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The number of cardiovascular surgeries in Japan may decrease after 2020

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ABSTRACT

The expected future number of cardiovascular operations is estimated based on the predicted Japanese population and the rate of cardiovascular surgery performance calculated from 16845 cases treated by the Nagoya University group of hospitals between 2001 and 2013. The population of <20-year-old individuals has decreased since 1990, while that of 20–64-year-old individuals has also decreased since 2000. The population of 65–79-year-old individuals is expected to peak in 2020, with only the population of ≥80-year-old individuals expected to increase until 2040. The performance rate of cardiovascular surgery per 100,000 population is low in the 20–64-year-old group and increases to reach a peak in the elderly population of 70–74-year-old individuals in valvular heart disease (55.5), ischemic heart disease (54.5) and thoracic aortic aneurysm (31.9) and decreases to about half those values in the ≥80-year-old age group. The number of cardiovascular operations (all types) per 100,000 was 40.6 in 2002, 42.1 in 2006 and 46.6 in 2010. The total number of expected cardiovascular operations is increasing slightly and will reach a peak in 2020 with an estimated 61,506 operations. It then decreases gradually to reach 55966 in 2035, on the premise that the cardiovascular surgery performance rate does not change from the present time. In order to maintain and expand to meet the medical needs of cardiovascular surgery, it is crucial that an effort be made to increase the cardiovascular surgery performance rate, especially in octogenarian patients.

Key Words: cardiac surgery, aortic surgery, future aspect, Japan

INTRODUCTION

The population structure of Japan is changing and shifting quickly towards that of an aging society. The government of Japan estimates that the number of birth had decreased to approximately 1 million babies per year in 2010 and will continue to decrease in future to half a million babies per year in 2060. In contrast, the number of deaths is 1.2 million per year in 2010 and will increase to up to 1.7 million deaths in 2040. Therefore, the total population of Japan peaked in 2010, began to decline thereafter, and will continue to decrease by approximately one million people per year from 2020. The peak total population was over 120 million in 2010. It will decrease to reach less than 100 million after 2045.

The number of cardiovascular surgeries performed principally depends on the total population. It is therefore expected that the number of cardiovascular surgeries will decrease in line with the

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total population. However, in Japan, the elderly (≥65 years) population is expected to continue to increase until 2040 and the number of patients undergoing cardiovascular surgery may be expected to increase according to the increase in the elderly population. This, however, is a vague expectation. We simulate the future changes in the number of the cardiovascular surgeries to clarify the above-mentioned expectation. The prediction of the future number of cardiovascular surgeries is important and helpful for considering the future medical needs related to cardiovascular surgery, to educate young surgeons and for the planning of the medical economy.

METHODS

The expected number of future cardiovascular operations was calculated based on the predicted Japanese population and the cardiovascular surgery performance rate per 100,000 population.

The expected changes in the Japanese population, are described for every age group in a Ministry of Internal Affairs and Communications publication.[1)] We calculated the future changes that are expected in the following age groups of the Japanese population (in years): <20, 20–64, 65–69, 70–74, 74–79 and ≥80 at 5-year intervals from 2015 to 2040.

The cardiovascular surgery performance rate was calculated based on the number of cardiovascular operations, which are published in the annual report of the Japanese Association of Thoracic Surgery (JATS), and the Japanese population. A total of 60,284 cardiovascular operations were performed in 2011, of which 9858, 19164, 15581 and 14126 were for congenital heart disease (CHD), valvular heart disease (VHD), ischemic heart disease (IHD) and thoracic aortic aneurysm (TAA), respectively.[2)]

While the calculation of the cardiovascular surgery performance rate is necessary for each of the above-mentioned age and disease groups, the JATS annual report shows no data on the age groups. We investigated the age distribution of cardiovascular operations, which were performed in Nagoya University Hospital and 11 affiliated hospitals in the period from 2001 to 2013. In that time, there were 16,845 cases, which were registered in the Japan Adult Cardio-vascular Surgery Database (JACVSD). The cases were classified into 6 age groups (in years): <20, 20–64, 65–69, 70–74, 74–79 and ≥80 and the 4 above-mentioned disease groups (CHD, VHD, IHD and TAA). The percentage of each subgroup was calculated for all of the 16,845 cases. The cardiovascular surgery performance rate for each of the age and disease groups was calculated using the following equation.

The number of operations for each age group and each disease group [A]

= number of operations for each disease group reported in the JATS annual report × the percentage of patients of each age group in the same disease group in the surveyed cases.

