Single port robotic radical prostatectomy with the da Vinci SP platform: a step by step approach

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The da Vinci single port (SP) robotic system (Intuitive Surgical, Sunnyvale, CA, USA) is a recently approved robotic platform designed with several modifications to the previously available multi-port robotic systems. This article describes the technique performed utilizing the SP robotic system for radical robotic-assisted laparoscopic prostatectomy (RALP) with or without bilateral pelvic lymph node dissection from a single institution. In this report we describe our step-by-step approach, technical modifications from the multi-port technique and initial results for performing single port robotic-assisted laparoscopic prostatectomy (SP-RALP). We describe our initial experience and technique with the SP robotic system consisting of 23 consecutive patients who underwent SP-RALP between December 2018 and May 2019. The median patient age was 62 years with approximately half of the patients undergoing pelvic lymphadenectomy. The median operative time was 236 minutes, median estimated blood loss was 50 mL and median length of hospital stay was 1 day. No unplanned port placements occurred and no conversions to open surgery occurred. We demonstrate the safety and feasibility of performing a transperitoneal prostatectomy with either a posterior or anterior approach.

Key Words: robotics, prostatic neoplasms, minimally invasive surgical procedures

Introduction

Over the past 20 years the surgical treatment of prostate cancer has undergone a fundamental change from primarily an open retropubic procedure, as first described by Millin in 1945,[1] to a laparoscopic approach. Arguably the single most influential driver toward minimally invasive surgery has been the introduction of the da Vinci surgical robotic platform (Intuitive Surgical, Sunnyvale CA, USA), first approved by the Food & Drug Administration (FDA) in 2000.[2] Robotic technology has been widely adopted for radical prostatectomy with evidence for reduced length of hospital stay, perioperative blood loss, rates of positive surgical margins and utilization of postoperative radiation treatment.[3] While there is significant heterogeneity in studies, robotic technology may be associated with improved erectile performance[4] and urinary continence postoperatively.[5] Since release of the initial da Vinci robotic platform, subsequent generations have shared a multi-arm design with a fixed laparoscopic camera.

In June 2018, the da Vinci single port (SP) system was approved by the FDA for urological surgery. The SP system utilizes a similar user interface to prior

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models but features several fundamentally different modifications. Notable new features include a single surgical arm, articulating instruments and a flexible camera placed through a single trocar, a relocation pedal allowing the operator to reach all abdominal quadrants by moving the entire trocar with attached arm and a virtual navigator function providing real time monitoring of the relative position of the instruments and the camera, even when they are off-the visual field. These new instrument mechanics and features create several specific technical adaptations from the multi-port approach, with subsequent benefits and limitations.

In this report, we discuss our initial results and describe a step-by-step technical approach to performing the Single Port Robot Assisted Laparoscopic Prostatectomy (SP-RALP), highlighting variations from the multi-port technique developed during our early experience with the SP platform.

Method and technique

The initial set-up and positioning for SP-RALP is similar to multi-port RALP (MP-RALP), with the patient either in supine or dorsal lithotomy, steep Trendelenburg, arms are tucked and padded shoulder pads or anti-slip mat are used to secure the patient.

To accommodate the single robotic trocar a 3 cm vertical skin incision is made 2 cm superior to the umbilicus. Under direct vision, the peritoneum is incised via a Hasson technique and a wound retractor is applied. A gel-port is then attached to the wound retractor with the securing clamp positioned superiorly to avoid pressure wounds from the insufflation channel. Alternatively, the single robotic trocar can be place without a wound retractor or gel-port. This is done using the blunt tipped obturator for placement of the robotic trocar. A 5 mm or 12 mm AirSeal (ConMed Corporation, Utica, NY, USA) port is placed 5 cm lateral to the midline incision in the right abdomen under direct laparoscopic vision to serve as an assistant port, per attending preference. The initial set-up is shown in Figure 1. We utilize a regular gel-port size that allows for an incision of 1.5 cm to 7 cm rather than the smaller gel-port to allow for placement of an additional assistant port within the fascial incision if necessary. While an additional assistant port through the fascial incision is not routinely used, this method keeps this option available.

