

ORIGINAL RESEARCH

Establishment and application of nursing standard operating procedures for DVSS-Si robot-assisted laparoscopic radical prostatectomy

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Abstract

This study aims to develop and implement standard operating procedures (SOPs) for nursing care during DVSS-Si robot-assisted laparoscopic radical prostatectomy (LRP) and to evaluate the clinical outcomes of these procedures. We included 140 patients who underwent robot-assisted LRP: 70 patients who received routine perioperative nursing care (control group) from July 2021 to February 2022, and 70 patients who were provided perioperative care according to the newly established SOPs (intervention group) from March 2022 to December 2022. Comparative analysis of operational metrics revealed that the intervention group had shorter operation position placement times, reduced robot installation times, decreased robot usage durations and fewer adverse events compared to the control group. Additionally, doctor satisfaction levels were significantly higher in the intervention group. In conclusion, the implementation of nursing SOPs for DVSS-Si robot-assisted LRP effectively standardized nursing practices in the operating room, leading to enhanced operational efficiency and improved quality of nursing services.

Keywords

da Vinci robot; Prostate surgery; Nursing; Standard operating procedure

1. Introduction

Prostate cancer is one of the most prevalent malignant tumors in the male urinary system, ranking as the second most common cancer among men. Due to its high incidence, prostate cancer poses a significant threat to male reproductive health [1–4]. Radical prostatectomy remains a critical treatment for localized prostate cancer, as it effectively removes cancerous tissues, controls disease progression, and enhances patient survival rates [5–7]. Laparoscopic radical prostatectomy (LRP) has become a widely adopted procedure for prostate cancer treatment. The indications for radical prostatectomy include: (1) Prostate specific antigen (PSA) levels ≤ 10 –20 ng/mL; (2) Gleason score of 7; (3) Clinical stage T1–T2C; and (4) Patients with a life expectancy exceeding 10 years.

However, as medical technology and scientific advancements have progressed, the proportion of patients undergoing traditional LRP has been steadily decreasing in favor of robot-assisted LRP. Although it has been shown that there is potentially no significant difference in tumor control between these two surgical approaches, the use of robotics has been associated with significant patient outcomes improvements. Specifically, robotic assistance has increased the success rate of controlled urination, improved maintenance of sexual function, and overall quality of life. Standard operating proce-

dures (SOPs) play an essential role in standardizing nursing workflows, offering a scientific, evidence-based and rigorous approach to nursing care. These procedures enhance clinical performance, improve efficiency and ensure consistency in nursing tasks, making them widely adopted in clinical practice [8, 9]. Since 2014, the First Affiliated Hospital of Nanchang University has implemented the DVSS-Si robot and has performed over 400 robot-assisted LRP operations.

Robot-assisted LRP necessitates close collaboration among the urologist, anesthesiologist and operating-room nurse(s). In this study, we developed nursing standard operating procedures (SOPs) for DVSS-Si robot-assisted LRP through a comprehensive review of relevant literature, expert consultations and our clinical experience. The implementation of these SOPs in robot-assist LRPs, demonstrating significant improvements in coordination and efficiency.

2. Patients and methods

2.1 Data collection

This was a retrospective study. We included 70 patients undergoing DVSS-Si robot-assisted LRP from July 2021 to February 2022 as the control group, and 70 patients who underwent the procedure from March 2022 to December 2022 as the

intervention group. The inclusion criteria were: a preoperative pathological diagnosis of prostate cancer, fulfillment of the indications for LRP, and voluntary participation with full informed consent. The study exclusion criteria were the presence of poor cardiopulmonary function that contraindicated surgery, poor compliance and unwillingness to cooperate. Patient characteristics for both groups are summarized in Table 1.

2.2 Methods

2.2.1 Formation of the nursing standard operating procedure expert group for DVSS-Si robot-assisted laparoscopic radical prostatectomy (LRP)

A 19-member expert group was established to develop the SOPs for DVSS-Si robot-assisted LRP. This group comprised 4 urologists, 1 anesthesiologist, 2 clinical nurse leaders, 1 da Vinci robot specialist group leader, 11 da Vinci robot specialist group members and 1 da Vinci robot engineer. One of the two clinical nurse leaders, both of whom have over 15 years of operating room experience and extensive familiarity with the da Vinci robotic surgical system, served as the expert group leader. The robot specialist group leader, specialist group members and engineers collaboratively drafted the SOPs for robotic surgical care. Urologists, anesthesiologists and robot specialist group members were involved in the formulation, implementation, and evaluation of these procedures.

