Clinical Observation on the Life Expectancy of Artificial Pacemakers Implanted into Humans

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ABSTRACT

As the life span has been extended, heart disease has also become increasingly common, making it the second leading cause of death in Korea. Advances in treatment include the use of cardiac devices, especially artificial pacemakers, which are mainly used for arrhythmias. Recently, the use of cardiac devices has been increasing, but there are insufficient data on their use in Korea. The life expectancy of cardiac devices is often not consistent with laboratory results and clinical outcomes. There has been little research on the actual life expectancy of cardiac devices implanted into the human body.

Patients who had implanted cardiac device for treatment of the cardiac arrhythmia at Keimyung University Dongsan Medical Center until August 2014 were collected the duration until replacement.

There were a total of 402 patients. 367 (91/3%) had only replacement of generator, and 32 (8%) patients were replaced with lead and generator. In case of the pacemaker, the duration of first and second replacement were 7.6 years (2778 days), 6.2 years (2256 days). There was the significant statistically reduction in second replacement. In case of defibrillator, the first and second replacement was 5.8 years (2124 days), 5.3 years (1940 days). The longer the implanted period, the shorter the replacement period.

1. Introduction

The prevalence of chronic disease is increasing due to changes in dietary habits and lifestyles, and the incidence of heart disease is increasing rapidly. Heart disease was ranked second among the top 10 causes of mortality in a 2015 report by Statistics Korea. Many deaths from heart disease are known to be caused by fatal arrhythmias.

Pacemakers are often used to treat severe conduction disturbances and bradycardia, which can cause symptoms such as syncope and severe dizziness. Patients with fatal tachycardia should receive an Implantable Cardioverter Defibrillator (ICD) for primary or secondary prevention. In addition to some genetic disorders that occur in Western and Oriental populations, some heart diseases require special treatment in Asians, especially Koreans.

2. Method

Data on patients who underwent cardiac device implantation for arrhythmias from March 1991 to August 2014 at Keimyung University Dongsan Medical Center were collected. The patients were retrospectively identified through medical records and registered patient information. Patients without sufficient follow-up or who did not undergo regular monitoring were excluded.

3. Result

A total of 402 enrolled patients underwent device replacement. Of these, 367 (91.3%) only had generator replacement, and 35 (8.7%) had replacement of the leads and generator.

The average lifespans of the first and second pacemakers were 7.6 years (2,778 days) and 6.2 years (2,256 days), respectively. The lifespan of the replacement pacemaker was significantly less.

The pacemakers had different modes, and were categorized according to the North American Society of Pacing and Electrophysiology system that usually consists of 3-5 letters. The meaning of the letters and modes is shown in Table 1. According to the pacemaker mode, DDDR, AAIR, VDDR, and VVIR models had average respective longevities of 6.9 years (2,514 days), 6.2 years (2,255 days), 6.4 years (2,339 days), and 5.9 years (2,160 days). The lifespan of DDDR

mode was not significantly different from that of AAIR (p=0.485) and VDDR modes (p=0.272), but was significantly different from that of VVIR mode (p=0.011). The lifespan of AAIR mode was not significantly different from that of VDDR mode (p=0.774) and VVIR mode (p=0.790). The lifespans of VDDR mode and VVIR mode (p=0.837) also did not differ significantly. The differences in lifespan according to manufacturer are shown in Table 2

Table 1. Pacemaker codes

Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ
Chamber(s) paced O = none A = atrium V = ventricle D = dual (A+V)	**Chamber(s) sensed** O = none A = atrium V = ventricle D = dual (A+V)	**Response to sensing** O = none T = triggered I = inhibited D = dual (I+T)	**Rate modulation** O = none R = rate adaptive	**Multisite pacing** O = none A = atrium V = ventricle D = dual (A+V)

A dual-chamber pacemaker is capable of dually pacing and sensing depolarization in both the atrium and ventricle. Thus, a DDDR pacemaker records both atrial and ventricular rates, and can pace either chamber when needed.

Table 2. Life expectancy of a pacemaker (years)

Manufacturer	DDDR	AAIR	VDDR	VVIR
A	6.76	4.36	4.30	5.23
B	3.78	7.75	5.34	3.03
C	2.92	4.34	0	3.22
D	7.16	6.02	5.63	5.91
E	8.51	5.37	8.79	8.02
F	9.74	7.55	7.21	7.99
G	9.33	7.87	9.08	8.18
H	0	0	4.51	5.77

The lifespan of the higher rate, atrial-sensing (AS)-ventricular-sensing (VS) DDDR mode pacemaker tended to be longer than those of the atrial-pacing (AP)-ventricular-sensing (VP) (p=0.237), AS-VP (p=0.237), and AP-VP (p<0.001) pacemakers. The lifespans of the first and second defibrillators were 5.8 years (2,124 days) and 5.3 years (1,940 days).

