Section

1

Tips and Tricks in Laparoscopic Urology

CHAPTERS

1

Ergonomics in Laparoscopic Surgery

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INTRODUCTION

Laparoscopic surgery has slowly and steadily evolved over the last century. It all probably started in the year of 1902 when Georg Kelling, a German surgeon, was working on minimally invasive techniques to stop gastrointestinal (GI) bleeding. Kelling proposed that creating a pneumoperitoneum and raising the intra-abdominal pressure could stop GI bleeding, he named this procedure Luft-tamponade (air-tamponade). In an endeavor to observe the effect of air-tamponade on the visceral organs, Kelling introduced the Nitze cystoscope through the abdominal wall of a dog and visualized the visceral organs. This was the genesis of laparoscopic surgery and it was named Coelioscopy.[1]

The first human laparoscopic observations were made by Hans Christian Jacobaeus, who was an internist from Stockholm Sweden. Jacobaeus introduced a trocar with a trap valve, in the abdominal cavity of the patients having ascites and after evacuation of the fluid, he created pneumoperitoneum and laparoscopy was again done using a cystoscope.[2]

In early 1980s Semm's demonstrated laparoscopic appendectomy, influenced by his work Erich Mühe on 12th September 1985 did the first laparoscopic cholecystectomy. He was a surgeon ahead of time, he had the tenacity to fight the German Medical and social system to prove his rationale. Today, it may seem the most predictive evolution but in the 1980s, Mühe's work was not very well received by the surgical community.[3]

Development of Laparoscopy in the Field of Urology

Laparoscopic surgery in the field of urology was relatively late to develop. Cortesi et al demonstrated first diagnostic use of laparoscopy in a case of undescended testis in 1976.[4] But, it was only in the year 1990 that Dr Ralph Clayman demonstrated laparoscopic nephrectomy.[5] Around the same time Schuessler, et al demonstrated first pelvic lymphadenectomy and later on he went onto describe laparoscopic radical prostatectomy.[6] In 1990, 1st laparoscopic varicocele surgery was also demonstrated. Laparoscopic donor nephrectomy was demonstrated by Ratner et al in 1995 and now progressively has become a very commonly done procedure.[7]

The development of laparoscopic urology was very slow, by 1990 it was already about 50 years since laparoscopy had come into existence and still there were not many surgeons around the world who were performing urological procedures laparoscopically.

Urological laparoscopic surgery developed late as it had a steep learning curve, two-dimensional vision was difficult to adapt, there was loss of haptic sensation, surgeons believed that very few urological surgical procedures could be done laparoscopically and lastly it was thought that urological laparoscopic procedures are much more complex as compared to gynecological and general surgical procedures.

Why do Urological Laparoscopic Surgery?

- *Magnificent visualization:* If there is one reason that a surgeon should start doing laparoscopic surgery, it is the magnificent visualization that laparoscopy offers. During the 1980s, major advances took place in the camera systems. By late 1990s and early 2000s, high definition (HD) camera systems became available. HD systems had higher resolution than standard definition systems, in general, they have a video image of greater than 480 vertical scan lines. After HD systems came the full HD systems with progressive scan which had 1080 vertical lines. These vertical lines are a measure of the clarity, the screen or the camera is going to offer. Now we have 4k systems available, these systems have a resolution of 2 times the vertical and 2 times the horizontal resolution of a full HD system (1080p). Further to this, quantum laser emitting diode (Q LED) and 8k technologies have already hit the television market and soon will be incorporated into medical grade monitors and cameras. The vision that laparoscopic surgery offers is only getting better with technology and surgeon has started to see anatomical details better than before.