2.2.2 Establishing the standard operating procedures for the DVSS-Si robot-assisted LRP

We developed the SOPs for DVSS-Si robot-assisted LRP through a comprehensive process that included reviewing relevant literature, consulting with experts and conducting group discussions. The SOPs were organized into three main categories: preoperative preparation, intraoperative cooperation and postoperative management. Each category was further divided into specific areas: instrument preparation, equipment layout in the operating room, patient positioning, intraoperative coordination between instrument nurses, intraoperative coordination between circulating nurses and management of instruments and equipment. We developed and refined seven key workflows focused on patient safety. These workflows were meticulously quantified to address critical elements and concerns. The finalized SOPs for DVSS-Si robot-assisted LRP are detailed in Table 2.

2.2.3 Implementation of the nursing standard operating procedures for DVSS-Si robot-assisted LRP

Once the nursing standard operating procedures (SOPs) for DVSS-Si robot-assisted LRP were established, the robot specialist group members executed their tasks according to these SOPs. For instrument preparation, the instrument nurses assembled the instruments and disposable sterile articles in accordance with the inventory list outlined in the SOPs. The circulating nurse arranged the instruments and equipment based on the preparation list specific to the da Vinci robot LRP. Both the instrument and circulating nurses meticulously checked the preparation and layout of all robot instruments, disposable sterile articles, and other equipment to ensure proper setup.

Following the SOPs for operating-room equipment layout, all instruments and equipment were managed and positioned consistently. In terms of patient positioning, the specialist group leader conducted theoretical lectures on the principles, methods and precautions for positioning during robotic LRP. Subsequently, the team members received training and evaluation using standardized patient models, as per the positioning SOPs. The training, overseen by the specialist team leader and the head nurse, comprised two components: theoretical and practical. The theoretical training included instruction on identifying common da Vinci robot instruments, understanding surgical steps and coordination, managing perioperative instruments and equipment and overseeing perioperative patient care. The practical training covered patient positioning, the use and disposal of common robotic equipment, specifications for installing robot-arm sleeves and robot lens installation and 3D calibration.

2.2.4 Evaluation factors

Several key factors were evaluated to assess the efficiency and effectiveness of the robot-assisted LRP procedures:

1. Surgical position placement time: the time taken to complete the surgical position placement was measured by the circulating nurses using a timer. This duration was recorded from the completion of anesthesia puncture and tracheal intubation fixation until the surgical position was finalized. Each operation's surgical position placement time was documented for analysis.
2. Robot installation time: this factor refers to the time required to complete the "Time Out" procedure, which is performed by the anesthesiologist, surgeon or nurse, until all robotic arms are properly installed. The duration for this process was carefully recorded.

TABLE 1. Data regarding the characteristics of the two groups (*t*-test).

Group	Number	Age (yr, $\bar{x} \pm s$)	BMI ($\bar{x} \pm s$)	Operation time (min) ($\bar{x} \pm s$)	Anesthesia time (min) ($\bar{x} \pm s$)	Bleeding volume (mL) ($\bar{x} \pm s$)
Control group	70	67.96 \pm 0.70	23.77 \pm 0.36	253.90 \pm 5.21	32.80 \pm 1.21	200.00 \pm 7.94
Intervention group	70	68.14 \pm 0.87	24.10 \pm 0.23	255.70 \pm 7.05	34.97 \pm 1.75	207.90 \pm 12.25
<i>t</i>		0.165	0.747	0.211	1.017	0.538
<i>p</i>		0.868	0.456	0.832	0.311	0.591

BMI: Body Mass Index.

TABLE 2. Standard operating procedures for LRP nursing care.

