Original Article

Korean J Transplant 2022;36:267-277
https://doi.org/10.4285/kjt.22.0038

KJT
KOREAN JOURNAL OF TRANSPLANTATION

pISSN 2671-8790
eISSN 2671-8804

Trends in contemporary advanced heart failure management: an in-depth review over 30 years of heart transplant service in Hong Kong

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Background: The year 2022 marks the 30th anniversary of heart transplant service in Hong Kong (HK). In this study, we describe prevailing trends and outcomes of advanced heart failure (AHF), including heart transplantations (HTx), in HK over the past 30 years.
Methods: Trends in heart failure prevalence in HK from 1993 to 2021 were analyzed based on data from the Hospital Authority Clinical Data and Reporting System. All AHF patients referred for HTx consideration between 1992 and 2021 were reviewed. The bridge-to-transplant (BTT) utilization of short-term mechanical circulatory support (ST-MCS) devices, including venoarterial extracorporeal membrane oxygenation (VA-ECMO) and durable left ventricular assist devices (LVADs), from 2010 to 2021 was reviewed.
Results: Overall, 237 heart transplants were performed in HK, with 10-year posttransplant and median survival of 68.1% and 18.7 years, respectively. An increase in AHF clinic referrals was correlated with increasing heart failure prevalence (R^2=0.635, P<0.001). In total, 146 referrals were made for ST-MCS, and an observed increase in ST-MCS referrals was correlated with increasing VA-ECMO utilization (R^2=0.849, P<0.001). Among 62 patients accepted for AHF therapy, those with durable LVAD implementation had better 1-year survival (71.5%) than those receiving an extracorporeal CentriMag (Levitronix) device as BTT (40%, P=0.008). In total, 143 LVADs were implanted, with 130 as BTT or bridge-to-candidacy (BTC) methods. The survival rate among the 130 BTT/BTC LVAD patients resembled that of HTx recipients (73.8% vs. 69.8% at 9 years, P=0.296).
Conclusions: The burden of AHF management has increased and gained complexity over the past 30 years in Hong Kong.

Keywords: Heart transplantation; Heart-assist devices; Heart failure

Received August 1, 2022
Revised October 5, 2022
Accepted October 6, 2022

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HIGHLIGHTS

- New data are presented on trends in the burden of advanced heart failure in Hong Kong (HK).
- New data are presented on the utilization and outcomes of mechanical circulatory support (MCS) in HK.
- Left ventricular assist device implantation was the preferred bridging strategy for patients with short-term MCS in HK.

INTRODUCTION

Heart failure syndrome affects an estimated 38 million people worldwide, with a prevalence of 1% to 2% among adults [1-3]. Advanced heart failure (AHF) refers to heart failure that has progressed to a stage in which traditional evidence-based treatments have become ineffective and the patient has severe symptoms, frequent episodes of decompensation, and poor survival [3-5]. The incidence of AHF is increasing despite dramatic innovations in medical and device-based treatments for heart failure in recent decades [3,4,6,7]. Heart transplant (HTx) remains the standard of care for AHF patients deemed appropriate candidates [3].

The first HTx in Hong Kong (HK) was performed on December 18, 1992 [8], and the year 2022 marks the 30th anniversary of both the first HTx recipient and the HTx service in HK. Long-term outcomes after HTx in HK have been promising and are comparable to international benchmarks [5]. However, the disparity between available donor hearts and potential recipients on the HTx waiting list has continued to grow [5]. As in the rest of the world, donor availability remains the major limitation for HTx service; on average, only 12 HTx have been performed annually in HK in recent years [5]. Meanwhile, care for patients with AHF remains challenging and continues to evolve in a complex milieu of therapeutic options, advanced technological interventions, and dedicated efforts to improve patient-centered management programs. The aim of this study is to describe the evolving trends and outcomes of AHF in HK over the past 30 years.

METHODS

Ethics Approval

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional Ethics Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (IRB/REC No. UW 20-388), and individual consent for this retrospective analysis was waived.

Data Attributes

Incidence and prevalence rates of heart failure in HK were estimated from anonymous data on heart failure-related coding retrieved from the Clinical Data and Reporting System (CDARS) of the Hong Kong Hospital Authority from 1993–2021. Heart failure-related coding was defined as including International Classification of Primary Care second edition code K77 and International Classification of Diseases ninth revision codes 428, 425, 398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 414.8, and 277.9. HK has only one HTx service for AHF management. All patients referred to this service from 1992 (when the service was established) until 2021 were reviewed, with data stratified into three 10-year eras (1992–2001, 2002–2011 and 2012–2021) for comparisons. All patient referrals to the HTx service related to short-term mechanical circulatory support (ST-MCS) devices, including venoarterial extracorporeal membrane oxygenation (VA-ECMO) and the Impella (Abiomed, Danvers, MA, USA) percutaneous intravascular microaxial left ventricular assist device, as well as all patients implanted with durable left ventricular assist devices (LVAD) for bridge-to-transplantation (BTT), bridge-to-candidacy (BTC) and destination therapy (DT) in HK from 2010 to 2021 were reviewed. VA-ECMO utilization in ECMO intensive care units and the AHF cardiothoracic transplant service in HK from 2010 to 2021 was also reviewed. Baseline demographics, including age and sex, and mortality outcomes during the study period were retrieved. For the HTx cases, preoperative demographic data of donors and recipients were obtained.

