transplant

The lines show an increasing trend over the years, with the number of patients in each category growing significantly.
Figure 1 (b)
Figure 2

The graph shows the trend of DM (yellow line), HTN (red line), and CGN (blue line) over the years from 1985 to 2018. The x-axis represents the years, while the y-axis shows the percentage.