Variable	Procedure
Preoperative instrument preparation	<ol style="list-style-type: none"> 1. Endoscopic basic instrument kit: includes robot-specific laparoscopic instruments such as a 30° lens, robotic trocars (4 × 8 mm Trocar, 4 × Cap), 1 Maryland bipolar forceps, 1 robot electric scissors, 1 robot grasper and 2 large needle holders. 2. Single-use sterile articles: consists of robot-arm sleeves, a robot camera arm sleeve, a lens sleeve and 1 disposable 12 mm trocar. 3. Operating table and supporting components: comprises a gel head ring, shoulder rest, leg belt, gel and hip pad. 4. DVSS-Si robotic system: includes the doctor's console, bedside robotic-arm system and video tower.
Operating-room equipment layout	<ol style="list-style-type: none"> 1. Patient positioning: place the patient in a supine position with legs apart. Adjust the equipment layout in the operating room based on the patient's position and the planned setup. 2. Equipment placement: position the anesthesia machine at the right side of the patient's head end, 50–100 cm from the operating table. Place the video tower on the left side of the patient's head, the bedside robotic-arm system at the middle of the bed's tail, the physician console on the left side away from the operating table, and the nurse instrument table on the right side of the patient, aligned with the bed's tail.
Patient positioning	After anesthesia induction and tracheal intubation, the anesthesiologist protected the patient's head while the circulating nurse padded it. The head loop and shoulder rests were positioned on both sides, and the patient's hands and forearms were placed on the body. The legs were separated at an angle of 60° and secured with leg straps. The heels were placed on heel pads to keep them suspended.
Intraoperative cooperation	<ol style="list-style-type: none"> 1. Preoperative power on self-test (POST): A 30-minute startup self-test was performed before the operation to ensure that the robotic system was functioning correctly. The corresponding doctor's console preferences were selected and set as a backup. 2. Instrument nurse coordination: the instrument nurse cleaned the organizer table, verified the integrity of all instruments and sterile items, and assisted the surgeon with disinfecting the table 30 min before the operation. In collaboration with the traveling nurse, the lens sleeve and camera arm sleeve were installed, and the robot lens was calibrated for white balance and 3D settings. The surgeon then guided the traveling nurse in positioning the robotic-arm system beside the bed. After positioning, the robotic arm and puncture device were connected, and the robotic instruments were installed under the direct guidance of the robot lens. The instruments were placed in the surgical target area, locked in position and replaced as needed based on the surgeon's requirements during the operation. 3. Circulating nurse cooperation: the circulating nurse initially adjusted the operating table to a 30° head-down and 15° feet-down position to facilitate the docking of the bedside robotic system. Following this, the circulating nurse assisted the instrument nurse and surgeon in connecting the robot lens and energy platform connection lines. It was essential to avoid adjusting the surgical position and bedside robotic-arm system during the operation. The pneumoperitoneum pressure was maintained at 12–15 mmHg throughout the procedure to ensure a clear operating field. If the robot arm collided during the operation, a prompting mechanism was activated.
Instrument and equipment management	<ol style="list-style-type: none"> 1. Instrument nurse responsibilities: after use, the instrument nurse cleaned the robotic instruments by removing blood stains and verifying their completeness. The instruments were then placed properly in their designated cases. Following the operation, the instrument arm was promptly replaced, and the handover of instruments was recorded with the disinfection supply center staff. 2. Circulating nurse management: the robot system was evacuated from the bedside promptly after using the instrument arm system. Once the robot arm was placed in the functional position, the bedside robotic-arm system was moved to its designated area. The number of times each instrument was used was recorded immediately after use. Video cables and wires were packed and stored appropriately, and all instruments and equipment were placed in their designated areas before shutdown. The robot's usage was documented in the robot use registration form, which was regularly maintained. Any unexpected events occurring during the robot system operation were recorded in the robot adverse event register, with the causes analyzed and documented.
Patient safety management	<ol style="list-style-type: none"> 1. Patient temperature management: the operating-room temperature was adjusted 25 min before the operation and again 23 min after disinfection. During the procedure, the infusion thermometer was used to heat the injected liquids, and an inflatable heating blanket was employed to maintain the patient's body temperature by dynamically adjusting the blanket's temperature. 2. Management of stress injuries: the operating bed was kept flat and tidy, and the patient's limbs were protected using a gel pad to prevent bone protrusion. An anti-pressure mask was applied to protect the head. Additionally, the operation of the robotic arm was continuously monitored to prevent medical-device-related stress injuries.

POST: power on self-test.

3. Robot usage time: this was defined as the period from when the surgeon began operating the robot handle to the moment the robotic-arm system was evacuated from the bedside. This time was tracked to evaluate the operational efficiency.

4. Incidence of robot adverse events: during the operation, any occurrence of yellow- or red-light alarms in the robot system's indicator lights, indicating issues such as electric leakage or damage to robot instruments, was recorded as an adverse event. These incidents were systematically documented to assess the reliability of the robotic system.

5. Physician satisfaction: following each operation, physicians completed a questionnaire to evaluate their satisfaction with the overall process. This included the preparation, position placement and cooperation throughout the operation. Satisfaction was rated on a scale where operation preparation and position placement were scored out of 30 points each, and cooperation was scored out of 40 points. Higher scores indicated greater satisfaction.

6. Statistical analysis: statistical analyses were performed using GraphPad Prism 6.02 software (GraphPad Software, San Diego, CA, USA). The *t*-test was employed to analyze the data, with a significance level set at $\alpha = 0.05$.

3. Results

Table 3 presents the comparative data for operation position placement time, robot installation time, robot use time and doctor satisfaction between the control and intervention groups.

A total of 20 cases (28.57%) of adverse events were observed in the control group, whereas the intervention group had only 5 cases (7.14%) of adverse events. The difference in the incidence of adverse events between the two groups was statistically significant, with a *t*-value of 10.96 and $p = 0.0009$.

