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ORIGINAL ARTICLE

Comparison of extracorporeal shock wave lithotripsy running models between outsourcing cooperation and rental cooperation conducted in Taiwan

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Background/Purpose: We conducted a retrospective study to compare the cost and effectiveness between two different running models for extracorporeal shock wave lithotripsy (SWL), including the outsourcing cooperation model (OC) and the rental cooperation model (RC).
Methods: Between January 1999 and December 2005, we implemented OC for the SWL, and from January 2006 to October 2011, RC was utilized. With OC, the cooperative company provided a machine and shared a variable payment with the hospital, according to treatment sessions. With RC, the cooperative company provided a machine and received a fixed rent from the hospital. We calculated the cost of each treatment session, and evaluated the break-even point to estimate the lowest number of treatment sessions to make the balance between revenue and cost every month. Effectiveness parameters, including the stone-free rate, the retreatment rate, the rate of additional procedures and complications, were evaluated.
Results: Compared with OC there were significantly less treatment sessions for RC every month (42.6 ± 7.8 vs. 36.8 ± 6.5, $p = 0.01$). The cost of each treatment session was significantly higher for OC than for RC (751.6 ± 20.0 USD vs. 684.7 ± 16.7 USD, $p = 0.01$). The break-even point for the hospital was 27.5 treatment sessions/month for OC, when the hospital obtained 40% of

Conflicts of interest: The authors have no conflicts of interest relevant to this article.

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the payment, and it could be reduced if the hospital got a greater percentage. The break-even point for the hospital was 27.3 treatment sessions/month for RC. No significant differences were noticed for the stone-free rate, the retreatment rate, the rate of additional procedures and complications.

Conclusion: Our study revealed that RC had a lower cost for every treatment session, and fewer treatment sessions of SWL/month than OC. The study might provide a managerial implication for healthcare organization managers, when they face a situation of high price equipment investment.

Introduction

Extracorporeal shock wave lithotripsy (SWL) has been a treatment of revolution for the management of urolithiasis. SWL is an alternative and preferred modality for the treatment of renal and ureteral stones.[1] In 1997 and 2007, the American Urological Association Ureteral Stones Clinical Guidelines Panel suggested that either ureteroscopic lithotripsy (URSL) or SWL was considered a minimally invasive and acceptable treatment option for distal ureteral stones $<$1 cm. The professional recommendations for treatment were based on success, retreatment and complication rates, and less on the cost of treatment or patient preference.[2]

In 2001, the cost of treating urolithiasis was $>$20 billion US dollars in the US.[3] Lotan and Pearle suggested that for ureteral stones, observation was the least costly treatment modality and URSL was less costly than SWL.[4] The SWL machine (HM3, Dornier Medtech, Kennesaw, Georgia) was introduced into Taiwan in 1985 for the treatment of patients, with great success. Therefore, many hospitals tried to purchase this high price SWL machine and increase their own competitive advantages. Most hospitals in Taiwan purchased the SWL machine (i.e., a self-support model) initially. For budget limitation, some hospitals tried outsourcing cooperation (OC) or rental cooperation (RC) to equip the machine from the cooperative company instead of purchasing it later. The payment of SWL reimbursement from the Bureau of Health Insurance (BNHI) was regulated as a case payment in 1995, and the reimbursement for each treatment session was fixed. The total number of treatment sessions of SWL has increased rapidly in the last decade; the BNHI implemented some rules (such as patients with a staghorn or partial staghorn stone, a renal stone size $>$ 2.5 cm or a ureteral stone $>$1.5 cm were excluded for SWL) to limit the growing expense from SWL.

In daily practice, the cost derived from SWL has become a very important impact factor in choosing the best therapeutic strategy for patients with urolithiasis. Cost-effectiveness analysis is a useful tool for comparing different treatment or running modalities, especially if the cost and effectiveness vary significantly among the modalities.[5] Our objective is to compare the cost-effectiveness between two different running models, OC and RC, for the SWL machine.