Statistical Analysis

Continuous variables were expressed as mean±standard deviation of the mean. Categorical data were expressed as numbers and percentages. Continuous variables were compared using the Student t-test or analysis of variance as appropriate. The chi-square test was used to assess

https://doi.org/10.4285/kjt.22.0038

the differences between categorical variables. Correlations between two continuous variables were analyzed using linear regression. Survival was analyzed with the Kaplan-Meier method and compared using the log-rank test. A Cox proportional hazards model was used, and factors with P≤0.1 on univariate analysis were accepted for subsequent multivariate analysis to identify independent predictors of mortality after heart transplantation. All preoperative demographic data of donors and recipients were entered into the risk factor analysis. Missing values for the HTx cohort were handled by multiple imputation, with five imputations used for a final pooled analysis. Missing data from the other cohorts were excluded from analysis. All tests were two-sided, and a P-value <0.05 was considered to indicate statistical significance. Statistical analysis were performed using IBM SPSS ver. 28 (IBM Corp., Armonk, NY, USA).

RESULTS

Heart Failure Burden in Hong Kong: an Overview

Since 1993, a total of 292,715 patients have been diagnosed with heart failure in HK (male, 47.5%; mean age, 76 years). All-cause mortality rates from the first heart failure diagnosis, after excluding 48 cases with uncertain survival intervals, were 28.5%, 57.1% and 75.2% at 1 year, 5 years and 10 years, respectively (Fig. 1A). After excluding 21,474 patients with unknown cause of death

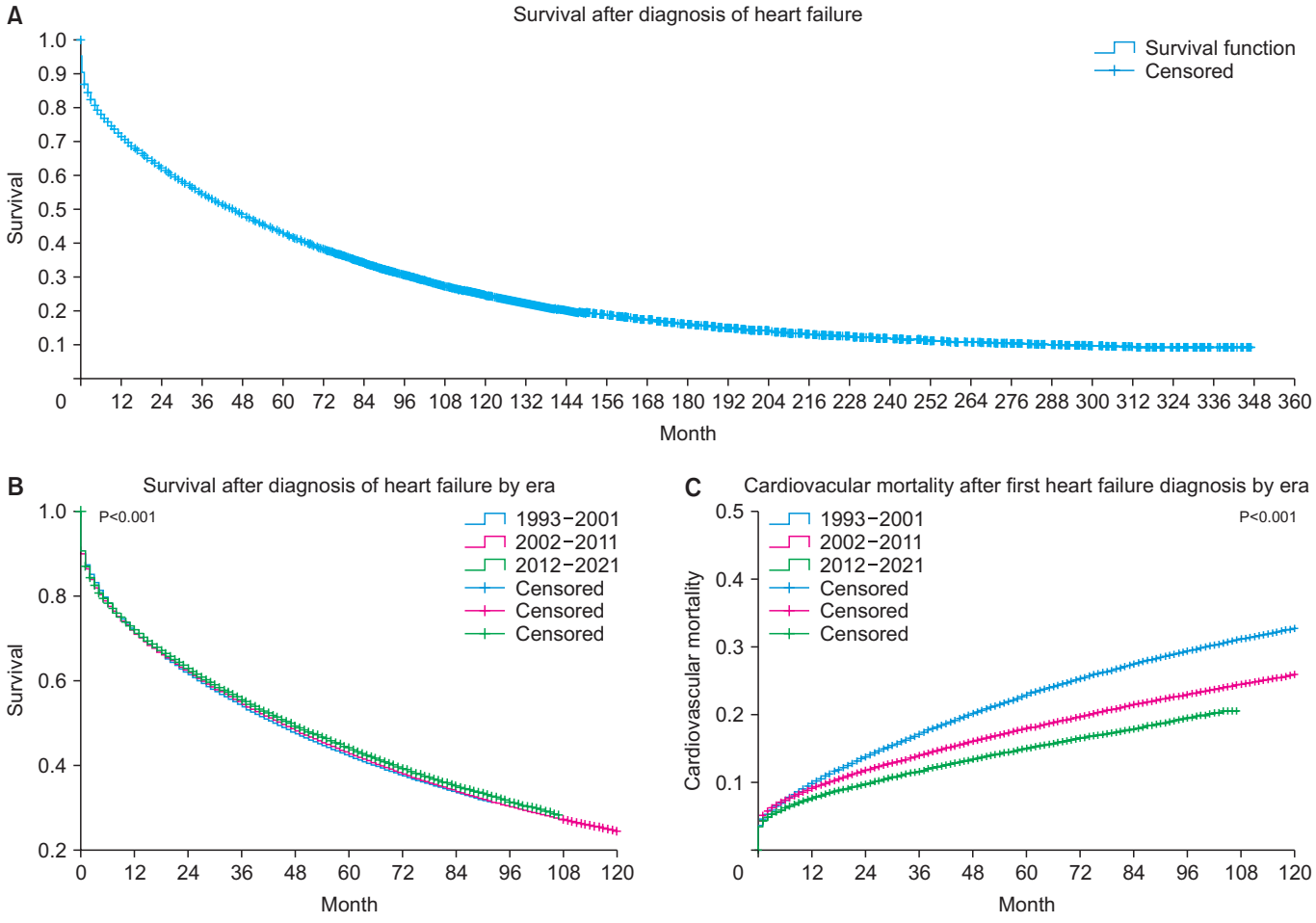

Fig. 1. Hong Kong heart failure statistics in 1993–2021. (A) Long-term survival after the first diagnosis of heart failure in Hong Kong in 1993–2021 (n=292,667). (B) A significant difference was observed across the examined eras in long-term survival after the first diagnosis of heart failure in Hong Kong (P<0.001). (C) A significant difference was also seen across eras in cardiovascular mortality after first diagnosis of heart failure in Hong Kong (n=271,241; P<0.001).

