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Cost-Effectiveness Analysis of Uvulopalatopharyngoplasty Versus Positive Airway Pressure in Patient With Obstructive Sleep Apnea in South Korea

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Background and Objectives: Although positive airway pressure (PAP) is known to be more effective than uvulopalatopharyngoplasty (UPPP) in the treatment of obstructive sleep apnea (OSA), PAP is a more expensive treatment in Korea. Therefore, it is necessary to compare the cost-effectiveness of these two treatments.

Methods: We assumed patients with moderate to severe OSA and divided them into three groups: those who used PAP (the PAP Treatment group), those who received UPPP (surgery group), and those who did not receive a diagnosis or treatment (No Treatment group). We compared their medical costs over 10 years. The incidence rate of common complications and accidents (coronary heart disease, heart failure, stroke, depression, diabetes, vehicle accident, and work-related accident) with or without treatment was adopted through a literature review. The average medical expenses for treating each complication and accident were also found by searching several databases.

Results: The incidence of all complications was higher in the control group than in the PAP Treatment group or the surgery group. However, since the absolute incidence rate was not high in all groups and medical expenses in Korea are low, the expected treatment cost was not high (KRW 108,209 per year for the PAP Treatment group, KRW 141,228 for the surgery group, and KRW 178,369 for the No Treatment group). In contrast, the costs of a polysomnography examination, PAP rental, and mask purchase were relatively high. Based on these results, the 10-year medical expenses for the PAP Treatment group were KRW 10,246,948, and those for the surgery were only KRW 925,095.

Conclusion: Although PAP treatment reduces the incidence of complications in OSA patients, it is not as cost-effective as UPPP in Korea, where medical costs are low.

Keywords: Obstructive sleep apnea; Cost-effectiveness analysis; Positive airway pressure; Uvulopalatopharyngoplasty.

INTRODUCTION

Obstructive sleep apnea (OSA) is a disease in which hypopnea or apnea is repeated for more than 10 seconds during sleep due to stenosis or obstruction of the upper airway and is accompanied by frequent arousal and decreased blood oxygen saturation [1]. Its prevalence in middle-aged men and women are considerably high, at 9.1% and 4.0%, respectively, and are gradually increasing with the rising obese population [1]. OSA causes symptoms such as fatigue, daytime sleepiness, and headache, and increases not only diseases such as coronary artery diseases, heart failure, stroke, depression, and diabetes, but also vehicle and workplace-related accidents, and ultimately increases mortality [1].

Treatment methods for OSA include body weight loss, lifestyle improvement, surgery, an mandibular advancement device, and positive airway pressure (PAP) [1]. PAP was developed for the first time by Dr. Sullivan of Australia in 1981 [1]. It opens the closed upper airway by injecting air into the nose using an air pump [1]. Although PAP is the most effective treatment for OSA, its use is limited because its adherence rate is low and the patient's cost burden is high. However, its use rapidly increased as it was started to be covered by National Health Insurance in 2018 [2]. On contrary to the increase in the use of PAP, the proportion of surgical treatment is gradually decreasing. In the case of uvulopalatopharyngo-

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plasty (UPPP) which is the most representative procedure, 3,958 cases were performed nationwide in 2013, but it has gradually decreased to 2,644 cases in 2021 [3]. Although complications such as severe pain and persistent foreign body sensation were also a problem with UPPP, the low treatment success rate was a bigger problem. According to a meta-analysis published in 1996 by Sher et al. [4], the treatment success rate was only about 40%. However, subsequent study reported that the success rate of UPPP was over 60%, and considering the low adherence rate and irregular use time of PAP, UPPP was a more effective treatment [5].

Recently, cost-effectiveness analysis has become a very important concern across all fields of medicine. If a new treatment method is a little more effective than the existing treatment but its cost is too high, it is socially unacceptable as the cost-effectiveness is consequentially low [6]. On the contrary, if the effect is much superior to the existing treatment method and the cost is increased only a little or if the effect is similar but the cost is reduced, the cost-effectiveness is increased [6]. Although PAP is certainly beneficial to an OSA patient as it could reduce complications [1], a study argued that its cost-effectiveness is not satisfactory considering treatment cost [7]. While the treatment costs of UPPP could be measured, it was impossible to carry out cost-effectiveness analysis as there were no clear data related to the preventive effect of complications from UPPP. However, as data from the National Health Insurance were released for research purposes in Korea, it was possible to perform the cost-effectiveness analysis of UPPP [8,9]. Although PAP is mainly used for the treatment of OSA patients recently in Korea, UPPP may be a more cost-effective treatment method. If so, this study can help patients choose treatment options and influence the establishment of insurance policy.

