Robotic Surgery: Operating Room Setup and Docking

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Introduction

Robotic surgery (RS) continues to impart its role in minimally invasive surgery (MIS) since its first emergence. It has rapidly been adopted by different specialties including general surgery, urology, gynecology, and orthopedic surgery, and now is becoming a mainstay of MIS technique around the globe [1–3]. During the last 30 years, many different robotic systems came into surgical practice but the da Vinci® is currently the most commonly utilized and is available in four different models (standard, streamlined, streamlined High definition, S-integrated). Despite its enhanced view of 3D system and angulations of instruments, its practical application for training surgical residents is less emphasized and addressed [4, 5]. This chapter will guide in the basic principles of setting operating room and equipments for da Vinici®. It is further emphasized that hands-on training on simulators and in operating rooms under a trained mentor is highly suggestive of learning robotic skills.

Practical Applications

Robotic surgery has successfully made it possible to complete complex and advanced surgical procedures with precision while staying with the promises of minimally invasive techniques [5]. Many surgeons around the globe have already been practicing RS in all specialties and disciplines like urology, general surgery, pediatric surgery, neurosurgery, gynecology, cardiac, and orthopedic surgery. It has been further applied to subspecialties of general surgery like colorectal, hepatobiliary, bariatric and antireflux surgery, gastric oncology, endocrine, hernia, and complex abdominal wall reconstruction [1, 5, 6].

In contrast to 2D view of laparoscopic surgery, operating surgeon is sitting comfortably on consol with physical ease, enjoying 3D view with depth perception. Robotic arm manipulation and 360 articulation is the beauty of RS which allows the surgeon to perform a more complex procedure without much strain [5–7].

Limitations

RS has few limitations despite rapidly developing technique. Cost and safety always remained questionable in this technique [8, 9]. Human error along with mechanical failures of RS component like robotic arm, lens, camera, and instruments can completely halt the procedure. Extreme

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body positions can cause nerve palsies in inexperienced hand [1, 8, 9].

Bulkiness of RS set may be overcome in large institute with dedicated RS operation suite but lack of tactile sensations and force feedback are still a major drawback of this technique [9–11].

Surgical Team

Minimum surgical team required to run RS setup is surgeon, surgical assistant, circulating nurse, and surgical technician. All surgical staff should be trained in robotic surgery and must have basic knowledge of it which must be gained by proper training. This team should be persistent and dedicated for RS cases to achieve a good learning curve. Surgeon and assistant must not only have mastering skills in operating Da Vinci but also have basic knowledge of RS system and also be aware of troubleshooting the system. Surgical assistant play a vital role and should be efficient enough in trocar placement, draping, docking, irrigation, retraction, changing instruments, and must have basic laparoscopic skills [12].

Basic Requirements for Robotic Surgery

The basic system for robotic surgery consists of three components: Vision Cart, Patient Cart, and Surgeon's Cart (Console) (Fig. 1). Other requirements are according to the type of surgery. This chapter will try to include the basic minimum requirements for any robot-assisted surgical procedure.

Minimum Personnel Required

- Trained robotic surgeon
- Anesthesia Team trained to conduct robotic surgery
- Trained surgical assistant(s)
- One/two trainees or residents

