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Under-Utilization of Donor Hearts in the Initial Era of the Heart Transplant Program in Korea

– Review of 13 Years' Experience From the Korea National Registry –

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Background: Heart transplantation (HTPL) is the effective treatment option to improve quality of life as well as survival of terminal heart failure patients. Shortage of donors, however, limits HTPL to all indicated cases. The temporal trend and clinical characteristics of HTPL donors in Korea were therefore investigated.

Methods and Results: Among 2,001 brain-death donors registered in Korean Network for Organ Sharing from February 2000 to May 2012, a total of 28% of hearts (n=552) were utilized for HTPL. The mean age of Korean heart donors was 10 years younger than that of heart recipients (33.2±12 years vs. 43.2±17 years, respectively). The oldest was 56 years old, and donors aged over 50 accounted for only 6.2% (n=34) of total cases. Female donors were utilized less than male donors (23.6% vs. 29.6%, respectively). To determine characteristics of declined donor heart candidates, subgroup analysis of echocardiographic data was done, and 74.6% had normal ventricular function and structure, although only 42.3% were actually transplanted. The utilization rate of donor hearts with minor echocardiography abnormalities was only 15.2%. Clinical outcomes of marginal heart donors were not different from non-marginal donors.

Conclusions: Although shortage of donor organs is an emerging issue, most donor hearts have been under-utilized in the past in Korea. In particular, aged and female donor hearts with minor echocardiographic abnormalities had a low rate of utilization. (*Circ J* 2013; **77:** 2056–2063)

Key Words: Donor; Heart transplantation; Korea

End-stage heart failure is a grave disease with a poor prognosis.[1] Heart transplantation (HTPL) is the only, but a very effective, way to improve quality of life as well as survival. In the global registry data annually published by the International Society for Heart and Lung Transplantation (ISHLT), the development of immunosuppressive therapy has led to an excellent 1-year survival rate of >90% after cardiac transplantation, with 50% of the patients surviving >11 years.[2] Due to the shortage, however, of donor availability, HTPL cannot be conducted in all indicated cases. In the USA, United Network of Organ Sharing (UNOS), established in 1977, strictly manages allocation according to the urgency status in order to best utilize the limited number of donor hearts. Acceptable donor criteria also become expanded, so that donors with comorbidities who would not have been suitable candidates in the past are now considered acceptable for HTPL.[3]

In Korea, the Korean Network for Organ Sharing (KONOS) was established in 2000, and 21 Hospital-based Organ Procurement Organization (HOPO) hospitals were appointed to take regional charge of the procurement and management of organs. As the organ donation rate after brain death has increased over the years, the donation rate of hearts has also increased.[4] Since the first HTPL was performed in Korea in 1992,[5] however, most studies on HTPL focused on the recipients, and studies on the utilization of donor hearts have yet to been initiated.

This study focuses on the current status of the selection and the recruitment of donor hearts. We investigated the characteristics of donor hearts that were acceptable according to global standards, but were not actually transplanted. The findings of KONOS data were compared with global representative data from the ISHLT.[6] Last, we suggest how to improve the utilization of donor hearts.

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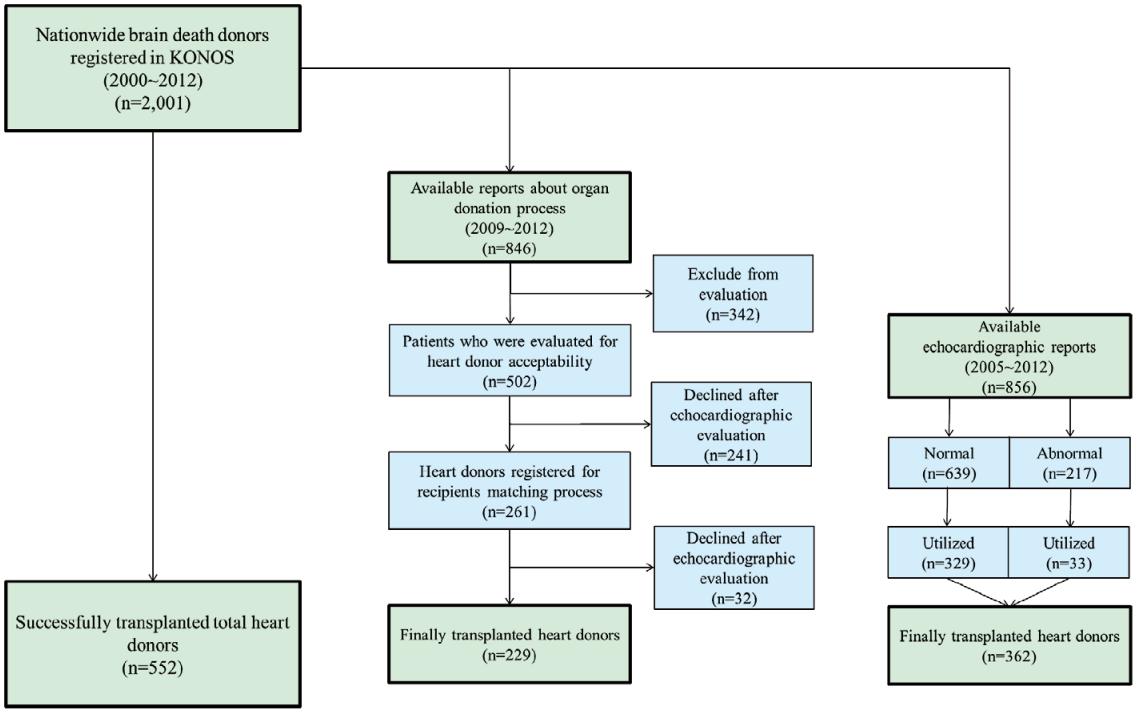