The purpose of the present study is to perform a cost-effectiveness analysis of PAP and UPPP in South Korea.

METHOD

Participants

Patients with moderate to severe OSA were assumed because many patients who come to hospital are at a moderate to severe stage than a mild stage, and most complications are known to occur in moderate to severe cases [1,7]. Among the complications of OSA, only coronary artery diseases, heart failure, stroke, depression, and diabetes were considered because these diseases are most highly related to OSA and their importance is great in the aspect of disease severity, prevalence, and medical expense [1,7,10].

Treatment model

PAP treatment group

Participants who use PAP after polysomnography were defined as the PAP Treatment group [7]. It was assumed that both the prescriptions of polysomnography and PAP are issued at clinics since most of the treatments for OSA are expected to take place at clinics in the future since the introduction of polysomnography equipment into clinics is rapidly increasing [7,11]. It was assumed that after using PAP, they would visit a clinic once every 3 months to receive an extended PAP prescription, and additionally visit a medical institution in case of complications or accidents. PAP was assumed to be the most frequently prescribed automatic type [12,13].

Surgery group

Participants who have UPPP after polysomnography were defined as the Surgery group. Since 63.6% of UPPP was carried out at clinics in 2021 and since the comparison with PAP Treatment group, both polysomnography and UPPP were assumed to be carried out at clinics [3]. These patients were assumed to visit a medical institution only when a complication or accident occurred after surgery.

No treatment group

Participants who do not undergo polysomnography, PAP, or UPPP were defined as the No Treatment group [7]. Based on the fact that more than 80% of OSA patients do not undergo any diagnosis, the patients were assumed not to undergo even polysomnography [1] and to visit a medical institution only when a complication or an accident occurs.

Cost-effectiveness analysis

Although the PAP Treatment group and the Surgery group spend medical expenses of diagnosis and treatment, there also are factors that reduce medical expenses because the occurrence of complications and accidents is reduced compared to the No Treatment group. In this study, we intended to carry out a cost-effectiveness analysis by comparing the treatment costs for the PAP Treatment group and the Surgery group with the treatment costs of complications and accidents reduced from those for the No Treatment group. A cost analysis for 10 years was performed for the two treatment models from the insurer's point of view, and the reason for selecting a 10-year period was because it was thought to be sufficient to reflect the effect of the occurrence of various complications. An analysis from the Insurer's point of view means a method that includes only the medical expenses and does not take into account non-medical expenses or productivity-loss cost such as transportation expenses, time cost, and nursing expenses.

For the expenses to be incurred in the future, 5% discount rate was applied [6].

Assumptions made for cost analysis

As to the probabilities for complications to occur in the PAP Treatment group and No Treatment group, the study result reported by Streatfeild et al. [10] was referred to [7], in which the authors put together the results of several studies to present the probabilities for coronary heart diseases, heart failure, stroke, depression, diabetes, vehicle accidents, and work-related accidents to occur in the patients with moderate to severe OSA. It was assumed that complications and accidents would occur at the same probabilities also in the case of Korea [7]. The probabilities for complications to occur in the Surgery group were calculated referring to various UPPP [8,9]. As to the complications on which no detailed study was conducted in relation to UPPP, it was estimated that 44.4% would decrease from that of the No Treatment group because the meta-analysis recently reported by He et al. [5] presented a long-term UPPP success rate of 44.4%. The probabilities for complications to occur in the three groups calculated by the above method are summarized in Table 1.

Medical expenses

In the case of the PAP Treatment group, the expenses for receiving polysomnography and continuously using PAP were calculated [7]. In the case of the Surgery group, since the patients were not required to regularly visit the hospital, only the expenses for polysomnography and surgery were calculated. In addition, to calculate the expected annual expenses for the treatment of each complication or accident, the average treatment cost based on various data was multiplied by occurrence probability.