  Many open surgeons who have started doing laparoscopy confess that they had never seen anatomical details like it is seen in laparoscopic surgery. To site a few examples, the two layers of Gerota's fascia or the course of lumbar vein on left side and the distinction between the retroperitoneal and gerotal fat are much better appreciated in laparoscopic vision.
- *Dramatic postoperative recovery:* The postoperative recovery after surgery is dramatic in patients undergoing laparoscopic surgery. The patients are ambulatory early, most of them ambulate by the evening of the surgery and allowed orally 8 hours after the surgery. Objectively, postoperative recovery has been studied in randomized controlled trails by measuring the levels of acute phase reactants like C-reactive protein (CRP), interleukin-6 (IL-6), HLA-DR expression on monocytes, level of growth hormone and cortisol levels. It is seen that the rise in these acute phase reactants is less in laparoscopic surgery when compared to open surgery, supporting accelerated recovery of patients post-laparoscopic surgery.[8] The above also proves that immune response to laparoscopic surgery is much less when compared to open surgery.[8]
- *Significant reduction in pain and decreased analgesic use:* Laparoscopic surgery induced pain is less in intensity than the pain caused by open surgery. The visual analog scale pain scores for the patients are significantly less. Though the pain is less it is different in character as compared to open surgical pain. It can be classified as visceral pain which is vague abdominal pain occurring predominantly in the first 24 hours of the surgery, second type of pain is parietal pain which arises from the incision site which also subside in the 1st 24 hours and the third type of pain is the shoulder pain which arises due to irritation of the diaphragm by CO_2, this pain is maximum on the 2nd day and decreases in intensity as the days pass by.[9]
- *Lesser wound related and infectious complications:* Laparoscopic surgery is associated with a lower risk of surgical site

infection.[10] As the wounds are smaller the incidence of infection is also less. Not only the superficial and deep wound infection occur with decreased severity and incidence, also the rate of infection in the deep organ spaces decreases with the use of laparoscopic surgery.[10] Incidence of deep organ space infection decreases in laparoscopic surgery as the abdominal contents are not exposed to the external environment.

- *Reduction in postoperative adhesions:* As the surgical incision is small in laparoscopic surgery, smaller raw areas are created, which in turn leads to a lesser adhesion. Although adhesion can occur at the port site.
- *Video imaging allows active participation of the mentors, trainees and theater technicians:* Laparoscopic surgery is team work and the video imaging system helps the whole team to be involved in the procedure. It makes mentoring possible and allows the team to be prepared for the next surgical steps. If the surgeon is going away at any surgical step, he can be guided by other team members.

Starting a Urological Laparoscopic Program

- Strong leadership support is required to set up a laparoscopic program.[11] As the program is equipment driven, procurement of the instruments is a major task, this is done by the people in leadership position. In an individual practice this role is done by the operating surgeon. In a corporate or government organization, it is the administration which does it.
- The chief surgeon is the center piece of the project; he should initially train himself by attending training program and short fellowship courses. Deterrent here is the cost of training and travelling, which has to be borne by individual surgeon in a stand-alone practice. Detailed description of the surgical procedure should be read, anatomy understood and teaching video watched. Simulation based training helps in developing laparoscopic skills, surgeon should start by doing simple exercises in dry lab, if facilities are not available office endotrainers are commercially available, they can be bought and training started. Cost may be deterring factor; this can be overcome by using low cost endotrainer which surgeon can himself developed (described later in text). Dry laboratory training is followed by wet laboratory simulations and finally the surgeon should embark on the real-time situation.
- *Developing a dedicated laparoscopic team* ***(Fig. 1.1)****:* Laparoscopic surgery is team work, surgeon is only as good as his team. The team consist of a chief surgeon, camera driver (ideally should be a surgeon), anesthesiologist, scrub nurse, circulating nurse and theater electronic technician who can manage all the electronic and other equipment (camera, light source, insufflator) which are used in laparoscopic surgery.
- *Inviting a proctor and sequential training:* The program should be started by inviting a proctor to mentor cases. He or she can be

Fig. 1.1: A dedicated laparoscopy team

Table 1.1: List of basic laparoscopic instruments

Basic instrumentation	
• Scissors • Hook • Suction and irrigation • *Grasping forceps:* Maryland, right angled, bowel holding, toothed grasper • *Diathermy:* Monopolar and bipolar • Harmonic scalpel • Port closure device • Specimen retrieval bag	• Laparoscopic cart • Television monitor • Color video chip camera • High intensity light source • High flow CO_2 insufflator • *Laparoscope:* 0 and 30° • Clip applicator: 5 mm/11 mm • *Trocars:* 12 mm and 5 mm