Figure 1. Analyzed donor heart flow through the study. KONOS, Korean Network for Organ Sharing.

Methods

Donor Database

A total of 2,001 brain-death donors registered in the KONOS database from February 2000 to May 2012 were investigated. Echocardiographic data for 856 cases, out of 1,693 donors after March 2005 were available for investigation, and further analysis was performed to determine the reason for not being used for transplantation. We compared the clinical characteristics of 329 utilized donors and 310 declined donors among 639 cases with normal echocardiography results. Echocardiography was performed by the corresponding procurement team. Detailed medical records of 92 donor hearts, including past medical history, serology, cardiopulmonary resuscitation history, admission duration, and cause of death, were separately analyzed. The study flow is described in Figure 1.

Outcome Analysis

To investigate the outcome of marginal donor hearts, we analyzed 67 heart donors and their matched recipients in a single center between October 2007 and May 2012. Marginal donor heart was defined as a potential donor heart without absolute contraindications that is transplantable, although not fully acceptable. In detail, marginal heart status was defined as one or more of the following: (1) ABO incompatibility; (2) age over 45 years (male) or over 50 years (female); (3) q wave on electrocardiogram (ECG); (4) abnormal echocardiography; and (5) under-sized or over-sized by >20% body weight difference. The primary endpoint was defined as the mortality incidence within 1 year after HTPL, and the secondary endpoint was defined as early overall mortality. Early mortality included all-cause death occurring within 30 days after operation.

Statistical Analysis

Continuous variables are expressed as mean±SD. Student's t-test was used for data comparison. Categorical variables were compared using Fisher's exact test and chi-square test. Cox proportional hazard regression model was used to identify whether donor heart characteristics affected recipient outcome. For multivariate analysis, recipient age, medical history (hypertension, diabetes, dyslipidemia, chronic kidney disease, and history of stroke), and donor heart ischemic time were used as variables. $P<0.05$ was considered statistically significant. Analysis was performed using SPSS Statistics version 18.0 (IBM, NY, USA).

Results

Current Status of HTPL in Korea

The total number of brain-death donors from 2001 to 2012 was 2,001, and cases have been increasing from 51 cases in 2001 to 368 cases in 2011. The 552 HTPL were performed during this period, and the annual number was increased from 21 cases in 2001 to 98 cases in 2011. The ratio of HTPL to total brain-death donors, however, has paradoxically decreased from 21 cases (41.1% of all brain-death donors) to 29 cases (20.6%) in 2006, and 65 cases (24.9%) in 2009, which has not improved (Figure 2).

Similar to other countries, the waiting list is stratified according to urgency status, as described in Table 1. The same list is used for both adult and pediatric recipients, but additional scores are used for pediatric recipients. The recipients are classified according to urgency status and hearts are allocated according to urgency status, then waiting time is combined with consideration of blood type, presence of infectious disease, former donation of organs by the patient or family, geological

