System Control Overview and Instruments

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Introduction

Science and technology have always been and will always be driving forces in the field of medicine. The evolution of surgery itself has been accelerated by advancements in technology as well. In our lifetime, we have seen the field of surgery grow from open to minimally invasive procedures. Within the last decade we have seen multiple advancements within the arena of minimally invasive surgery from standard laparoscopy to now robotic-assisted surgery. The catalyst for the development of these innovations has largely been to improve patient outcomes: improve recovery time, shorten hospital stays, decrease postoperative pain, decrease complications, etc.

With robotic surgery there have been additional benefits largely for the surgeon, including better visualization (3D), increased dexterity provided by wristed instruments, improved surgeon comfort, and improved ergonomics that may increase the surgeon's career. The advancements of robotic surgery in the field of minimally invasive surgery are not a revolution, but more of an evolution of the surgical techniques created by the founding surgeons of laparoscopy. Surgeons should use the robotic surgery tools to enhance their technique in order to provide patients with optimal outcomes. At the end of the day, the most important goal for a surgeon is to provide the technique that in their hands provides the best outcome they are capable of with the lowest risk for patient morbidity and mortality.

For more details on the Si and Xi platforms training modules at https://www.davincisurgerycommunity.com can be reviewed, login required.
All images were adapted from http://www.intuitivesurgical.com/products/instruments/with permission from Intuitive Surgical.

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da Vinci Systems

As discussed in the previous chapter, there are three iterations of the da Vinci system that have each seen incremental improvements. In this chapter, we will focus on the two newest and most commonly used versions, which are the Si and Xi systems. We will review the system components which include the Surgeon console, Patient cart, and vision cart (Fig. 16.1). We will also discuss the robotic instrumentation.

Surgeon Console

The surgeon console is the control center for the robotic platform. From the surgeon console, the surgeon can control the endoscope and instruments by using the hand controls and footswitch panel. All actions taken by the surgeon at the console are relayed to the vision system for processing and sent to the patient cart for implementation. The surgeon console is made up of several components that are similar on the two latest versions of the robotic system (Si/Xi): stereoviewer, master controllers, touchpad, and the footswitch panel (Fig. 16.2). One of the added benefits of the surgeon console is that it can be paired with a second console to allow two surgeons to work simultaneously on the same patient (Fig. 16.3). This feature can be used to collaborate with other surgeons, for proctoring, and for teaching.

The stereoviewer provides a high definition 3D view of the surgical field that can be magnified up to 10× (Fig. 16.2). The stereoviewer is ergonomically designed to support the surgeons head and neck during surgical procedures. Additionally, the stereoviewer displays messages and icons to the user about the system status.

The master controllers use fingertip controls that allow the surgeon to control the endowristed instruments and endoscope (Fig. 16.4). They are also designed with ergonomics in mind to optimize the comfort of the surgeon. The surgeon's