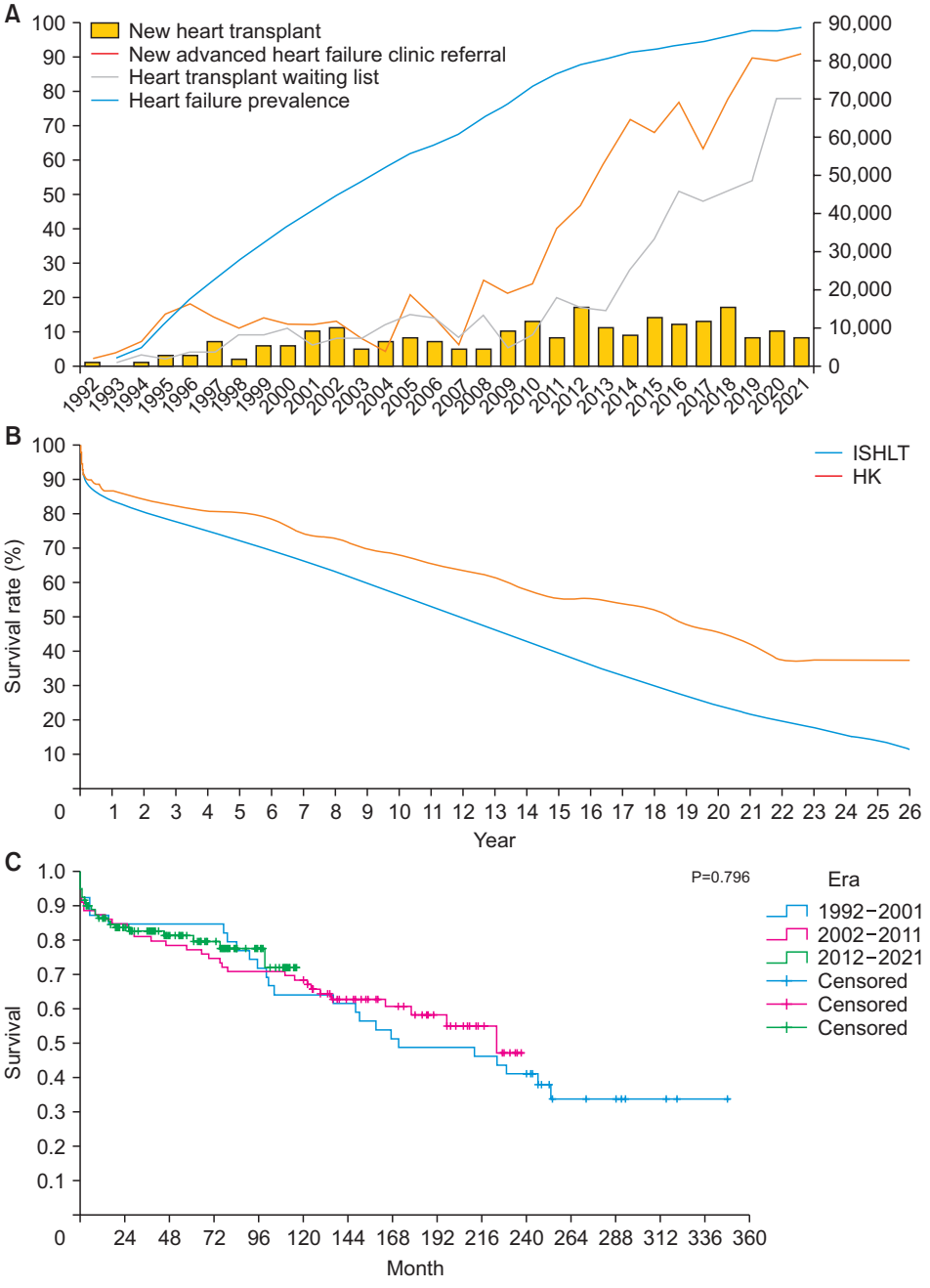

Fig. 2. Hong Kong heart transplant statistics in 1992–2021. (A) Trends in number of new heart transplantations, new advanced heart failure clinic referrals, active patients on the heart transplant waiting list, and heart failure prevalence in Hong Kong from 1992 to 2021. (B) Long-term survival after adult and pediatric heart transplantations in Hong Kong (HK; n=237) and the International Society for Heart and Lung Transplantation Registry (ISHLT; n=114,783). (C) Long-term survival after adult and pediatric heart transplantations in Hong Kong by era.

or uncertain duration of survival, cardiovascular mortality was 8.8%, 18.4% and 27.1% at 1 year, 5 years and 10 years, respectively. Mean incidence increased from 7419 cases in 1993–2001 and 11,272.6 cases in 2002–2011 to 11,321.5 cases in 2012–2021 (P<0.001). Mean prevalence increased from 21,744 cases in 1993–2001 and 60,417 cases in 2012–2011 to 84,631 cases in 2012–2021 (P<0.001) (Fig. 2A). In 2021, the prevalence of heart failure was 1.2% in a population of 7.41 million. The 5-year all-cause mortality rate was 57.9% in 1993–2021, 57.3% in 2002–2011, and 56.0% in 2012–2021 (P<0.001) (Fig. 1B). The 5-year cardiovascular mortality rate was 23% in 1993–2001, 18% in 2002–2011, and 15.1% in 2012–2021 (P<0.001) (Fig. 1C).