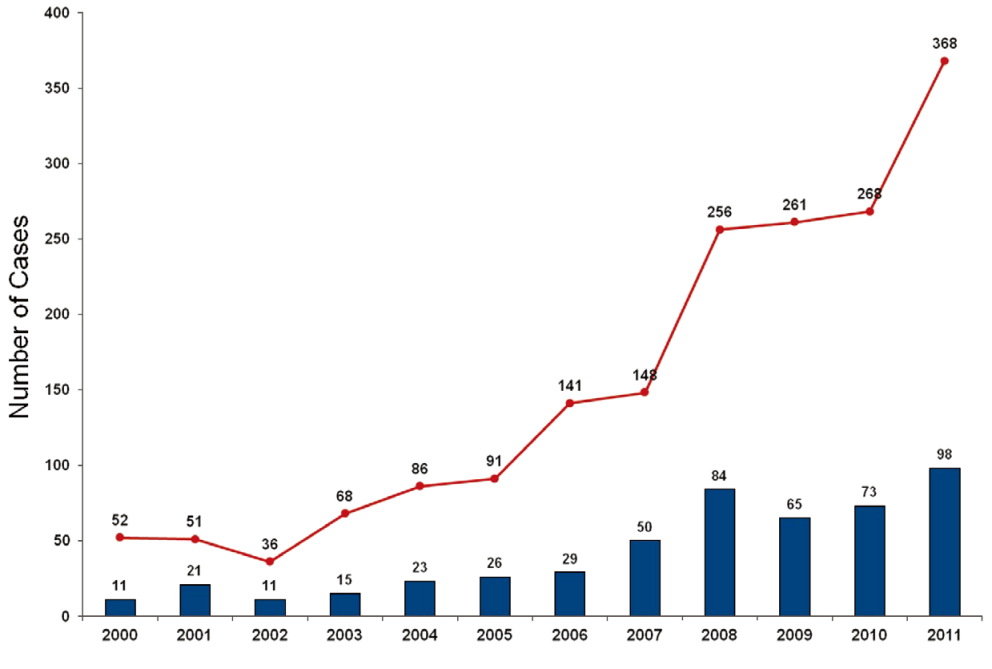

Figure 2. Annual trend of (red line) total brain-death donors and (blue bars) heart transplantation in Korea.

Table 1. Urgency Status for HTPL Candidates†

(A) Urgency status 0
① Mechanical ventilator with LVAD or RVAD
② Mechanical ventilator with ECMO
(B) Urgency status 1
① Artificial heart
② LVAD or RVAD
③ ECMO
④ Intra-aortic balloon pump
⑤ Heart failure with mechanical ventilator requiring urgent transplantation
⑥ I.v. inotropics continued longer than 4 weeks
(C) Urgency status 2
① I.v. inotropics continued shorter than 4 weeks
(D) Urgency status 3
① Does not meet status 0, 1 or 2 criteria
(E) Urgency status 7
① Temporarily unsuitable to receive organ

†Korean Task Force on Organ Transplantation.[7] ECMO, extracorporeal membrane oxygenation; HTPL, heart transplantation; LVAD, left ventricular assist device; RVAD, right ventricular assist device.

accessibility, age, difference of age, and difference of body weight. The urgency status and waiting time are the most important, and other factors are considered in the point scoring system. The consideration of former donation of organs by the patient or family is a unique characteristic in Korea. This is to encourage further donation, because organ donation is unfamiliar due to cultural tradition in Korea. Although the waiting list continues to grow longer, the waiting time for HTPL has not changed over the years. The waiting time (days) of the 552 heart recipients according to urgency status is described in Table 2. Currently, the most urgent HTPL candidates, defined as status 0, receive transplantation within 10 days, while status 1 patients wait approximately 1 month, which is shorter than that in the global registry data, reported to be at least 2 months for status 1A patients.[8]

Actual Utilization of Potential Heart Donors

The donor heart criteria suggested by the Korean Task Force on Organ Transplantation, are as follows: (1) ABO compatibility; (2) age up to 45 years (male) or 50 years (female), if possible; (3) no history of chest trauma or cardiac surgery; (4) no q wave on ECG (exception: normal echocardiography result); (5) normal echocardiography; (6) no evidence of sepsis; and (7) under-sized or over-sized by no more than 20% body weight.[7] In particular, male donors under 45 years old and female donors under 50 years old are favored, and normal echocardiographic result is considered an essential factor for HTPL. Marginal donors are defined as those who would be declined under normal circumstances, but can be used for transplantation in the case of urgent or emergency situations. Although several potential entities for marginal hearts have been suggested,[9–12] there are no formal indications on marginal donors in Korea as yet.

The mean age of Korean heart donors is 33.2±12 years old (range, 1–56 years; median, 35 years), and the mean age of heart recipients is 43.2±17 years old (range, 0–77 years; median, 46.5 years). The oldest donor was 56 years old. Remarkably, donors aged >50 accounted for 6.2% (34 patients), and the old-aged donors >55 years accounted for only 1.3% (7 patients) of the total HTPL (Table 3). The proportion of donors aged >50 years is lower compared to global data.[8] The proportion of recipients older than 50 years, however, increased >10% during a 5-year period. The mean age of recipients also increased from 39.0±16.8 years (range, 2–77 years) between