Fig. 1.2: A basic laparoscopic instrument trolley

Table 1.2: Criteria of patient selection for laparoscopic surgery for a novice

Patient selection
• Upper tract—preferable • Should have no history of: – COPD – *Obesity:* BMI >30 – Extensive prior abdominal or pelvic surgery – Pelvic fibrosis – Organomegaly – Ascites: Benign etiology – Hernia – Iliac or aortic aneurysm

an expert urological laparoscopic surgeon, if unavailable one can consider inviting and experienced laparoscopic general surgeon. Sequential training by observing a few cases, then assisting a few and finally doing a few steps of the surgery and then migrating to do the whole procedure. This basic Halstedian model along with simulation based training will go a long way in training surgeons to become experts.

- *Developing familiarity with basic instrumentation* ***(Table 1.1 and Fig. 1.2)****:* Surgeon should be familiar with the instruments and know correction of basic malfunction. This will remove the frustration barrier and help in development of the program.
- *Initial case selection* ***(Table 1.2)****:* Initial cases that an urologist does should be carefully selected, a well-done case will help the surgeon develop confidence and will go a long way in determining his learning curve. Initially one should start with a beginner-friendly case, in urologic laparoscopy, beginner-friendly case will be an upper tract extirpative surgery in a perimenopause female, with a body mass index of about 25–27. The patient should not have any comorbid illness like chronic obstructive airway disease and vascular malformations of great vessels. Patient should not be suffering from pelvic fibrosis, diseases which may ascites, hernias and any organomegaly.

Components of a Laparoscopic Operating Room (OR) Set up (Figs 1.3 to 1.5)

Components of OR set up include imaging systems, insufflators, hemostatic generators

Fig. 1.3: Components of OR set up

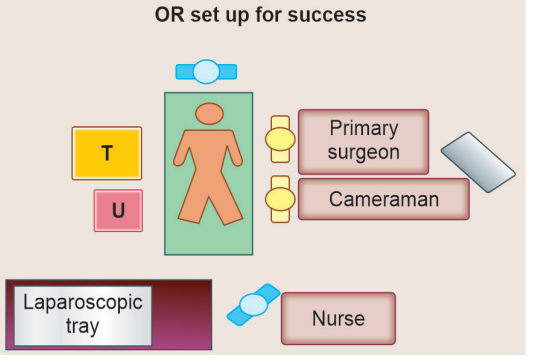


Fig. 1.4: OR set up for right upper tract laparoscopic procedure

Fig. 1.5: OR set up for left upper tract laparoscopic procedure

and instrumentation. For carrying out a surgical procedure there should be a smooth interaction between the various components and the surgical team.

General principles of laparoscopic or room set up:

- The OR room should have a vision cart, which should ideally be hanging from a boom. Vision cart has the monitor and below the monitor are 3–4 shelves which house the insufflator, camera unit, light source, electrosurgical units and other hemostatic generators **(Fig. 1.3)**.
- There should be at least 2 monitors on opposite sides of the OR table. The surgeon should be optically correct and the one monitor should be in front of the surgeon.
- Insufflator should be just below or along the side of the monitor, during initial cases if the surgeon has to turn to look at

