COST BENEFIT ANALYSIS OF CT AND MRI USING THE AHP

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Summary: *The importation of used medical equipments such as CT and MRI has been rapidly increasing each year. The question of how to manage medical equipments is one of the critical issues in the government sector. In this study, we will demonstrate how benefit/cost analysis using the Analytic Hierarchy Process (AHP) can be applied to the comparison between used and new CT/MRI equipments. The final results show that the new CT/MRI equipments are more attractive than the used.*

1. Introduction

Public demand for better quality medical services at the beginning of the 21st Century is rapidly increasing due to hazardous environmental health factors. Increase in national income and in the adoption and utilization of high-priced medical equipments in medical institutions has contributed to the rapid change in the medical environment.

Demands for medical equipments are increasing rapidly with the repeal of import ban regulation as of January 1997. Accumulated quantities for testing among computer tomography (CT) and magnetic resonance imaging (MRI) equipments installed after the performance tests by Korea Testing Laboratory and Korea Electric Testing Institute are 277 and 23 respectively as of the end of 2000, with average annul increase of 44% and 50% respectively after 1997(Korea Testing Laboratory, 2001).

Increase of used high-priced CT and MRI medical equipments is interpreted as medical institutions preferring imported used products to lower the initial purchasing expenses, instead of having to waste n expensive new imported goods due to the increase in foreign exchange rate since the economic crisis. Furthermore, the purpose of profit generation while recovering the invested fund earlier on by installing used imports to lower initial investment as a policy to improve on management aggravation caused by economic depression is perceived to be the main driving factor in this phenomenon(Korea Health Industry Development Institute, 2002).

Such import increase of inexpensive used medical equipments produces ill effects, such as excessive medical examinations, as the medical equipments are introduced for the purpose of uplifting the earning rate, rather than to expand public health benefits. Thus, there is a high possibility of this phenomenon resulting in an increase of economic burden by the people, the final consumers. This is a direct impediment against the movement and development of domestic manufacturing industry. Not only that, it contributes to increase in medical expenses for patients caused by unnecessary medical expenditure(Korea Health Industry Development Institute, 2001).

Unlike other industrial equipments, medical equipments may exert direct impact on the lives of the consumer. Thus importance of safety needs to be considered above all. Unfortunately in reality, a large number of inadequate points indicated in terms of its management system(Korea Institute for Health and Social Affairs, 2000).

The medical equipments are apt to generate problems in mechanical performances according to the time and frequency of use. The used medical equipments imported from the advanced countries are already outmoded models. As clinical tests are performed on new products, the used imports for which there are possibilities of abnormality in used terms, or which fall below a certain standard, thus unable to perform medical examinations are to be accompanied with clinical comments (clinical quality maintenance test) before market circulation. Such used equipments display high rates of problem generation in operation even after replacing consumable parts, yet only formal managements are carried out in terms of legal standards(Korea Health Industry Development Institute, 2001).

Even though the same medical equipments display differences in prices of sometimes on the upwards of three times according to their performance level and machine types, the treatment charges are fixed at the same level. Furthermore, the equal rates of health insurance charges are fixed for both new and used medical equipments, thus the purchase and expansion of low-priced medical equipments in hospitals and clinics are competitively increasing in terms of economic aspect, rather than pursuing specialization and accuracy in diagnosis. Consequently, this results in increase of re-examination rate and erroneous diagnosis. In addition, this also deepens the economic aggravation in domestic manufacturing industry (Korea Health Industry Development Institute, 2002).

This study intends to review the economic appropriateness of new and used CT/MRI equipments through cost benefit analysis according to the introduction of high-priced used importation medical equipments, particularly new and used CT/MRI equipments. To serve this purpose, the AHP, one of the multi-criteria decision making processes, has been used to design analysis model and to promote it application.

For evaluation and decision making issues on a complex system, the alternative evaluation criterion may be indicated via quantitative data. However, there are other aspects which can only be illustrated with qualitative data. The optimal decision making performed under such conditions can differ according to how priority is placed among evaluation criteria or alternatives based on such data. From this point of view, the method of approach adopted in this test by assessing the values of alternatives and determining their priorities by applying the AHP, which establishes priorities on decision making alternatives assessed under the criteria of the majority, is perceived to be adequate. In addition, the adequacy of this method is further secured by the fact that the AHP, the model with preference compensation for analysis of decision making performed under criteria adopted by the majority, analyzes the degree of susceptive in subjective judgments amongst participants in decision making and is able to compensate the result to a certain degree.