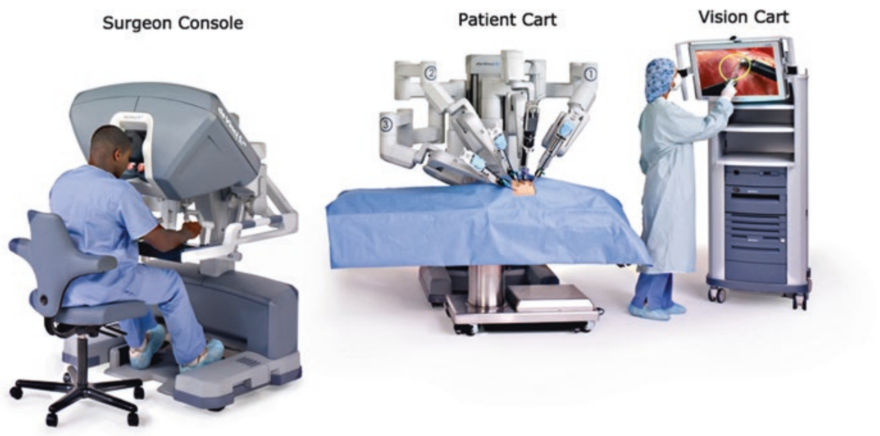

Fig. 16.1 Surgeon console, patient cart, and vision cart

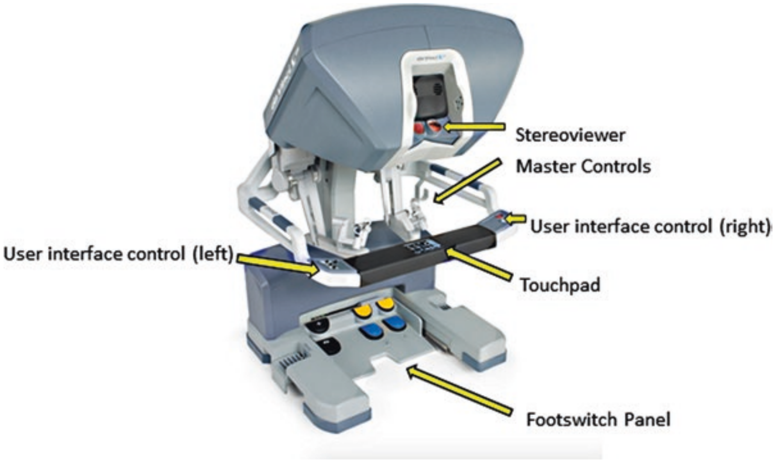

Fig. 16.2 Surgeon console—stereoviewer, master controls, touchpad, and footswitch panel

Fig. 16.3 Dual console

movements are instantaneously replicated at the patient cart while also filtering out potential hand tremors. With the addition of motion scaling the surgeon can fine tune the hand-to-instrument movement ratios to their choosing.

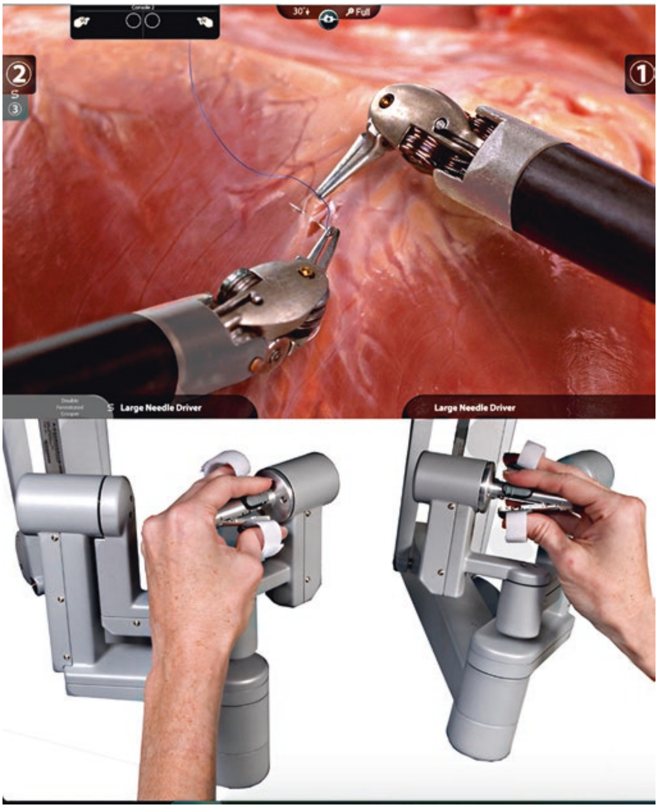

Fig. 16.4 Master controls

The user interface controls are housed in pods on the left and right side of the surgeon console arm rest (Fig. 16.2). The left sided pod contains the ergonomic control levers that allow the surgeon to adjust the height and tilt of the stereoviewer, adjust the armrest up or down, and move the footswitch panel in or out. The user's unique settings can be saved and when the user logs into the system they are automatically recalled. The right sided pod contains the power button and emergency stop button.

