



## Ergonomic Challenges during Laparoscopy

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Citation: Prabhal Lal, Suchitra N, Richa A, Renuka B (2017) Ergonomic Challenges during Laparoscopy. J Gynecol Neonatal 2(1): 101

Received: June 19, 2017; Published: October 11, 2017

### Abstract

Ergonomics is “the scientific study of people at work, in terms of equipment design, workplace layout, the working environment, safety, productivity and training”. Laparoscopy is recent advancement in surgery that requires no measure incisions in the patient, allows for quicker healing, reduced post-operative pain and reduced wound complications such as hernia formation and infections. Ergonomic integration and suitable laparoscopic operating room environment are essential to improve efficiency, safety, and comfort for the operating surgeon team. Understanding ergonomics is important because it makes life of the surgeon comfortable in the operating room and reduces physical strains on the surgeon.

The purpose of this paper is to review the occupational ergonomic issues and there solutions in the laparoscopic operating room environment.

**Keywords:** Challenges; Ergonomics; Laparoscopy; Operating Room; Surgeon

### Introduction

The term ergonomics id derived from the Greek word “ergon” meaning work and “nomos” meaning natural laws or arrangement. Ergonomics is “the scientific study of people at work, in terms of equipment design, workplace layout, the working environment, safety, productivity and training”. In simple words, ergonomics is the science of fitting the work environment to the worker. A fundamental principle of ergonomics is to design the work area and the task around the human body, rather than force the worker to adapt to poor design and task function. Ergonomics is an applied science concerned with designing products and procedures for maximum efficiency and safety. It is concerned with the “fit” between pupil and their work, it takes into account the workers capabilities and limitations in seeking to ensure that tasks, equipment, information and the environment suit each worker.

Laparoscopy is a relatively recent advancement in surgery that requires no measure incisions in the patient, allows for quicker healing, reduced post-operative pain and reduced wound complications such as hernia formation and infections. These benefits have made laparoscopy very popular to patients. However laparoscopy requires more effort from the surgeon than traditional open procedures. In 2010 survey Dr Park et al found that 86.9 % of the laparoscopic surgeons had physical discomfort and symptoms attributable to laparoscopy [1]. Laparoscopic techniques require greater concentration and plays greater mental stress on surgeons than open surgery [2]. Laparoscopic surgery requires surgeons to perform complex operative procedures using a standardized set of tools. The surgeon performs the operation with surgical tools and video cameras that are inserted into the patient through port sides. Surgical tools used in laparoscopic surgery are still being developed and many have been adapted from conventional surgical tools by adding a long (45-52 cm) stylus to fit through the trocar, putting the handle at the right angle to the long axis of the tool. The increased technological complexity and sometimes poorly adapted equipment have led to increase complain of surgeon fatigue and discomfort during laparoscopy surgery. The importance of ergonomics in the setting of laparoscopy cannot be overemphasized. Ergonomic integration and suitable laparoscopic operating room environment are essential to improve efficiency, safety, and comfort for the operating surgeon team. Understanding ergonomics cannot only make life of the surgeon comfortable in the operating room but reduce physical strains on the surgeon.

The purpose of this paper is to review the occupational ergonomic issues and their solutions in the laparoscopic operating room environment.

## Surgeon's Sensorial Ergonomic Challenges

In open surgery, we look at and touch the patient's directly using our hands or relatively simple instruments in this situation, our senses of vision, touch, position are working under normal conditions and with the large performance reserved so that standard surgical instruments all though perfect serve us well. During laparoscopy surgery, the situation is very different open surgery has high degree of freedom as surgeons work in line with visual axis. There is three dimensional direct vision and direct tactile feedback. While during laparoscopy surgery there is two dimensional direct vision and loss of depth perception to some extent. There are only 4 degrees of freedom of movement (rotation, up /down angulation, in/out movement, left/ right angulation). The major limitation is that view is not under control of the surgeon. The major factor unrelated to the skills which affect the efficiency of the surgeon is the decompiling of the visual and motor axis. There is also the loss tactile feedback owing to substitution of the instruments for the surgeon's hands. One of the most significant cognitive challenges for the general surgeon is his transformation into a laparoscopic surgeon is to overcome the spatial separation of the axis of vision and the axis of the physical aspect of the procedure. The surgeon does not get a chance to directly look at the instrument or his hands and also at the field of surgery at the same time. He has to learn to adapt to the difficulty of combining the two functions into the same channeled approach in order to dexterously manipulate the tissues without direct contact.