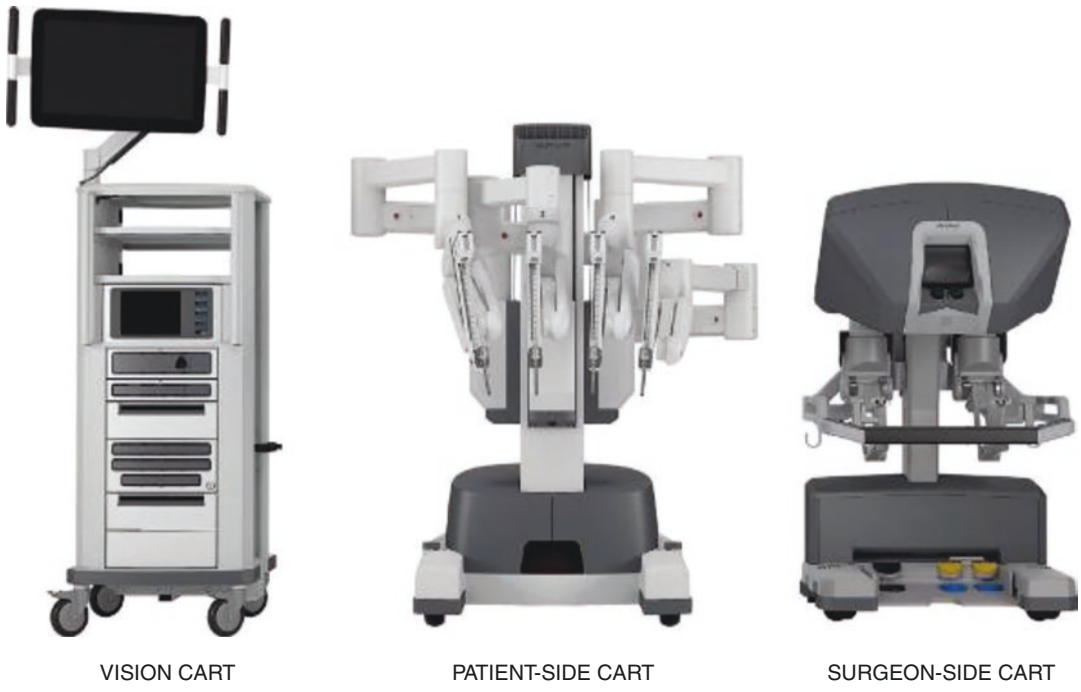

Fig. 1 Vision cart, Patient-side cart, and Surgeon-side cart

- Circulating nurse
- OR technicians

Laparoscopic Instruments

- Veress needle (optional)
- 12 mm × 1 Optiview Visiport for camera port
- 12 mm Xcel port × 2
- 6 mm port × 2
- Metzenbaum scissors
- Hook cautery, Maryland dissector, Needle driver
- 5 mm × 1 Hem o lok clips and its applicator
- 10 mm × 1 Hem o lok clips and its applicator
- 0 and 30° scopes
- Suction irrigation setup

Robotic Instruments

- da Vinci robotic system (Intuitive surgical, CA, US)
- 8 mm robotic trocar × 2
- 5 mm robotic trocars × 3
- Camera adapter
- Sterile camera trocar mount and drapes
- Sterile drapes for camera and instrument arms
- Sterile camera mount and instrument adapter
- Endowrist instruments

Operating Room Configuration

Operating Room Setup

Conventional operating room (OR) can be used to set up RS system but, due to its size and extra component, it is advised to have a dedicated RS room to accommodate not only the system and also to allow free movement of OR personnel. It will further allow docking of the robot from different angles depending on the type of surgery. Availability of space could be a major issue for already established OR setups but this problem can be overcome by restructuring operating room according to the need. Some of the components may be placed on vision cart. Ceiling-mounted booms can harbor insufflators, electrosurgical units, camera, and light source equipment. Operating room should be arranged in a fashion that surgeon has a clear view of the patient from console with a clear pathway for OR staff to move around (Fig. 2).

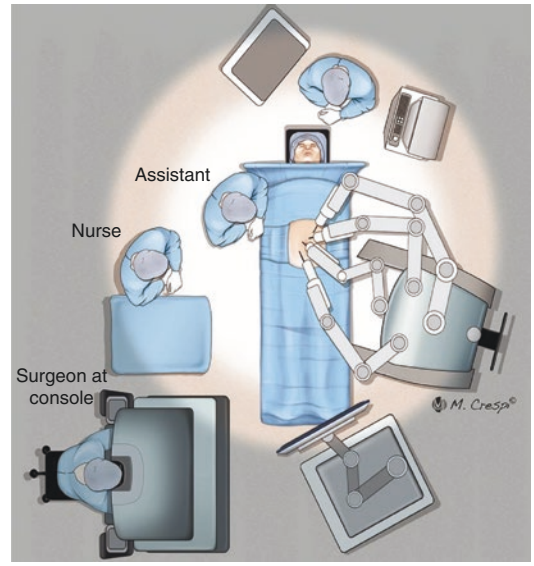

Fig. 2 Operating room setup

Patient Position and Preparation

In contrast to conventional laparoscopic surgery, extreme positioning is required in order to achieve optimized exposure for robotic surgery procedures and often requires a strong teamwork to ensure patient safety [13]. Patient safety concerns during RS are to maintain circulation, nerve protections, and pressure injuries to bony prominences. Every effort should bring in consideration to provide proper exposure of surgical site, adequate room for anesthetists to proceed. Another main concern regarding positioning is the safe docking of robot and safe access for bedside surgeon to the surgical ports [14].