Expense of polysomnography

As of 2022, when polysomnography was performed in clinics, the medical expense was KRW 525,718 [2].

Table 1. Probability of complications and accidents for 1 year in patients with obstructive sleep apnea

	PAP Treatment [10]	Surgery	No Treatment
Coronary heart disease	0.0185	0.0290 [9]	0.0310
Heart failure	0.0019	0.0022 [9]	0.0034
Stroke	0.0064	0.0051 [5]	0.0091
Depression	0.0186	0.0239 [8]	0.0264
Diabetes	0.0117	0.0102 [5]	0.0183
Vehicle accident	0.0033	0.0039 [5]	0.0071
Work accident	0.0009	0.0012 [5]	0.0021

PAP, positive airway pressure

Expense of PAP Treatment

Rent for PAP

As of 2022, the monthly rent for an automatic PAP was KRW 89,000 [12].

PAP mask

A mask can be purchased every year and KRW 95,000 is supported as of 2022 [12].

Diagnosis and treatment fee

As of 2022, the first medical examination fee at a clinic was KRW 16,970, and the re-examination fee was KRW 12,130. It was assumed that polysomnography was performed during the first medical examination and the patient would visit the clinic to extend the rental of PAP once every 3 months [2,7].

Expenses of UPPP

The total amount of diagnosis and treatment expenses was divided by the number of patients who underwent surgery at the clinic level and the result was considered as the expense of UPPP per person. The total amount of the diagnosis and treatment expense was KRW 392,123,000 and the number of patients who underwent surgery was 1,156, therefore, the UPPP expense per person was KRW 339,207 [3].

In addition to this, the pre-operative examination expense was also taken into account. There is no agreement on the list of pre-operative examination items, and each medical institution provides a wide variety of examinations [14]. In the present study, a whole blood test, general chemical test, bleeding-related test, infection test, urinalysis, ECG, and simple chest radiography were assumed to be performed, and the total examination expense was KRW 60,170.

The treatment costs of complications occurring during or immediately after surgery were not taken into account because there were no clear domestic data on the incidence rate of complications and it was impossible to make cost estimation. However, it was presumed that the expected expense per person would be very insignificant as the treatment costs of most complications were not great because they were simple bleeding and the incidence rates of these complications were not high.

Treatment costs of complications and accidents caused by OSA

Treatment costs of complications

After visiting the Healthcare Bigdata Hub, the average complication treatment cost per person was calculated by di-

Table 2. Average cost of treatment in case of complications and accidents

	ICD-10	Cost (KRW)
Coronary heart disease [3]	I21, 22	3,123,230
Heart failure [3]	I50, 099, 110, 130, 132, 971	904,986
Stroke [3]	I60–64	3,871,109
Depression [3]	F32, 33	519,828
Diabetes [3]	E10–14	292,166
Vehicle accident [15]		1,895,195
Work accident [16]		5,104,263

ICD, International Classification of Diseases, 10th version

viding the total amount of medical expenses for coronary artery diseases, health failure, stroke, depression, and diabetes in 2021 by the number of patients [3,7].

Treatment costs of vehicle accidents

To obtain the treatment costs of vehicle accidents, the statistical data of diagnosis and treatment costs in 2020 related to vehicle insurance was searched. The average treatment cost per person was calculated by dividing the total medical expense by the numbers of patients with severe injury and minor injury [7,15]. Compensation, shutdown loss, loss in earning, and lawsuit and other expenses were not included in the treatment costs of vehicle accidents.

Treatment costs of workplace accidents

To obtain the treatment costs of workplace accidents, the 2020 annual report of the Industrial Disaster Insurance was searched and only the healthcare benefits that fall under the direct treatment costs among the industrial disaster insurance benefits were included [7,16].

The average treatment cost of workplace accidents per person was calculated by dividing the total amount of healthcare benefits by the number of beneficiaries. The result is summarized in Table 2.

The present study did not require approval from the Institutional Review Board since it was a study that analyzed only indirect data, not a study that directly targeted patients.