https://doi.org/10.4285/kjt.22.0038

Table 1. Baseline characteristics of the heart transplant cohort before and after multiple imputation adjustment for missing values as well as the univariate and multivariate analyses for survival after heart transplantation in Hong Kong

Baseline characteristic	Original cohort (n=237)	After multiple imputation	Univariate		Multivariate	
			HR (95% CI)	P-value	HR (95% CI)	P-value
Transplant era						
1992–2001	39 (16.5)	39 (16.5)				
2002–2011	79 (33.3)	79 (33.3)	0.869 (0.504–1.498)	0.614		
2012–2021	119 (50.2)	119 (50.2)	0.813 (0.433–1.525)	0.519		
Recipient						
Male sex	165 (69.6)	165 (69.6)	1.365 (0.817–2.281)	0.235		
Age (yr)	43.7±13.4	43.7±13.4	1.001 (0.983–1.019)	0.935		
Blood group (group O)	86 (36.3)	86 (36.3)	1.098 (0.698–1.728)	0.685		
Smoking (n=233)	84 (36.1)	85.6 (36.1)	1.392 (0.895–2.167)	0.143		
Alcohol use (n=230)	36 (15.7)	40.2 (17.0)	1.067 (0.588–1.935)	0.831		
Diabetes mellitus (n=236)	53 (22.5)	53.6 (22.6)	1.289 (0.766–2.169)	0.339		
Hypertension (n=236)	37 (15.7)	37.4 (15.8)	0.830 (0.413–1.670)	0.602		
Hyperlipidemia (n=236)	56 (23.7)	56.4 (23.8)	0.850 (0.483–1.496)	0.574		
TIA/CVA (n=236)	19 (8.1)	19.6 (8.3)	1.470 (0.712–3.035)	0.297		
Peripheral artery disease (n=236)	3 (1.3)	3 (1.3)	1.417 (0.196–10.218)	0.730		
CKD (n=230)	40 (17.4)	44.4 (18.7)	1.545 (0.938–2.543)	0.087	1.364 (0.803–2.317)	0.250
Atrial fibrillation (n=236)	85 (36)	85.6 (36.1)	1.030 (0.652–1.627)	0.899		
Ventricular arrhythmia (n=236)	66 (28)	66.8 (28.2)	1.191 (0.730–1.942)	0.485		
Depression (n=236)	4 (1.7)	4.6 (1.9)	5.270 (1.720–16.151)	0.004	4.682 (1.410–15.549)	0.012
Asthma/COPD (n=236)	12 (5.1)	12.8 (5.4)	1.546 (0.596–4.010)	0.371		
History of tuberculosis (n=236)	7 (3.0)	7.2 (3.0)	0.929 (0.227–3.809)	0.918		
Obstructive sleep apnea (n=236)	9 (3.8)	9.4 (4.0)	1.814 (0.573–5.746)	0.311		
Overweight (n=236)[a]	35 (14.8)	36 (15.2)	1.556 (0.849–2.850)	0.152		
Thyroid disease (n=236)	28 (11.9)	28.8 (12.2)	1.286 (0.652–2.534)	0.468		
Hepatitis B carrier (n=234)	12 (5.1)	13.6 (5.7)	1.516 (0.638–3.603)	0.346		
Liver cirrhosis (n=235)	7 (3.0)	7.8 (3.3)	3.170 (0.868–11.581)	0.080	3.026 (0.935–9.800)	0.065
DVT/PE (n=236)	2 (0.8)	2.6 (1.1)	0.482 (0.000–12566)	0.887		
History of malignancy (n=236)	5 (2.1)	5.8 (2.4)	0.356 (0.004–29.917)	0.640		
HF etiology (ischemic)	44 (18.6)	44 (18.6)	0.577 (0.348–0.959)	0.034	1.783 (1.016–3.128)	0.044
HF duration (mo) (n=234)	57.3 (65.3)	57 (65.5)	0.997 (0.993–1.001)	0.141		
ICD	92 (38.8)	92 (38.8)	0.817 (0.508–1.313)	0.404		
CRT	67 (28.3)	67 (28.3)	0.871 (0.512–1.484)	0.612		
LVAD	35 (14.8)	35 (14.8)	0.937 (0.399–2.203)	0.882		
LVEDD (cm) (n=201)	6.5±1.4	6.5±1.4	0.961 (0.819–1.128)	0.627		
LVESD (cm) (n=195)	5.8±1.5	5.8±1.5	0.946 (0.813–1.100)	0.471		
LVEF (%) (n=217)	23.3±13	23.7±13.9	1.005 (0.990–1.021)	0.508		
Cardiac output (L/min) (n=201)	3±0.9	3±1	1.095 (0.873–1.374)	0.431		
Cardiac index (L/min/m^2) (n=200)	1.8±0.5	1.8±0.6	1.299 (0.856–1.973)	0.217		
PCWP (mmHg) (n=194)	21.2±9.5	20.8±10.1	1.021 (0.997–1.046)	0.080	1.005 (0.953–1.059)	0.856
RAP (mmHg) (n=173)	11.8±7.4	11.7±8.2	1.019 (0.989–1.051)	0.216		
PAPm (mmHg) (n=203)	29.7±11.9	29.7±12.3	1.018 (0.999–1.038)	0.069	1.015 (0.969–1.063)	0.521
PVR (Wood units) (n=195)	3.7±3.8	3.7±4.4	1.015 (0.949–1.085)	0.662		
VO_2max (mL/kg/min) (n=143)	14.2±4.2	14.4±6.3	1.003 (0.947–1.061)	0.917		