For ventral hernia, patients are directly moved onto OR table in supine position with both arms tucked in by the side of body. Arms can be placed in a sling or arm boards to optimize the access of da Vinci arms. All the bony

prominences and pressure areas should be covered with a gel pad. Patient cart approach side should be lifted up. The patient is then exposed in a way that he could be prepped from xiphoid to perineum and can be approached from any side if needed [15].

Patient Cart Position

Patient cart should be sterilized and draped before bringing into surgical field. Once the patient positioning is set and cart itself is draped, it should be moved in by using motor drive. Patient cart brakes are designed by default to stop if it is not in use, but it is advised to refer to the manual setting for safety concerns [14, 15].

Patient cart for standard systems has camera and instrument arms. Each arm has several joints and clutches for gross movements and also to insert and withdraw instruments. These arms have two clutch buttons. One dedicated to free gross movement and the other to adjust final trajectory of arm for final docking. The author advises to refer to the system manual for clutch settings as wrong movements can lead to a major disruption. Third arm is in alignment with camera arm therefore care must be taken into account to avoid sword fighting of arms. It is further recommended to refer to manual for color coding and numbering of arms for standard or S model. (Fig. 3).

An extra and very useful feature of Touch screen monitor is to use it to draw real-time images on monitor. This feature is very useful for teaching and training surgical residents and should be emphasized to use it during surgery to let them know about surgical steps and techniques.

Vision Cart Position

The vision cart should be next to patient cart in order to visualize the component display and also to prevent uninterrupted and free movement of camera cable during surgery. It contains many storage areas to harbor different equipment. It typically contains light source, video processor, and camera control. It can further house insufflators, DVD recorders, and electrosurgical units. Light source is connected with endoscope by a single cable and the endoscope comes in 0°and 30° lense and further has a right and left optical channel to record images. While the standard or S type higher robotic systems endoscopes are connected with higher magnification of 15× with 45° view or wider view of 60° with 10× magnifica-

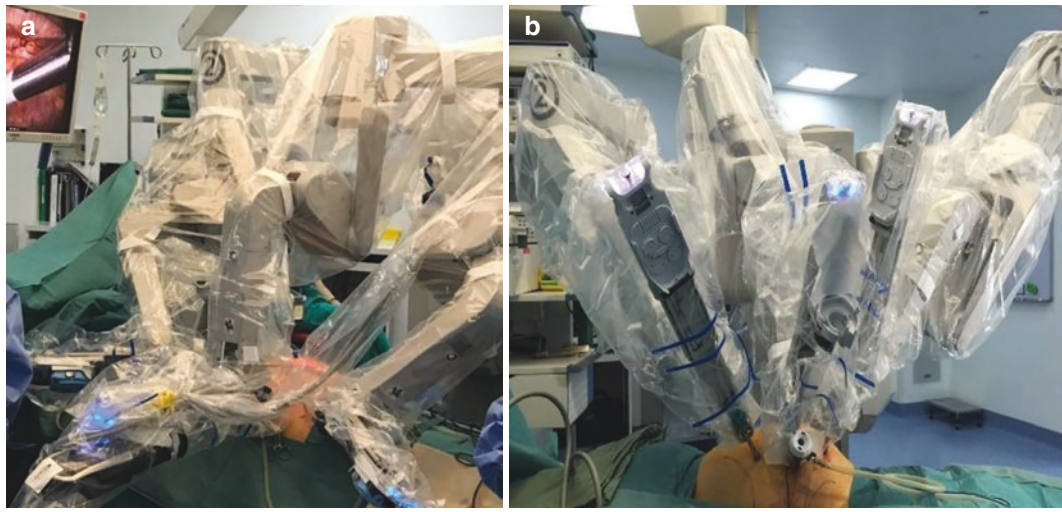

Fig. 3 Position of patient cart on patient for docking (**a, b**)

tion. Resolution and aspect ratio of images can be set from manual and new systems are designed with higher resolutions and AR.