RESULT

Cost estimation

Estimation of the PAP Treatment group expenses for 10 years

The diagnosis and treatment costs for the PAP Treatment group include the expense for polysomnography performed in the first year, rent for a PAP respirator to be paid monthly, outpatient diagnosis and treatment fee incurred once every 3 months, and the cost of a PAP mask incurred once a year. When all these expenses for 10 years are added up applying a discount rate of 5%, the total is KRW 10,246,948. A treatment cost of KRW 108,209 is expected to be incurred by the treatment of complications and accidents every year and, when these expenses are added up for 10 years applying a discount rate of 5%, the total is KRW 867,836.

Estimation of the Surgery group expenses for 10 years

In the case of the Surgery group, an expense of KRW 925,095 is expected to be incurred by polysomnography and UPPP as the diagnosis and treatment cost in the first year, and there is no additional cost since the patients are not required to receive a regular diagnosis. A treatment cost of KRW 141,228 is expected to be incurred by the treatment of complications and accidents every year and, when these expenses are added up for 10 years applying a discount rate of 5%, the total is KRW 1,132,649.

Estimation of the No Treatment group for 10 years

In the case of the No Treatment group, no cost of diagnosis and treatment is expected to be incurred and only the treatment costs of complications and accidents are expected to be incurred. As the probability for complications or accidents to occur in this group is higher than that of the PAP Treatment group or the Surgery group, the expected annual treatment cost is KRW 178,369. When these expenses are added up for 10 years applying a discount rate of 5%, the total is KRW 1,430,519.

The detailed figures are presented in Table 3.

Cost-effectiveness analysis of the PAP Treatment group and the Surgery group

In the case of the PAP Treatment group, while expected treatment costs of KRW 562,683 for complications and accidents have been saved for 10 years from those of the No Treatment group, the diagnosis and treatment cost used for PAP treatment amounts to KRW 10,246,948. In other words, KRW 18,210 should be spent to save KRW 1,000 of the complication and accident treatment costs. On the other hand, in the case of the Surgery Group, while expected treatment costs of total KRW 297,870 for complications and accidents have been saved for 10 years from those of the No Treatment group, which is a little smaller than the amount saved by the PAP Treatment group, it has used only KRW 925,095 for the diagnosis and treatment. Accordingly, the Surgery group should spend only KRW 3,106 to save KRW 1,000 of the complication and accident treatment cost. Therefore, the Surgery group is overwhelmingly more cost-effective than the PAP Treatment group in terms of saving the treatment costs of complications

Table 3. Cost analysis of PAP treatment and surgery for obstructive sleep apnea

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	
PAP Treatment	Polysomnography	₩525,718										
	PAP rent	₩1,068,000	₩1,068,000	₩1,068,000	₩1,068,000	₩1,068,000	₩1,068,000	₩1,068,000	₩1,068,000	₩1,068,000	₩1,068,000	
	PAP mask	₩95,000	₩95,000	₩95,000	₩95,000	₩95,000	₩95,000	₩95,000	₩95,000	₩95,000	₩95,000	
	Medical expense	₩53,360	₩48,520	₩48,520	₩48,520	₩48,520	₩48,520	₩48,520	₩48,520	₩48,520	₩48,520	
	Annual total	₩1,742,078	₩1,211,520	₩1,211,520	₩1,211,520	₩1,211,520	₩1,211,520	₩1,211,520	₩1,211,520	₩1,211,520	₩1,211,520	
	Discount rate	1	0.95	0.9	0.86	0.81	0.77	0.74	0.7	0.66	0.63	Sum
	Annual total with discount rate applied	₩1,742,078	₩1,150,944	₩1,090,368	₩1,041,907	₩981,331	₩932,870	₩896,525	₩848,064	₩799,603	₩763,258	₩10,246,948
	Expected cost for complications and accident treatment	₩108,209	₩108,209	₩108,209	₩108,209	₩108,209	₩108,209	₩108,209	₩108,209	₩108,209	₩108,209	
	Discount rate	1.00	0.95	0.90	0.86	0.81	0.77	0.74	0.70	0.66	0.63	Sum
	Annual total with discount rate applied	₩108,209	₩102,799	₩97,388	₩93,060	₩87,649	₩83,321	₩80,075	₩75,746	₩71,418	₩68,172	₩867,836
Surgery	Polysomnography	₩525,718										
	Surgery expense	₩339,207										
	Preoperative lab tests	₩60,170										Sum
	Annual total	₩925,095										₩925,095
	Expected cost for complications and accident treatment	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228
	Annual total	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228	₩141,228
	Discount rate	1.00	0.95	0.90	0.86	0.81	0.77	0.74	0.70	0.66	0.63	Sum
	Annual total with discount rate applied	₩141,228	₩134,167	₩127,105	₩121,456	₩114,395	₩108,746	₩104,509	₩98,860	₩93,210	₩88,974	₩1,132,649
No Treatment	Expected cost for complications and accident treatment	₩178,369	₩178,369	₩178,369	₩178,369	₩178,369	₩178,369	₩178,369	₩178,369	₩178,369	₩178,369	₩178,369
	Discount rate	1.00	0.95	0.90	0.86	0.81	0.77	0.74	0.70	0.66	0.63	Sum
	Annual total with discount rate applied	₩178,369	₩169,451	₩160,532	₩153,397	₩144,479	₩137,344	₩131,993	₩124,858	₩117,724	₩112,372	₩1,430,519