4. Discussion

Establishing and implementing standardized nursing operating procedures for DVSS-Si robot-assisted LRP can significantly enhance the quality of perioperative nursing care. Proper preoperative preparation is essential for successful robotic surgery. Incorrect patient positioning during endoscopic procedures can adversely affect the surgery and lead to pressure injuries related to medical equipment. Once the da Vinci robot's surgical positioning and the connection of the bedside robotic-arm system are completed, adjusting the patient's surgical position is not permitted. Therefore, thorough posture management before the operation is essential for ensuring optimal exposure of the surgical site, improving operational efficiency and reducing the risk of rhabdomyolysis

and other intraoperative and postoperative complications [10]. The adoption of standardized patient teaching methods has proven beneficial in clinical practice. This approach enhances the quality of clinical nursing, shortens the time required for position placement, and helps prevent instrument-related pressure injuries by optimizing position setting and utilizing hydrogel dressings [11]. Additionally, pretreatment of instruments effectively reduces contamination after use, improves the rate of instrument cleaning and accelerates the replacement of instruments during surgery [12, 13]. Nurses are also trained to understand the risk factors and complications associated with perioperative hypothermia and its management in surgical patients. Given that robotic LRP involves extended surgical durations, active body surface warming before and during surgery is critical for preventing complications related to accidental hypothermia [14, 15]. Thus, in addition to routine measures for maintaining body temperature during LRP, dynamic room temperature regulation, continuous inflation of a variable temperature blanket during the operation, and real-time temperature monitoring using ear temperature sensors were implemented to ensure patients' normal body temperature, which contributed to improved quality of operating-room nursing services and increased doctor satisfaction.

Moreover, establishing and implementing standardized operating procedures for DVSS-Si robot-assisted LRP have effectively reduced the incidence of adverse events during robotic operations. The advent of minimally invasive surgical technologies, such as the da Vinci robot system, has transformed traditional surgical practices. To ensure the safety of robotic urology surgeries, structured, mandatory, and centralized training is essential [16, 17]. Robotic LRP requires a range of equipment and disposable sterile articles, and relying solely on the scrub nurse's memory could disrupt the flow of the operation. To address this issue, an inventory list of surgical materials was developed following the nursing standard operating procedures for DVSS-Si robot-assisted surgeries. Both scrub and circulating nurses conducted thorough checks of the inventory to confirm that all required surgical materials were available and correctly prepared. Additionally, clear markings on the ground were used to indicate the types of equipment, which helped prevent collisions between the bedside robotic-arm system and other instruments or equipment, as well as the contamination of the robot-arm sleeve [18]. The nursing standard operating procedures also provided a framework for quantifying and refining operational coordination, including common adverse event codes and robot treatment methods. This framework

TABLE 3. Patient positioning time, robot installation time, robot use time and physician satisfaction.

Group	Number	Position-setting time (min)	Robot installation time (min)	Robot usage time (min)	Doctor satisfaction (points)
Control group	70	8.51 ± 0.094	22.89 ± 0.248	180.30 ± 5.855	87.86 ± 0.836
Intervention group	70	5.15 ± 0.080	15.93 ± 0.120	158.80 ± 6.883	97.14 ± 0.543
<i>t</i>		26.98	25.15	2.37	9.30
<i>p</i>		<0.0001	<0.0001	0.0187	<0.0001

ensured that each specialist team member could follow the procedures and methods precisely. Standardized training and learning enabled instrument and circulating nurses to perform thorough preoperative preparation, monitor the operation of each robotic arm throughout the procedure, and alert the surgeon and assistant in the event of or potential for collisions. Such measures promoted the standardization of medical practices and significantly reduced the incidence of adverse events involving the robot, thereby enhancing surgical efficiency.

5. Conclusions

The DVSS-Si robot has significantly advanced modern surgery with its high-definition, enlarged three-dimensional field of view, precise robotic-arm control and 540° maneuverability through the doctor's operating platform. Robotic prostatectomy is notable for its light pain, rapid recovery, reduced hospitalization time, favorable cosmetic outcomes and high patient satisfaction. By enhancing the protection of vital tissues and reducing surgical morbidity, robotic systems are poised to be a major trend in the future of surgery [13]. Our present study demonstrates that the establishment and application of nursing SOPs for DVSS-Si robot-assisted LRP adhere to scientific standards, standardizing nursing practices, enhance operational efficiency and promote consistency in the operating room. They also shorten the learning curve for robotic LRP coordination among operating-room nurses and reduce the incidence of nursing-related adverse events. Thus, both the quality of nursing services and doctor satisfaction have been significantly improved.

AVAILABILITY OF DATA AND MATERIALS

Data are available for research purposes upon reasonable request to the corresponding authors.

AUTHOR CONTRIBUTIONS

LHG, WH and YY—designed the research study. LHG, WH and CZ—performed the research; analyzed the data. JY, YLT and YPX—provided help and undertook the statistical analysis. LHG, WH, CZ and YY—wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of the First Affiliated Hospital of Nanchang University (CDYFYLK09-011). Informed consent was obtained from all participants.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Yuanping Xiong is serving as one of the Editorial Board members of this journal. We declare that Yuanping Xiong had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to KSH.

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