Steps of Docking

Abdominal Access and Port Placement

Abdominal access and port placement are very crucial to start RS. Pneumoperitoneum can be created using either open or closed technique, the author was working with MIS team and recommends to proceed with open technique to better avoid injury. Once peritoneum is accessed, 12 mm visiport for da Vinci endoscope must be introduced and secured in place.

Positions of various ports could vary from patient to patient according to the procedures and is also depended upon the surgeon's preference (Fig. 4). In order to have optimum working conditions, the following principles should be kept in mind.

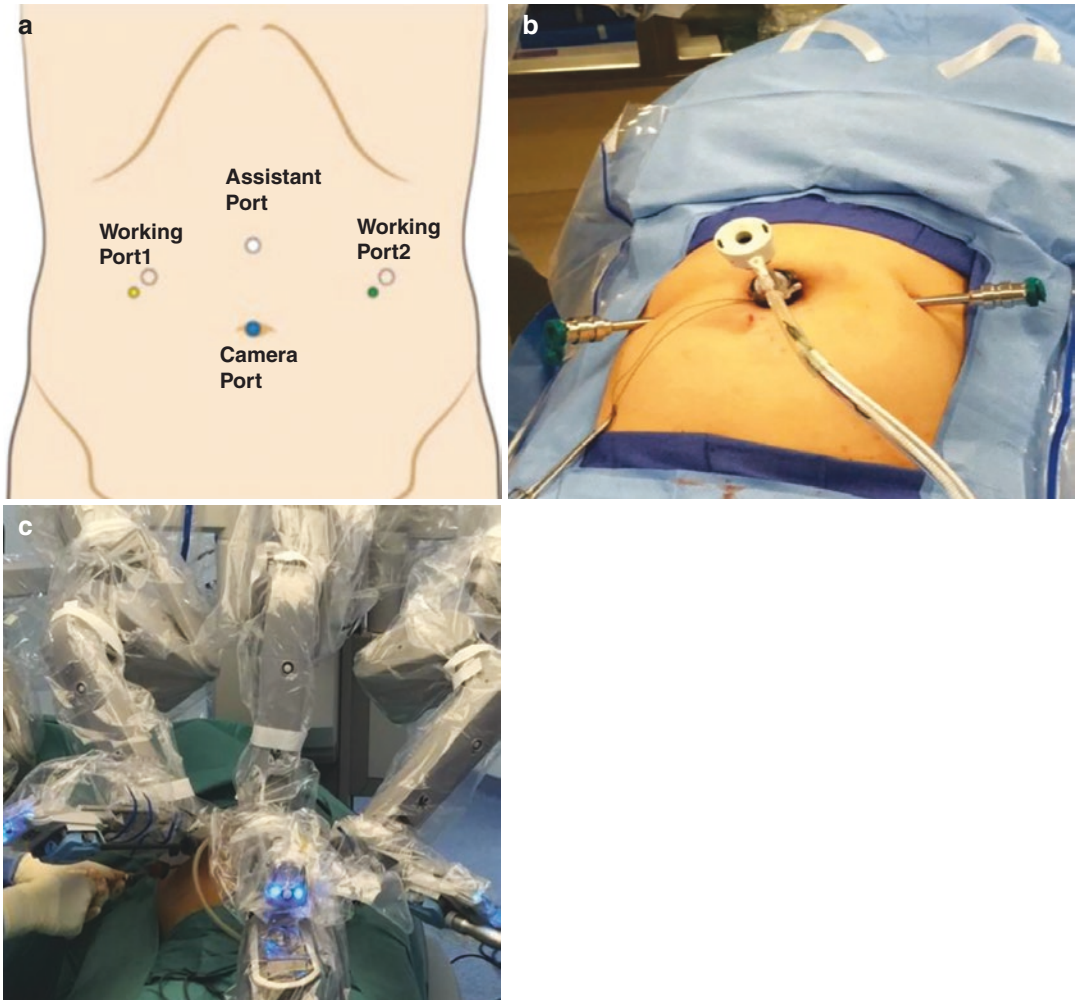

Fig. 4 Port placement (**a**), Position (**b**), and Docking with an extra assistant port (**c**)