## Surgeon's Physical Ergonomic Challenges

Although back posture tends to be straighter in laparoscopic surgery, more than 15% of surgeons still report frequent back pain stiffness following laparoscopic operations [3]. These symptoms are likely due to adoption of a more static posture which is the result of increased concentration and the frequent need to look in one direction in one direction at the monitor while manipulating instruments or foot paddles in another direction [4]. The static posture assumed by the surgeon during laparoscopic procedures leads to build up of lactic acid and toxins in muscles and tendons leading to musculoskeletal pain [4].

The goal of proper posture is comfort, efficiency of movement and minimization of the risk of musculoskeletal injuries to the operator. The surgeon's neck and back should be maintained in a comfortable and upright position facing forward. During laparoscopic surgery, the ability to achieve this ideal posture is determined by the following variables:

- Height of the operating room table
- Position of the visual display ( monitor)
- Foot paddle locations
- Selection of hand instruments

## Operating Table Height

The proper adjustment of the operating table height is very important in laparoscopic surgery. Ergonomically the angle between the lower and the upper arm should be between 90° and 120° when performing manual work [5,6]. The table height should be adjusted so that laparoscopic instrument handles after insertion are roughly at, or slightly below the level of the surgeon's elbow. An operating table too wide promotes abduction of the trunk to reach the patient and can cause pain in the surgeon's neck, back and lower extremities. Operating table with clamps on the side to affix the accessories can obstruct surgeon from standing in a desired position. The sides of the operating table should be padded with a foam support to prevent bruising tissues when leaned against.

## Foot Pedals

Foot pedals are commonly used during laparoscopic surgery to activate instruments such as cautery, ultrasonic shears, bipolar device, or other tissue welding, dividing instruments. Foot pedals may cause several physical ergonomic concerns like discomfort in the legs and feet while the surgeon keeps the operating foot dorsiflexed over the pedals and loads the body weight on the other foot to prevent losing contact with the pedal. In addition, foot pedals restrict the surgeon from moving around and promote static body posture. Foot pedals which are often poorly positioned, demand awkward and unnatural postures and should be avoided in favor of hand controls when possible. Pedal should be placed near the foot and aligned in the same direction as the instruments thus permitting the surgeon to activate the pedal without twisting their body or leg. A pedal with built-in foot rest is preferable so the surgeon does not have to hold their foot in the air or move it back and forth on the floor.

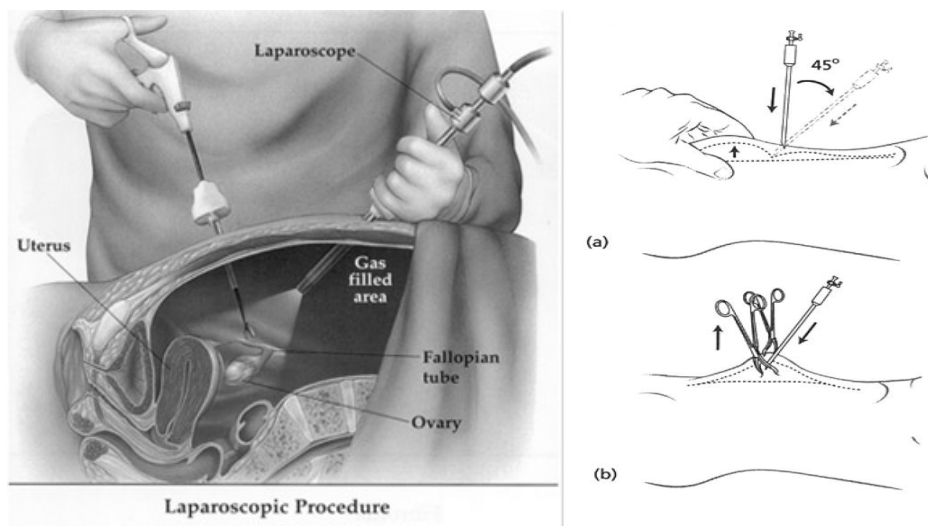
## Position of the Monitor

Since the surgeon views in the surgical field through a visual display for long durations during laparoscopic surgery, the position of the video monitor affects neck and back posture. The display should be placed directly in front of the surgeon,  $15^{\circ}$  to  $40^{\circ}$  below eye level for maximum comfort [7,8]. Video display devices that are mounted on flexible booms allow the surgeon to alter the vertical position of the monitor to obtain idle angle between eye level and the monitor. Flat screen high definition television with higher brightness and detailed picture can improve the visual quality.

