KJU Korean Journal of Urology

www.kjurology.org
http://dx.doi.org/10.4111/kju.2012.53.8.519

Urological Oncology

# Cost Aspects of Radical Nephrectomy for the Treatment of Renal Cell Carcinoma in Korea: Open, Laparoscopic, Robot-Assisted Laparoscopic, and Video-Assisted Minilaparotomy Surgeries

**Jae Won Park, Kyung Hwa Choi, Seung Choul Yang, Woong Kyu Han**

*Department of Urology, Urological Science Institute, Yonsei University Health System, Seoul, Korea*

**Purpose:** This study aimed to comparatively evaluate the cost-effectiveness of four different types of radical nephrectomy (RN) techniques: open, laparoscopic, robot-assisted laparoscopic, and video-assisted minilaparotomy surgery (VAMS).
**Materials and Methods:** Among patients who were diagnosed with renal cell carcinoma and underwent RN, 20 patients were selected who received open, laparoscopic, robot-assisted laparoscopic, or VAMS RN between January 2008 and December 2010. Their medical fees were divided into four categories: procedure and operation, anesthesia, laboratory test, and medical supply fees. The medical costs of the patients were also divided into insured and uninsured costs.
**Results:** The total direct cost of VAMS, open, laparoscopic, and robot-assisted laparoscopic RN were 2,023,791±240,757, 2,024,246±674,859 ($p=0.998$), 3,603,557±870,333 ($p<0.01$), and 8,021,902±330,157 ($p<0.01$) Korean Won (KRW, the currency of South Korea), respectively. The total insured cost of VAMS, open, laparoscopic, and robot-assisted laparoscopic RN was 1,904,627±231,957, 1,798,127±645,602 ($p=0.634$), 3,039,769 ±711,792 ($p<0.01$), and 899,668±323,508 ($p<0.01$) KRW, respectively. The total uninsured cost of VAMS, open, laparoscopic, and robot-assisted laparoscopic RN was 119,163±24,581, 226,119±215,009, 563,788±487,798 ($p<0.01$), and 7,122,234±56,117 ($p<0.01$) KRW, respectively. Medical supply fees accounted for the largest portion of the costs and amounted to 33.43% of the VAMS cost.
**Conclusions:** VAMS RN is as cost-effective as open surgery. Furthermore, it is comparatively more cost-effective than laparoscopic and robot-assisted laparoscopic RN.

***Key Words:*** *Cost analysis; Minimally invasive surgical procedures; Nephrectomy; Operative surgical procedures*



**Article History:**
received 12 February, 2012
accepted 14 May, 2012

**Corresponding Author:**
Woong Kyu Han
Department of Urology, Urological Science Institute, Yonsei University Heath System, 50 Yonsei-ro, Seodaemun-gu, Seoul 120-749, Korea
TEL: +82-2-2228-2325
FAX: +82-2-312-2538
E-mail: hanwk@yuhs.ac

## INTRODUCTION

Minimally invasive surgery was first described by Wickham [1] in 1987 and refers to surgical techniques that are less invasive than open surgery for the same purpose. Conventional open, laparoscopic, robot-assisted laparoscopic, and video-assisted minilaparotomy surgery (VAMS) have been performed as minimally invasive renal surgery. VAMS was conducted for the first time in 1991 for living donor nephrectomies [2]. This surgical technique was performed through minilaparotomy and patients who underwent it recovered quickly. More than 600 cases of living donor nephrectomy have been conducted successfully, and this technique is also widely used to manage renal malignancy [3,4].

Many studies have compared the cost-effectiveness of laparoscopic and robot-assisted renal surgeries with that of open surgery. Bolenz et al. [5] compared the costs of open surgery and robot-assisted laparoscopic radical prostatectomy for prostate cancer. They noted that robot-assisted laparoscopic prostatectomy was more expensive than open surgery in terms of medical supply and operation costs. Hamidi et al. [6] reported that laparoscopic living donor nephrectomy with low complication rates was a cost-effective renal surgery. However, there has been no research on the cost-effectiveness of minilaparotomy kidney surgeries such as VAMS. Therefore, this study aimed to compare the cost-analysis of VAMS versus open, laparoscopic, and robot-assisted laparoscopic radical nephrectomy (RN) surgery under Korean medical insurance.