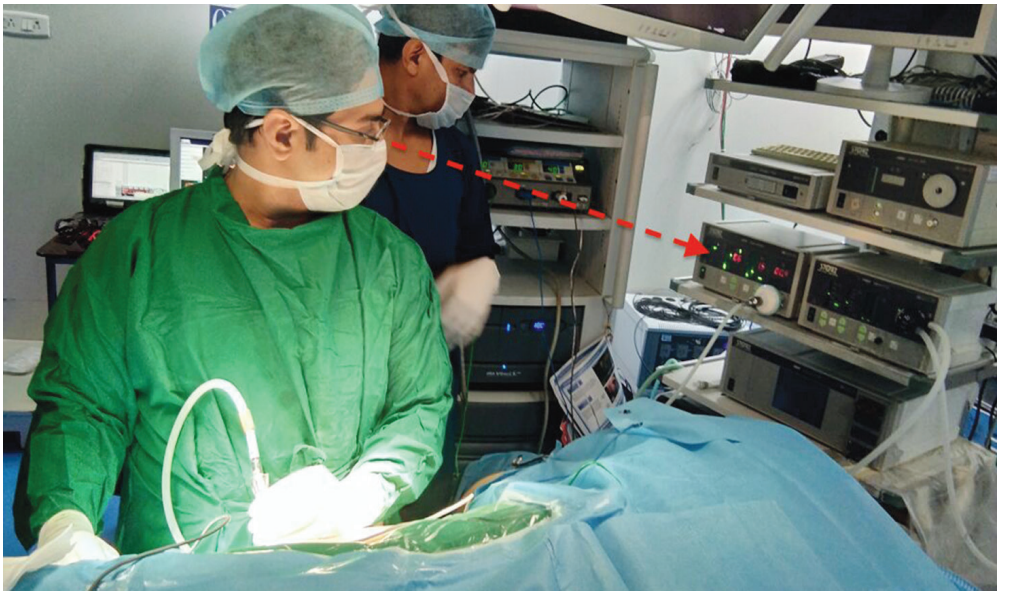


Fig. 1.6: Inappropriate positioning of insufflator

the quadromanometric indicator it will be anxiety provoking and also surgeon may not be able to appreciate the uniform distension of abdomen and other signs of appropriate intraperitoneal insufflation **(Fig. 1.6)**.

- The vision cart should be placed in front of the surgeon to make him optically correct.
- All the tubes and cable should be tangle free; this will help in free movement of all the instruments and make the surgery seamless **(Fig. 1.7)**.
- Specially designed drapes and custom made bags can be used to position the instruments, telescope and working elements of the hemostatic generators. The commercially available drapes are disposable, but have multiple pockets where instruments can be placed. If not available bags made of cloth can be designed and used by pinning these bags to the drapes, they can be re-sterilized and used **(Fig. 1.7)**.
- *Positioning of the personnel in the laparoscopic OR* ***(Fig. 1.5)****:* For an initial upper tact procedure the anesthesiologist is at the head and the camera driver stands cranial to the surgeon and the staff nurse will stand caudal to the surgeon. The 1st assistant should stand opposite to the operating surgeon and will visualize the procedure on the screen which is behind the operating surgeon. The circulating nurse stands behind the operating surgeon and the scrub nurse. For the right-sided upper tract surgeries, the camera driver may move caudal to the surgeon when the surgeon is working in the area of upper pole of the right kidney. The camera driver and surgeon should adjust to each other's body habitus so that minimal restriction of instrument movement occurs **(Fig. 1.8)**. If there is a height discrepancy between the operating surgeon and the camera driver, the camera driver can sit down on an operating chair **(Fig. 1.9)**. Other way around a tall surgeon can sit down and a shorter assistant can drive camera while standing. There may be situations like doing a single port surgery where both may have to sit.