Methods

Between January 1999 and December 2005, OC for the SWL machine was implemented, and from January 2006 to October 2011, RC was applied. The SWL machine was electro-hydraulic (Lithotron, High Medical Techonologies, Switzerland) for both OC and RC. The machine was provided and maintained by the cooperation company, and a technician was also provided. The hospital provided medical staff, including physicians, nurses and administration staff, and a place for the SWL machine. With OC, the hospital paid the cooperation company 60% of the payment from BNHI for each treatment session. With RC, the rent for the lithotripter was a fixed payment/month and was contracted based on previous experience of self support and OC. In our study, the rent was 60% of the payment from BNHI for each treatment session multiplied by 27.5 (previous break-even point of OC).

The perceived cost for each treatment session was the sum of the lithotripter associated cost, consumptive materials and the salary of the medical staff. The formula for the perceived cost consisted of two parts, i.e., the variable cost and the fixed cost. With OC, the variable cost included 60% of the payment from BNHI for each treatment session and the cost of direct labor and direct materials, while the fixed cost included the cost of indirect labor and indirect materials. With RC, the variable cost included the cost of direct labor and direct materials, while the fixed cost included the rent/month divided by the treatment number/month and the cost of indirect labor and indirect materials.

The cost of direct labor included the salary of the in-charge physician and the technician, attributed by working hour, and the cost of indirect labor consisted of the salary of other medical staff, multiplied by the ratio (revenue from SWL divided by total revenue in the hospital). The cost of direct materials included the cost of medications and consumptive materials associated with the SWL procedure. The cost of indirect materials consisted of electricity, water and others, multiplied by the ratio (revenue from SWL divided by total revenue in the hospital). The details of the formula are shown in Table 1. Sensitivity analysis was based on the change of payment from the BNHI (increase or decrease). Evaluation of profit or loss for the SWL machine was based on the break-even point, which was defined as the lowest number of SWL sessions to maintain a balance of the costs every month. The payment by the insurance was variable in a different time period. For the purpose of comparability in cost analysis, we calculated the payment for each treatment session at a different period as that in January, 1999.

Patients with a staghorn or partial staghorn stone, a renal stone size $>$2.5 cm or a ureteral stone $>$1.5 cm were excluded from receiving SWL. Effectiveness parameters, including the stone-free rate, the retreatment rate, the rate for additional procedures and the complication rate, were evaluated. The stone-free state was confirmed by

Table 1 Cost of each treatment session of lithotripsy for the outsourcing cooperation model and the rental cooperation model.

	Outsourcing cooperation	Rental cooperation	Specifications
Variable cost			
Cost of lithotripter: 60% of the payment from BNHI	Yes	No	
Direct labor[a]	Yes	Yes	
Direct materials[b]	Yes	Yes	
Fixed cost			
Cost of lithotripter: rent per month divided by treatment number per month	No	Yes	When the treatment sessions increased, every session shared a decreased cost.
Indirect labor[c]	Yes	Yes	
Indirect materials[d]	Yes	Yes	

[a] Cost of direct labor included: salary of the in-charge physician and the technician, attributed by working hour.
[b] Cost of direct materials included: medications and consumptive materials associated with SWL procedure.
[c] Cost of indirect labor included: salary of other medical staff multiplied by the ratio (revenue from SWL divided by total income in the hospital).
[d] Cost of indirect materials included: electricity, water and others multiplied by the ratio (revenue from SWL divided by total income in the hospital).

plain X-ray or ultrasonography 4 weeks after SWL. A second treatment was suggested if the stone was not broken down, or residual stones were noticed. Additional procedures, such as URSL or percutaneous nephrolithotripsy (PCNL), were recommended if poor effectiveness of SWL was noticed. There were some major complications in those who required hospitalization or additional interventions (such as hematoma or severe urinary tract infection), and minor complications (such as colic, fever and mild urinary tract infection) were seen in those who did not require hospitalization or additional interventions.

The Mann-Whitney U test was used for comparison of continuous variables and the Chi-square test was used for comparison of categorical data between different groups. A p value < 0.05 was considered as significant.