A touch pad is located in the center of the surgeon console armrest (Fig. 16.2). The touchpad can be used by the surgeon to save and access their own user preferences and ergonomic settings. Again, when the surgeon logs into the system their system preferences and ergonomic settings will automatically be recalled. After logging in, a home screen will appear that gives the surgeon access to surgeon console controls and settings. Along the bottom of the screen, there are tabs for accessing video, audio, and utility preferences. The video tab gives the surgeon the ability to adjust brightness, make advanced video adjustments, modify camera and endoscope setup, and access display preferences. The audio tab allows for volume adjustments and/or muting the surgeon console microphone. The utility tab allows entry into account management, inventory management, event logs, and control

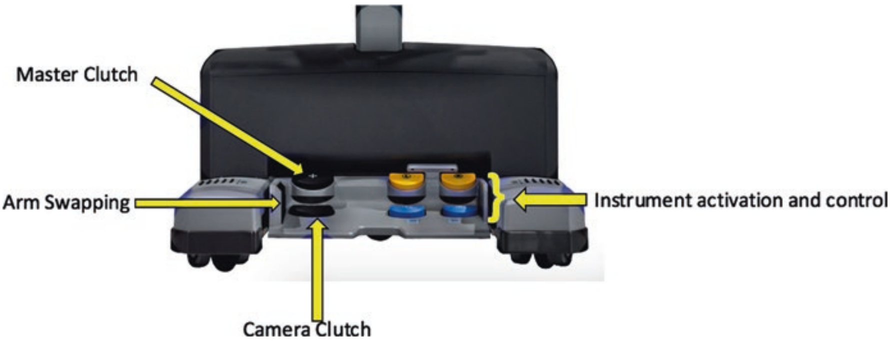

Fig. 16.5 Footswitch panel components

preferences; scaling, finger clutch, TilePro QuickClick, haptic zoom, master associations. There are also three quick settings buttons down the middle of the touchpad that contain settings for scope angle, zoom level in the stereoviewer, and motion scaling.

Lastly, the footswitch panel is used by the surgeon for robotic arm swapping, master clutching, cameral control, and instrument activation and control (Fig. 16.5). The left lateral pedal allows the user to swap control of the instrument arms so the user can control a different instrument arm with one of their master controllers. This is done by tapping the pedal with the side of your foot. The left upper pedal is a master clutch pedal and can be used to decouple the masters from the controls of the instruments which allows the user to relocate the masters for improved comfort. The left lower pedal is the camera clutch and allows the user to control the focus and position of the endoscope. The right sided foot pedals are used for instrument activation and control. For example, the right sided foot pedals can be used by the surgeon to activate the coagulation function of a vessel sealer as well as the cutting function when necessary.

Patient Cart Components

The patient cart is composed of several components. The setup joints position the robotic arms to optimize range of motion for the endowristed instruments and endoscope (Figs. 16.6 and 16.7). The instrument arms and the camera arm(s) on the Si and Xi systems interface with the robotic instruments and the camera assembly. The instrument and camera arms are draped for sterility and allow the surgeons and/or assistant to attach and adjust the robotic instruments and camera assembly at bedside. The instrument and camera arms also give the surgeon control over the robotic instruments and endoscope. The robotic arms use remote center technology, allowing the instruments and camera assembly to move around a fixed point in space. LEDs on top of the robotic arms provide feedback on the arm status to the surgeon/assistant.

The greatest difference between the Si and Xi systems lies with the patient cart (Figs. 16.6 and 16.7). One of the enhancements to the patient cart is the adjustable column and overhead boom. The boom is an adjustable support structure from