## MATERIALS AND METHODS

Twenty patients with suspected renal cell carcinoma who underwent VAMS, open, laparoscopic, or robot-assisted laparoscopic RN between January 2008 and December 2010 were selected. The patients sampled for this study were treated between 2008 and 2010 while the insurance system applied, and the most recent 20 cases not subject to the exclusion criteria were selected.

Patients who met the following criteria were excluded: 1) those who underwent another surgery apart from RN, 2) those who incurred additional medical fees owing to postoperative complications, 3) those who underwent RN during hospitalization in another department, and 4) those whose final pathological finding was not renal cell carcinoma.

Patient information (age, gender, body mass index [BMI], and length of hospital stay) was retrospectively collected from medical records. Tumor size was based on reports from pathologists after the patients underwent RN. Tumor stage was based on the American Joint Committee on Cancer Tumor, Nodes, Metastasis staging, 7th edition [7].

Detailed cost information was collected from the Billing Department and the Medical Information Center. Cost information was based on itemized statements of patient medical service fees. Four items considered to be related to the surgery were compared from the itemized statements: procedure and operation, anesthesia, laboratory testing, and medical supply fees. Items such as room and meal charges and medications, which were regarded as being minimally related to surgery, were excluded.

Procedure and operation fees refer to the costs of management and surgery. Management refers to surgical management, enemas, etc. Surgery was defined as a medical service directly performed by doctors with their hands or tools. Laboratory test fees refer to costs associated with extracting and testing specimens to diagnose a disease or ascertain its progression. Anesthesia fees refer to the costs of anesthesia for a surgery or treatment associated with alleviating pain. Medical supplies refer to the costs of materials used in a test or a surgery. Criteria for insured and uninsured costs were based on benefit coverage criteria prescribed by the Health Insurance Review and Assessment Service. For laparoscopic RN, routine disposable laparoscopic equipment was used. For robot-assisted laparoscopic RN, the da Vinci robot (Intuitive Surgical Inc., Sunnyvale, CA, USA) was used. VAMS was performed by use of a standardized surgical technique [4].

All statistical analyses were made by use of the IBM SPSS ver. 18.0 (IBM Co., Armonk, NY, USA). To determine the significance of the differences observed between the means of continuous variables, Student's t-test was used. To determine the significance of the differences observed between the rates of categorical variables, Fisher's exact test was used. A p-value less than 0.05 was considered statistically significant.

## RESULTS

There was a significant difference in patient age and BMI ($p < 0.05$) between the laparoscopic and the VAMS group. There was no significant difference in tumor sizes or stage distributions between the VAMS group and the other three groups (Table 1).

Patient costs (mean±standard deviation) were 2,023,791±240,757, 2,024,246±674,859, 3,603,557±870,333, and 8,021,902±330,157 Korean Won (KRW, the currency of South Koea) for the VAMS, open, laparoscopic, and robot-assisted RN groups, respectively. Among them, the sum of the insured costs was 1,904,627±231,957, 1,798,127±645,602 ($p=0.634$), 3,039,769±711,792 ($p < 0.01$), and 899,668±323,508 ($p < 0.01$) KRW in the VAMS, open, laparoscopic, and robot-assisted RN groups, respectively, whereas the sum of the uninsured costs was 119,163±24,581, 226,119±215,009, 563,788±487,798 ($p < 0.01$), and 7,122,234±56,117 ($p < 0.01$) KRW, respectively (Table 2).

In the VAMS group, medical supply fees accounted for the highest portion of total costs at 38.63% (insured costs were 33.43% and uninsured costs were 5.20%), followed by procedure and operation fees at 29.99% (insured costs were 29.99%). Procedure and operation fees in the open RN group, medical supply fees in the laparoscopic RN group, and procedure and operation fees in the robot-assisted laparoscopic RN group accounted for the largest percent at 33.19% (insured cost at 33.19%), 60.51% (insured cost at 45.3% and uninsured cost at 15.08%), and 88.24% (insured cost at 0.98% and uninsured cost at 87.26%), respectively (Fig. 1).