PAP, positive airway pressure

and accidents.

DISCUSSION

Most cost-effectiveness analyses of PAP have been conducted in Western countries [17-20]. The results are very different for each study, but to enjoy one unit of quality-adjusted life year, which means one year of perfect health, it costs between KRW 4 million and KWR 60 million [6,7,17-20]. However, when analyses are conducted from a social point of view, the cost is significantly reduced [6,17-20], because PAP is a more cost-effective treatment when non-medical expenses and productivity-loss cost resulting from diseases or accidents are taken into account. Cost-effectiveness analyses are greatly influenced by the medical environment of the relevant country or society [6]. It is because medical service costs for the same treatment are different, and non-medical expenses and productivity-loss cost are also calculated differently. In Western countries, since the treatment costs of complications or accidents resulting from OSA were overwhelmingly higher than the PAP costs, the cost-effectiveness of PAP could have been evaluated to be high in general. On the other hand, in Korea, since medical expenses are very low, there may be no significant benefit in terms of cost-effectiveness because the treatment costs of complications or accidents are low and the treatment costs of PAP are relatively high [7].

According to our result, KRW 925,095 has been used for 10 years in the case of UPPP to reduce KRW 297,870, the treatment costs of complications and accidents. On the other hand, KRW 10,246,948 of diagnosis and treatment costs were used to reduce complications and accident treatment costs by KRW 562,683 won for 10 years when receiving PAP treatment. Therefore, UPPP is overwhelmingly more cost-effective than PAP. When the study of Català et al. [18] is applied to our study, in the case of PAP treatment, KRW 10,977,403 is required to be spent to enjoy one unit of quality-adjusted life year [7]. It is difficult to make a direct comparison because there is no data of quality-adjusted life year for UPPP. However, based on the reduction in the treatment costs of complications and accidents calculated in this study, as the difference in quality-adjusted life year between the Surgery group and the No Treatment group is estimated to be 0.53 times the difference between the PAP Treatment group and No Treatment group, KRW 1,219,006 is required to be spent to enjoy one unit of quality-adjusted life year in the case of UPPP [18]. UPPP is overwhelmingly more cost-effective than PAP treatment from a quality-adjusted life year perspective.