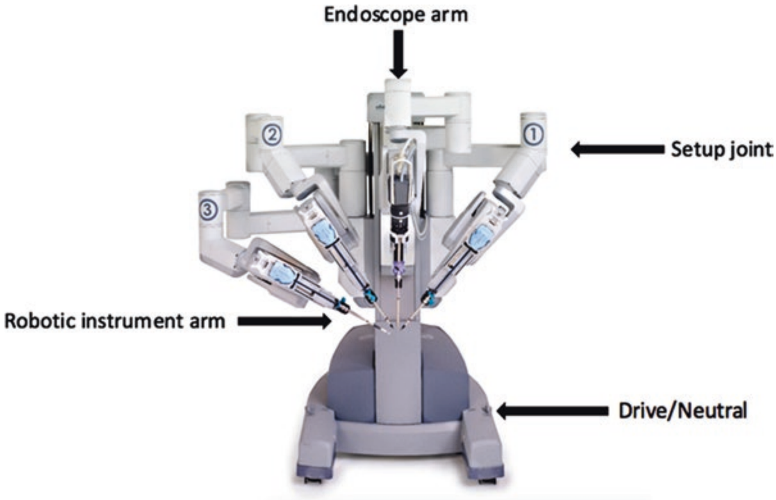

Fig. 16.6 Si patient cart

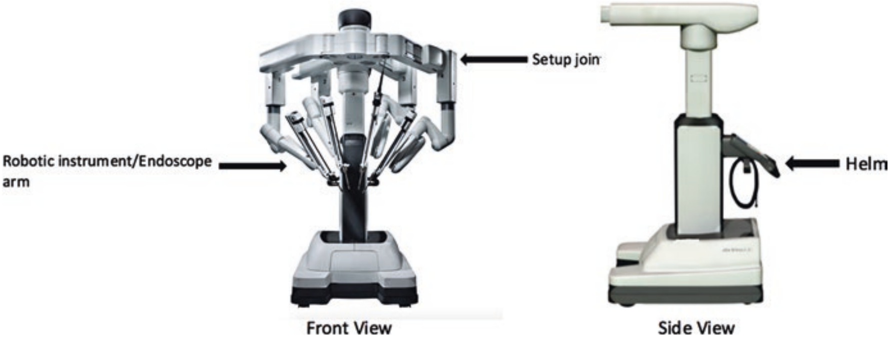

Fig. 16.7 Xi patient cart

which the robotic arms are now attached. The boom allows easier docking, extended range of motion, as well as more flexibility with patient positioning. The docking process has also been enhanced with the use of a laser pointing system that helps direct arm placement. The arms on the Xi system are also smaller, lighter, and now universal, meaning the instruments and endoscopes can be used interchangeably in any of the robotic arms. Additional upgrades to the endoscope have also been made. The endoscope no longer needs calibration, white balance, or draping.

There are several differences in the patient cart drive controls between the Si and Xi systems. First, we will discuss the Si system. The shift switches and motor drive control the movement of the patient cart. The shift switches allow the patient cart to be moved manually (N) or with a motor drive (D) (Fig. 16.6). Manual mode is for moving the patient cart long distances, for example, moving the cart from OR to OR. Motor drive is designed to provide faster and easier docking and quick OR reconfiguration. Drive (D) is also used to set the patient cart brakes. An unsterile OR staff member will drive the patient cart into the desired location for docking. The Xi system's patient cart is moved using the helm (Fig. 16.7). The helm has a touch screen that is used for guided setup. The assistant will select the target anatomy as well as the cart position. Next, the deploy for docking icon is selected. The boom will simultaneously raise, pivot, extend, and rotate into position and audio feedback will notify the staff that deployment is complete. Once deployed the staff member will drive the cart into position over the patient using the helm. A laser-guiding system assists in positioning of the patient cart.

Vision Cart Components

The Si system vision cart is composed of the CORE, illuminator, camera assembly, camera control unit, touch screen, and tank holder (Fig. 16.8). The endoscope provides a 3D, HD image of the surgical field. The video travels through the endoscope cable to the vision system. The vision system components process the video feed and send the feed to the touch screen monitor as well as the surgeon console 3D viewer. The CORE is the processing center for the robotic system. The system cables, auxiliary equipment, and AV connections are channeled through the CORE. The illuminator is the light source for the endoscope which is supplied via a single fiber optic cable. The front panel controls are used to power on the lamp as well as adjusting the light output. The camera assembly contains an integrated light guide cable for illuminating the surgical field and provides a 3D, HD view that can be magnified up to 10×. The camera control unit acquires and processes images from the camera assembly. A touch screen on the vision cart provides audio and