- Camera port should be in the same line as surgical target area
- Target area should not be more than 20 cm from camera port
- Working ports should be at least 8 cm form camera port on each side
- Assistant port, if needed, should be atleast 4 cm from camera port

Ports placement in robotic complex ventral or lateral hernia is a critical step and patient factors and anticipated docking should be kept in mind before this step. Patient BMI, body habitus, previous surgery, defect orientation, and its size may affect port positioning and minor amendments can be done accordingly. Port should be placed as much laterally as possible and after insufflations up to 15 mmHg. Assess defect orientation and mark the site. Consider additional 3–5 cm for mesh placement around the defect. Mark the anticipated mesh perimeter at which fixation will be considered latterly. Draw a semicircular line around the mesh perimeter marking, 10–12 cm away from mesh perimeter. Camera port should be placed on this line exactly opposite to anticipated patient cart. Two working arms ports should be placed on each side of camera port almost 8 cm away and on semicircular line. It is better to place assistant port at this stage if needed. Later, once docking is done, we cannot move the patient or patient cart afterward. Assistant port is placed almost 4 cm from camera port and at least 6 cm away from the semicircular line. These port placements are critical for surgery because this will ultimately bring optimal triangulation [15].

Preparing da Vinci

Operating room preparation should be started well before patient's arrival in preoperative area. Surgical team can follow steps that should be considered while setting up system for surgery.

- Before turning on the system, it is advised to connect all cables necessary to run it and do not manipulate system until it is on and self-testing is done.
- Camera arm and other instruments should be positioned in ways that smooth functioning and movements can be observed during procedure.
- After initiating homing sequence, camera, endoscope, instruments, and touch screen are draped and locked.
- Similar to laparoscopic setting, proceed with white balance.
- Align camera port towards targeted anatomical area and surgical cart center column.
- Lock the wheels once cart is in position.
- "Sweet spot" (arrow is pointing towards thick blue line) of camera arm should be set by bringing the trocar mount in alignment with the center of the patient cart column and also by simultaneous extension of camera arm.
- Check the set up joint angles to minimize the potential collision. The angle at the second joint should be 90°.
- System is ready to use and is docked (Fig. 5).

Console Function and Terminology

Surgeon should be aware of the console's different part and terminology being used. Basic terminology according to the site is mentioned in the picture (Fig. 6).