Table 2. Waiting List Numbers and Mean Waiting Time for HTPL in Korea

Waiting time (days)	2000	2001	2002	2003	2004	2005	2006
Mean±SD [median] (n)	120.42±133 [76.5] (n=12)	194.76±94 [170] (n=21)	199.91±99 [136] (n=11)	225.33±375 [47] (n=15)	68.52±8 [39] (n=23)	94.46±4.4 [55] (n=26)	161.24±61 [45] (n=29)
Status 0	– [–] (n=0)	– [–] (n=0)	– [–] (n=0)	– [–] (n=0)	10 [10] (n=1)	– [–] (n=0)	2 [2] (n=1)
Status 1	137.40±37 [95] (n=10)	192.76±92 [159.5] (n=20)	– [–] (n=0)	63.50±3.5 [63.5] (n=2)	4.50±5 [4.5] (n=2)	13.00±3 [13] (n=3)	8.00 [8] (n=1)
Status 2	35.50±5.5 [35.5] (n=2)	249.00 [249] (n=1)	222.71±22.7 [136] (n=7)	121.50±21 [27] (n=8)	62.89±2.8 [40] (n=19)	65.89±5.8 [55] (n=18)	180.08±80 [47] (n=25)
Status 3	– [–] (n=0)	– [–] (n=0)	160.00±60 [148] (n=4)	456.20±56 [298] (n=5)	362.00 [362] (n=1)	246.20±46.2 [118] (n=5)	82.00±2.0 [82] (n=2)

Waiting time (days)	2007	2008	2009	2010	2011	2012	Total
Mean±SD [median] (n)	87.26±7.2 [45] (n=50)	556.42±6 [20.5] (n=84)	124.03±24 [34] (n=62)	124.78±24 [54] (n=73)	142.14±42 [36] (n=98)	164.29±64 [46.5] (n=48)	122.35±291 [43.5] (n=552)
Status 0	38.71±49 [24] (n=7)	17.20±31 [8.5] (n=10)	36.56±70 [11] (n=9)	8.88±7 [8] (n=8)	43.36±105 [11.5] (n=14)	6.83±5 [5.5] (n=6)	26.84±63 [9] (n=56)
Status 1	23.67±3.6 [9] (n=6)	52.82±2.8 [17] (n=38)	67.48±7.48 [30] (n=27)	114.81±14 [50] (n=26)	121.21±21.2 [64] (n=24)	239.91±39 [49] (n=11)	105.31±162 [42.5] (n=170)
Status 2	106.76±6 [57] (n=37)	69.12±9.1 [56] (n=33)	200.25±10.2 [61] (n=24)	69.09±9.09 [19] (n=11)	65.81±5.8 [19] (n=21)	257.00±57.0 [49] (n=12)	119.25±263 [46.5] (n=218)
Status 3	– [–] (n=0)	93.00±3.0 [129] (n=3)	366.50±66 [366] (n=2)	189.04±89 [94] (n=28)	231.59±31.5 [44] (n=39)	111.68±11.6 [89] (n=19)	204.97±491 [84.5] (n=108)

HTPL, heart transplantation.

Table 3. Mean and Median Age of HTPL Donors

	2000	2001	2002	2003	2004	2005	2006
Korean data							
Mean±SD	27.0±10	28.5±11	26.6±13	30.13±11	35.6±10	29.0±11	32.0±12
[median]	[23.5]	[32.0]	[25.0]	[27.0]	[39.0]	[29.5]	[34.0]
(max)	(44)	(46)	(47)	(49)	(52)	(46)	(50)
(n)	(n=12)	(n=21)	(n=11)	(n=15)	(n=23)	(n=26)	(n=29)
Age >50	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	8.7% (n=2)	0.0% (n=0)	3.4% (n=1)
Global data							
Mean (n)	29.3 (n=2,284)	29.1 (n=2,276)	28.6 (n=2,223)	28.4 (n=2,120)	28.3 (n=2,096)	28.0 (n=2,220)	27.9 (n=2,276)
Age >50	9.8% (n=224)	9.0% (n=204)	9.4% (n=211)	8.4% (n=179)	8.9% (n=187)	8.0% (n=177)	7.8% (n=179)

	2007	2008	2009	2010	2011	2012	Total
Korean data							
Mean±SD	34.0±13	34.4±13	32.9±12	33.7±12	33.8±12	36.6±13	33.20±12
[median]	[37.5]	[38.0]	[34.5]	[36.0]	[33.8]	[36.6]	[35.0]
(max)	(53)	(56)	(53)	(55)	(56)	(56)	(56)
(n)	(n=50)	(n=84)	(n=62)	(n=73)	(n=98)	(n=48)	(n=552)
Age >50	8.0% (n=4)	5.9% (n=5)	6.5% (n=4)	5.5% (n=4)	9.2% (n=9)	10.4% (n=5)	6.2% (n=34)
Global data							
Mean (n)	27.8 (n=2,286)	27.5 (n=2,222)	28.0 (n=2,281)	NDA	NDA	NDA	28.3
Age >50	7.1% (n=161)	7.2% (n=160)	8.2% (n=187)	NDA	NDA	NDA	8.4%

NDA, no data available; HTPL, heart transplantation.