There was a significant difference between the VAMS and open RN groups in the laboratory test (insured) and surgical material fees (insured and uninsured; $p < 0.05$). Medical supply fees were the item with the greatest difference between the laparoscopic and the VAMS groups ($p < 0.05$). There was likewise a significant difference between the groups in terms of laboratory test fees (insured; $p < 0.05$). In the robot-assisted laparoscopic RN group, procedure and operation fees had the greatest difference compared with those of the VAMS group. Laboratory test costs (insured) and medical supply costs (insured) were also significantly different from those of the VAMS group ($p < 0.05$).

There was no significant difference in total cost between the VAMS and the open RN groups ($p=0.998$). There was

**TABLE 1.** Patient characteristics

| Characteristic | Open | | Laparoscopic | | Robot-assisted | | VAMS |
|---|---|---|---|---|---|---|---|
| | Frequency | p-value[b] | Frequency | p-value[b] | Frequency | p-value[b] | Frequency |
| Number | 20 | | 20 | | 20 | | 20 |
| Operation date | Oct. 5-Oct. 12 | | Aug. 4-Oct. 12 | | Oct. 4-Oct. 12 | | Oct. 2-Oct. 11 |
| Mean age (yr) | 56.9±12.4 | 0.171 | 60.15±11.5 | 0.028 | 55.3±11.7 | 0.324 | 51.45±12.6 |
| Male gender (%) | 70 | 0.465 | 60 | 0.288 | 80 | 1 | 80 |
| BMI ($kg/m^2$) | 23.6±3 | 0.692 | 25±2.2 | 0.032 | 24.2±2.9 | 0.275 | 23.2±2.9 |
| Tumor size[a] (cm) | 7.91±4.1 | 0.067 | 6.86±2.5 | 0.221 | 4.71±2.2 | 0.177 | 5.8±2.8 |
| Stage | | 0.196 | | 0.266 | | 0.887 | |
| 1 | 6 | | 7 | | 13 | | 12 |
| 2 | 6 | | 7 | | 5 | | 5 |
| 3 | 7 | | 6 | | 2 | | 3 |
| 4 | 1 | | 0 | | 0 | | 0 |
| Length of stay (d) | 8±2.3 | 0.002 | 7.4±2.8 | 0.034 | 6±1.5 | 0.5 | 5.6±2.1 |

Values are presented as mean±standard deviation.
BMI, body mass index; VAMS, video-assisted minilaparotomy surgery.
[a]:Tumor size was measured from the specimen, [b]:Compared with VAMS.

**TABLE 2.** Comparison by each surgical procedure category

| | Insurance | Open | | Laparoscopic | | Robot-assisted | | VAMS |
|---|---|---|---|---|---|---|---|---|
| | | Mean±SD | p-value[a] | Mean±SD | p-value[a] | Mean±SD | p-value[a] | Mean±SD |
| Procedure and operation | Insured | 671,820±162,325 | 0.090 | 631,846±173,522 | 0.530 | 78,684±167,068 | <0.01 | 606,957±10,880 |
| | Uninsured | 0 | | 0 | | 7,000,000 | | 0 |
| Anesthesia | Insured | 390,892±103,137 | 0.594 | 418,207±98,735 | 0.118 | 415,156±84,537 | 0.108 | 376,372±62,960 |
| | Uninsured | 3,256±4,645 | 0.260 | 4,558±6,054 | 0.634 | 9,551±6,235 | 0.096 | 5,643±8,103 |
| Laboratory test | Insured | 411,988±175,486 | <0.001 | 352,750±209,478 | 0.037 | 347,471±113,310 | <0.001 | 244,759±55,315 |
| | Uninsured | 10,150±8,701 | 0.354 | 15,716±22,788 | 0.162 | 15,716±22,788 | 0.160 | 8,300 |
| Medical supplies | Insured | 323,428±296,102 | <0.001 | 1,636,966±339,529 | <0.001 | 58,357±85,657 | <0.001 | 676,539±186,448 |
| | Uninsured | 212,713±214,634 | 0.038 | 543,514±490,640 | <0.001 | 97,057±40,260 | 0.431 | 105,220±21,738 |
| Sum | Insured | 1,798,127±645,602 | 0.503 | 3,039,769±711,792 | <0.001 | 899,668±323,508 | <0.001 | 1,904,627±231,957 |
| | Uninsured | 226,119±215,009 | 0.033 | 563,788±487,798 | <0.001 | 7,122,234±56,117 | <0.001 | 119,163±24,581 |
| Total cost[b] | | 2,024,247±674,860 | 0.998 | 3,603,558±870,334 | <0.001 | 8,021,902±330,158 | <0.001 | 2,023,791±240,757 |

VAMS, video-assisted minilaparotomy surgery.
[a]:Compared with VAMS, [b]:Total cost=insured cost+uninsured cost.

a significant difference in the sum of insured costs, uninsured costs, and total costs between the VAMS and the laparoscopic RN group ($p<0.01$).