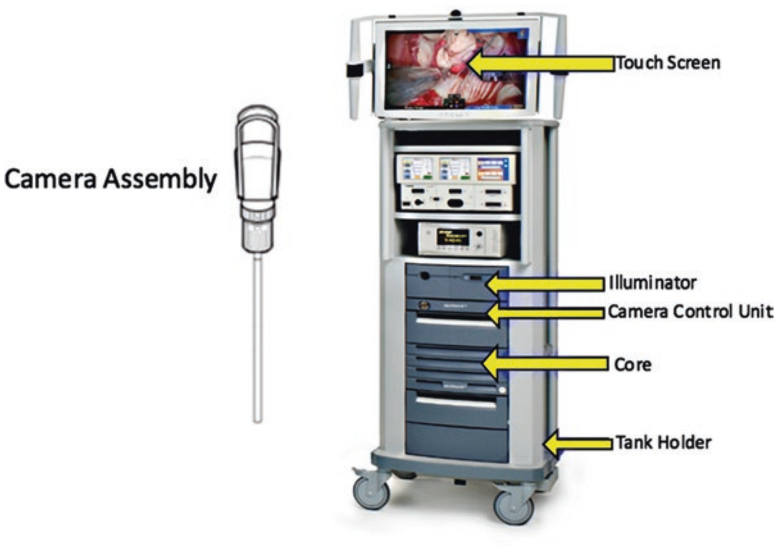

Fig. 16.8 Si vision cart

Fig. 16.9 Xi vision cart

video controls patient side. Additionally, the touch screen is capable of telestration which can be used to guide the surgeon during a case. Lastly, the tank holder is housed on the vision cart for storing insufflation tanks.

The Xi system vision cart is similarly to the Si systems, but there are a few differences. The Xi system vision cart is composed of system electronics (CORE), endoscope controller, video processor, camera assembly, touch screen, and tank holder (Fig. 16.9). The systems electronics (CORE) on the Xi system also processes all the information from each system component. The endoscope cable is connected to the endoscope controller, which provides the light source for illuminating the surgical field. It also contains the electronics for the initial processing of the endoscopic video. The video processor contains a USB port that allows the staff to capture images from a procedure onto a flash drive. The camera assembly for the Xi system has an integrated design and does not require draping, focusing, white balance, or calibration. The touch screen again provides a view of the surgical field at the patient side. The touch screen also gives the OR staff the ability to adjust audio, video, and system settings controls as well as telestration capabilities.

Robotic Endoscopes, Trocars, and Instruments

The robotic endoscope is a dual-channel laparoscope that generates a three-dimensional (3D) high definition image for the surgeon. The endoscopes come in 8.5 and 12 mm sizes as well as 0° and 30° angles. Additionally, da Vinci® now offers scopes with integrated fluorescence imaging, also known as Firefly, which can assist in identifying anatomy using near-infrared technology.

The abdominal cavity is accessed in the same fashion as laparoscopic surgery. Robotic reusable trocars are available from 5 to 13 mm sizes. The robotic endoscopes can be used with standard 12 mm laparoscopic ports or can be used with their respected robotic reusable trocars. The robotic instruments must be used with the robotic reusable trocar cannulas. Once the trocars are placed they can be docked with the patient cart. Once docked the endowristed instruments and endoscope can be inserted.

One of the greatest benefits afforded by the robotic surgery platform is the endowristed instruments. The endowristed instruments are designed to mimic the dexterity of the human wrist (Fig. 16.10). Most of the robotic instruments are designed with seven degrees of freedom (insertion, external pitch, external yaw, rotation, wristed pitch, wristed yaw, and grasp) and 90° of articulation which give the surgeon a tremendous range of motion. This is an advantage over standard laparoscopic instruments as it may lower the learning curve for surgeons performing complex minimally invasive tasks, and in some instances it allows the surgeon to perform tasks that may not be possible laparoscopically. The endowristed instruments provide the surgeons additional angles to approach dissections and to operate more precisely in confined spaces.