Table 1. Continued

Baseline characteristic	Original cohort (n=237)	After multiple imputation	Univariate		Multivariate	
			HR (95% CI)	P-value	HR (95% CI)	P-value
Donor						
Male sex	154 (65)	154 (65)	0.708 (0.455–1.102)	0.126		
Age (yr)	41.6±13.7	41.6±13.7	1.012 (0.995–1.029)	0.157		
Blood group (group O)	136 (57.4)	136 (57.4)	0.967 (0.622–1.502)	0.880		
Weight (kg)	64.4±11.1	64.4±11.1	0.993 (0.972–1.015)	0.529		
Height (cm) (n=233)	165.7±10.6	165.8±10.6	0.975 (0.955–0.995)	0.016	0.977 (0.955–1.001)	0.057
BMI (kg/m^2) (n=233)	23.3±3	23.3±3.1	1.034 (0.959–1.115)	0.384		
Smoking (n=222)	79 (35.6)	89.4 (37.7)	1.628 (0.993–2.669)	0.054	1.693 (0.989–2.898)	0.055
Alcohol use (n=151)	18 (11.9)	69 (29.1)	0.892 (0.857–4.179)	0.110		
Diabetes mellitus (n=220)	7 (3.2)	15.6 (6.6)	1.108 (0.395–3.102)	0.846		
Hypertension (n=223)	49 (22.0)	53.2 (22.4)	1.876 (1.145–3.072)	0.012	2.123 (1.237–3.641)	0.006
Malignancy history (n=223)	10 (4.5)	18.2 (7.7)	1.240 (0.488–3.156)	0.651		
Inotrope use (n=236)	212 (89.8)	212 (89.5)	1.316 (0.678–2.556)	0.417		
CPR (n=220)	42 (19.1)	48.4 (20.4)	1.192 (0.641–2.216)	0.579		
Ischemic time (n=156)	162.4±56.5	162±77.5	1.000 (0.994–1.007)	0.883		

Values are presented as number (%) or mean±standard deviation.

HR, hazard ratio; CI, confidence interval; TIA, transient ischemic attack; CVA, cerebrovascular accident; CKD, chronic kidney disease with estimated glomerular filtration rate less than 60 mL/min/1.73 m^2; COPD, chronic obstructive pulmonary disease; DVT, deep vein thrombosis; PE, pulmonary embolism; HF, heart failure; ICD, implantable cardioverter defibrillator; CRT, cardiac resynchronization therapy; LVAD, left ventricle assist device; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; LVEF, left ventricular ejection fraction; PCWP, pulmonary capillary wedge pressure; RAP, mean right atrial pressure; PAPm, mean pulmonary arterial pressure; PVR, pulmonary vascular resistance; VO_2max, peak oxygen consumption on cardiopulmonary exercise test; BMI, body mass index; CPR, cardiopulmonary resuscitation.

[a)]BMI >25 kg/m^2.

Heart Transplant Outcomes and Waiting List Trends

Over the studied period, 237 HTx procedures were performed in HK, including two heart-liver transplants and one retransplantation. Table 1 shows the baseline characteristics of this HTx cohort. The 1-year and 10-year posttransplant survival rates were 86.8% and 68.1%, respectively, with a median survival of 18.7 years (Fig. 2B). No significant difference was observed in survival after heart transplantation among the three eras (1992–2001, 2002–2011, and 2012–2021) (P=0.796) (Fig. 2C). Multivariate Cox regression analysis revealed that a history of depression in the recipient (hazard ratio [HR], 4.682; 95% confidence interval [CI], 1.410–15.549; P=0.012), ischemic cause of heart failure (HR, 1.783; 95% CI, 1.016–3.128; P=0.044) and a history of hypertension in the donor (HR, 2.123; 95% CI, 1.237–3.641; P=0.006) were independently associated with increased risk of mortality after heart transplantation in HK (Table 1). A significant increase was observed over time in the mean number of active patients on the HTx waiting list at the end of each year (5.4 in 1992–2001, 11.4 in 2002–2011, and 45.8 in 2012–2021) (P<0.001) (Fig. 2A). A significant increase was also seen in the mean number of new referrals to the AHF clinic, from 10.9 in 1992–2001 to 17.6 in 2002–2011 to 73.5 in 2012–2021 (P<0.001) (Fig. 2A). The increase in new AHF clinic referrals correlated with the increase in background heart failure prevalence (R^2=0.635, P<0.001). The increase in active patients on the HTx waiting list at the end of each year correlated with the increase in the number of new AHF clinic referrals in 1992–2001 (R^2=0.830, P<0.001).