2000 and 2005 to 44.25±17.4 years (range, 0–76 years) between 2006 and 2012.

Of the total 2,001 deceased organ donors, 1,382 (69.1%) were male. Among them 406 deceased male donor hearts (29.3%) were actually transplanted, whereas a smaller proportion of female donor hearts (n=146, 23.6%) were transplanted (P=0.003). Among 552 transplantation cases, there were 174 gender-mismatched transplantation cases, including 79 cases of female donors to male recipients (20.3% of 389 male recipients) and 95 cases of male donors to female recipients (58.3% of 163 female recipients).

The mean body weight of Korean heart donors was 61.6±14.1 kg (body mass index: 22.6±3.3), which is lower than the global data by approximately 20 kg.[8] There were 36 cases of

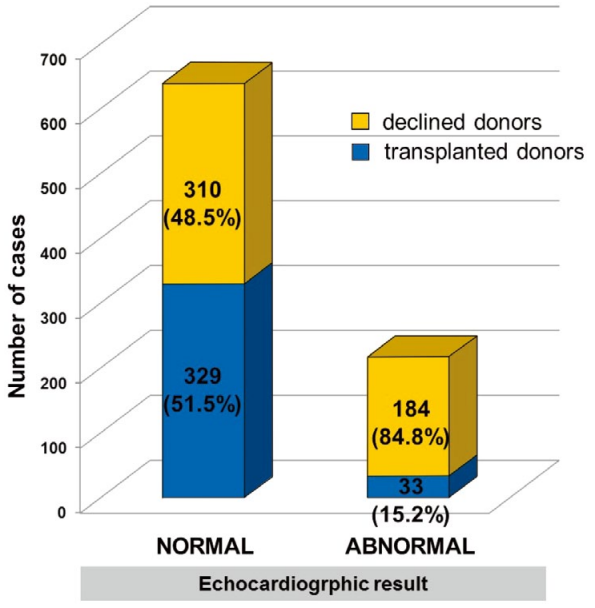

Figure 3. Heart transplantation status according to echocardiography results of 856 donors since 2005. Among the total 856 donors, 48.5% (n=310) with normal echocardiography results were declined.

under-sized donor, defined as <80% of recipient's actual body weight, and 167 cases of over-sized donor, defined as >120% of recipient's actual body weight. The mean body weight discrepancy was 10.4±9 kg (range, 0–53 kg; median, 8.0 kg), but 19.6±8.0 kg (range, 2–53 kg; median, 17.5 kg) for the under- or over-sized donors.

The blood-type distribution of total brain-death donors is similar to that of the general population in Korea (deceased donors: A, 35.2%; B, 26.1%; O, 27.6%; AB, 11.1%; general Korean population: A, 34.4%; B, 26.8%; O, 27.4%; AB, 11.2%).[13] Among heart donors, however, blood type O had higher transplantation rate, whereas blood type AB had a lower rate (A, 31.7%; B, 25.4%; O, 39.6%; AB, 3.2%) compared to the distribution pattern of brain-death donors as well as the general population. Among 159 ABO mismatched donors (28.8%), blood type O accounted for 99 cases (25 for type B and 35 for type A).

Further analysis was performed in 856 HTPL donor candidates after 2005 for whom echocardiographic data were available. Echocardiographic data were not collected before 2005. Among them, 639 (74.6%) had normal result and 217 (25.4%) were reported as abnormal. Among them, 494 (57.7%) were declined and 362 (42.3%) were used for HTPL. In detail, 184 (84.8%) of 217 cases with abnormal findings were not utilized, and only 33 hearts (15.2%) were used for transplantation. More importantly, 310 (48.5%) of 639 cases with normal echocardiography findings were not utilized for HTPL. As a whole, more than half of potential HTPL donors were discarded (Figure 3).

Characteristics of Declined Donor Hearts

As described previously, among all 2,001 deceased donors, 552 hearts were transplanted. KONOS retained detailed reports about organ donation process, however, only after November of 2009. Among 846 detailed reports about organ donors, 502 patients were evaluated for heart donor acceptability. The remaining 342 donors were not evaluated for HTPL, due to known heart disease history or denial of heart donation. Among the evaluated 502 potential donors, 261 heart donors were considered for recipient matching, and the remaining 241 hearts were declined mainly due to echocardiographic abnormalities. Among the 261 potential donor hearts, 229 hearts were actually transplanted (Figure 1).