## Hand-held Instruments

Surgeons experience discomfort in the arms and hands due to using surgical instruments and forceful exertions and repetitive upper limb movements [9]. A common musculoskeletal disorder called laparoscopist's thumb occurs in surgeons when the nerves of the thumb are damaged in performing laparoscopy.

Laparoscopic instruments are lengthy because they must reach inside the inflated but closed abdomen. Unlike open surgery, the surgeon works at considerable distance from the target organ. The instruments are passed through narrow ports that are in fixed positions. Various attributes of the laparoscopic instruments account for their handling characteristics including decreased mechanical efficiency, increased length, movement about a fulcrum on the body wall (port) and design of the handler. The surgeon needs to squeeze harder bend the wrist more and hold there are arms higher than using laparoscopic instruments compare to open instruments leading to substantial hand shoulder fatigue and discomfort during laparoscopic surgery [3].



Performing laparoscopic surgery requires the proper placement of the access ports and efficient use of instruments to accomplish tissue dissection, division, sealing and re-approximation. Current hand held laparoscopic instruments offers only  $4^{\circ}$  of freedom of movement which coupled with the fixed entry positions significantly limit the surgeons ability to achieve to optimal instrument positioning for each part of the laparoscopic operations [10]. The large instruments are problem for surgeons with small hands and can lead to chronic paresthesias [11]. A manipulation angle range of  $45^{\circ}$  to  $75^{\circ}$  with equal azimuth is recommended [12]. Ideally same elevation angles for each of the instruments held should be maintained [13].

Instrument should be inserted such that half of the instrument inside the patient. If the instrument is utilized while inserted less than half of its length, excessive motion at the shoulder will be required leading to surgeons fatigue [13]. A typical laparoscopic grasper transmit the force of the surgeons hand from the handle to the tip with the ratio of only 1:3 as compared to 3:1 with the hand-held hemostack [14]. This means that the surgeon must work about six times as hard to accomplish the same grasping task with the laparoscopic instrument [15].

Laparoscopic needle drivers and forceps should incorporate a locking mechanism to hold needle, thus obviating the need for the constant application of force by surgeon. Palming an instrument can reduce amount of wrist flexion and increase the surgeon's power when grasping tissues for a long period of time or when especially forceful grip is required. The pistol grip allows the hand to remain at an angle to the instrument shaft and can lessen the ulnar deviation needed to use the axial handles. Laparoscopic suturing is generally best performed with axial instruments

because they allow the surgeon to firmly grasp the needle holder and facilitate rotation of the instrument with simple wrist motions.

## Surgeon's Cognitive Ergonomic Challenges

Laparoscopic surgeons encounter unique cognitive ergonomic challenges due to reduced access to the patients, fewer degrees of freedom in their interventions and lack of direct visualization of surgical field [9].

### Dark room

The operating room lights are often turned off during laparoscopic surgery increasing the risk of choosing the wrong instruments and of collision hazards.

### More clutter

Laparoscopic operations substantially increase the amount of equipment and the number of tubes and cables in the operating room decreasing the efficiency of instrument handling, positioning and exchanges [16,17].

### Fulcrum effect

Another limitation in the surgeon's acquisition of laparoscopic skills is due to the fulcrum effect as an interval movement to the right is displayed as a movement to the left on the monitor [9].

## Conclusion

Currently, laparoscopic ergonomic research is lagging behind the pace of new laparoscopic operative procedure development. Ergonomic researcher's input should be incorporated in the development of surgical instruments, as laparoscopy is associated with significant ergonomic problems, proper training and awareness among laparoscopic surgeons is essential. Accreditation council to set the guidelines and oversee the training programs should be set up. Better ergonomic integration and understanding ergonomics cannot make the life of surgeon comfortable in the operating room but also reduce the physical strains on the surgeon.

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