

CHAPTER

3

System Components

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The da vinci Surgical System is a sophisticated robotic platform designed to enable complex surgery in a minimally invasive approach. It consists of three main components (Fig. 1):

1. Surgeon Console
2. Patient Cart, which holds the endowrist robotic instruments
3. Vision Cart



Fig. 1: Components of robotic system



Fig. 2: Surgeon Console

SURGEON CONSOLE

This is the place where the surgeon sits comfortably and via hand manipulators controls the EndoWrist Instruments movements at the surgical site. . The Surgeon Console (Figure 2) operator sits outside of the sterile field and controls instruments and a 3D endoscope with his/her hands, using two master controllers and with his/her feet, using foot pedals. It is also considered the control unit for the rest of the parts.

The console is provided by a "Stereo Viewer" that translates the image of the surgical site acquired by the endoscope and displays it in front of the surgeon's eyes (surgical immersion). Instrument tips appear to align with the surgeon's hands at the master controllers as seen in the stereo viewer. This design simulates the natural eye-, hand- and instrument-alignment of open surgery. Natural alignment, in turn, helps to optimize hand- eye coordination. This means that the robotic platform allows the surgeon to be as dexterous as in open surgery while operating in a minimally invasive environment. Further control is provided by motion scaling and tremor reduction, which minimizes the impact of natural hand tremor or inadvertent movement. The Surgeon Console operator also has the option to change the view from full screen mode to a multi-image mode (TilePro Display), which displays the 3D image of the operative field along with up to two additional images provided by auxiliary inputs. This helps in simultaneously view the radiological imaging during the surgery in the same screen.

Surgeon console has the following components:

1. Master Controllers
2. Stereo Viewer
3. Left and Right side Pods
4. Footswitch Panel



Fig. 3: Master Controllers

Master Controllers

The master controllers (Fig. 3) are provided for the surgeon to control the instruments and endoscope inside the patient. These are designed to allow natural range of motion, dexterity and to provide ergonomic comfort, which help the surgeon to continue long procedures without fatigue.

To use the master controllers, the Surgeon Console operator grasps each Controller with his/her index finger and thumb. The endowrist Instruments are activated by bringing his/her index finger and thumb together or apart; he/she maneuvers the instruments and endoscope inside the patient by moving his/her hands and/or arms. The precise replication of these movements at the patient cart virtually extends the operator's hands into the surgical field.

Stereo Viewer

The stereo viewer (Fig. 4) provides the video image for the Surgeon Console operator. The ergonomically designed stereo viewer's view port provides support to the head and neck of the surgeon for added comfort during long procedures. A 3D video image is displayed by the stereo viewer's integrated left and right video channels when the endoscope is activated. It virtually immerses the operator into the surgical field. The view port also displays messages and icons which convey various information regarding instruments and procedure to the surgeon.

Left and Right Side Pods

The left-side and right-side Pods (Fig. 5 & 6) are located on either side of the surgeon console armrest. The pods provide user interface functions for system configuration.



Fig. 4: Stereo Viewer



Fig. 5: Left side pod



Fig. 6: Right side pod

Footswitch Panel

The footswitch panel (Figure 7) is located on the floor directly beneath the Surgeon Console operator. It provides the user interface for instrument arm repositioning, camera and focus control, and energy use during surgery.

PATIENT CART

The Patient Cart (Figure 8) is the operative component of the da Vinci System. It is the slave unit of the system and functions to support the instrument arms and camera arm.



Fig. 7: Footswitch panel



Fig. 8: Patient Cart

Remote center technology is used in the robotic system. The remote center is a fixed point in space around which the patient cart arms move. Remote center technology enables the System to maneuver instruments and endoscopes in the surgical site while exerting minimal force on the patient's body wall.

The assistant surgeon operates the patient cart, exchanges instruments and endoscopes, and performs other patient-side activities. The patient cart operator can view the operative site using an optional touchscreen monitor. To help ensure patient-safety, the actions of the assistant surgeon operating the patient cart take precedence over actions of the Surgeon Console operator.