- Clutch plate
- Camera peddle
- Focus bar
- Cautery peddle

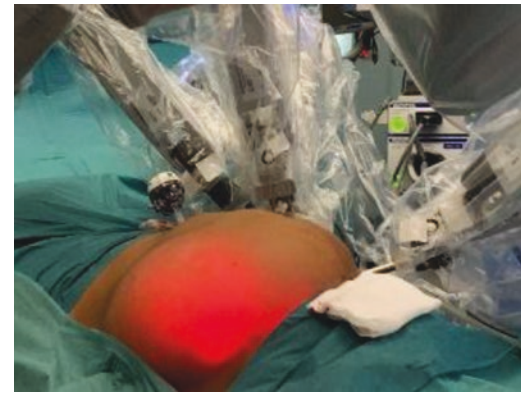

Fig. 5 Docked system

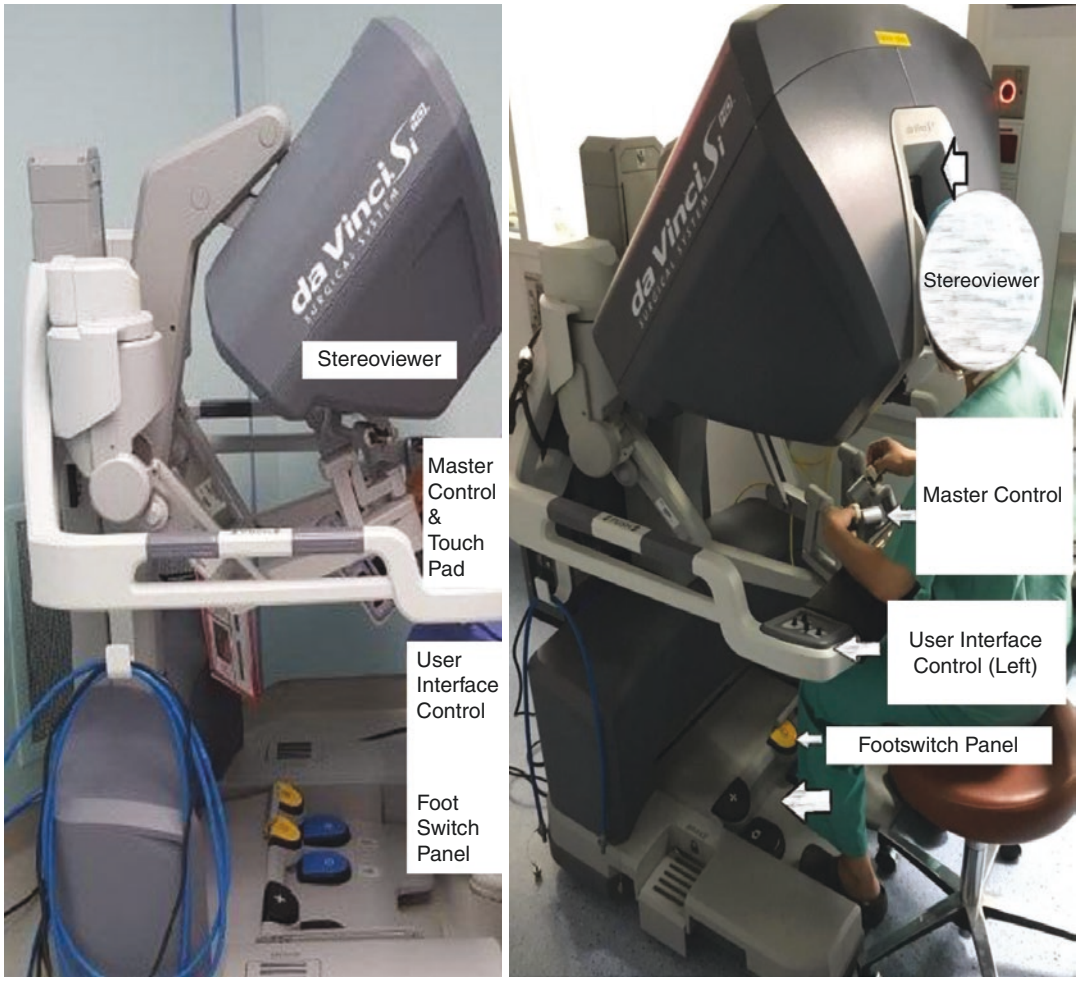

Fig. 6 Surgeon's Cart/Console and its various parts

Left Side

Left side of console bears the following buttons and controls

- Stop angle button
- Console height adjustment button
- Fault reset button

Right Side

- On/Off button
- Ready button
- Emergency stop button

Inserting/Changing Instruments

Always start by straightening the instrument tip and slide it to port to bring under vision. Push the instrument into surgical area by pressing the arm clutch button. If any resistance is felt during this manure, stop and check to identify the problem and address it accordingly. Surgeon should only proceed to drive once the LED light indicator is "ON" (Fig. 7).

Fig. 7 Control and Clutch with LED indicator ON to proceed

Instruments Removal

Instruments being removed should be straightened and jaws should be visualized. Before proceeding with instrument removal, make sure that no tissue is being held in the jaws of instruments. Simply press the release lever on instrument housing and take out the instruments.

System Shutdown

Once the surgery is completed, all the instruments are removed first same as laparoscopic surgery, followed by endoscope removal. Arms are disconnected from the trocars and patient cart is undocked from the patient. New system does not allow undocking by no activation of motor drive system until the instruments and camera are removed and undocked. 12 mm trocar incision or any other incision more than 12 mm should be considered for fascial closure. 8 mm or 5 mm trocar incision is not required to be closed. All sterilized drapes or clothes used should be removed and system can be switched off. If there is any subsequent case, it is better to keep the system on.

Conclusion

Limitations of conventional laparoscopy like 3D visualization and good ergonomics have been overcome by the use of technology of robots. Robotic surgery procedure has dramatically increased during the last decade. Complete understanding of instrumentation, knowledge of robotic system, and robotic program hinges on a proper OR is a mainstay for successful outcome. Well trained, enthusiastic, dynamic, and knowledgeable surgical team is a key for OR dynamics to provide excellent quality care to patients.

Acknowledgments Professor Davide Lomanto.
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