Ultimately, this study intends to assist in establishing systematic/politic plans to establish efficient management scheme by providing politic direction on high-priced medical equipments via economic analysis of CT and MRI equipments using the AHP.

2. Designing Analysis Model

2.1 Analysis Model

(1) Definition and Establishment of Alternatives for Imported Used High-Priced Medical Equipments.

The notification No. 1996-80 (Dec. 30, 1996) by the Ministry of Health and Welfare specifies the list of high-priced specialized medical equipments for installation approval. It also specifies the high-priced equipments according to the installation approval screening criterion on high-priced specialized medical

equipments to be the medical equipments and MRI devices over US$ 500 thousand in terms of their costs.

So far, there has not been a definition on the concept of used imported high-priced medical equipments. The used imported high-priced medical equipments mentioned in this study refer to imported medical supplies among the high-priced medical equipments installed and used in institutions higher than medical practitioners, which are used and high-priced equipments, rather than the new products.

The 'used imported medical equipments' referred to in this study only indicate the used equipments which had been previously used at the time of importation. Therefore, despite the term 'used equipments', the equipments whether domestic brand, or new product at the time of importation, used after its distribution in Korea, thus circulated as a used item in the market have not been considered.

The scope of equipments for cost benefit analysis only applies to the two items of computer tomography (CT) and magnetic resonance imaging (MRI) devices. According to the specifications on medical instrument by Korea Food & Drug Administration, the study has been performed by restricting the scope of CT (A11010) as computed tomography and MRI (A12010) as magnetic resonance computed tomography.

(2) Establishment of Evaluation Criteria

For the purpose of analyzing economic factors of used and new CT and MRI devices, this study has established the evaluation criteria by itemizing them into the large and small heads to promote convenience as seen is <Table 14> and <Table 15>. Here, the previously researched quantitative data has been used for the initial capital of economic factor, which is the criterion of assessing the cost efficiency. The level structure model for cost benefit analysis in the new and used CT/MRI equipments is illustrated in Fig. 1.

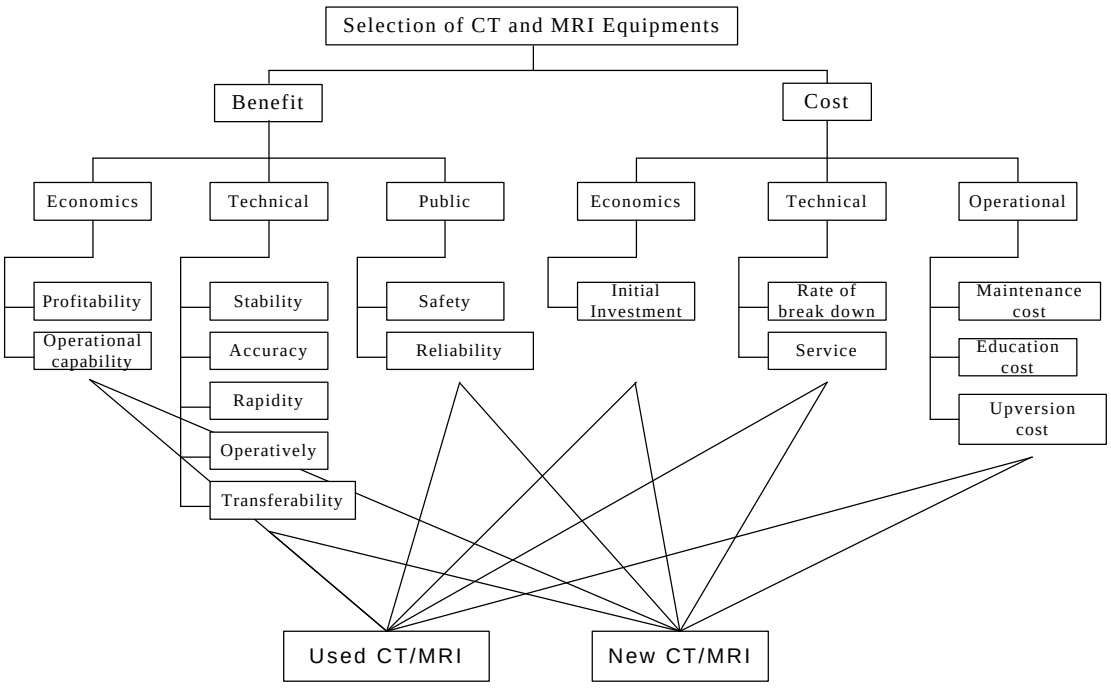

Fig. 1. Hierarchy for Selection of CT and MRI Equipments

(3) Method of Analysis Administration

The traditional method of AHP benefit/cost analysis is to be used to separate the levels in the aspects of cost and benefit and derive the cost priority and benefit priority accordingly. Then, the benefit/cost priorities for the alternatives of each level are to be derived to conclude the final priority on alternatives.