This section provides overviews for the following Patient Cart Components:

- Setup Joints
- Instrument Arms
- Camera Arm
- Touchscreen Monitor
- Motor Drive
- Endowrist robotic instruments

Setup Joints

Setup joints (Figure 9) are used to position the Patient Cart arms in order to establish the remote center in the surgical field. Design of setup joints with limited freedom of movement is such so as to facilitate port placement.

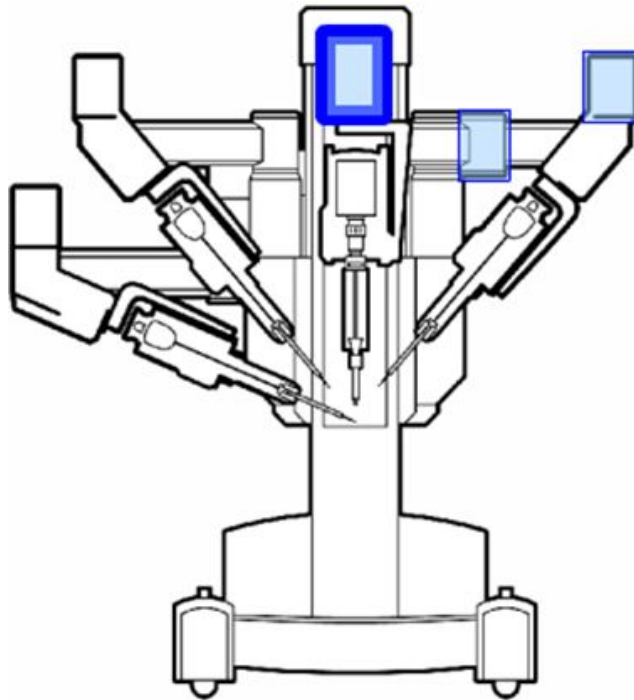


Fig. 9: Line diagram highlighting setup joints



Fig. 10: Example of instrument arms with attached instruments

Instrument Arms

Instrument arms (Figure 10) provide the support and sterile interface for the endowrist instruments. Initially, the assistant surgeon positions the instrument arms in a neutral position before the procedure begins. The Surgeon Console operator moves the instrument arms using the master controllers.

A telescoping insertion axis is designed to minimize collisions and allow the patient cart operator to reposition the instrument arms with one hand. The wide range of motion of instrument arms is intended to help simplify port setup and provide greater reach into the patient anatomy. The instrument arm remote center is indicated by the thick, center black band on the instrument cannula. The location of the instrument arm remote center is intended both to minimize port-arm site trauma to the patient and to minimize stress exerted on the EndoWrist Instruments during surgery. After docking, the instrument arm remote center should be located just above the patient's anatomy, in line with the port site. The instrument arm remote center can not be moved by the Surgeon Console operator. However, the Patient Cart operator can reposition the remote center by depressing the instrument arm clutch button and repositioning the instrument arm. There are LEDs at the top of the three instrument arms which provide feedback on the status of each arm.

Camera Arm

The 3D endoscope is attached and supported by the camera arm using a sterile interface (Fig. 11). The Patient Cart operator initially positions the camera arm in a neutral position before the procedure begins. The Surgeon Console operator moves the camera arm using the Master Controls. The camera arm remote center is located near the tip of the camera cannula. There is an LED at the top of the camera arm to provide feedback on the status of the arm.

Patient Cart Touchscreen (Optional)

The optional patient cart touchscreen monitor (Figure 12) is mounted on the same setup joint as the camera arm to allow for optimal viewing. The touchscreen's integrated intercom system consists of speakers on the backside of the monitor and a microphone on top. It is designed to facilitate intraoperative communication with the chief surgeon.

The touchscreen also provides a control interface for selecting the video source, telestration and patient side scope configuration features.

Motor Drive

A motorized drive (Figure 13) is designed to provide faster and easier docking of the patient cart and help in OR re-configuration. The motor drive includes a steering column, throttle, throttle- enable switch and shift switches.