## DISCUSSION

With patients placing importance on quality of life and decreased postoperative pain, demand for minimally invasive surgery is increasing. Furthermore, along with the development of imaging and operative equipment, surgical techniques have undergone much improvement.

Four minimally invasive surgical techniques are being used for kidney surgery in the urological field: laparoscopic surgery, minilaparotomy surgery, robot-assisted laparoscopic surgery, and percutaneous cryotherapy or ablation therapy. In 1990, Clayman et al. [8] reported on a laparoscopic nephrectomy performed on humans for the first time. This surgical technique, compared with conventional open surgery, caused less postoperative pain and required a shorter hospital stay and time to return to normal life [9]. In 2001, Guillonneau et al. [10] reported robot-assisted laparoscopic nephrectomy on a non-functioning hydronephrotic kidney. Subsequently, other studies reported good functional and oncologic outcomes in patients undergoing this surgical technique [10,11]. For the minilaparotomy technique, Yang et al. [12] reported the first living donor nephrectomy using VAMS, and since then, data on safety and clinical usefulness from more than 600 cases of nephrectomy have been reported [2,3]. Currently, VAMS is used for diverse renal surgeries including radical, partial, and living donor nephrectomies [4]. The clinical usefulness of percutaneous techniques has been verified by many reports, but they have limits in that they are applied to selected patient cases only [13].

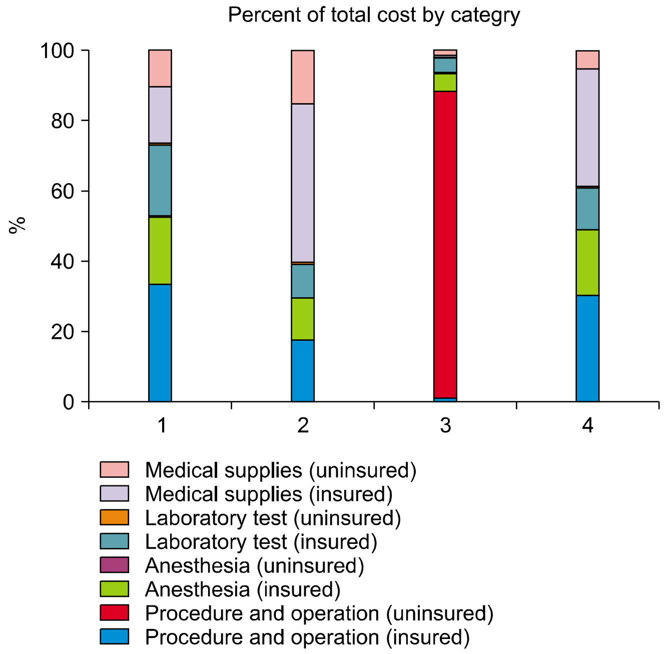


**FIG. 1.** Percentage of total cost by category.

Conventional open, laparoscopic, robot-assisted laparoscopic, and VAMS have been performed for renal masses. VAMS is a minilaparotomy technique in which an endoscope is used and a technique of internal traction is applied with a piercing retractor. It is one of the minimally invasive techniques for renal surgery. It leaves minimal operation-related scars owing to the surgical window available through minilaparotomy [14,15].

For a certain surgical technique to become widely used, it should be associated with advantages in terms of cost-effectiveness, patient benefits, and postoperative outcomes. However, there has been no study on the cost-effectiveness of VAMS compared with other surgical techniques for RN.

For comparison and analysis, we divided patients who were diagnosed with renal cell carcinoma and underwent RN into the open, laparoscopic, robot-assisted laparoscopic, and VAMS RN groups. To research the cost-effectiveness of surgical techniques, it is necessary to evaluate complications from such procedures, because complications affect total cost. Therefore, only four direct cost items related to surgery were compared and analyzed: procedure and operation, anesthesia, laboratory testing, and medical supply costs.