(4) Evaluation Group

Investigations have been made by dividing evaluation subjects into group A, which is consisted of nine medical practitioners in university hospitals and group B, which is consisted of six medical practitioners in private hospitals. The members of evaluation group A are specialist doctors in radiology recommended by the Korean Radiological Society who simultaneously perform research and medical treatment activities with many years experience in a variety of university hospitals, such as A San Medical Center and Samsung Medical Center. In addition, these specialist groups actually employ and utilize medical equipments for various purposes, such as for MRI and CT examinations. On the other hand, evaluation group B is mainly consisted of general private practitioners who are recommended by Korean Association of Private Practitioners. These practitioners directly take practical charge in purchasing and operating equipments and display slightly susceptibility.

In most university hospitals, medical devices are discarded within 5 years from new production. Thus, doctors in university hospitals are susceptible towards using new devices, yet are deficient in experiences of utilizing used equipments and rather insusceptibility to economic aspects. On the contrary, the private practitioners have abundant experiences of employing used equipments for economic reasons and are very susceptive of economic aspects. Therefore, it would be appropriate to simultaneously consider the evaluation results from these two groups.
The questionnaire survey evaluation for the purpose of pair-wise comparison of each element in different levels has been carried out for almost 2 hours after thoroughly describing the AHP method for approximately 40 minutes to each of doctor groups in separate locations.

3. Model Application

3.1 Cost Benefit Analysis on New and Used CT Equipments

3.1.1 Cost

(1) Importance of Evaluation Criteria

The evaluation group A has given points of 0.450 for technical efficiency, 0.362 for operational efficiency and 0.188 for economic efficiency, placing the highest degree of importance in technical efficiency. Within the items of technical efficiency, the rate of break down has been analyzed as the most important criterion, scoring the point of 0.297. (Table 1) On the contrary, the evaluation group B has given points of 0.523 for economic efficiency, 0.272 for operational efficiency and 0.205 for technical efficiency, placing the highest degree of importance in economic efficiency. Within the items of economic efficiency, the rate of break down has been analyzed as the most important criterion, scoring the point of 0.152. From these results, it can be confirmed that group A places the highest importance in academic aspect and group B in on-site aspect.

<Table 1> Importance of Evaluation Criteria

Evaluation Criteria			Evaluation Sub-criteria		
	Evaluation Group A	Evaluation Group B		Evaluation Group A	Evaluation Group B
Economics	0.188	0.523	Initial investment	0.188	0.523
Technical	0.450	0.205	Rate of break down	0.297	0.152
			Service	0.153	0.054
Operational	0.362	0.272	Maintenance cost	0.198	0.155
			Education cost	0.058	0.055
			Upversion cost	0.106	0.062

(2) Importance of Alternatives

In terms of cost, evaluation group A has given points of 0.305 for new CT equipments and 0.695 for the used, resulting in the analysis of the used CT equipments have cost priority of 2.3 times higher (Table 2). Despite the relatively high initial investment cost, this group assesses that the new products require 2.3 times less cost compared with the used. This outcome has been produced as a result of this group placing the highest degree of importance in technical efficiency, which includes the rate of break down and degree of service as its sub-elements. On the contrary, evaluation group B has given points of 0.532 for new CT equipments and 0.468 for used, indicating that the priority of new CT equipments is higher than used by 1.14 times, however, assessing the difference to be insignificant.

<Table 2> Importance of Alternatives

	Cost priority	
	Evaluation Group A	Evaluation Group B
Used CT	0.695	0.468
New CT	0.305	0.532

3.1.2 Benefit

(1) Importance of Evaluation Criteria

It has been indicated that evaluation group A places the degree of importance in the order of technical efficiency (0.510), accessibility (0.299) and economic efficiency (0.191). Particularly, in the aspect of technical efficiency, the degree of accuracy has been analyzed as the most important criterion (Table 3). However, evaluation group B has analyzed economic efficiency (0.455) to be the most important criterion, followed by accessibility (0.279) and technical efficiency (0.265). In the sub-criteria, the degree of importance has been analyzed in the order of profitability (0.312), accuracy (0.176) and reliability by patients (0.164).