Short-term and Durable Mechanical Circulatory Support

The utilization of VA-ECMO and extracorporeal cardiopulmonary resuscitation in HK significantly increased from an average of 31.7 and 4.7 cases per year, respectively, in 2010–2015 to 125.7 and 41.8 cases per year, respectively, in 2016–2021 (P<0.001) (Fig. 3A). In total, 146 urgent referrals (male, 76.0%; mean age, 49.4 years) were made to the transplant service related to ST-MCS (including the use of VA-ECMO and Impella [Abiomed]) between 2010 and 2021. These referrals significantly increased from a

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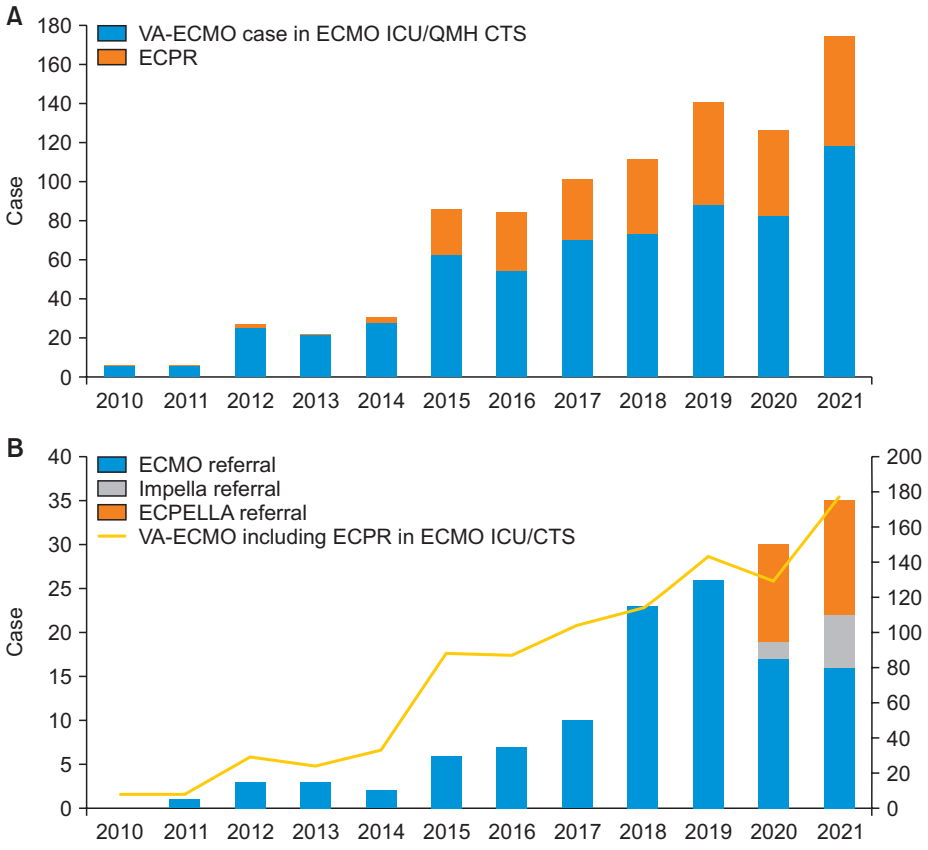

Fig. 3. Mechanical circulatory support statistics in Hong Kong in 2010–2021. (A) Trend in the utilization of venoarterial extracorporeal membrane oxygenation (VA-ECMO) and extracorporeal cardiopulmonary resuscitation (ECPR) in Hong Kong from 2010 to 2021. (B) Trend in VA-ECMO or percutaneous microaxial left ventricular assist device (Impella; Abiomed)-related referrals to the heart transplant service as well as total background numbers of VA-ECMO and ECPR cases in Hong Kong from 2010 to 2021. ICU, intensive care unit; QMH, Queen Mary Hospital; CTS, cardiothoracic surgery; ECPELLA, extracorporeal membrane oxygenation and impella.

mean of 2.5 cases per year in 2010–2015 to a mean of 21.8 cases per year in 2016–2021 (P=0.002) (Fig. 3B). The increase in ST-MCS referrals was correlated with the increase in VA-ECMO utilization in HK (R^2=0.849, P<0.001). Among the referrals, 52 (35.6%) were declined, 32 (21.9%) were weaned from ST-MCS due to improvement, and 62 were eventually accepted for AHF treatment. Among the 62 accepted patients, 25 had CentriMag (Levitronix, Waltham, MA, USA) implanted as the bridging device, while 37 underwent LVAD implantation. Thirty-day and 1-year survival rates were 25% and 7.7% for the declined group, 87.1% and 58.6% for the accepted group, and 100% and 96.9% for the improved group, respectively (P<0.001) (Fig. 4A). Among the accepted group, patients receiving LVAD implantation had a significantly greater 1-year survival rate at 71.5% compared to 40% among those who had CentriMag (Levitronix) as a bridging device (P=0.008) (Fig. 4B).

Since the first LVAD implantation in 2010, a total of 143 LVADs were implanted (male, 83.2%; mean age, 50 years), and the number of LVAD implantations significantly increased from 5.2 cases per year in 2010–2015 to 18.3 cases per year in 2016–2021 (P=0.002). Among the 143 LVAD implantations, 30 were HeartWare (HeartWare International Inc., Framingham, MA, USA), 43 HeartMate II (Abbott, Chicago, IL, USA), and 70 HeartMate 3 (Abbott) devices; with regard to initial strategy, 130 were intended for BTT/BTC and 13 were for DT. Thirty-six patients were undergoing HTx, and 38 patients died on LVAD support. The 1- and 4-year survival rates were 81.7% and 68.8%, respectively, after implantation (Fig. 5A). The survival rate among the 130 BTT/BTC LVAD patients resembled that among HTx recipients in HK (73.8% vs. 69.8% at 9 years, P=0.296) (Fig. 5B).