The cardiovascular surgery performance rate for each age group and each disease group per 100,000 [B] = (number of operations by each age group and each disease group [A] / Japanese population by each age group) × 100,000.

The cardiovascular surgery performance rate for each age group and each disease group was calculated at the following 3 points; 2002, 2006 and 2010. The performance rates of 2002, 2006 and 2010 were calculated with the percentages of each subgroup for 2001–2004, 2005–2008 and 2009–2013, based on the JATS annual reports of 2002, 2006 and 2010 and the Japanese population of 2002, 2006 and 2010.

The expected number of operations in each disease group was predicted by the following equation.

The expected number of operations for each age and each disease group [C] = (the cardiovascular surgery performance rate by each age group and each disease group in 2010 per 100,000

[B] × expected population in each age group) / 100,000
The expected number of operations for each disease group [D]
= Σ{the expected number of operations for each age group and each disease group [C]}
The total number of expected cardiovascular operations [E]
= Σ{ the expected number of operations in each disease group [D]}

RESULTS

1) The expected population changes for each age group

The total population of Japan peaked at 128 million in 2010 and began to decrease gradually thereafter. With respect to the different age groups, however, the changes of the expected populations vary. The population of <20-year-old individuals has been decreasing since 1990 due to a low birthrate and is expected to continue decreasing in the future. The population of 20–64-year-old individuals, the so-called productive population, peaked in 2000 and has also decreased gradually thereafter. The population of 65–79-year-old individuals is still increasing but is expected to peak in 2020 and to begin to decrease thereafter. The population peaks for the respective groups are as follows: 2015 in 65–69-year-old individuals, 2020 in 70–74-year-old individuals and 2025 in 75–79-year-old individuals. Only the population of ≥80-year-old individuals is expected to increase until 2040 (Figure 1).

2) The age distribution of cardiovascular operations in Nagoya University and 11 affiliated hospitals

Between 2001 and 2013, 16,845 cardiovascular operations were performed at Nagoya University and its 11 affiliated hospitals, of which 1,558 were for CHD, 5,217 were for VHD, 6,932 operations were for IHD and 2,698 operations were for TAA. The age distribution of the CHD operations was as follows: <20 (70.9%), 20–64 (22.5%), 65–69 (3.1%), 70–74 (2.2%),

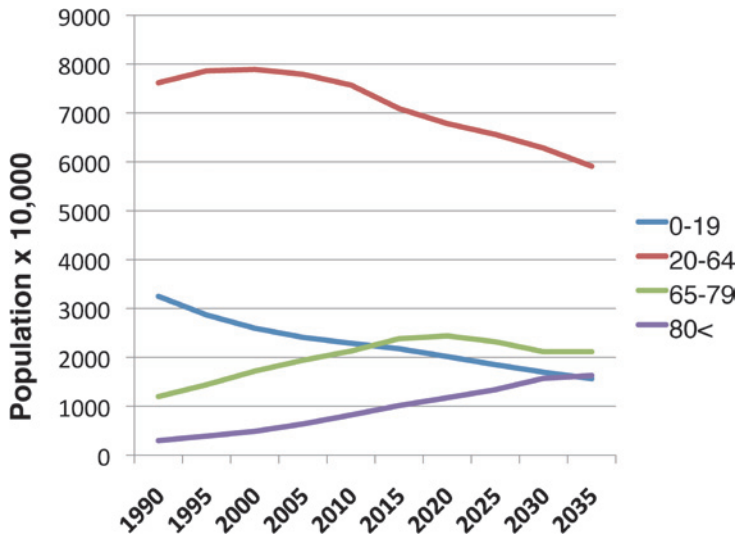

Fig. 1 The changes in expected population for each age group
The figure shows the changes of expected population for the <20-year-old (blue line), 20–64-year-old (red line), 65–79-year-old (green line) and ≥80-year-old (purple line) populations from 1990 to 2035.

75–79 (1.1%) and ≥80 (0.1%). The age distribution of the VHD operations was as follows: <20 (0.1%), 20–64 (34.2%), 65–69 (16.7%), 70–74 (20.6%), 75–79 (16.9%) and ≥80 (11.4%). The age distribution for the IHD cases was as follows: <20 (0.1%), 20–64 (31.5%), 65–69 (17.5%), 70–74 (22.5%), 75–79 (18.9%) and ≥80 (10.3%). Finally, the age distribution for the TAA cases was as follows: <20 (0.4%), 20–64 (42.1%), 65–69 (15.9%), 70–74 (17.5%), 75–79 (13.9%) and ≥80 (10.2%).