Regular follow-up monitoring includes voltage assessment, which is the most commonly used measurement of the pacing threshold. If a pacemaker shows a battery reserve less than 2.6 V or impedance (where applicable) greater than 3,000 Ω, the physician should be consulted about the possible need for elective replacement. The life expectancy curves of pacemakers and ICDs according to battery impedance are obtained by collecting data based on the known lifespans of actual implanted pacemakers. The formulas are shown in Table 3.

Table 3. Expected pacemaker longevity according to impedance

	DDD(R)	AAI(R)	VDD(R)	VVI(R)
ACTROS			y= 315.8 In(X)-265.51	
Adapta	y=606.89 In(x)-618.2	y= 383.51 In(X)-1754.8	y= -153.8 In(X)+892.45	y=402.98 In(X)-1771.5
Affinity	y=2219.4 In(x)-14356	y= 3851.6 In(X)-25208	y= 2470 In(X)-161.40	
AT500	y=-109.4 In(x)+2140			
COSMOS	y= 794.2 In(x)- 4505.3			
DART		y= 339.36 In(X)-658.79		
DASH		y= 634.42 In(X)-3247.1		y= 744.92 In(X)-4183.3
EnPulse	y=696.2 In(x)-3105.7	y= 345.28 In(X)-1172.2	y=468.01 In(X)-2176.3	y=534.36 In(X)-2367.7
Identity	y=624.8 In(x)-3620.8	y= 1147.4 In(X)-6357.7	y=1580.4 In(X)-10702	y=590.4 In(X)-3621.2
Integrity	y=708.4 In(x)-4604.3	y= 401.07 In(X)-1625.5		y=658.56 In(X)-4098.8
Kappa	y=718.66 In(x)-3139	y= 589.41 In(X)-2523.1	y=642.44 In(X)-3089	y=495.57 In(X)-1809.2
Paragon	y=1512 In(x)-9110.7			
Philos	y=36.34 In(x)-284.26			
Phoenix		y= 856.42 In(X)-4315		y=380.81 In(X)-168.66
Prodigy	y=881.25 In(x)-3950.7	y= 550.94 In(X)-2450.3	y=875.27 In(X)-3800.2	y=849 In(X)-3871.4
Quantum		y= 1030.1 In(X)-5938.5		y=531.77 In(X)-1356.3
Relay		y= 1387.2 In(X)-8941.8		
Sigma	y=1030.2 In(x)-4693.1	y= 902.79 In(X)-4472.5	y=840.76 In(X)-4101.2	y=881.57 In(X)-4142.6
Solus				y=1359.8 In(X)-8556.9
Thera	y=908 In(x)-3862.6	y= 948.58 In(X)-4723.5	y=852.44 In(X)-3509.5	y=863.96 In(X)-3929.8
Unity			y=983.57 In(X)-6229.7	y=718.31 In(X)-3645.8
Vitatron	y=2471.1 In(x)-17905		y=1528.7 In(X)-10160	y=3753.8 In(X)-27450
Zephyr	y=32 In(x)-170.67			

4. Discussion

The lifespan of a pacemaker has been thought to be approximately 10 years. However, the actual intervals between first and second implantations were about 6-7 years. The interval for ICDs was roughly 5-6 years. There was a difference in lifespan according to the pacemaker mode. It was thought that the lifespan of the battery might depend on the operating algorithm of the pacemaker and ICD. Rosenthal et al. (2010) showed that lower ventricular pacing, and high impedence lead result in increased device longevity. The DDDR mode has a slightly longer lifespan. And Fleischmann et al. (2006) showed that Pacemaker implantation improved health-related QOL. Nowadays DDDR mode was common using. The longer the implanted period, the shorter the replacement period.

The limitations in this study are due to use of single-center data and a variety of models; there is a high probability of statistical bias due to the small sample size. Moreover, newer pacemaker models were not evaluated, and information on recently implemented cardiac resynchronization devices is lacking.

5. Conclusion

Pacemakers and ICDs have an average lifespan of about 5 to 7 years. Therefore, patients with implanted cardiac devices require careful monitoring.

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