Original Article

Robot-assisted radical resection in prostate cancer comparative assessment with conventional laparoscopic prostatectomy: a retrospective comparative cohort study with single-center experience

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Background: Radical prostatectomy is the standard of care in patients with prostate cancer. Robot-assisted prostatectomy have been used as alternatives to open surgery as they result in less bleeding and allow patients to return to normal activities sooner. This study sought to evaluate the medical factors and health economics of robot-assisted and laparoscopic-assisted prostate cancer surgery to provide a valuable reference for clinicians, patients, and their families when selecting a surgical method for prostate cancer.

Methods: Patients treated with Da Vinci robot-assisted surgery (DVRS) or laparoscopic-assisted surgery (LS) between January 1, 2019, and June 1, 2021, were included in this retrospective analysis. The general baseline data included age, height, weight, body mass index (BMI), preoperative total prostate specific antigen (TPSA), Gleason score, tumor stage, operation time, intraoperative blood loss volume, hospital stay, drainage volume within 24 hours postoperatively, extubation time, postoperative hospital stay, and detailed hospitalization expenditure. The medical and health economics factors were compared between the two prostatectomy techniques.

Results: The preoperative characteristics of the patients in the DVRS group and LS group were comparable, and the differences were not statistically significant (all $P>0.05$). Compared to the LS group, the operation time was significantly longer in the DVRS group, whereas the volume of intraoperative blood loss, hospital stay, extubation time, and postoperative hospital stay were all markedly lower (all $P<0.05$). Also, the treatment, nursing, and total operation costs were considerably lower in the DVRS group compared to the LS group, while the medical material cost, total hospitalization cost, and personal expenses were all notably higher (all $P<0.05$).

Conclusions: Da Vinci robot-assisted prostatectomy is safe; however, the health economics should not be neglected that the robot-assisted operation cannot completely replace the conventional laparoscopic operation in the short term. The consideration of both clinical efficacy and health economics is necessary to provide suggestions for the choice of modus operandi.

Keywords: Prostate cancer; robot-assisted; laparoscopic-assisted; health economics

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Introduction

Prostate cancer is a prominent disease affecting the health of men worldwide, accounting for 14.1% of all new cancer diagnoses and 6.8% of all cancer deaths in men in 2020 (1). At the time of diagnosis, 78.2% of the patients are in a clinically localized stage, and the 5-year survival for localized prostate cancer is 100% (2). Radical prostatectomy is the standard of care in patients with localized disease and the life expectancy is >10 years (3).

Radical prostatectomy can be performed via open, laparoscopic-assisted, or robot-assisted surgery. Recently, conventional laparoscopic-assisted prostatectomy and robot-assisted prostatectomy have been used as alternatives to open surgery because they result in less bleeding and allow patients to return to normal activities sooner (4-6). However, the high cost of robotic technology had led numerous authorities to question its value to patients and healthcare providers. Meanwhile, the conventional laparoscopic-assisted method continues to be practiced in most medical centers in China (7).

To determine whether the additional costs of robot-assisted prostatectomy can be offset by its potential to provide rapid recovery and better outcomes, we performed this retrospective study to compare the medical safety, hospitalization index, and economic costs between the laparoscopic-assisted and robot-assisted prostatectomy techniques. The findings of this study can provide useful evidence that could help to promote clinical decision-making based on the health economics and management of Da Vinci robot-assisted surgery (DVRS) for the treatment of prostate cancer, contribute to therapeutic standardization, and provide further suggestions for the application of DVRSs. Moreover, the data presented in this study could be used as a valuable reference by clinicians, patients, and their families when selecting a surgical method for prostate cancer. We present the following article in accordance with the STROBE reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-22-739/rc).

Highlight box

Key findings

- When balancing efficacy and cost, we speculate that the robot-assisted operation cannot completely replace the conventional laparoscopic operation in the short term.

What is known and what is new?

- The Da Vinci robotic surgical system has the potential for even greater safety improvements;
- As for the health economics parameters, the total hospitalization cost and personal expenses were significantly different between the DVRS and LS groups.

What is the implication, and what should change now?

- Da Vinci robotic operation in the short term. The consideration of both clinical efficacy and health economics is necessary to provide suggestions for the choice of modus operandi.