In this study, items such as room and meal charges related to the length of stay were excluded from the evaluation of the cost-effectiveness of surgical techniques. In Korea, the cost of ward stay is approximately 10,000 KRW per day, which is inexpensive and therefore may lead to longer hospital stays.

According to our study results, VAMS was more cost-effective than laparoscopic and robot-assisted laparoscopic RN ($p<0.01$) (Table 2). The greatest difference in medical supply fees was between the VAMS and laparoscopic RN groups ($p<0.01$). In Korea, changes in the benefit coverage criteria of health insurance in 2006 enabled medical supply fees in laparoscopic surgery to be covered by health insurance. However, such a difference between the two groups in medical supply fees was probably due to fees for the disposable device (e.g., Autosuture Multifire Endo GIA 12 mm [Covidien plc, Dublin, Ireland]) that is currently used and which is expensive (more than 100,000 KRW).

Disposable devices (e.g., Floseal Hemostatic Matrix [Baxter Healthcare Co., Hayward, CA, USA], Harmonic Scalpel [Ethicon Endo-Surgery, Cincinnati, OH, USA]) are expensive and are rarely used in open or VAMS RN. This increases the cost of laparoscopic and robot-assisted laparoscopic RN, making them more expensive compared with the open or VAMS group.

Laboratory testing (insured) fees were less in the VAMS group than in the laparoscopic RN group ($p=0.037$), which is related to the shorter length of stay in the former group. Among the itemized costs, the greatest difference in produced and operation fees (uninsured) was between the VAMS and robot-assisted laparoscopic RN groups.

In robot-assisted surgery, many reusable devices (e.g., Endowrist [Intuitive Surgical Inc., Sunnyvale, CA, USA]) were used. Those devices are reusable several times with cleansing and sterilization; thus, it was not feasible to charge this cost for each surgery. At most hospitals, the maintenance cost for reusable devices is included in the uniform procedure and operation fee. Disposable devices were not charged separately, and the cost was also included in the uniform fee. Therefore, the cost of medical supplies for the robot-assisted laparoscopic RN group can seem to be lower than the costs for other groups. Currently, the price of the da Vinci robot ranges from 1.5 to 1.75 million Dollars and maintenance costs from 112,000 to 150,000 Dollars [16]. This is why procedure and operation fees are more expensive in the robot-assisted laparoscopic RN group than in the VAMS group.

Laboratory test fees were greater in the open than in the VAMS group because of the former group's longer length of hospital stay. The mean total costs of laboratory tests in the immediate postoperative 5 days were almost the same in all groups; after that period, the cost increase was proportional to the length of hospital stay. Medical supply fees were greater in the VAMS group than in the open RN group. This is due to the use of an endoscope and a disposable device 12 mm Visiport Plus (Tyco Healthcare, Norwalk, USA) accompanying it. Nevertheless, there was no significant difference in the total cost between the open RN and VAMS groups.

Judging from the study results thus far, VAMS seems to be more cost-effective than laparoscopic and robot-assisted laparoscopic surgeries. Comparison of VAMS with open surgery showed no significant differences in costs between them, proving that VAMS is a competitive modality in renal minimally invasive surgery.

However, our study had some limitations. First, it compared only the direct costs of surgeries. In addition to direct costs, Hamidi et al. [6] compared and analyzed social costs after discharge, including costs resulting from complications in laparoscopic donor nephrectomy. When a patient undergoes a surgery, other costs such as medication and room and meal charges are incurred in addition to the direct costs related to the surgery. Furthermore, patients may be subject to complications. After discharge, patients may incur indirect costs such as sick leave, copayments for health care, and hiring fees for home work. Our study compared only costs directly related with surgery and therefore was unable to predict outcomes resulting from the incurrence of other costs. Also, our study's VAMS was performed by two experienced surgeons. Surgeons who have not yet overcome the associated learning curve tend to have higher complication rates than do experienced surgeons. In this study, the surgeries of the VAMS group were conducted by experienced surgeons, which suggests that their complication rates would not be significantly different from those of the patients who underwent an open surgery [15]. Therefore, itemized amounts that may be affected by complications were excluded. Although the learning curve of VAMS is not very steep [17], it is not a common technique; therefore, a large-scale multi-center study is necessary. Finally, this study only examined RN, which does not represent all VAMS procedures. Recent medical advancements, including abdominal ultrasonography, have resulted in increased discovery rates of small renal masses [18]. The standard method for treating small renal masses is shifting from radical to partial nephrectomy [19]. To fully research the cost-effectiveness of VAMS from different aspects, studies on other surgical techniques such as partial nephrectomy and pyeloplasty in addition to RN are necessary.

