Introduction to laparoscopy

Know your laparoscopy stack

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Introduction

Laparoscopic stack is the instrument cluster used to perform laparoscopic surgeries.

The laparoscopic stack is the heart and brain of all laparoscopic surgeries[1]. The perfect synchronization and compatibility of its components is essential to deliver the optimum functionality. Each component of the stack is inter-connected to each other as well as to a multitude of accessories for versatility. For example, smoke production during diathermy will automatically activate smoke evacuation via the insufflator.

Having a thorough knowledge of each of the components in the stack enables the operator to optimize the surgical performance as well as troubleshoot effectively[2]. Appropriate instrument procurement plays a major role in establishing a fully functional operating theatre. In-depth knowledge of the instruments in the stack will facilitate this process.

Components

The main components of the laparoscopy stack are as follows (Figure 1).

1. Monitor
2. Insufflator
3. Electro-surgical generator
4. Video processor
5. Cold light source

The laparoscopic stack is arranged in such a way that the surgeon has a clear view of the display screens. The most important displays during the surgery are the insufflator and the electrosurgical generator, which should be in full view as dynamic changes in the parameters are important for patient safety. (Figure 1)

An integrated laparoscopic cart is a value addition which will contribute towards the preservation of these expensive components during use and mobility.

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Figure 1. **Laparoscopic stack including instrument cart, HD monitor, camera head, video processor, light source, insufflator, electro-surgical generator.**

Monitor

Monitor displays the video signal received from a processor.

Resolution of the monitor denotes the number of pixels [smallest individual areas of a screen which displays colours] along horizontal and vertical axes respectively. Eg – 1920 × 1200 px where there are 1920 columns and 1200 rows [lines] of pixels.

For laparoscopy, usually monitors higher than 1920 × 1200 pixels of resolution are used[3].

Refresh rate denotes the number of times an image is displayed on the monitor per second. It is better when the screen refresh rate is more than 24 Hz as the human eye perceives it as one. Therefore, as the frequency increases the blinking effect of the image decreases.

There are two different methods of refreshing the screen, namely progressive and interlaced scan. In progressive scan, the entire array of pixels is refreshed sequentially per each refresh whereas in interlaced scan, every other array is refreshed where half of the image that should be displayed is drawn on the screen per each scan. Interlaced scanning is inferior to progressive due to non-precise line overlapping producing an artifact named "combing".

Colour depth is a measurement of the total number of colors a monitor can reproduce. Each bit can represent two colour gradients. 1 bit represents 2 colour gradients and 2 bit represents 4 colour gradients. In this manner, considering sub-pixels which can show red, green or blue basic colours, 8 bit screen means 16.8 million colours, 0% illumination of all the three sub-pixels of a pixel will show black where as 100% illumination of all the three sub-pixels will show white.

3D laparoscopy

In 2D laparoscopy the depth is perceived by the brain using depth cues[4] (List 1).

List 1: Depth cues for 3D laparoscopic view
1. Shadows cast by illumination
2. Relative size of organs
3. Clarity of each object (where closer objects are clearer)
4. Knowledge of anatomy
5. Previous experience with laparoscopy

In 3D laparoscopy, two camera units simultaneously record images similar to binocular vision. These two feeds are projected by a single monitor viewed with 3D glasses. There are two types of 3D glasses; In active 3D glasses, a shutter mechanism alternatively shuts each eye rapidly whereas in passive 3D glasses, the monitor shows two overlapping feeds with two different polarizations where the lenses of the glass will only allow one feed intended for each eye[5].

Insufflator

The laparoscopic surgical field is created by the pneumoperitoneum. An insufflator pumps gas into the peritoneal cavity to achieve this. The pneumoperitoneum enables a clearer vision, wider surgical field, helps magnification and opens up dissection planes[6].

Most insufflators have the following in-built components (Table 1).

Table 1. Components of insufflator

Component	Description
Pinch valve	Automatically releases gas from the pneumoperitoneum to negate the excessive pressure.
Gas outlet	Pumps out pre-heated CO_2 from the insufflator via a bacterial filter.
Gas supply indicator	Monitors the pressure of the CO_2 source (gas cylinder)
Intra-abdominal pressure indicator	Indicates the intra-abdominal pressure
Gas flow rate indicator	Indicates the flow rate of CO_2 (L/min)
Gas flow rate modes	Three gas flow rate modes are shown as low, medium and high • Low - 0.1 to 1.0 L/min • Medium - 1.1 to 19 L/min • High -19.1 to 35 L/min
Volume indicator	Indicates the total amount of CO_2 used
Warning panel	Alerts for excessive intra-abdominal pressure
Foot switch terminal	connects the foot switch to manually activate smoke evacuation
Electrosurgical unit terminal	Connects the electrosurgical unit to the insufflator for automatic evacuation of smoke

CO_2 is the commonest gas used in laparoscopy because of its special properties[7] (List 2).