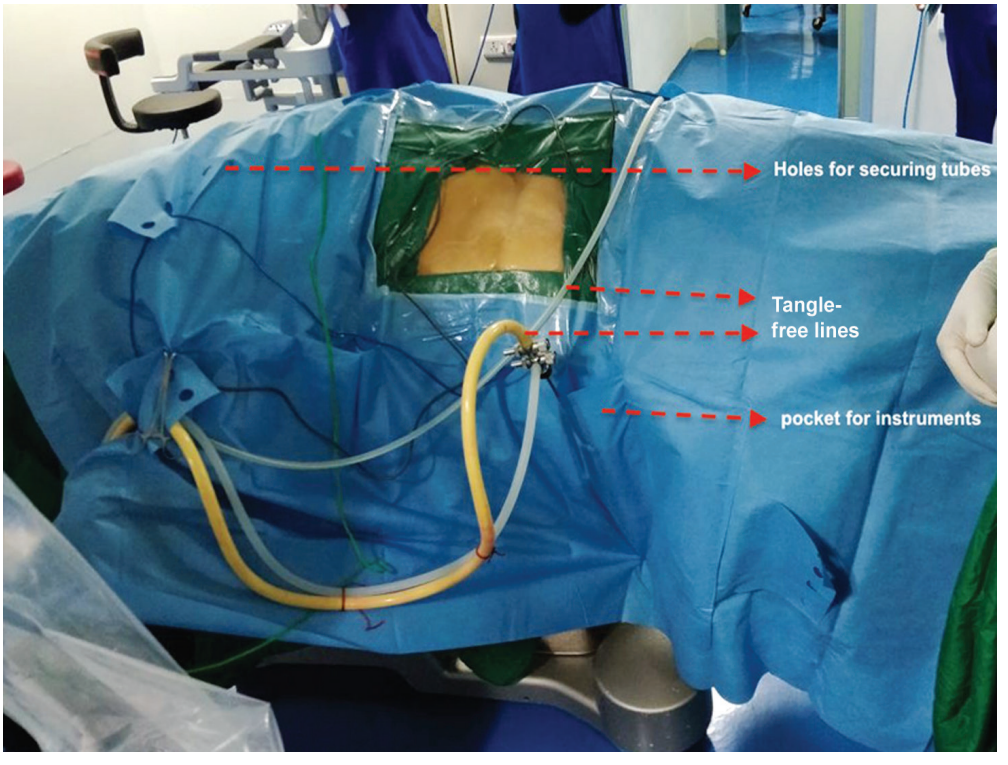


Fig. 1.7: Inappropriate positioning of insufflator

Fig. 1.8: Appropriate positioning of camera driver and surgeon

Fig. 1.9: Appropriate camera driver sitting and driving the camera and surgeon is standing and operating

Urological Surgeries can be Done Laparoscopically

- Surgeries which are accepted as standard of care when done laparoscopically:
  - Adrenalectomy for benign pathology

- Radical nephrectomy for T1–T3a renal cell carcinoma
- Simple nephrectomy for benign disease
- Nephroureterectomy for transitional cell carcinoma
- Dismembered pyeloplasty in adults
- Pelvic lymphadenectomy

Note: Excluding severe inflammatory conditions such as XGP

- Surgeries which are being done routinely at many centers laparoscopically:
  - Partial nephrectomy
  - Radical prostatectomy
  - Living donor nephrectomy
- Surgeries which are only done at centers of excellence:
  - Radical cystectomy and urinary diversion
  - Adrenalectomy for adrenal cortical carcinoma
  - Adrenalectomy for masses greater than 6 cm
  - Retroperitoneal lymph node dissection.

Laparoscopic OR Checklist

The famous book by Dr Atul Gawande "The checklist Menifesto" led to the birth of WHO checklist. In his book, the author talks about the errors in medicine, and they are basically either errors of ignorance which are due to lack of knowledge or there are errors of ineptitude, these errors occur due to lack for appropriate application of the existing knowledge. Modern medicine is all about errors of ineptitude and these sorts of errors can be corrected using checklist.

Laparoscopic surgical checklist that can be used by novice surgeon

- Irrigation aspiration working: Yes/No
- Electrosurgical unit working: Yes/No
- CO_2 tank full and extra CO_2 tank available: Yes/No
- Camera is white balanced and light source is working: Yes/No
- Insufflation is checked for flow and response to kinking of tubing: Yes/No
- Veress needle is checked for flow and proper tip retraction: Yes/No

All the OR (operating room) staff and surgeon should make a checklist which should be pasted on the wall of the laparoscopic or next to the WHO checklist and before incision in all the cases, a ritual of reading though all the checklist items should be done.