For further detailed analysis, we investigated the echocardiographic report of each HTPL donor candidate. There were echocardiographic data for only 856 HTPL donor candidates, and 362 donors were utilized. Among those utilized, 329 had normal echocardiography and 33 had abnormal echocardiography (Figure 1). To determine the reasons why the hearts were declined, we compared the characteristics of declined donors with those with normal echocardiographic data. The clinical characteristics of 329 utilized donors and 310 declined donors among 639 with normal echocardiography are described in Table 4. Compared to the overall female proportion of 29.7% (n=190), 33.9% (n=105) of declined donors were female. In other words, 55.3% (n=105) of female donors (n=190) were not utilized, which is a higher rate compared to the total non-

Table 4. Utilization Status of Potential Heart Donors With Normal Echocardiography

	Total (n=639)	Transplanted (n=329)	Declined (n=310)	P-value
Gender				0.016
Female	190 (29.7)	85 (25.8)	105 (33.9)	
Male	449 (74.3)	244 (74.2)	205 (66.1)	
Age	36.4±13.6	32.5±12.1	40.5±13.8	<0.001
Age >50 years	97 (15.2)	16 (4.9)	81 (26.1)	<0.001
Male >50	64	13	51	
Female >50	33	3	30	
Body weight	63.1±14.3	63.0±15.2	61.8±14.0	0.424
BMI	16.5±10.5	16.84±10.6	16.17±10.5	0.423
Blood type				<0.001
Type A	224 (35.1)	108 (32.8)	116 (37.4)	
Type B	170 (26.6)	80 (24.3)	90 (29.0)	
Type O	184 (28.8)	131 (39.8)	53 (17.1)	
Type AB	61 (9.5)	10 (3.0)	51 (16.5)	

Data given as mean±SD or n (%). BMI, body mass index.

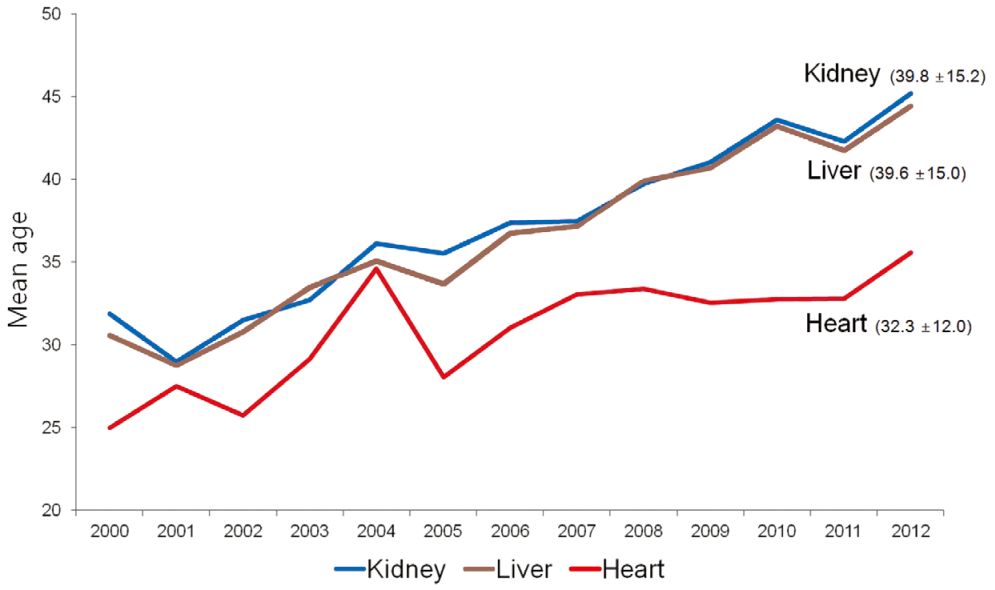

Figure 4. Comparison with other brain-death organ transplantation in Korea. The mean age of Korean heart donors is 33.2±12 years (range, 1–56 years; median, 35 years), but 39.8±15.2 years (range, 1–83 years; median, 42 years) and 39.6±15.0 years (range, 0–83 years; median, 42 years) for kidney and liver, respectively. The mean age of kidney and liver donors is getting older annually, compared to heart donors.

utilized donor proportion of 48.5% (n=310, P<0.001). Despite the fact that 54.3% (n=244) of male donors were utilized, only 44.7% (n=85) of potential female donors with normal echocardiographic results were used for transplantation (P=0.007). The mean age of 329 utilized donors and 310 declined donors was 32.5±12.1 years and 40.5±13.8 years, respectively. Although 81 (26.1%) out of 310 declined donors were aged >50, only 16 (4.9%) out of 156 utilized donors were aged >50 (P<0.001). In summary, the utilization rate was especially low if the donor was female or over 50 years.