Fig. 11: Example of a Camera Arm with Attached Endoscope



Fig. 12: Patient cart touchscreen



Fig. 13: Motor Drive

ENDOWRIST INSTRUMENTS

In the robotic surgical system, the tips of the instruments are designed to mimic the dexterity of the human hand and wrist. It allows seven degrees of freedom and 90 degrees of articulation even though it cannot be exactly similar with the dexterity of the human hand (Fig. 14 A & B). This is a very different

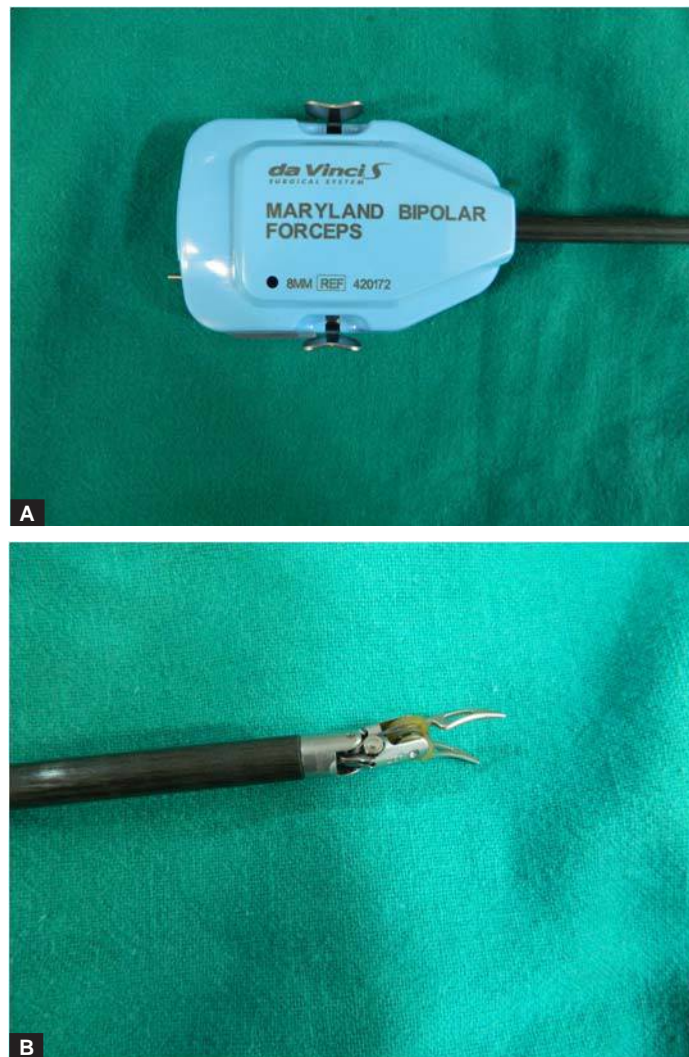


Fig. 14A and B: Endowrist instruments

technology compared with conventional laparoscopic instruments which have five degrees of freedom and is called an endowrist function. This allows for greater precision when operating in a minimally invasive environment. These instruments help in the most rapid and most precise suturing, dissection and tissue manipulation available with any surgical platform.

Endowrist instruments are multi-use instruments available in 8mm and 5mm diameters.

VISION CART

Vision Cart (Figure 15) houses the image processing equipments of the system. It is operated by a non sterile assistant during surgery. It also provides for an optional touchscreen monitor and ancillary surgical equipment.



Fig. 15: Vision Cart

There are two types of vision systems available with the da Vinci System: The Standard Definition (SD) vision System and a High Definition (HD) vision System. The vision cart consists of the following components:

- Illuminator
- Endoscopes
- Stereo Camera Head
- Camera Control Units (CCUs)
- Vision Cart Touchscreen
- Intercom System
- Isolation Transformer and Power Strip
- Tank Holders

Illuminator

Lighting is provided by the illuminator (Figure 16). From the illuminator, light is delivered to the endoscope via a fiber-optic bifurcated light guided cable and projected onto the surgical site.