Important Pillars of Laparoscopic Surgeries

Laparoscopic surgery stands on the shoulder of excellence in open surgery, because it was the open surgery that gave the surgeons a detailed insight into the human anatomy. But, when this interface of minimally invasive surgery was developed, it required more than only knowledge of surgery. The pillars of laparoscopic surgery are:

- Ergonomics
- Task analysis
- Psycho-engineering

Ergonomics in Laparoscopic Surgery

The word ergonomics come from the Greek words "ergon" meaning work and "nomos" meaning laws of nature. By definition ergonomics is a scientific study of people at work, considering the equipment design, workplace layout, the working environment, safety, productivity and training. In simpler terms, it is designing a working interface between man and the machine to improve task performance. The above can be done by creating working environment that fits the worker's needs. Ergonomics can be universal or specific, and sensorial and physical.

Universal ergonomics include creating a well-ventilated room with appropriate temperature and specific ergonomics include maneuvers like adjusting the height of the operating table to surgeon's height.

Sensorial ergonomics are issues like improving vision, with use of better camera and optical systems precision and dexterity will improve. Physical ergonomics include positioning of surgeon's hands, neck, back in a relaxed position to generate maximum surgical performance.

Factors Unrelated to Human Skill Which Affect the Efficiency in Laparoscopic Surgery

- *Decoupling of the visual and motor axis:* In open surgery vision and the motor movements are in the same axis and they get decoupled in laparoscopic surgery. Humans have to train for this decoupling.
- *Loss of tactile feedback:* There is loss of haptics and the laparoscopic instruments replace the human fingers.
- *Changed visual orientation:* The anatomy that an open surgeon was used to seeing outside-in, will now be oriented inside-out. The surgeon has to compensate for the same.
- *The loss of depth perception* ***(Table 1.3)****:* Initially surgeon will not be able to make out whether the structures are near or far as laparoscopy offers monocular vision which leads to loss of depth perception.
- *Loss of peripheral vision:* Monocular vision is responsible for loss of peripheral vision.
- Relatively static posture during major part of the procedure gives rise to fatigue and ergonomically speaking, contributes to the inefficiency.

Equipment Related Challenges in Laparoscopic Surgery

- 2D vision
- Loss of peripheral vision
- Laparoscopic instruments have only 4 of freedom of movement, which are rotation, up/down angulations, left/right angulations, in/out movement. The robotic endo-wrist technology has 7 of freedom movement as it can flip back on itself.
- Laparoscopic instruments work on reduced efficiency.
- The instrument movements are counter-intuitive, which means that the instrument tip moves to right when the handle is moved to left.

Comparison of open and laparoscopic surgery is given in **Table 1.4**.

Ergonomical considerations for laparoscopic instruments ***(Figs 1.10 to 1.12)****.*

- The instruments should be held at the level of the elbow of the operating surgeon. This will keep the shoulders relaxed.
- *Manipulation angle:* Manipulation angle is the angle formed by the tip of two working instruments. Ideally the manipulation angle should be 60°. If the manipulation angle increases to >75°, there will be abduction of shoulder and fatigue will occur after a period of time.[12]

Manasnayakorn et al in an experimental set up studied the manipulation angle. Ten different surgeons were asked to do a 5 cm porcine enterotomy closure in a wet lab using different ports which corresponded to different manipulation angle ranging from 45° to 90°. The muscle workload was studied using an electromyography electrode. It was concluded that when

Table 1.3: Comparing open and laparoscopic surgeon

Open vs laparoscopic surgeon	
• Fast • Hand is as good as eye • Dissection precedes • Ergonomics optional	• Slow and steady • Stop when you do not see • Hemostasis precedes • Ergonomics vital

Table 1.4: Comparison of open and laparoscopic surgery

Potential problematic areas	
Open	***Laparoscopy***
• High degree of freedom • Surgeons work in-line with visual axis • Three-dimensional direct vision • Direct tactile feedback	• 2D vision • Loss of depth perception to some extent • Fulcrum effect with tremor enhancement • Only 4° of freedom • View is not under the control of operating surgeon