3) The cardiovascular surgery performance rate per 100,000 population

Figure 2 shows the changes in the cardiovascular surgery performance rate per 100,000 population for each age group and each disease group in 2002, 2006 and 2010. The performance rate varies year by year. For all surgeries the performance rate was 40.6 in 2002, 42.1 in 2006 and 46.6 in 2010. A slight year-by-year increase was observed.

In 2010, the performance rates of VHD surgery by age group were as follows: 20–64 (8.1), 65–69 (36.9), 70–74 (55.5), 75–79 (54.0) and ≥80 (30.1). Those of all VHD surgeries were 9.0 in 2002, 11.8 in 2006 and 14.7 in 2010. An apparent year-by-year increase was observed in performance rate, especially among ≥80-year-old individuals, which was 8.0 in 2002, 14.2 in 2006 and 30.1 in 2010.

On the other hand, in 2010 the performance rates of IHD surgery were as follows 20–64 (7.1), 65–69 (36.0), 70–74 (54.5), 75–79 (51.6) and ≥80 (21.1). The performance rate of IHD surgery for all age groups was 17.9 in 2002, 14.8 in 2006 and 13.3 in 2010. There was a definite decrease in the 65–69-year-old age group, which showed 73.4 in 2002, 52.9 in 2006 and 36.0 in 2010. However, there was no significant change observed in the ≥80-year-old age group (18.7

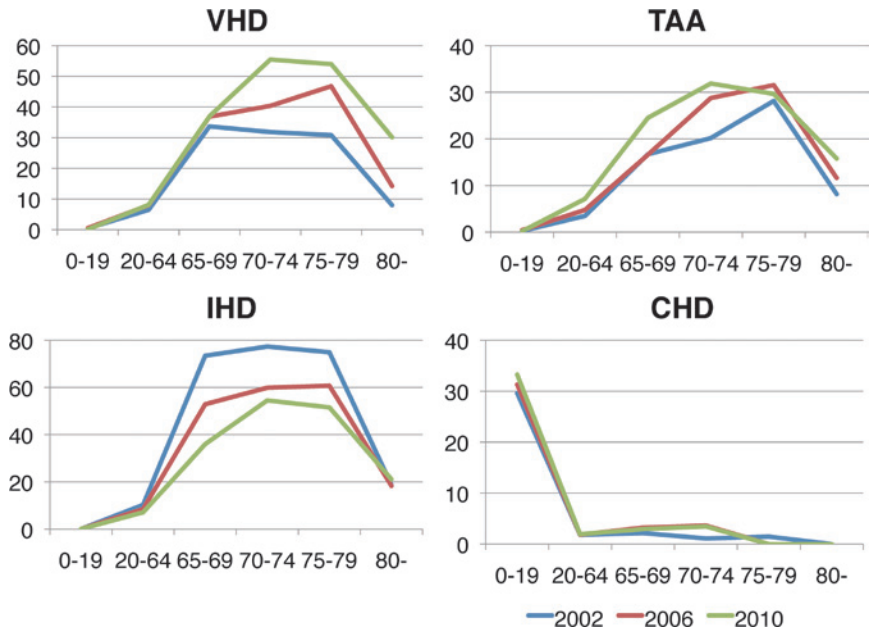

Fig. 2 The cardiovascular surgery performance rate per 100,000 population
The figure shows the changes in surgery performance rates for each age group: <20, 20–64, 65–69, 70–74, 75–79 and ≥80-year-old, and for each disease group; valvular heart disease (VHD), ischemic heart disease (IHD), thoracic aortic aneurysm (TAA) and congenital heart disease (CHD) in 2002 (blue line), 2006 (red line) and 2010 (green line).

in 2002, 18.3 in 2006 and 21.1 in 2010).

In 2010, the performance rates of TAA surgery were as follows: 20–64 (7.1), 65–69 (24.5), 70–74 (31.9), 75–79 (29.6) and ≥80 (15.8). The performance rate of TAA surgery for all age groups showed a definite year-by-year increase with the following number of surgeries performed per 100,000 population: 5.5 in 2002, 7.3 in 2006 and 10.0 in 2010. There was a notable increase in the number of surgeries in the ≥80-year-old group, which almost doubled in value from 2002 to 2010 (8.2 in 2002, 11.6 in 2006 and 15.8 in 2010).

