

Projections of Demand for Cardiovascular Surgery and Supply of Surgeons

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Background: While demand for cardiovascular surgery is expected to increase gradually along with the rapid increase in cardiovascular diseases with respect to the aging population, the supply of thoracic and cardiovascular surgeons has been continuously decreasing over the past 10 years. Consequently, this study aims to achieve guidance in establishing health care policy by analyzing the supply and demand for cardiovascular surgeries in the medical service area of Korea. **Methods:** After investigating the actual number of cardiovascular surgeries performed using the National Health Insurance claim data of the Health Insurance Review and Assessment Service, as well as drawing from national statistics concerning the elderly population aged 65 and over, this study estimated the number of future cardiovascular surgeries by using a cell-based model. To be able to analyze the supply and demand of surgeons, the recent status of new surgeons specializing in thoracic and cardiovascular surgeries and the ratio of their subspecialties in cardiovascular surgeries were investigated. Then, while taking three different scenarios into account, the number of cardiovascular surgeons expected to be working in 5-year periods was projected. **Results:** The number of cardiovascular surgeries, which was recorded at 10,581 cases in 2014, is predicted to increase consistently to reach a demand of 15,501 cases in 2040—an increase of 46.5%. There was a total of 245 cardiovascular surgeons at work in 2014. Looking at 5 year spans in the future, the number of surgeons expected to be supplied in 2040 is 184, to retire is 249, and expected to be working is 309—an increase of -24.9%, 1.6%, and 26.1%, respectively compared to those in 2014. This forecasts a demand-supply imbalance in every scenario. **Conclusion:** Cardiovascular surgeons are the most central resource in the medical service of highly specialized cardiovascular surgeries, and fostering the surgeons requires much time, effort, and resources; therefore, by analyzing the various factors affecting the supply of cardiovascular surgeons, an active intervention of policies can be prescribed for the areas that have failed to meet the appropriate market distributions.

Key words: 1. Health policy
2. Economics, medical
3. Thoracic surgery
4. Health services needs and demand

Received: October 6, 2016, Revised: October 23, 2016, Accepted: October 24, 2016, Published online: December 5, 2016

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Introduction

Among the necessary medical resources in the provision of national health service, medical personnel are the most central resources; in some medical fields, services are provided by highly specialized professional labor. Since fostering these medical personnel requires much time, effort, and resources, an extremely precise prediction of demand and supply is needed. Among these medical personnel, surgeons are the most important provider of medical service, and they should not only be adequately supplied in a timely manner, but also be well-trained, appropriately distributed in each region, and efficiently utilized [1,2].

Cardiovascular surgery is a representative tertiary medical service in the treatment of cardiovascular diseases that requires an integration of high levels of skilled and specialized professionals; thus, fostering well-trained surgeons is the most important factor, and this requires a greater amount of resources and longer hours of training than other fields. Becoming a specialist in cardiovascular surgery in the USA requires an average of 8.3 years of training after achieving a medical license in the completion of specialty training, as well as an additional 2 to 3 years of fellowship for subspecialty training [3,4]; likewise, working as a professional specialist in Korea requires 10 to 15 years after graduating from a college of medicine. Consequently, considering these factors, an imbalance between demand for medical service and employment, support, and maintenance of surgeons must be prevented by developing effective surgeon residency programs and by establishing policies such as human resource development plans [2].

In Korea, concern for the lack of cardiovascular surgeons in the future began with the decrease in the number of applicants for thoracic and cardiovascular surgeons in the late 1990's; the number of medical students acquiring a specialty in cardiothoracic surgery decreased from an average number of 47 students per year in the 1990's to an average of 25 in the 2010's. A demand and supply imbalance began in 2015, and it is projected that by 2025, the imbalance will increase twofold in thoracic and cardiovascular surgeries [5]. In the case of the USA, the demand for coronary artery bypass grafts, which had accounted for the majority of cardiovascular surgeries,

greatly decreased due to a rapid increase in the use of percutaneous coronary intervention, now a universal trend. Consequently, the supply of new doctors has also decreased; nevertheless, a demand-supply imbalance is said to be predicted due to continuous demands resulting from the aging population rather than a decrease in the supply of surgeons [6].