Following insertion of the SP trocar, an entry guide is attached to the trocar to facilitate instrument insertion and exchange. The SP robot is docked with the flexible endoscopic camera placed through the designated camera channel in the entry guide. The instrument and camera placement through the trocar are shown in Figure 2. The da Vinci SP system allows for defining a vertical limit for the surgical arm's range of motion. We limit-set the range of motion after draping and insertion of the camera to avoid collisions with the patient and to provide sufficient clearance for the anesthesia team. Unlike our traditional positioning for MP-RALP, the Mayo stand above the patients' head is omitted and ample space is available around the patient.

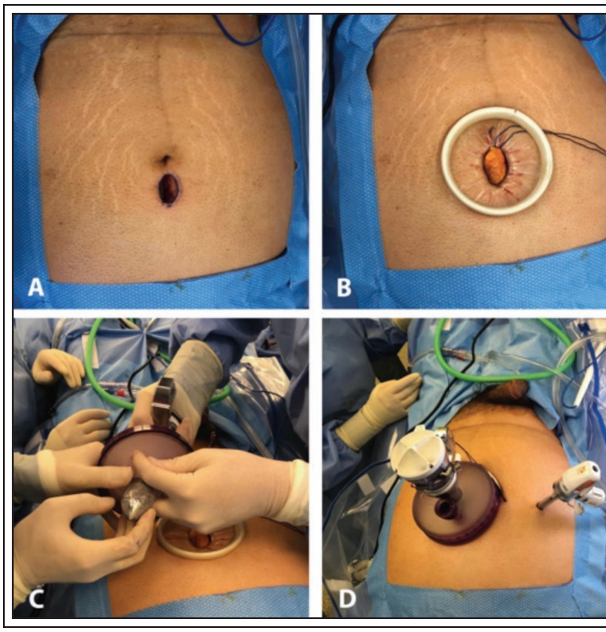

Figure 1. Initial incision and port set-up for SP-RALP. **A)** Supraumbilical incision for the SP trocar; **B)** Placement of Alexis retractor; **C)** Perforation of GelPoint port by the SP trocar; **D)** Final port alignment with 5 mm Airseal port.

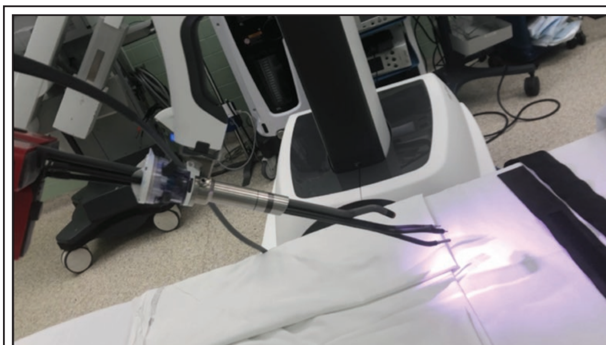

Figure 2. SP trocar with articulating instruments and camera.

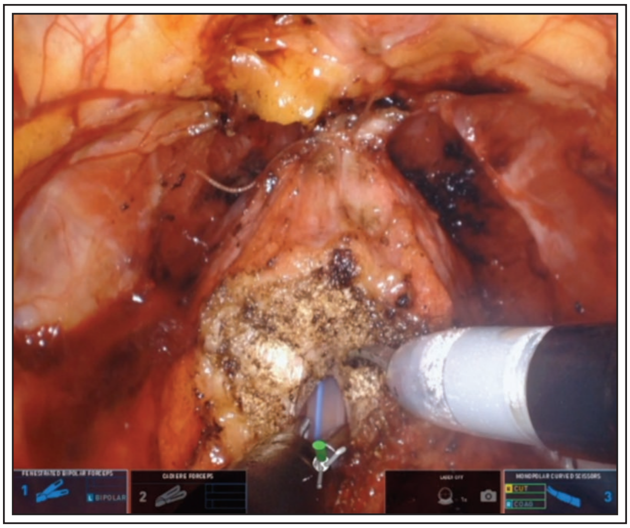

Figure 3. Anterior bladder neck dissection. Instruments are in an optimal position as demonstrated by green color of the Navigator function in the inferior aspect of the image.

Instrument setup begins with the camera placed in the "above" position, through the 8 mm trocar channel at 12 o'clock. Monopolar scissors are placed in the right-hand position in instrument arm #3, bipolar fenestrated forceps are placed in the left-hand position in instrument arm #1, and Cadiere forceps are placed in the inferior position in instrument arm #2.