Results

Compared with RC, there was a significantly higher number of treatment sessions every month for OC (42.6 ± 7.8 vs. 36.8 ± 6.5, $p = 0.01$). The baseline characteristics of the patients are listed in Table 2. The operation times for OC and RC were 57.3 ± 6.2 minutes versus 59.2 ± 7.1 minutes, respectively, and the number of shock waves for OC and RC was 3411.8 ± 346.9 versus 3394.3 ± 329.6, respectively. There were no significant differences in stone size, operation time, number of shock waves and power for SWL between the two running models. The effectiveness parameters, including the stone-free rate, the retreatment rate, the rate of additional procedures and complication rates (including major and minor) are shown in Table 3, and no significant differences were noticed between the two running models. The cost of direct labor and indirect labor/treatment session was higher for RC than for OC, but the difference was not significant. The cost of the lithotripter for every treatment session was significantly higher for OC (Table 4). The total cost of every treatment session was significantly higher for OC (751.6 ± 20.0 USD vs. 684.7 ± 16.7 USD, $p = 0.01$).

If the hospital obtained 40% of the payment for lithotripsy, the break-even point was 27.5 for OC, which

Table 2 Baseline characteristics of patients in two running models.

	Outsourcing cooperation ($n = 3577$)	Rental cooperation ($n = 2574$)	p
Number of treatment sessions every month	42.6 ± 7.8	36.8 ± 6.5	
Renal stone (n)	2462	1617	
Stone size (cm)	1.51 ± 0.42	1.49 ± 0.44	0.88
Ureteral stone (n)	1115	957	
Stone size (cm)	1.11 ± 0.19	1.12 ± 0.21	0.85
Upper third	1.12 ± 0.22 ($n = 372$)	1.13 ± 0.23 ($n = 327$)	0.79
Middle third	1.01 ± 0.15 ($n = 337$)	1.02 ± 0.13 ($n = 274$)	0.76
Lower third	1.13 ± 0.18 ($n = 406$)	1.12 ± 0.19 ($n = 356$)	0.71
Operation time (min)	57.3 ± 6.2	59.2 ± 7.1	0.87
Number of shock wave	$3,411.8 \pm 346.9$	$3,394.3 \pm 329.6$	0.86
Power of ESWL (KV)	18.0 ± 1.9	18.5 ± 2.0	0.73

The data were represented as mean $\pm$ standard deviation; statistical analysis by t test; $p < 0.05$ was considered as significant.

Table 3 The effectiveness parameters of SWL in the two models.

Parameters/running model	Outsourcing cooperation (%)	Rental cooperation (%)	*p*
Stone-free rate	67.0	65.7	0.79
Retreatment rate	23.2	24.1	0.82
Additional procedural rate	9.8	10.2	0.83
Complication rate	27.5	29.3	0.80

decreased if the hospital got more than 40%. The break-even point for RC was 27.3 sessions, when the fixed rent every month was 60% of the payment from BNHI for each treatment session multiplied by 27.5. By sensitivity analysis, the break-even point increased and the profit decreased, if the payment decreased (Table 5).

Discussion

For the last three decades, SWL was recognized as a minimally invasive procedure for patients with a renal or ureteral stone, and can be performed at out-patient clinics conveniently. SWL has a success rate of 85—96% for small, non-obstructive upper ureteral calculi, but a low success rate for large impacted ureteral stones.[6—8] The clearance of stones after SWL depends on the stone size, location and composition, the SWL machine, and the number and the power of the shock wave.[9]

In this study, a significantly higher number of treatment sessions was noticed for OC than for RC. The possible explanation is that RC (from 2006 to 2011) was implemented later than OC (from 1999 to 2005). The number of SWL in local areas might increase and patients could receive SWL with more options. In addition, the BNHI implemented some audit rules to limit the growing expense from SWL in recent years, which may have reduced the number of treatment sessions for each hospital.

There were no significant differences in the effectiveness parameters, including the stone-free rate, the retreatment rate, additional procedures and the complication rates of SWL between the two running models.

Cost has been an issue in deciding the technique for treating patients with urolithiasis.[4,10] Budget and cost-effectiveness are also important in considering the investment of expensive medical equipments. One study was conducted in Taiwan, to compare the cost and benefit between self-support and OC for the SWL machine. The authors reported that when OC was used, there were significantly more treatment sessions of SWL/month than when utilizing self-support (36.3 vs. 48.1) and the cost of SWL for every treatment session was significantly higher for self-support than for OC.[11] In our study, either with OC or RC, the cooperative company provided the SWL machine, and the hospital did not need to prepare a budget for purchasing a lithotripter. The difference was that with OC, the hospital shared a variable payment according to treatment sessions with the cooperation company, and with RC, the hospital shared a fixed rent every month with the cooperation company. If the number of treatment sessions is more than the breakeven point, the profit of the hospital for RC (a fixed rent in this model) is more than that for OC. On the contrary, if the number of treatment sessions is small, or the reimbursement for SWL from the BNHI decreases, the rental cooperation might not be able to keep a balance between cost and revenue. In this study, the number of treatment sessions/month for OC and RC was 42.6 and 36.8, respectively. The number of treatment sessions/month, with both OC and RC, was much more than the break-even point (27.5) and the cost related to the lithotripter was lower for RC. Therefore, compared with RC, OC carried a lower risk and a higher profit of each treatment session currently.