This study aims to provide guidance in establishing a supply policy for cardiovascular surgeons by analyzing the current state of cardiovascular surgery in Korea and predicting its demands for the future, as well as analyzing the trend of demand for cardiovascular surgeons, a profession that requires an extended period of time from training to an actual placement in the field.

Methods

1) Estimation of demand for cardiovascular surgery

To estimate the demand for cardiovascular surgery, health insurance expenditure claims data from the Health Insurance Review and Assessment Service (HIRA) were used. A cell-based model developed by the Personal Social Services Research Unit of the London School of Economics and Political Science in England was used as the method of estimation. This model has also been used to project the demands when estimating the cost of long-term care in Korea by applying the population composition such as the distribution of age and gender [7,8]. Each cell was categorized by the patient's place of residence within one of 16 cities as well as by the patient's gender and age level. Then the number of individuals subject to cardiovascular surgery was calculated for each cell, and the calculation was then used to reflect the amount of medical service required and factors that affect the use of medical care. Among the factors that affect the administration of cardiovascular surgery, variables that can be used as claims data such as gender, age level, type of healthcare coverage, and comorbidity index were used, which were obtained from other sources. The method of estimation for each level of demand for cardiovascular surgery based on the cell-based model is as follows:

(1) Level 1: categorization of cell

- Patient's place of residence: 16 cities
- Gender: male, female
- Age level: under 20 years, 20-39 years, 40-59 years,

60–79 years, 80 years and over

(2) Level 2: calculation of the number of patients associated with cardiovascular surgery for each cell (patient's place of residence, gender, age level)

-Number of patients associated with cardiovascular surgery in 2014÷Korean registered population at the end of 2014' used to calculate the proportion of patients associated with cardiovascular surgery for every patient's place of residence, gender and age level of patients

-Number of patients associated with cardiovascular surgery for every patient's place of residence, gender, age level of patient=correction factor (gender, year)×estimated future population×number of patients associated with cardiovascular surgery for each patient's place of residence, gender, and age level

(3) Level 3: application of type of healthcare coverage as variable: proportion of each type of healthcare coverage for each cell was estimated by applying the patient's type of healthcare coverage at the end of 2014 (national health insurance, medical aid) using logistic regression

(4) Level 4: application of patient severity scale: the proportion of the Charlson Comorbidity Index being '0' or 'above 1' estimated for each cell by calculating the Charlson Comorbidity Index of patient at the end of 2014 using logistic regression

(5) Level 5: estimation of usage rate of cardiovascular surgery for each cell

-Using logistic regression, the usage rate of cardiovascular surgery for each patient's place of residence, gender, age level, type of healthcare coverage, and comorbidity index of patient were estimated

(6) Level 6: number of cardiovascular surgery patients per year in each cell=number of patients associated with cardiovascular surgery per year for each patient's place of residence, gender, age level of patient (level 2)×probability rate for every type of healthcare coverage (level 3)×percentage for every level of comorbidity index (level 4)×usage rate of cardiovascular surgery (level 5)

2) Estimation of supply of cardiovascular surgeons

Based on the current state of members reported by the Korean Society for Thoracic and Cardiovascular Surgery in 2014, surgeons who specialize in pediatric and as well as adult cardiovascular surgeries were analyzed based on the factors such as current em-

ployment status, age, type of affiliation, and time of retirement assuming the retirement age is 65 years old. In order to examine the latest supply level of cardiovascular surgeons, the number of people who have acquired a specialty in thoracic and cardiovascular surgery during the period of 5 years from 2003 to 2007 (*A*) and the number of surgeons, who are currently working in the department of cardiovascular surgery (*B*) were identified and the ratio was calculated (*B/A*). In addition, the number of thoracic and cardiovascular surgeons to be supplied in cardiovascular surgery every 5 years from now (*S₀*) was then predicted by applying the ratio of subspecialty in cardiovascular surgery (*B/A*) as the standard value for the number of people who have acquired thoracic and cardiovascular surgery specialty during the period of 5 years from 2011 to 2015 (*C*).