Camera positioning is performed using two available commands, "Camera Adjust" and "Camera Control," which are activated respectively by the camera pedal and the right master control. The flexible camera features the ability to move between the Adjust or Control modes and allows for independent camera movement while the other instruments maintain a fixed position. Additional coordinated movement functions include a "Relocate" mode, wherein the instruments and camera move together en bloc as the entire single-port robotic arm pivots around the trocar. Coordination of the instruments and camera is aided using another new feature, the Navigator. The Navigator is a virtual image at the bottom of the surgeon console that projects the instrument and camera positions relative to each other, even when instruments are outside the video field of view. Additionally, the Navigator provides feedback for instrument positioning related to excursion and angulation: a green indicator of the camera icon (as shown in Figure 3) indicates optimal positioning, while orange indicates the instrument's lateral limit has been reached and an adjustment is necessary.

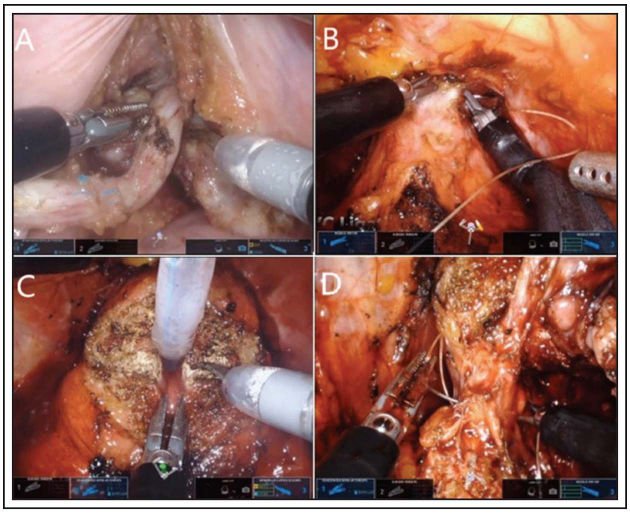

Figure 4. Intraoperative images for SP-RALP. **A)** Posterior approach for seminal vesicle dissection; **B)** Ligation of the dorsal venous complex; **C)** Posterior bladder neck dissection; **D)** Dissection of the neurovascular pedicle.

We then proceed with either an anterior or posterior approach per attending surgeon preference. For the posterior approach, the vas deferens is dissected and severed bilaterally more proximally than we would normally do for the MP-RALP technique. Several critical surgical steps for the SP-RALP are demonstrated in Figure 4. During the dissection of the seminal vesicles, upper traction is provided by the assistant using a suction device to lift the vas deferens while the Cadiere forceps is used for traction on the inferior peritoneal edge. In general, all the instruments are closer to the target tissue with the SP system as compared to the MP technique. Therefore, while previously with the MP platform we used the 4th arm to provide constant tension with a Prograsp off the surgical field of vision, this tension is replicated with the SP platform using the Cadiere with a much tighter arrangement of instruments. While the loss

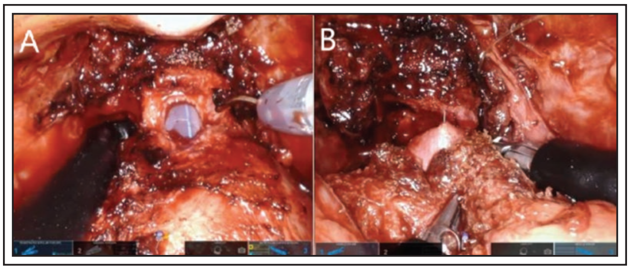

Figure 5. A) Apical dissection; **B)** Vesico-urethral anastomosis.

of the 4th arm translates to less tissue tension than the MP platform, this is mitigated by greater operator autonomy in managing traction, fewer conflicts among instruments and the use of the navigator to guide off-screen movements.

At this point the bladder is released from the abdominal wall and pubic ramus to expose the bladder neck, and the endopelvic fascia is incised bilaterally. We now use a 2-0 barbed absorbable suture (V-Loc Medtronic plc Dublin, Ireland) on an SH needle to ligate the dorsal venous complex, placed through the 5 mm assistant port. We previously used a 0-0 polygalactin suture on a CT-1 needle for our MP-RALP technique, however the size of this needle was not amenable to passage through the entry guide without bending it. Use of the 12 mm AirSeal port allows for passage of larger needles for DVC ligation should this be preferred.