There were 33 cases in which donor hearts with echocardiographic abnormalities were transplanted. Later reviews indicated that among these, 4 had grade 1 diastolic dysfunction, which is a mild condition that can also be termed as early stage diastolic dysfunction based on the previous diagnosis and classification.[14] But, because there were no descriptive data on chamber size or symptoms, it was difficult to assess the clinical significance in these 4 cases. There were 3 cases of left ventricular (LV) ejection fraction 55–58%, 5 of poor sonic window, 1 of normal report with unknown arrhythmia history, and another 19 cases were reported only as "abnormal echocardiogram".

The clinical characteristics available including past medical history medication history, serology (HIV, hepatitis B, syphilis), cardiopulmonary resuscitation including chest compression, admission duration, or cause of death did not have a statistical effect on donor heart utilization. Detailed data are given in **Table S1**.

Comparison With Other Brain-Death Organ Transplantation in Korea

Among 2,001 brain-death donors, the utilization rate of kidney and liver was far higher than HTPL (heart 27.7% vs. kidney 95.4% and liver 81.9%, respectively). And the mean age of donors used for kidney transplantation (39.8±15.2 years; range, 1–83 years; median, 42 years) and liver transplantation (44.3±15.2 years; range, 0–78 years; median, 44.5 years) is older than those used for HTPL. Moreover, the kidney and liver donors are getting older annually, compared to heart donors (**Figure 4**).

Although female donor hearts are less utilized than male donor hearts, kidney and liver transplantation did not show significant gender difference of utilization (kidney: male 94.8% vs. female 96.8%, P=0.051; liver: male 81.0% vs. female 83.8%, P=0.132).

Marginal Heart Status

Among 67 recipients analyzed in a single center, marginal status factors were ABO incompatibility (n=1), age >45 years (male, n=3), age >50 years (female, n=11), abnormal echocardiography (n=12), and under-sized or over-sized by >20% body weight (n=18). Thirty-two donor hearts did not have any marginal status factors, while 35 donor hearts had at least 1 marginal status factor (4 had 2 factors, 2 had 3 factors). Recipients of marginal donors were significantly older, otherwise there were no baseline differences between the 2 groups. Detailed data on recipient characteristics with regard to marginal donor heart status are described in **Table S2**. For each of the marginal status factors, age (P=0.225), body weight (P=0.459), over-sizing (P=0.466), and echocardiographic abnormality (P=0.276) were not correlated with increased death within 1 year.

There were 6 deaths (18.8%) in non-marginal and 7 (20.0%) in marginal heart recipients. Death within 1 year occurred in 5 (15.6%) non-marginal and 7 (20.0%) marginal heart recipients. In the non-marginal heart recipients, the cause of death was sudden death (n=2), pneumonia or other infections (n=3), and lymphoma recurrence (n=1). For recipients who received marginal hearts, the causes were sudden death (n=1), gastrointestinal perforation (n=2), postoperative bleeding (n=1), and pneumonia (n=3). Statistically, there were no significant dif-

ferences in overall death (P=0.694) and 1-year death (P=0.670) between the groups on Cox regression analysis.

Discussion

Although the history of HTPL in Korea extends back for only 20 years, more than 500 HTPL had been carried out by May 2012. The clinical outcome is superior to those of Western countries, in that the 1-year survival rate is >95% and 5-year survival rate is >85%.[15] The present results, however, show that old-aged, female, or hearts with only minor echocardiographic abnormalities have been underutilized. More effort is needed to further utilize marginal donor hearts.

Donor age is the first category on which to focus attention. Due to the short history of HTPL in Korea, the recipients were chosen according to operation safety. Therefore the heart donor age was relatively younger than other organ donors. The mean age is younger than the global data but that is because pediatric heart donation in the under 17 s is not popular in Korea as yet (around 12% in Korea vs. >20% in USA), like Japanese society,[16] so they cannot be matched directly. Even considering the low rate of pediatric HTPL, however, the number of donors aged >50 years is still very low. The oldest donor in Korea was 56 years old (only 3 patients in 20 years), while global data show successful transplantation results with donors aged >65 years (7 in 2000, 4 in 2004, 1 in 2009).[17] It is evident that the recipients are getting gradually older, considering that the proportion of ischemic heart disease patients already exceeded that of dilated cardiomyopathy. Moreover, with the improvement of surgical technique and transplantation outcome,[18] the number of old-aged HTPL candidates is sure to increase. If the age of donor hearts is not increased in parallel to the age increase of recipients, the waiting time might be prolonged.

In this study, we found that female heart donors were currently under-utilized and female recipients received more gender-mismatched hearts than male recipients (58.3% vs. 20.3%, respectively). Past studies, however, have suggested the significance of donor–recipient gender matching in HTPL outcome.[17,19,20] Prendergast et al reported on the role of donor gender in HTPL in a retrospective study, and found reduced 1-year survival in gender-mismatched recipients compared to gender-matched HTPL (66.7% vs. 84.8%, respectively).[19] Therefore efforts to utilize female donor hearts are needed for female recipients in Korea.