List 2: Special properties of CO_2 gas

1. Inert gas
2. Natural metabolic end product
3. Dissolves in blood readily and has a high diffusion co-efficient
4. Low risk of air embolism
5. Commercially available
6. Cheap

Electrosurgical generator

Electrosurgical generator creates monopolar and bipolar diathermy energy to be used with various electro-surgical instruments. The details of electro surgical devices will be discussed in another article.

Video processor

Video processor converts the electronic data captured by the image sensor of the camera unit to a real-time video signal for viewing. High definition (HD) processors will produce the best quality images when used with HD monitors.

The processor and the light source are interconnected to automatically control the brightness as necessary as determined by the processor.

Processor has various output ports to record or view the processed video eg. DVI, SDI, Y/C and USB (Figure 2). In addition, the processor itself can be used for compiling and printing reports when connected to a keyboard[8].

The components and the main functions of the video processor are given in[9] Table 2.

Cold light source and cable

The cold light source illuminates the peritoneal cavity during the laparoscopic procedure. A light source has to produce, condense and focus the light, having the ability to control the brightness while dissipating the heat produced.

A light source produces light by electric lamps which could either be Halogen, Metal Halide, Xenon or LED. LED has the best colour temperature (1700k-6000k) and the best lifespan (100000 hours). It is common to use a second Halogen light as a spare lamp in case the main lamp burns out[9].

Components of the light source are given in Table 3.

Light is transmitted from the light source to the telescope by a light guide cable. Light guide cables are of two types; fiber optic and fluid light cables. Fiber optic light cables are commonly used as they are easy to handle, light-weight, flexible and autoclavable. The main disadvantage is breakage of the fibers with time, reducing clarity.

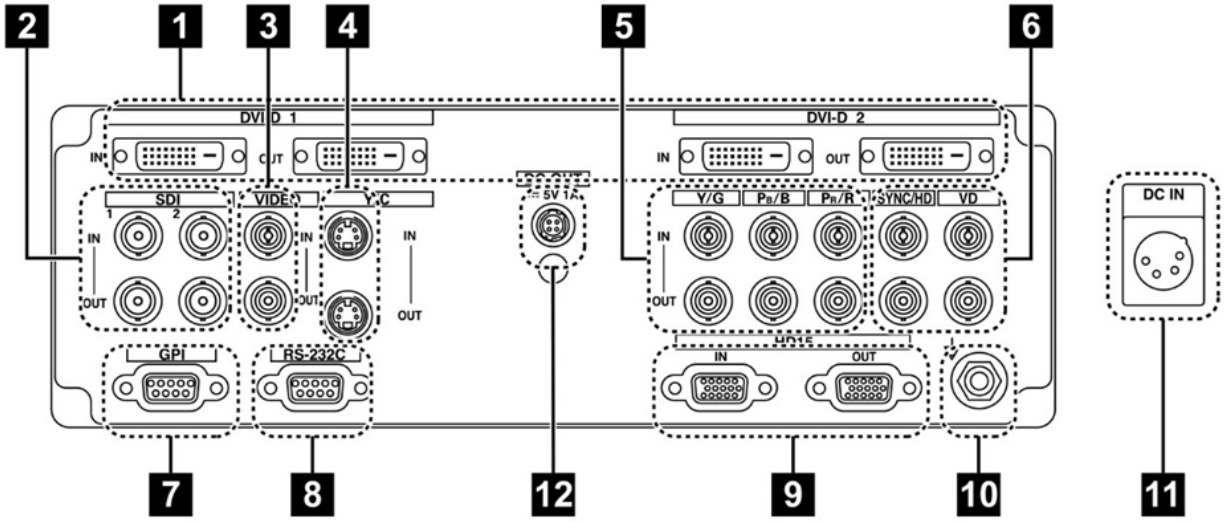

Figure 2. **Video processor – rear view.**

1 – DVI [Digital Visual Interface] terminals

2 – SDI [Serial Digital Interface] terminals

3 – Video terminals

4 – Y/C [Separate Video] terminals

5 – RGB [Red, Green, Blue] terminals

6 – SYNC/HD, VD terminals

Table 2. Components of video processor

Component	Description
White balance button	Adjusts the colour casts displayed in the monitor, so as to render images which are closer to natural colours
DVI, SDI, Y/C output ports	Transmits data from the processor to monitor or recording devices
Port for portable memory medium	For recording still images taken during the procedure
Port for foot pedal switch	For giving the command to capture still images

Table 3. Components of the light source

Component	Description
Output socket	Connects the light guide cable to the light source
Lamp indicators	Indicates whether the lamp is on or off
Brightness intensity indicator	Indicates the operating brightness of the lamp
Manual brightness adjustment buttons	Controls the brightness level manually
Lamp usage indicator	Indicates how many hours the lamp has been used.

Conclusion

A proper understanding of the components constituting the laparoscopic stack will enable the surgeon to perform surgery efficiently and safely.

An article on electrosurgery in laparoscopy will follow this article.

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