In 2010, the performance rates of CHD were as follows <20 (33.2), 20–64 (1.9), 65–69 (2.9), 70–74 (3.4), 75–79 (0.2) and ≥80 (0.2). Operations for CHD were mainly performed in the <20-year-old age group, with the following performance rates: 7.2 in 2002, 7.4 in 2006 and 7.5 in 2010; the rate has shown no change over the last decade.

These results show that for VHD, IHD, and TAA, so-called acquired heart disease, the performance rate peaks in the 70–74-year age group. The number of surgeries decreases to approximately half of the peak value in the ≥80-year-old age group (Figure 2).

4) The expected number of cardiovascular operations

Figure 3 shows the changes in the expected number of operations for VHD, IHD, and TAA. They increase slightly and reach a peak in 2020, with 20,830 VHD operations, 18,760 IHD operations and 13,616 TAA operations. The expected number decreases gradually thereafter for

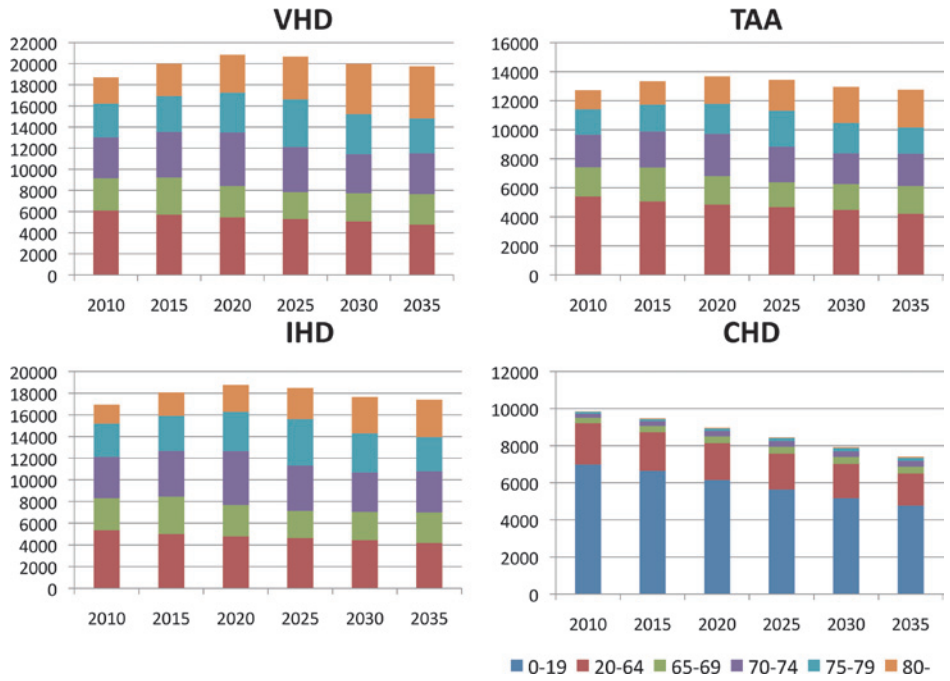

Fig. 3 The expected number of cardiovascular operations
The figure shows the changes in the expected number of operations for valvular heart disease (VHD), ischemic heart disease (IHD), thoracic aortic aneurysm (TAA) and congenital heart disease (CHD) from 2010 to 2035. Each bar is piled up with columns for each age group: <20 (dark blue column), 20–64 (red column), 65–69 (green column), 70–74 (purple column), 75–79 (light blue column) and ≥80-year-old (orange column).