Estimation of supply was calculated by first setting the number of cardiovascular surgeons at work in 2014 (*K*) as the standard value, then subtracting the actual number of retired surgeons in every 5-year span (*R*) from the following year and adding the expected number of new surgeons to be supplied in each type of scenario in order to predict the number of surgeons at work per period. Since the recent number of doctors who have acquired specialties and the number of applicants for fellowship is nearly identical as is the percentage of successful applicants for specialty, no change was assumed to be expected in the number of people acquiring specialties in the future. Therefore, three scenarios were established: first, the ratio of subspecialty in cardiovascular surgery (*B/A*), the only variable, being the standard value; second, -10% from the standard value; and third, +10% from the standard value (*S₀*, *S₋₁₀*, *S₊₁₀*). Additionally, neither the returnees to their jobs nor the surgeons from overseas were taken into account. It was also assumed that the number of surgeons who have changed their status to non-clinical physicians or the number of deceased would be small, and thus they were disregarded as well.

Results

1) Estimation of demand for cardiovascular surgery

As estimated by national statistics, the elderly population of age 65 years and over is expected to in-

Table 1. Expected number of cardiovascular surgery with increasing elderly population

Age	No. of patients related to cardiovascular surgery in 2014	Year			
		2030		2040	
		Expected no. of patients	Increase rate compared to 2014 (%)	Expected no. of patients	Increase rate compared to 2014 (%)
Total	989,243	1,552,358	56.9	1,835,584	85.6
≥ 65 yr	125,803	380,878	202.8	598,939	376.1
≥ 75 yr	52,130	154,202	195.8	309,241	493.2

Table 2. Demand estimates for cardiovascular surgery

	Year					
	2014	2020	2025	2030	2035	2040
No. of cases of surgery	10,581 (100.0)	11,888 (112.4)	13,228 (125.0)	14,347 (135.6)	15,224 (143.9)	15,501 (146.5)

Values are presented as number (%).

Table 3. Projection of the number of cardiovascular surgeons at work for each scenario

	Period of time					
	2014	2020	2025	2030	2035	2040
Scenario (S_{-10})	245 (100.0)	246 (100.4)	246 (100.4)	231 (94.3)	215 (87.8)	184 (75.1)
Scenario (S_0)	245 (100.0)	259 (105.7)	272 (111.0)	270 (110.2)	267 (109.0)	249 (101.6)
Scenario (S_{+10})	245 (100.0)	272 (111.0)	298 (121.6)	309 (126.1)	319 (130.2)	309 (126.1)

Values are presented as number (%).

crease by more than 10 million, with an increase of 99.6% and 160.0% in 2030 and 2040 compared to 2014, respectively. Using the cell-based model, the number of patients associated with cardiovascular surgery is expected to increase to approximately 1.84 million by 2040, with patients aged 65 years and above comprising approximately 600,000 (Table 1).

Meanwhile, upon investigating the total number of cases of cardiovascular surgery from 2010 to 2014 based on the claims data of HIRA, approximately 10,000 cases of surgery were performed, which revealed that the demand for cardiovascular surgery in the elderly population is increasing, as the rate at the age level of 75 years and over increased by 33.1% during the 5 years—an average of 7.2% per year; additionally, the number of surgery cases requiring cardiovascular surgery in the future was predicted to increase by 35.6% and 46.5% in 2030 and 2040 compared to 2014, respectively, according to the cell-based model estimation of demand (Table 2).

2) Estimation of supply of cardiovascular surgeons

Among the total of 1,237 thoracic surgeons in Korea, 245, or approximately 20% (K) of the surgeons, were associated with cardiovascular surgery. By age, there were 71 surgeons in their 30's, 93 in their 40's, and 81 surgeons in their 50's, the majority of whom were working in university hospitals. Based on the year of birth, upon cumulating the expected number of surgeons retiring at the age of 65 every 5 years, the numbers showed to be 26 by 2020 (R_1), 25 by 2025 (R_2), 40 by 2030 (R_3), 41 by 2035 (R_4), and 56 by 2040 (R_5). Meanwhile during the 5 years from 2003 to 2007, there was a total of 162 (A) thoracic and cardiovascular surgeons trained, among whom 48 surgeons were working in the department of cardiovascular surgery (B), and so the recent ratio of subspecialty in cardiovascular surgery (B/A) was found to be 29.6%. Additionally, the number of thoracic and cardiovascular surgeons trained in the most recent 5 years were 28 in 2011, 27 in 2012, 18 in 2013, 28 in 2014, and 27 in 2015—a total of 128