Methods

Study design

This is a retrospective cohort study conducted in a class A tertiary general hospital. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by Institutional Review Boards of Shanghai General Hospital (No. 2022KY115). Individual consent for this retrospective analysis was waived.

Study participants

Patients with prostate cancer who received DVRS and conventional LS for radical prostatectomy at the Shanghai General Hospital between January 1, 2019, and June 1, 2021, were retrospectively included in this study. The inclusion criteria were as follows: (I) diagnosed with prostate cancer; and (II) underwent DVRS or conventional LS for radical prostatectomy. Patients who met one of the following criteria were excluded: (I) post-operative death; (II) developed severe complications; or (III) important data missing.

Study endpoints

The endpoints for efficacy included operation time, hospital stay, postoperative extubation time, and post-operative hospital stay. The safety endpoints were intraoperative blood loss volume, post-operation drainage volume within 24 h, and post-operative hemoglobin (Hb) and hematocrit (HCT) reduction.

Data collection

The data including age, height, weight, body mass index (BMI), preoperative total prostate specific antigen (TPSA), Gleason score, tumor stage, operation time, intraoperative blood loss volume, hospital stay, drainage volume within

Table 1 Patient demographics between the DVRS group and LS group

Parameters	DVRS group (n=120), median (95% CI)	LS group (n=140), median (95% CI)	P
Age (years)	66.3 (62.5, 73.4)	70.1 (66.6, 75.8)	0.08
Height (cm)	171.1 (162.5, 175.3)	171.8 (163.1, 176.1)	0.93
Weight (kg)	69.5 (60.3, 72.5)	70.1 (61.1, 73.1)	0.81
BMI (kg/m^2)	24.1 (22.4, 25.6)	24.5 (22.8, 27.4)	0.18
Preoperative TPSA (ng/mL)	8.9 (5.7, 14.8)	7.3 (2.9, 12.1)	0.15
Gleason score	7.0 (7.0, 7.0)	7.0 (7.0, 7.0)	0.41
Tumor stage, N			0.77
I	22	28	
II	34	34	
III	44	49	
IV	20	29	

DVRS, Da Vinci robot-assisted surgery; LS, laparoscopic-assisted surgery; CI, confidence interval; BMI, body mass index; TPSA, total prostate specific antigen.

24 hours postoperatively, extubation time, and postoperative hospital stay were collected form the electronic medical record system. Medical and hospitalization cost categories for individual patients including total hospitalization cost, diagnosis and examination cost, operation cost, nursing cost, medical material cost, and drug cost were extracted and analyzed.

Sample size estimates

Sample size estimation based on statistical analysis can ensure sufficient statistical power. However, this retrospective study was limited by the size of the existing database, so that we screened all the available patients for potential inclusion.

Statistical analyses

Normally distributed continuous variables were expressed as the mean ± standard deviation (SD) and were compared using the Student's *t*-test. Quantitative data that was not normally distributed were described as the medians (interquartile ranges), and the Wilcoxon rank-sum test was used for comparison between the two groups. Binary variables were expressed as count and percentage and were compared using the χ^2 or Fisher Exact Probability tests, as appropriate. The Chi-square test was used to compare the qualitative data in this study. A two-tailed P<0.05 was considered statistically significant. EpiData 3.0 (The EpiData Association, Denmark) was used to input the data, which was performed twice by two independent investigators. SPSS 23.0 software (IBM Corporation, NY, USA) was used for the statistical analysis.

Results

A total of 120 patients with prostate cancer who underwent DVRS and 140 patients who underwent conventional LS were included for analysis. The median age of patients in the DVRS and LS groups was 66.3 [95% confidence interval (CI): 62.5, 73.4] and 70.1 (95% CI: 66.6, 75.8) years, respectively. The patients' demographics are presented in *Table 1*. The age, height, weight, BMI, preoperative TPSA, Gleason score, and tumor stage were comparable between the two groups, and the differences were not statistically significant (all P>0.05).