The robotic catalog of instruments is robust and has instrument offerings that parallel those in laparoscopy, offering tools for grasping, retracting, suturing, dissecting, dividing tissue, hemostasis, aspirating, clipping, as well as stapling. Some of the instruments can be paired with energy in order to perform electrosurgery, while the platform also offers its own vessel sealer. The most common sized instruments are 8 mm, but some of the robotic instruments come in 5 and 12 mm sizes as well. Unlike the majority of laparoscopic instruments, the robotic instruments do have a limited number of uses. The number of uses left on an instrument can be visualized at the surgeon console. Next, we will briefly review some of the more commonly utilized robotic instruments.

Fig. 16.10 Endowristed instrument

Fig. 16.11 Cadiere grasper

Fig. 16.12 Double fenestrated grasper

Fig. 16.13 ProGrasp™

The robotic platform has a variety of grasping forceps that are designed for various tissue types. The Cadiere (Fig. 16.11) and Double fenestrated graspers (Fig. 16.12) can be utilized for grasping finer tissue like peritoneum and bowel. For denser or more fibrous tissue, a ProGrasp™ (Fig. 16.13) can be utilized as it has more grip strength. A traumatic grasper such as the Cobra (Fig. 16.14) is designed with teeth at the tip of its jaws that can be utilized for securing thicker tissue or organs that one plans on excising, for example, retracting the fundus of an inflamed and/or distended gallbladder.

There is also a variety of instruments for suturing. Two examples are the Mega™ needle driver (Fig. 16.15) and Mega SutureCut™ (Fig. 16.16). The Mega™ needle driver is used solely for suturing, while the Mega SutureCut™ has built in scissors in the heel of the instrument so that I can be used for suturing and cutting. This dual ability instruments advantage is that it may decrease the number of instrument exchanges during cases.

Fig. 16.14 Cobra grasper

Fig. 16.15 Mega™ needle driver

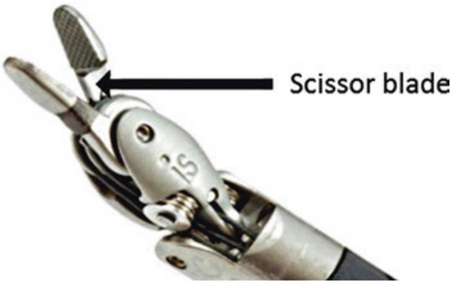

Fig. 16.16 Mega SutureCut™

For electrosurgery, there is an assortment of instruments that can be paired with energy. This includes monopolar instruments such as Hot Shears™ (Fig. 16.17) and the Permanent cautery hook (Fig. 16.18). Some examples of bipolar instruments are Maryland bipolar forceps (Fig. 16.19), PK® dissecting forceps (Fig. 16.20), Fenestrated bipolar forceps (Fig. 16.21), and the Vessel sealer (Fig. 16.22). For ultrasonic shears, the system also carries the Harmonic ACE® curved shears (Fig. 16.23).

Several specialty instruments also exist. Those most commonly used for general surgery procedures included the robotic suction/irrigator (Fig. 16.24) and clip appliers. The clip appliers come in small, medium-large, and large sizes. The small clip applier supports Weck HemoClip® small titanium clips (Fig. 16.25). The medium-large (Fig. 16.26) and large (Fig. 16.27) clip appliers utilize Weck Hem-o-lock medium-large and large polymer clips, respectively.

Fig. 16.17 Hot Shears™

Fig. 16.18 Permanent cautery hook

Fig. 16.19 Maryland bipolar forceps

Fig. 16.20 PK® dissecting forceps

Fig. 16.21 Fenestrated bipolar forceps

Fig. 16.22 Vessel sealer

Fig. 16.23 Harmonic ACE® curved shears

Fig. 16.24 Suction/irrigator

Fig. 16.25 Small clip applier

Fig. 16.26 Medium-large clip applier

Fig. 16.27 Large clip applier