The cost-effective analysis (CEA) compares the costs and outcomes of the two different running models. According to our data, where the cost (USD) was divided by the stone-free rate (%), the results of CEA were 1121.8 with OC and 1042.2 with RC. It seems that the CEA is much favorable with RC.

With the break-even analysis, we could estimate the lowest number of treatment sessions of SWL necessary to maintain a balance, and with the sensitivity analysis, we could estimate the risk of investing in a new SWL machine. It was estimated, according to the population and the prevalence rate of urolithiasis, that there were about 70,000 persons requiring SWL lithotripsy every year in Taiwan.[11] In 2003, there were about 20,000 people undergoing SWL lithotripsy, and 32 SWL machines in Taipei. Accordingly, the therapeutic capacity of an SWL machine in Taipei was 600 treatment sessions/year (i.e., 50/month). It is reasonable to invest in a new SWL machine in Taipei.[11] According to this

Table 4 The cost of every treatment session in the two models.

Parameters/running model	Outsourcing cooperation (USD)[a]	Rental cooperation (USD)[a]	*p*
Direct labor	67.6 ± 2.9	70.7 ± 2.5	0.15
Direct material	219 ± 3.5	216.8 ± 3.3	0.63
Indirect labor	33.3 ± 1.0	34.1 ± 1.0	0.41
Indirect material	52.8 ± 1.2	45.5 ± 0.8	0.09
Lithotripter[b]	379.9 ± 6.9	317.6 ± 9.8	0.03
Total cost	751.6 ± 20.0	684.7 ± 16.7	0.01

[a] The data were represented as mean $\pm$ standard deviation; statistical analysis by t-test; $p < 0.05$ was considered as significant.
[b] The cost for outsourcing cooperation was 60% of the payment from BNHI and that for rental cooperation was rent per month divided by treatment number per month.

Table 5 Sensitivity analysis of SWL according to the decrease or increase of reimbursement from BNHI.

Decrease or increase rate of reimbursement by BNHI	+20%	+10%	−10%	−20%
Reimbursement of every treatment session by BNHI (USD)	1077	987	808	718
Break-even point (treatment sessions/mo)	21.3	23.9	32.6	37.9
Profit for every treatment session over break-even point (USD)	712	817	524	441

study, from the point of view of the hospital, if the payment from the BNHI does not change considerably, a hospital with a higher number of treatment sessions should implement self-support or RC as a running model for SWL, because it would get more profit than OC. On the contrary, if the payment from the BNHI is uncertain, or the number of treatment sessions is lower, there would be more loss and a greater risk with self-support or RC than with OC.

In this study, we have to mention several limitations, which could be improved by the following. First, before treatment, the cost of prevention, such as the use of alternative treatments, correction of renal or systemic disease, treatment of existing urinary tract infections with prophylactic antibiotics and improvement of SWL efficacy, should be evaluated.[12] Second, we have to put more effort into epidemiologic studies, to estimate the demand of the SWL-related treatment. Third, the payment for each SWL treatment session from the BNHI was higher than URSL in Taiwan, which might influence the decision making of the urologist and increase the probability of unnecessary treatment with SWL. Fourth, the cost of the SWL machine might influence the manager of the hospital to purchase a lower priced machine, with a lower maintenance expense, and to overlook its quality, safety, effectiveness and efficacy. Fifth, the reimbursement system for SWL seemed dissimilar to other countries and the study was only based on the BNHI system in Taiwan.[11]

Conclusions

There were no significant differences in the effectiveness parameters of SWL between the two running models. RC had the lower cost (every treatment session) with fewer treatment sessions of SWL/month than OC. This study might provide a managerial implication and reference for healthcare organization managers, when they face a situation of high price equipment investment.

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