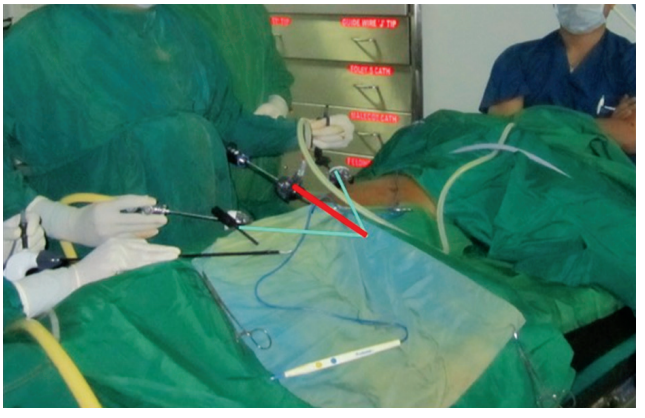


Fig. 1.10: Manipulation and azimuth angles

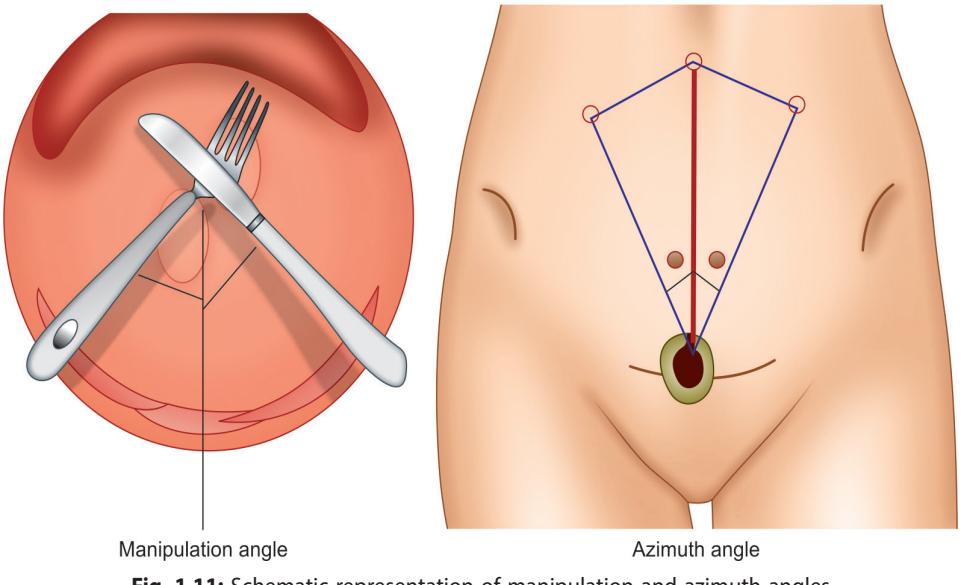
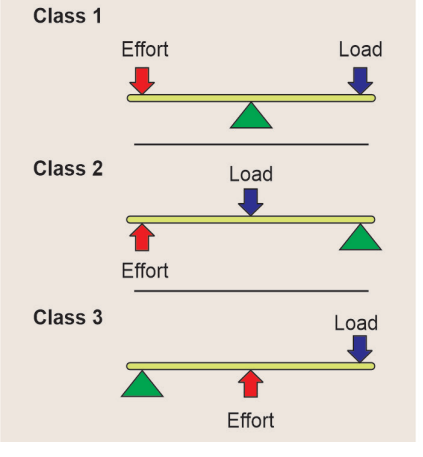


Fig. 1.11: Schematic representation of manipulation and azimuth angles

the manipulation angle is between 45° to 60° the workload on deltoid, trapezius and forearm muscle was least with best outcome which was measured as leak pressures of anastomosis, execution time and error score.[12]

- *Azimuth angle:* Azimuth angle is the angle formed between the single working instrument and the laparoscope. This angle should ideally be 30°, if this angle is less than 15° or greater than 45°, there will instrument fighting and a lot of strain on the upper limbs. Task efficiency is better if both the azimuth angles are equal.[13]
- *Elevation angle:* It is the angle formed between the instrument and the body of the patient. Ideally it should be 30°, whenever it increases to greater than 60°. Shoulder becomes abducted and fatigue occurs. Also, if the elevation angle decreases to 15°, shoulders will have excessive adduction and movement of the instrument will be difficult.