Within the benefit levels, it has been analyzed that evaluation group A places the most importance on technical efficiency, whilst group B on economic efficiency. This indicates almost identical results as in the degree of importance in cost levels. It can be confirmed that a division has been made between evaluation group A, which represents the situations in university hospitals and evaluation B, which represents the situations in private hospitals.

<Table 4> Importance of Evaluation Criteria

Evaluation Criteria			Evaluation Sub-criteria		
	Evaluation Group A	Evaluation Group B		Evaluation Group A	Evaluation Group B
Economics	0.191	0.455	Profitability	0.069	0.312
			Operational capability	0.122	0.143
Technical	0.510	0.265	Stability	0.090	0.058
			Accuracy	0.241	0.076
			Rapidity	0.083	0.046
			Operatively	0.056	0.048
			Transferability	0.039	0.037
Public	0.299	0.279	Safety	0.224	0.116
			Reliability	0.075	0.164

(2) Importance of Alternatives

In the aspect of benefit, evaluation group A has given points of 0.857 for new CT equipments and 0.143 for the used, producing a result of analysis that the new CT equipments has approximately 5.9 times higher benefit priority. (Table 4) That is, as expected, the benefit factors have been indicated significantly higher in new products compared with the used. On the contrary, in terms of benefit, evaluation group B has given points of 0.578 for new CT equipments and 0.422 for the used, indicating higher priority for new CT equipments by 1.34 times, yet the difference is also perceived to be insignificant. In general, it has been analyzed that the new CT equipments display significantly higher benefit factor in comparison with the used CT equipments. This is interpreted as a result of the used CT equipments being advantageous in economic efficiency, yet the importance of this criterion being assessed as not significant, whilst the new CT equipments scoring high points in significantly assessed criteria of accuracy and safety aspects.

<Table 4> Importance of Alternatives

	Benefit priority	
	Evaluation Group A	Evaluation Group B
Used CT	0.143	0.422
New CT	0.857	0.578

3.1.3 Result

The result of cost benefit analysis on CT equipments has indicated the benefit/cost priority of 0.206 for the used CT equipments in evaluation group A. Correlatively, it can be concluded that purchasing new CT equipments is approximately 13.6 times more beneficial than purchasing used equipments. (Table 5) On the contrary, for the evaluation group B, the benefit/cost priority of the used CT equipments has been indicated as 0.902 while of the new equipments as 1.086. Correlatively, it can be concluded that purchasing new CT equipments is approximately 1.2 times more beneficial than purchasing used equipments.

As the final conclusion, it has been displayed that in terms of the aspects of cost/benefit, the new CT equipments are more appropriate in economic efficiency in both groups. However, whilst the evaluation group A has scored the standard of new CT equipments to be significantly higher than that of the used equipments, the evaluation group B has concluded the standards of new and used CT equipments to be of similar level. This can be seen as the result of differences in the degree of importance in evaluation criteria. That is, whilst the evaluation group A, which is consisted of practitioners of general hospital, attaches importance on technical efficiency, the evaluation group B, which is consisted of private practitioners, value economic aspect. The important fact is that even the private practitioners who place

the top priority in economic aspect assess that the overall advantage in terms of cost/benefit analysis, although insignificant, lies in the new CT equipments.

<Table 5> Result of Cost Benefit Analysis

	Cost priority		Benefit priority		Benefit/Cost priority	
	Evaluation Group A	Evaluation Group B	Evaluation Group A	Evaluation Group B	Evaluation Group A	Evaluation Group B
Used CT	0.695	0.468	0.143	0.422	0.206	0.902
New CT	0.305	0.532	0.857	0.578	2.810	1.086

3.2 Cost Benefit Analysis on New and Used MRI Equipments

3.2.1 Cost

(1) Importance of Evaluation Criteria

The evaluation group A has given points of 0.444 for the criterion of technical efficiency, 0.342 for operational efficiency and 0.213 for economic efficiency, placing the highest degree of importance in technical efficiency. As in the case of CT equipments, it can be concluded that more importance is placed on technical aspect rather than on economic or operational aspect in comparing new with used MRI equipments.. (Table 6) Furthermore, most important sub-elements have been analyzed to be the rate of break down in the criterion of technical efficiency and the cost of maintenance in the criterion of operational efficiency, both scoring 0.260 and 0.203 respectively.