DISCUSSION

To our knowledge, this is the first study in which the burden of AHF in HK was analyzed over the past 30 years. Previously, the best available data regarding the burden of heart failure in HK was published in 2016 and extrapolated from a single center [9]. In HK, clinical data of the

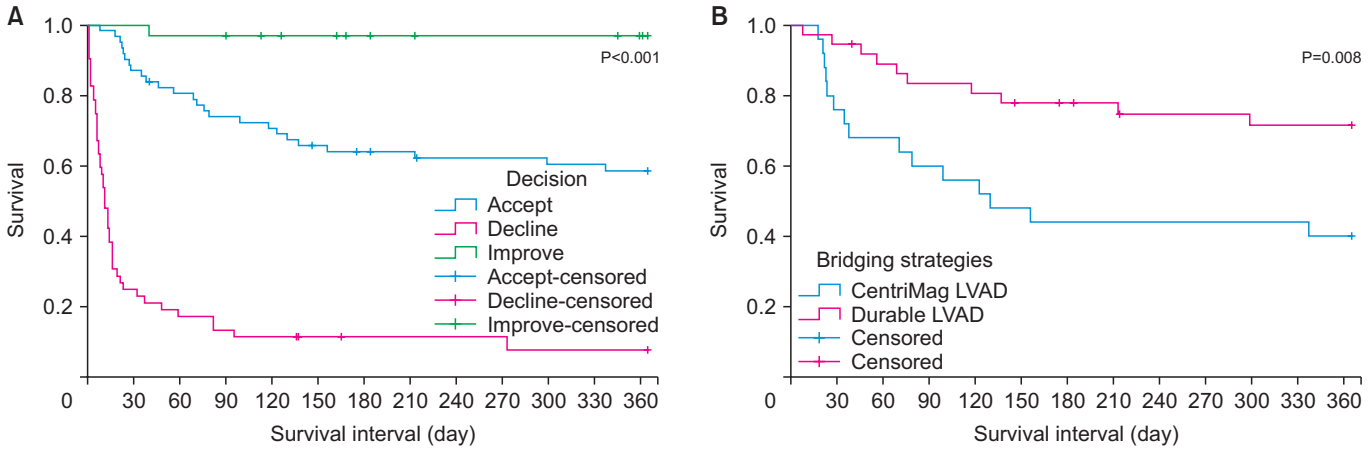

Fig. 4. (A) Survival of patients referred for advanced heart failure therapy related to the use of short-term mechanical circulatory support devices. A significant difference in survival was observed by decision after patient referral to the advanced heart failure service related to short-term mechanical circulatory support (P<0.001). (B) Survival of patients accepted for advanced heart failure therapies by different bridging strategies. Significantly better survival (71.5%) was observed at 1 year after durable left ventricular assist device implantation compared to 40% at 1 year after CentriMag (Levitronix) left ventricular assist device implantation as bridging strategies for transplantation/candidacy (P=0.008). LVAD, left ventricular assist device.

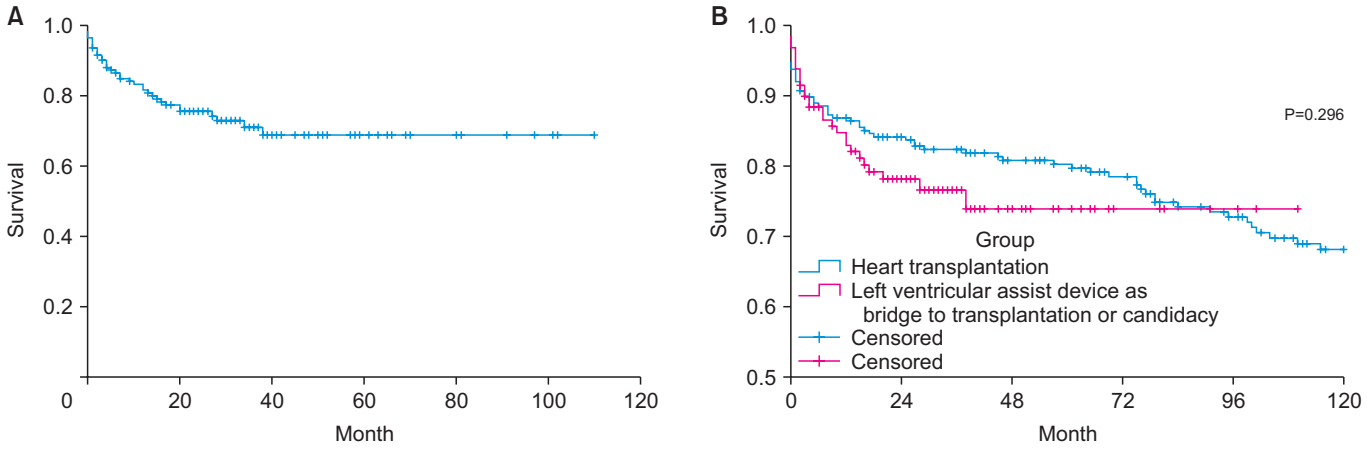

Fig. 5. (A) Survival after durable left ventricular assist device implantation in Hong Kong between 2010 and 2021 (n=143). (B) Comparison of survival after durable left ventricular assist device implantation as a bridge to transplantation/candidacy strategy and survival after heart transplantation in Hong Kong (P=0.296).

public health care service from 1993 onward are accessible from the CDARS database [10]. Previous studies have demonstrated high accuracy in CDARS coding for various cardiovascular conditions [11,12]. In the present study, heart failure prevalence from CDARS data was found to correlate with the increase in *de novo* AHF clinic referrals over the past 30 years. The prevalence of heart failure is known to be approximately 1%–2% in Western countries, while the range is wider in Asian countries, ranging from 0.4% to 5% [9,13-15]. The prevalence of heart failure in HK was 1.2% in 2021, which is consistent with the prevalence in other parts of the world. In the present study, the 5-year all-cause mortality and cardiovascular mortality of heart failure were 57.1% and 18.4%, respectively, which were similar to the rates of 54% and 20.7% in the previous single-center study. Thus, the findings in the present study were consistent with existing data [9].