The single arm of the SP system allows for rotation of the instruments and the camera around a central axis. During the anterior and posterior bladder neck dissection, we tried several different configurations of the camera and instruments during our initial cases to optimize traction and visualization. We found that maintaining the camera in an "above" (superior or 12 o'clock) position during the bladder neck dissection provides an ideal view and best maneuverability of the instruments. To approach the anterior bladder neck, the instruments are positioned as at the beginning of the procedure, with the Cadiere providing traction of the anterior bladder wall. Once the Foley catheter is in view, we switch the fenestrated bipolar (# 1 entry guide channel, 9 o'clock) with the Cadiere (#2 entry guide channel, 6 o'clock) in order to have an ideal angle to the posterior bladder neck thanks to the Cadiere providing superior traction on the Foley. If a large median lobe is present, placing an additional figure-of-eight stitch using a barbed absorbable suture can provide superior retraction with the Cadiere forceps while providing exposure of the posterior bladder neck. An alternative to the above retraction for the posterior bladder neck is to use a suture passer using a free tie to hold and retract the catheter superiorly and aid in posterior bladder and seminal vesicle visualization and dissection. Minor camera adjustments are made throughout these steps to achieve ideal positioning, indicated by the green Navigator light.

Dissection of the posterior recto-prostatic plane, the posterior pedicles and the interfascial nerve plane can be aided with a 180^{o} re-positioning of all instruments. Using the ability of the SP trocar to rotate, the camera is moved to a "below" (inferior or 6 o'clock) position, the fenestrated bipolar and the scissor are switched and the control of the Cadiere (which is at 12 0'clock, channel #2) is typically transferred to the right hand.

Both vasa are grabbed by the Cadiere. As the SP Cadiere is smaller than the MP Prograsp, it is helpful to have long vasa deferens attached to the seminal vesicles to allow for retraction and avoid these structures falling into the surgical field and obscuring the surgical view. The posterior prostatic plane is then dissected below Denonvilliers fascia to the apex in standard fashion. Medium-large (green) Hem-o-lok clips or a figure-of-eight stitch may be used for providing hemostasis during ligation of the pedicles and during nerve sparing. The pedicle dissection is carried on using the Cadiere to put traction to the seminal vesicle from 12 o'clock and the Fenestrated Bipolar and the Monopolar scissor to advance the dissection toward the apex.

Once the pedicle dissection is complete, we rotate the SP camera back to the "above" position and again switch instruments position prior to completing the apical dissection. The urethra is then transected sharply, and the Foley catheter removed. In the author's opinion, the apical and urethral dissection represents one of the most significant advantages of the SP system. The flexible camera allows for the ability to continuously adjust the perspective to allow for visualization during this step.

After the prostate and seminal vesicles are removed, a pelvic lymphadenectomy is performed based on the preoperative risk stratification by the Memorial Sloan Kettering preoperative prostate cancer nomogram.[6] Using the "relocate" mode, the single-port robotic arm pivots around the trocar and can be directed to the lymph node bed. This is carefully performed using the "Navigator" to locate the position of all the instruments. Using the Cadiere to provide retraction the peritoneum is open over the lymph node bed. The external iliac artery is used as the landmark for dissection and dissection occurs from the level of the ureter proximally and is advanced distally to the node of Cloquet and the femoral canal. The medial dissection border is performed to the medial umbilical ligament and the lateral border is that of the external iliac artery. The external iliac artery is completely skeletonized and sent as a lymph node packet. The obturator nerve and vessels are also skeletonized along with lymph tissue medial to the external iliac vein to obtain another lymph node packet within the obturator fossa. If needed, a laparoscopic clip applier can be used through the 12 mm assistant port for lymph vessels. This dissection is done bilaterally and can be done without the aid of the assistant. If more proximal dissection is needed for an extended pelvic lymph node dissection, the camera relocation mechanism can be used to obtain a more proximal view.