On the contrary, the evaluation group B has given points of 0.410 for operational efficiency, 0.385 for technical efficiency and 0.205 for economic efficiency, displaying the highest degree of importance in operational efficiency. Unlike the case of CT equipments, significant importance is placed upon the aspect of operation, rather than technical or economic factors in comparing the new with the used MRI equipments. Furthermore, in terms of the sub-elements of operational efficiency, the cost of maintenance with the point of 0.256 has been analyzed as the most important criterion.

<Table 6> Importance of Evaluation Criteria

Evaluation Criteria			Evaluation Sub-criteria		
	Evaluation Group A	Evaluation Group B		Evaluation Group A	Evaluation Group B
Economics	0.213	0.205	Initial investment	0.213	0.385
Technical	0.444	0.385	Rate of break down	0.260	0.151
			Service	0.185	0.054
Operational	0.342	0.410	Maintenance cost	0.203	0.256
			Education cost	0.057	0.067
			Upversion cost	0.083	0.087

(2) Importance of Alternatives

In the aspect of cost, the evaluation Group A has given points of 0.308 for the new MRI equipments and 0.692 for the used, displaying 2.3 times higher cost priority for the used MRI equipments. (Table 8) That is, likewise in the case of CT equipments, it has been concluded that the cost of the new equipments is 2.3 times lower than that of the used, despite its relatively high initial investment expenses. This can be interpreted that the used MRI equipments require more expenses in terms of installation and operation.

Particularly, excluding the initial capital, it has been indicated that more expenses are consumed in terms of service and maintenance costs. (Table 7) On the contrary, evaluation group B has given points of 0.412 for the new CT equipments and 0.588 for the used, thus displaying 1.4 times higher priority in new equipments, although the difference is insignificant.

<Table 7> Importance of Alternatives

	Cost priority	
	Evaluation Group A	Evaluation Group B
Used MRI	0.692	0.588
New MRI	0.308	0.413

3.2.2 Benefit

(1) Importance of Evaluation Criteria

In the large evaluation criteria, it has been indicated that the evaluation group A has placed the degree of importance in the order of technical efficiency (0.514), accessibility (0.276) and economic efficiency (0.210) as in the cost level. Particularly, in the small evaluation criteria of technical efficiency, the accuracy (0.226) has been analyzed as the most important criterion over other criteria. The economic efficiency, which is generally placed with the highest degree of importance in the aspect of benefit, has scored the lowest point, this could be because of the fact that the specialists responding to the survey are working in university hospitals, thus relatively unsusceptible towards the economic aspects. (Table 8)

On the contrary, evaluation group B has analyzed, unlike in cost level, technical efficiency (0.527) to be the most important criterion among the large criteria of benefit level, followed by economic efficiency (0.248) and accessibility (0.226). Particularly, accuracy (0.148) has been analyzed as the most important criterion among other small criteria of technical efficiency.

<Table 8> Importance of Evaluation Criteria

Evaluation Criteria			Evaluation Sub-criteria		
	Evaluation Group A	Evaluation Group B		Evaluation Group A	Evaluation Group B
Economics	0.210	0.248	Profitability	0.100	0.069
			Operational capability	0.110	0.040
Technical	0.514	0.527	Stability	0.107	0.135
			Accuracy	0.226	0.148
			Rapidity	0.094	0.076
			Operatively	0.048	0.091
			Transferability	0.039	0.078
Public	0.276	0.226	Safety	0.173	0.109
			Reliability	0.103	0.117

(2) Importance of Alternatives

In general, the evaluation group A has analyzed that the new MRI equipments are significantly higher in the aspect of benefit compared with the used equipments. In particular, is has been indicated that the factors of accuracy and safety are more important that any other criteria in the new MRI equipments, thus producing results that the new MRI equipments of 0.838 is approximately 5.2 times higher in benefit priority than the used MRI equipments of 0.163. (Table 9)

On the contrary, the evaluation group B has concluded that in general the new MRI equipments to produce higher benefit priority than the used equipments. In terms of benefit priority, the new MRI

equipments have scored the point of 0.612 and the used of 0.366, thus resulting in the new MRI equipments to have a higher benefit priority by approximately 1.6 times.