As shown in *Table 2*, the operation time was significantly longer in the DVRS group than in the LS group (P<0.05), but the hospital stay, postoperative extubation time, and postoperative hospital stay were markedly shorter (all P<0.05). Also, the intraoperative blood loss volume and drainage volume within 24 h after surgery were lower in the DVRS group (P<0.05), while the postoperative Hb reduction and postoperative HCT reduction (compared with before surgery) did not differ notably between the two groups (all P>0.05).

Table 2 Comparison of the operation parameters between the DVRS group and LS group

Operation parameters	DVRS group (n=120), median (95% CI)	LS group (n=140), median (95% CI)	P
Operation time (minute)	219.3 (181.1, 246.2)	173.1 (149.2, 203.1)	<0.001
Hospital stay (day)	13.5 (11.0, 14.5)	14.0 (12.5, 15.5)	0.002
Postoperative extubation time (day)	6.0 (5.0, 6.0)	6.5 (6.0, 7.0)	0.032
Postoperative hospital stay (day)	7.0 (7.0, 7.5)	7.5 (7.5, 10.0)	0.002
Intraoperative blood loss volume (mL)	5.0 (0.0, 200.0)	100.0 (50.0, 200.0)	<0.001
Drainage volume within 24 h after operation (mL)	74.0 (31.0, 98.5)	81.5 (51.0, 100.5)	0.049
Postoperative Hb reduction (comparing with before operation) (g/L)	16.2 (10.2, 20.3)	17.2 (11.3, 23.9)	0.156
Postoperative HCT reduction (comparing with before operation) (%)	6.1 (4.2, 8.5)	5.3 (3.2, 7.5)	0.127

DVRS, Da Vinci robot-assisted surgery; LS, laparoscopic-assisted surgery; CI, confidence interval; Hb, hemoglobin; HCT, hematocrit.

Table 3 Comparison of the hospitalization cost between the DVRS group and LS group (Chinese Yuan)

Cost	DVRS group (n=120), median (95% CI)	LS group (n=140), median (95% CI)	P
Total hospitalization cost	67,380.5 (35,197.4, 66,610.7)	38,727.3 (36,731.1, 41,836.5)	<0.001
Diagnosis and examination cost	13,612.2 (11,823.5, 14,403.7)	13,304.2 (10,814.2, 14,853.3)	0.173
Operation cost	21,104.4 (20,625.5, 21,807.3)	24,001.1 (22,905.6, 24,623.3)	<0.001
Nursing cost	652.4 (587.3, 758.2)	746.3 (630.5, 864.3)	<0.001
Medical material cost	816.3 (706.7, 912.2)	710.2 (573.4, 834.8)	<0.001
Drug cost	3,362.2 (2,927.7, 3,981.3)	3,482.6 (2,927.3, 4,248.1)	0.608
Other costs	31,511.3 (2,818.3, 31,696.7)	3,325.6 (2,852.6, 3,728.5)	<0.001
Personal expenses (not covered by health insurance)	33,205.4 (3,738.4, 33,666.2)	1,989.1 (1,621.6, 2,623.6)	<0.001

DVRS, Da Vinci robot-assisted surgery; LS, laparoscopic-assisted surgery; CI, confidence interval.

As shown in *Table 3*, the operation and nursing costs were significantly lower in the DVRS group than in the LS group, while the medical material cost, total hospitalization cost, and personal expenses (including 30,000 Chinese Yuan for using the Da Vinci system) were substantially higher in the DVRS group compared to those in the LS group (all P<0.05). However, the diagnosis, examination, and drug costs did not significantly differ between the two groups (all P>0.05).

Discussion

Prostate cancer is the fifth leading cause of cancer mortality among men worldwide (1). With the ease of access to health care, screening schedules, and the widespread use of prostate specific antigen (PSA) in China, patients are diagnosed with prostate cancer at an earlier age and an earlier stage. Radical prostatectomy is the standard of care for clinically localized prostate cancer, and the life expectancy is at least 10 years. The proportion of patients undergoing radical prostatectomy via open surgery is becoming smaller. For instance, in the past few years in our hospital in Shanghai, if open surgeries are excluded, the proportion of laparoscopic-assisted and robot-assisted prostatectomies accounts for about 40% and 60%, respectively. However, there are few studies comparing these two surgical methods in China, which prompted the present study.