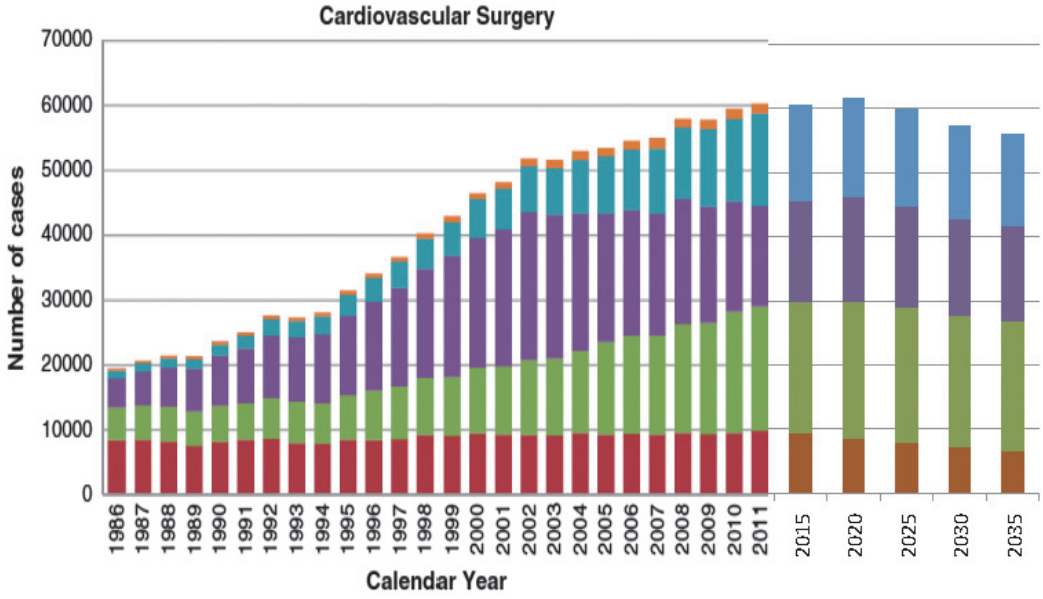

Fig. 4 The total expected number of cardiovascular operations
The figure shows the changes in the total expected number of cardiovascular operations. The data from 1986 to 2011 are cited from the annual report by the Japanese Association of Thoracic Surgery (JATS). The total expected number of cardiovascular operations from 2015 to 2035 was calculated by the sum total of the expected number of operations for valvular heart disease (VHD; green column), ischemic heart disease (IHD; purple column), thoracic aortic aneurysm (TAA; blue column) and congenital heart disease (CHD; red column).

each disease group. The expected number of operations for CHD, however, has already been gradually decreasing since 2010.

The total expected number of cardiovascular operations is calculated by the sum total of the expected number of operations for each disease group. The number increases slightly year-by-year, until it reaches a peak of 61,506 in 2020. Thereafter, the number is expected to gradually decrease, and is expected to fall to 55,966 in 2035 (Figure 4).

DISCUSSION

The average lifespan of Japanese people has been extended. In 2014, it reached 86.6 years in females, which is the longest in the world, and 80.2 years old in males, which is the 4th longest. The number of births in Japan, however, has been in decline since 1973 (from 209 million in 1973 to 103 million in 2013). The total fertility rate of Japanese women fell to lower than 2.05, which is the minimum rate to maintain a population, in 1974 and has shown a gradual decline thereafter, it was 1.43 in 2013. Japan has rapidly become an aging society as a consequence of the low birthrate, which creates a serious population problem. While the total population of Japan reached a peak in 2010 and gradually decreased thereafter, the population of elderly people is expected to continue to increase until 2040.

The estimated changes in the Japanese population vary according to age group. The population of <20-year-old individuals has been decreasing since 1990, while there has been a slight decrease

in the population of 20–64-year-old individuals since 2000. Hereafter, the elderly population will increase, with the number of 65–79-year-old individuals peaking in 2020. Only the ≥80-year-olds will continue to increase until 2040.

The number of cardiovascular surgeries performed is principally based on the population. Therefore, the number of cardiovascular operations should be expected to decrease in line with falls in population. In Japan, however, the number of operations may be expected to remain stable due to the increase in the elderly population, which will continue to increase until 2040.

The total number of cardiovascular operations in Japan was about 60,000 in 2011. This includes approximately 19,000 operations for VHD, 17,000 for IHD, 14,000 for TAA and 10,000 for CHD. With the Japanese population of 120 million, the annual number of cardiovascular surgeries equates to approximately one operation for every 2,000 people. The cardiovascular surgery performance rate is therefore about 50 cases per 100,000 population. The cardiovascular surgery performance rate also varies by each of the age and disease groups. It is higher in the elderly population (65–79 years old) and peaks in the 70–74-year-old age group. In the ≥80-year-old age group, the rate declines to approximately half that of the peak values in the VHD, IHD and TAA groups. The total number of expected cardiovascular operations mostly depends on the population of 65–79-year-old individuals. It can therefore be expected to increase slightly, reach a peak in 2020 and then gradually decrease. From the results of this study it can be said that only 5 years remain until Japan faces the peak number of cardiovascular operations and that a subsequent reduction in the surgery rate can then be expected. The total number of cardiovascular operations in Japan was about 60,000 in 2010 is expected to decrease to approximately 55,000 in 2035, which amounts to a reduction of approximately 10%. While this estimation is calculated based on the premise that the performance rate of surgery will not change hereafter, it gives cause for physicians to remain alert with regard to the future of medical needs and the economics of cardiovascular surgery. This kind of estimation is also helpful for the planning of training systems for cardiovascular surgeon.[3)]

The performance rates of surgery varied year by year and will certainly change in future. Multiple factors may affect the surgery performance rate, including new therapeutic strategies with novel techniques or procedures, new guidelines for the application of surgical therapy, the general health levels of society and the medical-economic state of Japan.