Fig. 16: Illuminator

Endoscopes

Two endoscope sizes are available with the da Vinci Surgical System:

- 12mm 3D endoscope (straight or angled)
- 5mm 2D endoscope.

Light from the illuminator is sent down the shaft of the endoscope (Figure 17) via fiber optic cables and then projected onto the surgical site. Fogging is minimized at the endoscope lens because of heat from the fiber optic cables helps. The video image of the surgical site captured by the endoscope is sent back through the left and right channels to the camera head. The camera head connects to the left and right CCUs, as well as the focus controller.



Fig. 17A: Example of 12mm 3D (30° and 0°) endoscopes



Fig. 17B: Tips of 12mm 3D (30° and 0°) endoscopes

Stereo Camera Head

The High Definition and Standard Vision Systems each use a specific stereo camera head (Figure 18). The HD camera is designed with a 60-degree field of view (FOV) while the standard camera head is available in both a 60 degree FOV (wide-angle) and 45 degree FOV (high mag). When combined with stereo endoscopes, the vision system provides an average of 6-10 x magnification of the surgical field. For example in a mitral valve repair procedure, the surgical view is magnified 6-10 times greater than what is seen during open surgery without loops.



Fig. 18: Stereo camera head



Fig. 19: Right and left Camera Control Units located in the Vision Cart

CCUs (Camera Control Units)

Similar to the stereo camera head, there is both a Standard and a High Definition version of the CCU (Fig. 19). The CCUs act as the central processing unit for the camera and are connected to the camera by a cable. The CCU controls the acquisition and processing of the image from the camera and provides outputs for different types of video signal (S-video, Composite, HD-SDI).

Vision Cart Touchscreen

The Vision Cart Touchscreen (Figure 20) has the same functionality as the Patient Cart Touchscreen, with exception of the intercom system.

Focus Controller

The Focus Controller (Figure 21) is designed to adjust the endoscope lens focus to sharpen the surgical image by the assistant. The Surgeon Console operator may also adjust the focus by use of the Footswitch Panel.

Intercom System

The Intercom System (Figure 22) is designed to facilitate audio communication between the Surgeon Console and Patient Cart operators. Speakers and microphones are located on both the Surgeon Console and either the Patient Cart Touchscreen or the Vision Cart.



Fig. 20: Vision cart touchscreen

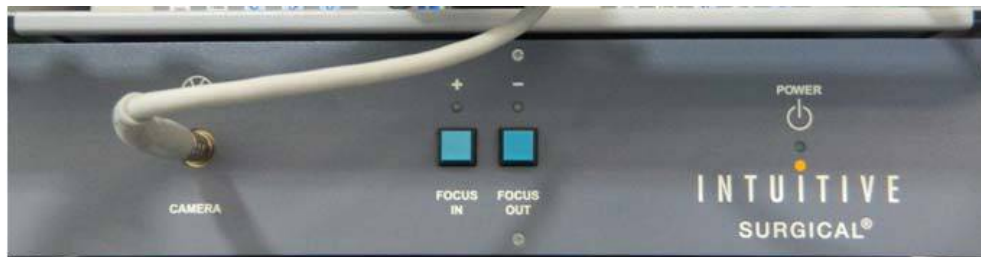


Fig. 21: Focus controller



Fig. 22: Audio intercom system on top of vision cart



Fig. 23: Power Strip



Fig. 24: Tank Holders

Isolation Transformer and Power Strip

The isolation transformer and power strip (Figure 23) allow the Vision Cart to power non medical grade equipment as well as auxiliary OR equipment (e.g. insufflator or medical grade video recorder). Do not exceed maximum power on the unused outlets. 100 VA maximum power is available from unused receptacles on the isolation transformer and 400 VA maximum power is available from unused receptacles on the power strip.

Tank Holders

Tank holders (Figure 24) are provided on the Vision Cart to support the use of an insufflator.