The long-term survival rates of HTx recipients in HK were 86.8% and 68.1% at 1 year and 10 years, respectively, with a median survival of 18.7 years. These rates were comparable to the international survival benchmarks reported by the International Society of Heart and Lung

https://doi.org/10.4285/kjt.22.0038

Transplantation Registry of 84.0% and 56.8% at 1 year and 10 years, respectively, with a median survival of 11.9 years [16]. During the first era examined in the present study (1992–2001), heart transplantations were mainly performed using the technique of biatrial anastomoses. However, from 2002–2011, a gradual transition occurred from biatrial anastomoses to the bicaval method, in which the superior and inferior vena cava of the donor heart are anastomosed to the recipient's superior and inferior vena cava. Finally, by the most recent era studied (2012–2021), the bicaval method had become the standard technique and was found to have a lower incidence of tricuspid insufficiency and atrial arrhythmia than previous methods [17]. Although a significant increase was noted in the average number of HTx procedures performed over the past 30 years, the actual heart transplantation rate remained low at 1.1 per million population (PMP) in 2021, which was similar to the global heart transplantation rate (1.06 PMP) in 2016–2018 [18]. The significant increase in the number of AHF referrals (reaching 73.5 per year in 2012–2021) and the low number of HTx procedures performed (averaging 11.9 per year in that same period) highlight the increasing disparity in the HTx service burden and donor heart supply.

The utilization of ST-MCS remained limited before 2010 but rapidly evolved afterwards. The ECMO service was initially intended for veno-venous use in response to the CESAR trial [19] and H1N1 influenza acute respiratory distress syndrome demand in 2009, and few centers in HK provided routine VA-ECMO service at that time. With increased experience in the technique and approval of central reimbursement for VA-ECMO as a life-saving procedure in January 2015, a significant increase was observed in the utilization of VA-ECMO for the management of critical cardiogenic shock. In addition, due to the publication of the Intraaortic Balloon Pump in Cardiogenic Shock 2 trial [20], the use of intraaortic balloon pumping in cardiogenic shock diminished, particularly in the setting of acute myocardial infarction, and an alternative MCS device was needed to support these patients [21]. The Impella (Abiomed) device has been approved for central reimbursement in HK since January 2020. The increase in AHF referrals associated with the use of these ST-MCS devices correlated closely with the increase in overall VA-ECMO utilization numbers in HK.

Durable LVAD support is an established therapy for both BTT and DT [22]. Currently, durable LVAD implantation is only eligible for reimbursement in HK for BTT/BTC indication as a life-saving strategy. Support for LVAD implantation as indicated for DT has not yet been established in HK. The first LVAD implantation in HK was performed in August 2010, and the overall survival rates were 81.7%, 75.6%, and 68.8% at 1 year, 2 years, and 4 years, respectively. These compare favorably to the benchmark survival rates of 82%, 72%, and 54% at 1 year, 2 years, and 4 years, respectively, in the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) [22]. In early years, an external extracorporeal CentriMag (Levitronix) device was used as the bridging strategy for patients with INTERMACS profile 1 on ST-MCS devices, given the elevated risk of durable LVAD implantation among this group of patients [23]. However, durable LVAD use became more common with improvements in technology and experience [22,24]. In the present study, we demonstrated that the durable LVAD was superior to the CentriMag (Levitronix) device as a bridging strategy for patients on ST-MCS with better 1-year survival. Additionally, the overall medium-term survival rates of patients with LVAD as BTT/BTC were comparable to those of HTx recipients in HK up to 9 years. The data analyzed in the present study illustrate the paradigm shift behind the utilization of these devices in BTT strategy, which has become the standard of care for many patients awaiting transplant who develop end-stage organ dysfunction or a life-threatening exacerbation of existing heart failure in HK. However, this study includes only data from a single Asian city, limiting its generalizability.

In conclusion, the burden of AHF management has increased over the past 30 years in HK and has become more complex with the increase in utilization of both short-term and durable mechanical circulatory support, especially in the past 10 years. In the contemporary era, outcomes have improved to the point that patients supported by durable LVAD as BTT have similar survival outcomes to post-HTx patients in HK.

ACKNOWLEDGMENTS

Conflict of Interest
No potential conflict of interest relevant to this article was reported.

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Conceptualization: all authors. Data curation: all authors. Formal analysis: all authors. Methodology: all authors. Project administration: all authors. Visualization: all authors. Writing–original draft: all authors. Writing–review & editing: all authors.

Additional Contributions

We would like to thank the Hospital Authority Joint Intensive Care Unit and Cardiology Extracorporeal Membrane Oxygenation Working Group for sharing VA-ECMO and E-CPR utilization statistics. No potential conflict of interest relevant to this article was reported.

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