<Table 9> Importance of Alternatives

	Benefit priority	
	Evaluation Group A	Evaluation Group B
Used MRI	0.162	0.388
New MRI	0.838	0.612

3.2.3 Result

The result of cost benefit analysis on MRI equipments have indicated the benefit/cost priorities of the used and new MRI equipments to be 0.234 and 2.721 respectively in the case of evaluation group A. Correlatively, it can be concluded that purchasing a new MRI equipments will be approximately 11.6 times more beneficial than purchasing the used (Table 10). In case of the evaluation group B, the benefit/cost priorities of the used and new CT equipments have been indicated as 0.660 and 1.485 respectively. It can be concluded that purchasing new CT equipments will be approximately 2.25 times more beneficial than purchasing used.

In conclusion, it has been displayed that in terms of the aspect of cost/benefit, the new MRI equipments are more appropriate in economic efficiency in both groups. However, evaluation group A has scored the standard of new MRI equipments to be significantly higher than that of used, while evaluation group B has concluded the standards of both new and used MRI equipments to be of a similar level. This result displays a similar pattern to that of the CT equipments.

<Table 10> Result of Cost Benefit Analysis

	Cost priority		Benefit priority		Benefit/Cost priority	
	Evaluation Group A	Evaluation Group B	Evaluation Group A	Evaluation Group B	Evaluation Group A	Evaluation Group B
Used MRI	0.692	0.588	0.162	0.388	0.234	0.660
New MRI	0.308	0.412	0.838	0.612	2.721	1.485

4. Conclusion

For this study, evaluation groups have been divided into a group of specialists working in university hospitals (group A) and specialists based in private practitioners (group B) for the purpose of simultaneously considering the deviations according to the constitutions of evaluation groups. The elements of cost and benefit according to the application of CT and MRI equipments have been itemized and the Analytic Hierarchy Process (AHP), one of the quantitative decision-making techniques has been employed to perform cost benefit analysis.

In result, the evaluation group A has indicated to place the most importance on technical efficiency in both CT and MRI equipments in terms of cost and benefit aspects while evaluation group B has indicated to place importance on economic efficiency for CT equipments, on operational efficiency in terms of cost aspect for MRI equipments and on technical efficiency in terms of benefit aspect for MRI equipments.. Thus, as expected, the evaluation group A tends to reflect on the opinions of the academic circle and the evaluation group B on the on-site opinions.

The result of cost benefit analysis on CT equipments has indicated the correlative figure of new product against used to be 13.6 times higher in the evaluation group A and 1.2 times higher in the evaluation group B. In addition to this, the result of cost benefit analysis on MRI equipments has indicated the correlative figure of the new product against the used to be 11.6 times higher in the evaluation group A and 2.25 times higher in the evaluation group B. In both groups, the new CT and MRI equipments have displayed higher economic efficiency than the used. Even the private practitioners who place

significance in economic factor assess new products in general to have cost/benefit priorities despite the significantly high initial purchasing expenses compared to that for used.

Therefore, on the basis of such analysis, the government is to clearly acknowledge the fact that the new CT and MRI equipments, despite their expensive initial costs, are by far more economic in general in the long run financially and professionally. Thus, new equipments need to be promoted to hospitals and medical clinics so that the end consumers can benefit from higher quality of medical services. Furthermore, in order to secure competitiveness of the domestically manufactured high-priced medical equipments in global scale, governmental policies, such as tax benefits when purchasing domestic equipments in order to establish the foundation of domestic production line.

Current exposed issues on the prevailing problem of excessive induction of the imported used high-priced medical equipments are by large, the initial investment cost on the equipments, the indiscriminate application of health insurance charges for the equipments and the management system as well as operation/maintenance of the equipments.. Since health insurance charges or non-allowance charges are applied according to the overall charge system of health insurance policy regardless of the equipments performance, the lower-priced used medical equipments are preferred. As health insurance charges are fixed at a low level in reality regardless of the quality and performance of equipments, the currently prevailing charge rate can not allow for the purchase and maintenance of equipments with high screen definition and a variety of tomography techniques.

Therefore, differentiation in insurance charges according to the terms of durability and performance levels of CT and MRI equipments needs to be carried out. Differentiation of insurance allowances between the clinics in which treatments and examinations are performed, together with the specialist doctors of diagnostic radiology and those without also need to be carried out. In addition, the issue of excessive expenses on maintenance and management by allotting exorbitant supplying cost for main parts is to be solved.

Thus, inferior equipments are to be weeded out through strengthening the after-management on medical equipments, while the issues related to the promotion of domestic medical equipment industry is to be profoundly investigated and back by more comprehensive researches, to enable establishment and revision of related laws to better domestic medical issues, in due course protecting end consumer.

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