One of the most astonishing results of this study was that PAP or UPPP had very little effect on reducing the expected treatment costs of complications or accidents of OSA. It is because the incidence rate of complications or accidents in OSA patients is not high [10]. As shown in Table 1, in the No Treatment group of patients with moderate to severe OSA, the probability of having a stroke was 0.91% but, when using PAP, it decreased to 0.64%. In other words, it can be said that PAP treatment reduces the incidence of stroke by about 30%, which may be thought to be a great effect, but the absolute value of reduction is as small as 0.27%. In addition, the effect of OSA on the incidence of such a complication is also insignificant. The concept that reflects the contribution of a certain risk factor to the incidence of a specific disease is a population-attributable fraction [21], and the population-attributable fractions of OSA for complications are very small showing a value of 4.8% for coronary heart disease, 1.5% for heart failure, 4.8% for stroke, 3.6% for depression, 1.7% for diabetes, 3.8% for vehicle accidents, and 1.3% for work-related accidents [7,22]. Accordingly, even when OSA is actively treated, the benefit that can be obtained by reducing actual complications or accidents may be not very large. Although various other complications are known to occur, as their population-attributable fractions are lower than those of the representative complications included in this study, their effects on the reduction of the treatment costs are presumed to be not large. In addition, as the treatment costs are very low even when a complication or an accident occurs because the medical expenses in Korea are very low, the preventive effects of PAP or UPPP also decrease. When the expected treatment cost for 1 year is obtained by multiplying the probability of the incidence of complications or accidents and the average treatment cost, it is KRW 108,209 in the case of the PAP Treatment group and KRW 178,369 in the case of the No Treatment group, and the difference is only KRW 70,160. This means that PAP treatment only has the effect of reducing medical expenses by KRW 70,160 for a year. If medical expenses were 10 times higher than the current expenses, the savings would have increased 10 times to KRW 701,600.

Another noteworthy finding is that UPPP has an effect of reducing the incidence of complications [8,9]. Although it was presumed that UPPP would reduce the incidence of complications also in the past, direct evidence was not sufficient. This was because it was difficult to conduct long-term monitoring of the patients who had undergone UPPP. However, as the National Health Insurance data were released for research purposes in Korea, the long-term result of UPPP could be observed, and the preventive effect on some complications could be proven, at least indirectly [8,9]. Although it was difficult to directly compare it with PAP, it was confirmed that the treatment costs of complications and accidents were reduced from those of the No Treatment group. However, the reduction was smaller than that of the PAP Treatment group and, as this also

corresponds to the result expected, various assumptions of the present study are thought to be appropriate. In addition, it was far more cost-effective than PAP, and this was because the surgical expense is very low although the effect of UPPP was not superior to PAP.

In a cost analysis, the viewpoint of the cost analysis is very important [6]. The present study analyzed costs from the insurer's point of view, and only official medical expenses, meaning only the expenses that fall under insurance benefits and non-insurance benefits were taken into account. In the case of healthcare system viewpoint, non-medical expenses such as transportation expenses, time cost, and nursing expenses are included and the social viewpoint is the most comprehensive concept that includes even the productivity-loss cost [6,7]. However, since data were not sufficient in the case of the healthcare system viewpoint or social viewpoint, calculation could not be made in the present study. If the harmful effects of OSA are investigated from a wider point of view as in the cases of other countries, PAP treatment will be found to be more cost-effective than in the result presented by this researcher as the expenses required for the treatment of complications or accidents will increase and productivity loss will be included.

This cost-effectiveness analysis has limitations [7]. First, the analysis was conducted using a simple model, not the diagnosis and treatment records or billing data of actual OSA patients. However, it is difficult to take into account very diverse diagnosis and treatment realities and a reasonable model may help in more clearly understanding the real situation. Second, as there were no data related to the incidence probabilities of complications or accidents in Korea, foreign country data were used. Third, PAP treatment had a high dropout rate, which was not taken into account for simple analysis. Fourth, although it is required to take into account not only the expenses but also the quality of life, it could not be performed due to the lack of data. Fifth, as the effects of UPPP were analyzed under somewhat unreasonable assumptions for the items that did not have clear data, the result may be different from the real situation. In addition, as no sufficient matching was achieved for the two groups, the accurate incidence rate of complications may be different. Lastly, it should be also taken into account that the treatment effects of PAP and UPPP may vary depending on the patients group.

In conclusion, it is presumed that UPPP is far more cost-effective for the treatment of OSA patients in the Korean medical environment.

Ethics Statement

Ethical approval and informed consents does not apply to this article.

Availability of Data and Material

All data generated or analyzed during the study are included in this published article.

Conflicts of Interest

Jae Hoon Cho who is on the editorial board of the *Journal of Rhinology* was not involved in the editorial evaluation or decision to publish this article.

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