In order to preserve the size of our assistant port at 5 mm, a 10 mm specimen retrieval bag is inserted through the midline incision. This requires temporary removal of the robotic trocar and placement of the retrieval bag through the gel-port alongside a grasper and a 5 mm laparoscopic camera through the assistant port. Once the prostate is placed within the bag and the bag closed, the robotic trocar is replaced, and insufflation reinitiated. Given the short time required to dock and undock with the SP system, this maneuver does not add significant delay to the procedure.

A posterior sphincteric reconstruction can then performed in with a 3-0 barbed absorbable suture, incorporating Denonvilliers fascia with the posterior bladder neck and posterior urethra via a modified Rocco technique.[7] The placement of a posterior reconstruction is based on surgeon preference. The anastomosis is completed using the Van Velthoven method using a barbed absorbable running 3-0 suture prior to final Foley catheter placement.[8] During the vesicourethral anastomosis a second suction is placed to the catheter which may allow for port reduction as alluded to above. The anastomosis is tested with water placed in the bladder to assess for anastomotic leak with single interrupted correction stitches placed as needed. The apical dissection and anastomosis are shown in Figure 5.

A drain is then placed through the assistant port under direct vision; however this is determined for each case and again is dependent on surgeon preference. The robot is undocked, and the prostate is removed within the specimen retrieval bag through the supra-umbilical incision. The fascia and skin are then closed in standard fashion.

Results

Between December 2018 and May 2019, a total of 23 SP-RALPs were performed at our institution for patients with available 30-day postoperative follow up by two experienced robotic surgeons. The median length of follow up for the entire cohort was 97 days (range 30-169 days). The median patient age was 62 years old (range 48-77) with a median BMI of 30.0 (range 24.4 to 47.4) and a median American Society of Anesthesiologists (ASA) score of 2 (range 2 to 3). The median prostate-specific antigen (PSA) prior to surgery was 8.3 (range 6.0 to 40.7). The most common preoperative biopsy pathology was Gleason 3+4 (n = 15), with smaller cohorts of 3+3 (n = 3),

TABLE 1. **Intraoperative timing (n = 10)**

Step	Median time (min)	IQR	Min (min)	Max (min)
Console time	188.5	171-206	157	225
Port placement/docking	18.5	15.2-20	12	31
Adhesion dissection	1.5	0-4.8	0	17
SV dissection	18.5	12.5-29.8	9	64
Bladder dissection	10.5	9-14	8	17
Endopelvic fascia dissection	10	7.3-11	2	18
DVC ligation	5.0	4-7.3	3	30
Bladder neck dissection	23.0	13.5-29.8	9	39
Rectoprostatic plane dissection	8.5	6.5-11	3	19
Pedicle dissection	22.0	19.3-25	10	38
Apical dissection	8.0	5.5-10	3	12
Lymphadenectomy (n = 4/10)	37.0	35.8-39.3	35	43
Bladder neck reconstruction (n = 5/10)	11.0	8-14	4	15
Posterior reconstruction	10.5	9-11.8	5	16
Vesicourethral anastomosis	10.0	8.5-11.8	4	15
Specimen retrieval	7.0	6.3-8	4	12
Closure	23.0	20-31.3	17	35

SV = seminal vesicles; DVC = dorsal venous complex

4+4 (n = 3), 4+5 (n = 1) and 5+5 (n = 1). Median prostate volume was 48.6 cc (range 32 to 184).

Bilateral pelvic lymphadenectomy was performed for 12 of the 23 patients (52.2%) by preoperative risk stratification by the Memorial Sloan Kettering preoperative prostate cancer nomogram.[6] The median estimated blood loss (EBL) was 50 cc (range 20-500 cc) and the median operative time is 236 minutes (range 191 to 343 minutes). There was 1 intraoperative complication of note with a serosal injury of the bowel during lysis of adhesions which was repaired primarily without additional sequelae. No conversions to an open technique were required and no additional port placements were performed. Detailed timing of operative steps for the first 10 cases are shown in Table 1.