Currently the waiting time in Korea is shorter than the global average,[8] and the fraction of status 0 patients is very low. Globally, LV assistance device (LVAD) has been successfully used in the clinical field since the 1970 s.[21,22] In Korea, however, although LVAD was first introduced in 2008, the LVAD system has been used very little, because LVAD is not covered by insurance, whereas HTPL is fully covered. Therefore, nearly all status 0 cases belong to the 'mechanical ventilator with extra-corporeal membrane oxygenation (ECMO)' category. In Korea, the proportion of status 0 patients has continuously increased after 2007 due to the very rapid spread of the ECMO system.

A relatively short waiting time may lead to clinical inertia in the full utilization of transplantable donor hearts. The important factor inhibiting maximum utilization might be adherence to the strict criteria for heart donor selection, and not allowing the possibility of the efficacy of marginal donor hearts.

In the present data, marginal donor hearts were successfully transplanted to recipients with no worse outcome. Moreover, there were more overall sudden death events in non-marginal recipients. There were 14 over-sized donor hearts, and the mortality rate remained unchanged regardless of adding over-sizing as a marginal status factor in the data. Currently, according to Korean criteria, however, oversized donors are not recommended for transplantation due to difficulties in surgical procedure involving the insertion of a large heart into a small pericardial space, and occurrence of constrictive physiology after surgery. Twenty-five recipients of marginal donor hearts, regardless of over-sizing factors, did not show an increased death rate within 1 year. Because the transplantation rate has been on a steep rise during recent years, 35 out of 67 recipients underwent transplants after 2011, and the mean follow-up time was only 17.5 months. Due to insufficient follow-up duration, the current study lacks the ability to provide information on long-term mortality, and follow-up studies are needed. There are already a number of reports, however, indicating that hearts from donors aged >55, and also those from high-risk donors can be successfully transplanted.[23–26] According to reports, in the early period of HTPL, most institutions excluded donors >40 years of age with extended comorbidities, and younger age was thought to enhance graft function. Organ shortages, however, led to increasing acceptance of more marginal, especially older aged donors, and it was found that the results obtained with donors older than 40 years are not significantly different from those with younger donors.[23–26] Drinkwater et al reviewed early and late HTPL results with the use of older donors from 1987 to 1994, and found similar survival outcomes between younger and older donor groups. There were no differences in the development of transplant-associated coronary artery disease during the follow-up period.[25] Pflugfelder et al examined 219 HTPL patients, and found no relationship between donor age and 90-day graft loss. Cardiac function at 3 and 12 months, assessed on treadmill exercise duration, rest and peak supine exercise hemodynamics, and radionuclide angiography, was also unrelated to donor age.[27] Experts are addressing the feasibility as well as the necessity of donor criteria expansion to increase utilization of marginal donor hearts. Efforts to utilize marginal donor hearts in Korea, however, are still insufficient to satisfy the expanding needs of HTPL.

In previous studies, donor heart graft survival has been greatly influenced by donor-recipient racial mismatch.[28,29] Recipients of other organs such as liver or lung also had worse outcomes when their races were different from that of the donors.[30,31] Moreover, Kilic et al reported that Asian subjects had a lower 1-year rejection rate than other races with regard to recipient ethnicity.[29] Because the Korean population is ethnically homogenous, it could be an important reason why the survival rate in Korean HTPL is better than the global data. Although results of HTPL utilizing marginal donors are not available, in this aspect, even marginal donor hearts might bring better results in Korea compared to global data.

According to global data, the reasons for non-use of donor hearts are as follows: no recipients found; poor donor organ function; infection; and donor medical and social history. In Korea, there still is a large number of hearts discarded due to vague criteria and insufficient efforts to fully utilize them.

The limitation of this study was the lack of detailed data in the early period of HTPL. Donor privacy is considered important in Korea, and detailed donor information was not secure enough to be analyzed.

Conclusion

HTPL is an established treatment modality for terminal heart failure in Korea. A shortage of donor hearts is anticipated in Korea, and the waiting time for HTPL will soon increase rap-

idly. To solve the donor shortage problem, a forward-looking policy in donor heart utilization is required. Utilization of old-aged donor hearts, donor hearts with minor echocardiographic abnormality, and establishment of practice guidelines for marginal donor utilization are 3 important suggestions. HTPL is a very effective treatment modality to improve quality of life as well as survival, and Korean HTPL show better results than global data probably due to ethnic homogeneity. Therefore, broadening donor criteria and maximizing utilization could enhance survival and quality of life in the overall heart failure patient group.

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Disclosures

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Supplementary Files

Supplementary File 1

Table S1. Donor Utilization According to Transplantation Status

Table S2. Recipient Characteristics vs. Marginal Donor Heart Status

Please find supplementary file(s);
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