Table 1 shows that the general data of patients in the two groups were comparable, while the operation time was significantly longer in the DVRS group compared

to the LS group, which could be attributed to the extra time needed for assembling the mechanical arms to the Da Vinci robotic system. However, a previous study has shown that with the accumulation of experience and skill improvement of surgeons operating the Da Vinci robotic system, the operation time could be substantially shortened or even shorter than that needed for LS (8). The findings of this study also showed that the intraoperative blood loss volume, hospital stay, postoperative extubation time, and postoperative hospital stay were all lower in the DVRS group than in the LS group. After carefully reviewing the patients' medical histories, we found that no patients in the DVRS group received a blood transfusion, as compared to six patients in the LS group.

Regarding the maturity of the surgical techniques, in the present study, patients from both groups successfully completed the surgeries, with no deaths or secondary surgeries. Also, all of the patients recovered and were discharged following the removal of the drainage tubes. These findings demonstrated that robot-assisted surgery had the advantages of being minimally invasive and allowing for rapid recovery. It should be noted that the volume of intraoperative blood loss in DVRS has been associated with several factors, including the skillfulness of the surgeons and the close cooperation of the surgical team. In addition, our findings showed that the safety parameters, including postoperative Hb reduction and postoperative HCT reduction (compared with before surgery), did not significantly differ between the two groups, indicating that compared with the relatively mature LS, the Da Vinci robotic surgical system is quite reliable in terms of safety.

The Da Vinci robotic surgical system has the potential for even greater safety improvements. A previous study has demonstrated that in the processes of Da Vinci robot-assisted radical prostatectomy, the anatomy of blood vessels and nerves was clear, the ligation was reliable, the damage to surrounding normal tissues was limited, the postoperative recovery of patients was rapid, and the improvement of life quality was substantial, which is consistent with our findings (9). These findings were also in agreement with the postoperative follow-up visits of patients. The robot-assisted surgical system has several advantages, including high image resolution, high precision, and high stability, which could further promote highly precise surgeries in the limited working room available on tissues that are rich in nerves and blood vessels, such as the prostate. The stable Da Vinci robot surgical system also reduces the rate of device failure and could effectively limit the surgical risks and concerns of both surgeons and patients. Combining this with a haptic feedback system could further reduce the uncertainties and risks. Finally, the learning curve of operators is generally short. Also, the operators are generally in a sitting position during the operation, which could reduce their fatigue and risk of handshaking and assist in completing time-consuming, complex surgeries.

As for the health economics parameters, the total hospitalization cost and personal expenses were significantly different between the DVRS and LS groups, with a total cost and personal expenses of 28,653.2 Yuan and 31,216.3 Yuan higher in the DVRS group compared to the LS group, respectively. The higher cost was mainly due to the expenditure of using the Da Vinci robot-assisted system on the day of the operation, which is not covered by health insurance in China. When balancing efficacy and cost, we speculate that the robot-assisted operation cannot completely replace the conventional laparoscopic operation in the short term.

In the future, the robot-assisted surgical system could be further improved, at least from the following aspects: (I) further stabilization of the surgical system, reduction of device failure, prevention of surgical risks, and reduction of the concerns of doctors and patients; (II) further updating the haptic feedback system to reduce the risks and uncertainties; (III) development of new types or domestically-made operation systems to further reduce the operation cost, or including robot-assisted surgery into health insurance policies to reduce the economic burden on patients; (IV) further increasing the number of training centers for robot operation, encouraging institutions to apply for qualification in systemic robot training, and promoting education into robot operation by surgeons in China (10,11); and (V) further increasing the service time and efficiency of robots to meet the requirements of more patients.

Conclusions

In summary, this study verified the safety of DVRS and suggested that health economics should not be neglected when evaluating the clinical efficacy. The consideration of both clinical efficacy and health economics is necessary to provide a valid reference for clinicians, patients, and their families when deciding whether or not to opt for DVRS.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tau.amegroups.com/article/view/10.21037/tau-22-739/rc

Data Sharing Statement: Available at https://tau.amegroups.com/article/view/10.21037/tau-22-739/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-22-739/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Institutional Review Boards of Shanghai General Hospital (No. 2022KY115). Individual consent for this retrospective analysis was waived.

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