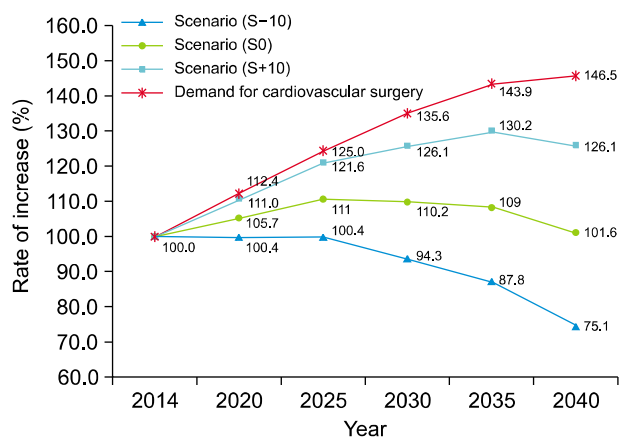


Fig. 1. Prospect of supply of cardiovascular surgeons compared to the demand for cardiovascular surgery.

surgeons (C) during the 5 years. Upon estimating the number of surgeons to be supplied in the department of cardiovascular surgery every 5 years from now for each scenario, the number was predicted to be 38 (S_0), 25 (S_{-10}), and 51 (S_{+10}) after applying the standard ratio, -10% , and $+10\%$, respectively. The estimation of the number of surgeons at work per time period after calculating the number of retired surgeons (R_1 – R_5) and the number of supplied surgeons for each scenario (S_{-10} , S_0 , S_{+10}) from the number of surgeons currently at work (K) are as follows (Table 3).

3) Prospect of demand and supply of cardiovascular surgery

Based on the number of surgeons supplied for the demand for cardiovascular surgery in 2014, the actual number of surgeons at work was estimated under the assumption that a certain number of surgeons will be continuously supplied in each scenario every 5 years from now; however, no scenarios were found to be able to follow the increase in demand for cardiovascular surgery (Fig. 1).

Discussion

The demand for cardiovascular surgery is generally closely associated to the population structure, and it is expected that the elderly population of age 65 years and over will increase to nearly 10 million by 2040 due to the dramatic aging population in Korea. Among them, the number of patients with diseases

related to cardiovascular surgery to reach 600,000; consequently, the demand for cardiovascular surgery is also expected to increase and there are projected to be approximately 15,500 cases in 2040—an increase of 46.5%. In the case of Japan, which already has an aging population structure, there were approximately 50 cases of demand for cardiovascular surgery per 1 million people in 2011; approximately 60,000 cases of cardiovascular surgery had been performed, among which the demand was highest in the population aged between 65 and 79 years [9]. Similarly, in the USA, the demand for thoracic and cardiovascular surgeons per 1 million was 61 in the age range of 65 to 75 years, whereas the demand was 77 for those aged 75 years and over, showing high demand for thoracic and cardiovascular surgeons for the elderly population [6]. The demand for cardiovascular surgery in Korea is very low—approximately 20 people per population of 1 million; however, considering the rapid growth rate during the past 5 years in the demand for cardiovascular surgery in the elderly population 75 years and older, similar to other countries, it seems obvious to expect a gradual increase in the demand for cardiovascular surgery in the future in respect to the aging population structure [10]. Nevertheless, the predicted estimation of demand for cardiovascular surgery of 30 people per 1 million in 2040 is still low compared to Japan, another Asian country; this is, however, a result predicted based on the current level of use of cardiovascular surgery. Considering the low use of cardiovascular surgery in Korea now, an increase greater than the results estimated in the study is to be expected, depending on a change in perception of the suppliers and users of cardiovascular surgery [10,11].