Postoperatively, the median hospital stay was 1 day (range 1 to 6) with the majority (n = 13) of patients discharged on postoperative day 1. The median duration of catheterization was 9 days (range 6 to 34) with prolonged catheterization (greater than 14 days) required for 4 patients for urine leak (n = 2, 8.7%) and patient preference/scheduling (n = 2). Clavien-Dindo[9] complications ≥ 2 were noted for 6 patients (26.1%) and included epididymitis/urinary tract infection (n = 3), delayed extubation postoperatively due to prior pulmonary comorbidities (n = 1), pelvic hematoma requiring transfusion (n = 1) and Foley catheter exchange and cystogram under sedation (n = 1). Postoperative outcomes are shown in Table 2.

Postoperative PSA values were available for 22 of the 23 patients, at most recent follow up, PSA values were undetectable for 16 of 22 men (72.7%), with 0.1 ng/mL (n = 3) as the next most common result. Three patients were noted to have PSA persistence after surgery; the first featured Gleason 5+5 biopsy pathology and was counseled preoperatively that he would require additional multi-modal treatment, and 2 patients who were found to have metastatic disease on lymph node dissection. In all, 3 patients (13.0%) were found to have positive lymph nodes with a median lymph node yield of 12.5 (range 5 to 41) on pathological analysis for the 12 patients who were treated with bilateral pelvic lymphadenectomy. Positive surgical margins (PSM) were noted for 9 of 23 patients (39.1%).

Discussion

SP-RALP appears to represent a safe and feasible approach to performing radical prostatectomy. During our initial experience with a high-risk diverse cohort of men we were able to successfully perform SP-RALP without the need for conversion to an open technique or without additional ports. Transperitoneal prostatectomy was feasible both from a posterior

TABLE 2. **Postoperative outcomes**

	Median	%	Min-Max	IQR
Hospital LOS (days)	1		(1-6)	1-2
Duration of catheterization (days)	9		(6-34)	8-10.5
Transfusion rate (%)		4.3% (n = 1/23)		
Incisional hernia rate (%)	-	0% (n = 0/23)		
Total morphine equivalents (TME) consumption (mg) during hospitalization	22.5		(0-102.5)	9.25-41.25
Pain free percent on POD1 (%)		47.6% (n = 10/21)		
Clavien-Dindo complications ≥ 2		26.1% (n = 6/23)	Included: Epididymitis/urinary tract infection (n = 3) Delayed extubation postoperatively due to prior pulmonary comorbidities (n = 1) Pelvic hematoma requiring transfusion (n = 1) Foley catheter exchange and cystogram under sedation (n=1)	

LOS = length of stay; POD = postoperative day approach as well as an anterior approach. In this cohort of 23 men, postoperative outcomes were acceptable for the initial learning curve with one patient requiring Foley exchange and cystogram and one patient requiring a blood transfusion for pelvic hematoma.

Previously, similar initial case series have been published describing other centers' initial experience with performing SP-RALP.[10-12] As the SP technology has only been recently approved, these series feature many of the same drawbacks as our series;[13,14] namely small sample sizes, limited follow up, single institution design and results indicative of the initial learning curve with this platform. Agarwal et al[11] noted a higher rate of positive surgical margins (28%) than their multi-port experience in a series of 49 patients, which was attributed to their initial learning curve and was similar to Kaouk et al who reported a 33% PSM.[12] This is in line with prior studies with multi-port robotic technology demonstrating that positive surgical rates are often over 30% during a surgeon's first 50 cases.[15] While our series featured a higher PSM than other previously published series, this is likely reflective of our initial experience with the technique as well as an enriched population with a higher preoperative PSA and approximately twice as many patients found to have metastatic disease on pathology as previously published series.[11] Further long term follow up and a structured approach to recording patient outcomes with quality improvement benchmarks will be critical for best outcomes and improving surgical outcomes going forward.

Understanding the optimal surgical technique and approach to this operation will allow for more robust multi-center assessment of this technology and evaluation of postoperative functional outcomes. We believe that our technique reflects a safe and reproducible approach that will facilitate these studies.

Conclusions

With some technical modifications to the standard MP approach, SP-RALP represents a safe and feasible approach to performing transperitoneal laparoscopic with robotic-assistance prostatectomy from both an anterior and posterior approach. Potential advantages of this system include improved cosmesis, reduced pain requirements and improved operative visualization during critical operative steps. Further investigation will be necessary to evaluate the potential advantages of this approach as well as functional and oncological outcomes.

Disclosure

Dr. Crivellaro is a consultant for Intuitive Surgical Inc. ☐

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