The cardiovascular surgery performance rate, in the case of VHD, has apparently increased for the last decade, most markedly in elderly patients of over 70 years of age. This was due to an increase in the number of patients with calcified senile aortic valve stenosis, which occurred due to the aging of the population. The surgical outcomes of aortic valve replacement (AVR) for elderly patients have improved and the surgical indication of AVR has been to expanded to even include octogenarians.[4,5)] Trans-catheter aortic valve replacement (TAVR) is a new surgical technique for high risk patients with aortic valve stenosis. TAVR has been clinically available in Japan since 2013. An increase in the surgery performance rates for aortic valve stenosis may occur in the near future due to the expanding of the indications of TAVR.[6-8)] There has also been an increase in the number of surgeries for mitral valve disease. This may be because of improved techniques for mitral valveplasty and due to the popularity of minimally invasive valve surgery.[9,10)]

The change of the IHD performance rate is remarkable. There has been a clear decrease in the number of surgeries over the last decade. It is likely to be because of the emergence of the drug eluting stent (DES) for coronary artery disease. Coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI) are two major strategies for treating coronary artery disease. The performance rate of CABG is totally dependent on the balance of indications for CABG or PCI. The ratio of CABG and PCI is reported to be 1:7, which denotes an extreme shift to PCI in Japan.[11)] The Japanese guidelines for myocardial revascularization to treat stable

ischemic heart disease were revised in 2012. CABG is a primary indication for patients with stable coronary artery disease, especially with those with more complex left main trunk disease and/or multi-vessel disease. The indications of CABG or PCI were subsequently changed.[12] The number of isolated CABG cases increased from 14,256 in 2011 to 16,462 in 2012.[2,13] The guidelines for surgery have been a major factor in the cardiovascular surgery performance rate. Another feature of Japanese cardiovascular surgery is the high rate (60%) of off-pump coronary bypass grafting (OPCAB), in comparison to a rate of 15–20% in the United States. OPCAB requires higher surgical skills as it involves the beating heart, and is suited to elderly patients because of the reduced risk of surgical damage. Japanese cardiac surgeons have therefore provided a higher quality of surgery, even for elderly patients.[14-17]

There has been a clear increase in the TAA performance rate in the last decade, especially in elderly patients of over 65 years of age.[18] Stent grafts has been clinically available for TAA since 2008, after which the number of trans-endovascular aortic repair (TEVAR) dramatically increased.[19,20] A hybrid procedure that combines TEVAR with open surgery has also become a popular surgical treatment strategy for TAA.[21] Furthermore, TEVAR has even been applied to cases of chronic type B aortic dissection.[22] The performance rate of TAA may increase in the future.

The operations for CHD are mainly performed in the <20-year-old age group. The surgical outcomes for CHD have dramatically improved, even cases of complex heart anomalies and surgical indications for CHD have been expanded to include such cases.[23,24] The CHD performance rate has not shown any significant changes for the last decade and the number of procedures may stabilize in the future, however, the number of surgeries performed for adult congenital disease may increase.[25]

The average Japanese life span is extremely long and is expected to increase in the future. The healthy life expectancy, which will be extended due to the extension of the life span, is also important for surgical indications. Thus, the surgical indications of cardiovascular surgery for octogenarians will likely be expanded and the cardiovascular surgery performance rate in octogenarians will also likely increase in the future. The diversity of surgical strategies has been increasing. New surgical strategies should be developed to treat elderly patients, especially octogenarians. In order to maintain and expand capacity to meet the medical needs of cardiovascular surgery, efforts to increase the cardiovascular surgery performance rate are crucial, especially for octogenarian patients.

The total number of expected cardiovascular operations is estimated to increase slightly, and reach a peak in 2020 and then gradually decrease based on the assumption that the surgery performance rate will not change. Efforts to increase the cardiovascular surgery performance rate are important to maintain the number of operations, especially for octogenarians.

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