## CONCLUSIONS

VAMS RN is as cost-effective as open surgery. Furthermore, the procedure has cost-effectiveness advantages compared with laparoscopic and robot-assisted laparoscopic RN.

## CONFLICTS OF INTEREST

The authors have nothing to disclose.

## REFERENCES


1. Wickham JE. The new surgery. Br Med J (Clin Res Ed) 1987;295:1581-2.
2. Yang SC, Park DS, Lee DH, Lee JM, Park K. Retroperitoneal endoscopic live donor nephrectomy: report of 3 cases. J Urol 1995;153:1884-6.
3. Choi KH, Yang SC, Lee SR, Jeon HG, Kim DS, Joo DJ, et al. Standardized video-assisted retroperitoneal minilaparotomy surgery for 615 living donor nephrectomies. Transpl Int 2011;24:973-83.
4. Kim DJ, Rha KH, Yang SC. Clinical experience of video-assisted minilaparotomy radical nephrectomy for renal cell carcinoma. Korean J Urol 2003;44:959-63.
5. Bolenz C, Gupta A, Hotze T, Ho R, Cadeddu JA, Roehrborn CG, et al. Cost comparison of robotic, laparoscopic, and open radical prostatectomy for prostate cancer. Eur Urol 2010;57:453-8.
6. Hamidi V, Andersen MH, Oyen O, Mathisen L, Fosse E, Kristiansen IS. Cost effectiveness of open versus laparoscopic living-donor nephrectomy. Transplantation 2009;87:831-8.
7. Edge SB, Byrd DR, Compton CC, Fritz AG, Greene FL, Trotti A. AJCC cancer staging manual. 7th ed. New York: Springer; 2010.
8. Clayman RV, Kavoussi LR, Soper NJ, Dierks SM, Merety KS, Darcy MD, et al. Laparoscopic nephrectomy. N Engl J Med 1991;324:1370-1.
9. Mues AC, Haramis G, Rothberg MB, Okhunov Z, Casazza C, Landman J. Contemporary experience with laparoscopic radical nephrectomy. J Laparoendosc Adv Surg Tech A 2011;21:15-8.
10. Guillonneau B, Jayet C, Tewari A, Vallancien G. Robot assisted laparoscopic nephrectomy. J Urol 2001;166:200-1.
11. Benway BM, Bhayani SB, Rogers CG, Porter JR, Buffi NM, Figenshau RS, et al. Robot-assisted partial nephrectomy: an international experience. Eur Urol 2010;57:815-20.
12. Yang SC, Lee DH, Rha KH, Park K. Retroperitoneoscopic living donor nephrectomy: two cases. Transplant Proc 1994;26:2409.
13. Berger A, Kamoi K, Gill IS, Aron M. Cryoablation for renal tumors: current status. Curr Opin Urol 2009;19:138-42.
14. Yang SC, Han WK, RHa KH, Lee SR, Jeon HG. Video-assisted minilaparotomy surgery. Seoul: Yonsei University Press; 2009.
15. Han WK, Lee HY, Jeon HG, Joo DJ, Rha KH, Yang SC. Quality of life comparison between open and retroperitoneal video-assisted minilaparotomy surgery for kidney donors. Transplant Proc 2010;42:1479-83.
16. Steinberg PL, Merguerian PA, Bihrle W 3rd, Seigne JD. The cost of learning robotic-assisted prostatectomy. Urology 2008;72:1068-72.
17. Hwang HH, Park RJ, Cheon SH. The early experience of video-assisted minilaparotomy surgery (VAMS). Korean J Urol 2007;48:158-62.
18. Berger A, Crouzet S, Canes D, Haber GP, Gill IS. Minimally invasive nephron-sparing surgery. Curr Opin Urol 2008;18:462-6.
19. Lee SY, Choi JD, Seo SI. Current status of partial nephrectomy for renal mass. Korean J Urol 2011;52:301-9.