Among the specialized medical personnel responsible for surgical treatment in the medical service of cardiovascular diseases, training qualified thoracic and cardiovascular surgeons is the most important factor in determining the capacity of suppliers; however, in the past 10 years, the number of applicants for thoracic and cardiovascular surgery fellowship training decreased rapidly in Korea, raising concerns regarding a deficiency in suppliers of cardiovascular surgery medical service. This phenomenon is observed similarly in developed countries; for in the case of the USA, there was over a 38% decrease in the use of coronary artery bypass starting from 1996

[12], which accounted for the majority of cardiovascular surgeries, and was thus criticized as the main cause of a drastic decrease in the rate of total cases of cardiovascular surgeries. However, because the demand for other cardiovascular surgeries related to diseases such as heart valve disorder and arrhythmic disorder is consistently increasing as a result of the aging population, it is reported that a deficiency in thoracic and cardiovascular surgeons was to be expected [5]. In contrast, the percentage of coronary artery bypass surgeries in Korea is below 30%, and therefore relatively much lower than other developed countries; furthermore, since Korea's proportion of ischemic cardiovascular disease compared to coronary interventions has already been abnormally lower for a long time, there was no change in the total number of cardiovascular surgery cases resulting from the decrease of coronary artery bypass surgeries during the past 10 years [10,11]. Consequently, when considering the possibility of increase in demands for cardiovascular surgery in the future for heart valve disorder, aortic disorder, and other cardiovascular diseases in respect to the aging population, it is expected that the degree of demand-supply imbalance resulting from deficiency of cardiovascular surgeons will be much greater.

This study shows that when the current state of demand for cardiovascular surgery and supply of surgeons is taken as a reference point, the future supply of surgeons in the cardiovascular surgery subspecialty will not be able to meet the increase in demand for cardiovascular surgery. Likewise, despite the consistent projected demand for cardiovascular surgery up until 2040, each scenario showed a shortage in the number of applicants for subspecialty training in cardiovascular surgery; additionally, the current state where only 5 to 6 cardiovascular surgeons are entering the workforce each year indicates that the control of demand and supply equilibrium in the free market is already under significant stress. A decrease in the number of applicants may be explained by various factors; one of which is related to the recent tendency in society to avoid challenging and tiresome work, as well as to the perception that despite completing a long and difficult training course, acquiring a quality job opportunity is difficult due to the tendency of patients favoring large hospitals in metropolitan areas, which tends to result in

relatively poor training conditions and working environments in the other hospitals, including regional hospitals [5,13].

Although plenty of resources and personnel have been invested for prevention and management of cardiovascular disease, it has the highest death rate in many Organization for Economic Cooperation and Development countries; in Korea, cardiovascular disease, as a single disease, has the highest death rate, even exceeding the death rate of cerebrovascular disease. Regardless of strict enforcement in prevention and management as well as development of new technology and drugs, it will be difficult to expect an end to the demand for cardiovascular surgery in Korea in the future, and thus we should strive to avoid failure in market control resulting in incapability of providing appropriate service in a timely manner. The Korean government does not have any way to intervene in the civilian medical markets and in the individual choices of medical specialty other than by means of social insurance or adjustment of insurance fee; however, it is Korea's responsibility to learn from other developed countries such as England and Germany, who have made national investments in the development of infrastructure for cardiovascular surgery, and thereby establishing active policies to address demand-supply issues.

In conclusion, in this study regarding demand for cardiovascular surgery and supply of cardiovascular surgeons, the demand for cardiovascular surgery is estimated to be approximately 15,500 cases per year by 2040—an increase of 46.5% with respect to the aging population structure compared to 2014. Based on the demand and supply system of 2014, the supply of cardiovascular surgeons, which is the most important resource in the provision of cardiovascular medical service, is projected to be unsatisfactory under all scenarios. Consequently, the Korean government should analyze the various factors affecting the shortage of supply of cardiovascular surgeons due to the failed market control and active policy intervention should follow.

Conflict of interest

No potential conflicts of interest relevant to this article are reported.

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