Fig. 1.12: Elevation angle



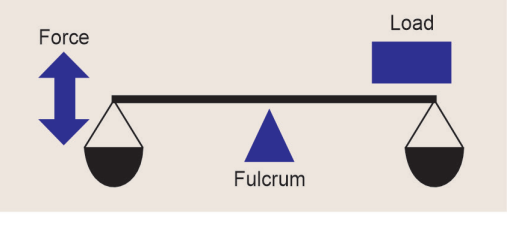


Fig. 1.13: Fulcrum effect

The elevation angle increases when the target organ is too near the port and decreases when the target organ is too far.

Mechanism of working of laparoscopic instruments and its ergonomical implication ***(Fig. 1.13)****:* If the long laparoscopic instrument is used to perform an open surgery, surgeon will surely not be able to operate. This is because the instrument will tend to wobble and there will be minimal control. Laparoscopic instruments behave like levers and abdominal wall is a fulcrum on which this lever moves, therefore, it is possible to do laparoscopic surgery. The portion of the instrument inside the abdominal wall is called the force arm and the portion outside is called the load arm.

Laparoscopic Instruments as Type 1 Lever

Ideally the length of the load arm and the force arm should be the same, this will lead to 1:1 transmission of movement and tip of the instrument will move only as much as the handle moves. Most of the adult instruments are 36 cm in length; so, ideally always 18 cm should be inside. Whenever this happens instruments behave like type 1 lever and there is an exactly equal and opposite transmission of force at the two ends. This may not be always possible; therefore, it is practical to have 18–24 cm of a 36 cm instrument inside the abdominal cavity.

Laparoscopic Instruments as Type 2 Lever

If more than two-thirds of the working length of the instrument are outside, the laparoscopic instrument behaves like type 2 lever. Large movements outside will lead to smaller movement inside. Force is magnified and the movement is rectified (large movement outside leads to smaller movements inside). This what a laborer does when he has to push a large stone, a rod is placed at the edge of the stone with another small stone is placed near the large one, supporting the rod and acting as a fulcrum. Large force can be now applied on the rod to cause small movement of the large stone.

Ergonomically speaking whenever instrument behaves like a type 2 lever, the port is very near the target organ. This leads to another problem, that is, it causes increase in the elevation angle beyond 60°, leading to fatigue. In cases where metal ports are being used and the instrument behaves like type 2 lever, direct coupling of the electric current may occur as the metal tip of the operating instrument is very close to the metal port.

Laparoscopic Instruments as Type 3 Lever

When greater than two-thirds the length of the working instrument are inside the abdomen, the instrument behaves like a type 3 lever. Small movement outside gets transmitted as large movements inside, force gets rectified and movement gets magnified. Type 3 lever behavior of a working instrument is seen when the ports are placed far away from the target organ. When a surgeon is working on the upper pole of the kidney, typically the instrument behaves like a type 3 lever, overshooting of the tip of the instrument may occur, which may lead to the instrument tip to go out of field of vision and injure the spleen or diaphragm on the left side. Diving board used by swimmers is an example of type 3 lever, where the swimmer jumps from the tip of the board and his movement get amplified with minimal force. When working instrument behaves like type 3 lever, the elevation angle decreases leading to fatigue of shoulders. Also, majority of the long length of the instrument is not under vision, this can potentially cause injury.

Ideal Instrument Characteristics

- Length of instrument 36 cm for adults and 28 cm for pediatric patient
- Half inside and half outside
- Type 1 lever
- Telescope should be in the middle to get a better depth perception.

Ergonomic port positioning (baseball diamond concept) ***(Fig. 1.14)****:* Ergonomic port positioning is the port positioning by which a surgeon can achieve ideal working instrument characteristics. If all the ports are ergonomically placed, then the instruments behave like a type 1 lever, the manipulation angle is 60° and telescope is in the middle of the working instruments.

For ergonomic port positioning, baseball diamond concept should be followed. The concept states that 1st determine the target area, for a nephrectomy renal hilum is the target area, for a pyeloplasty pelviureteric

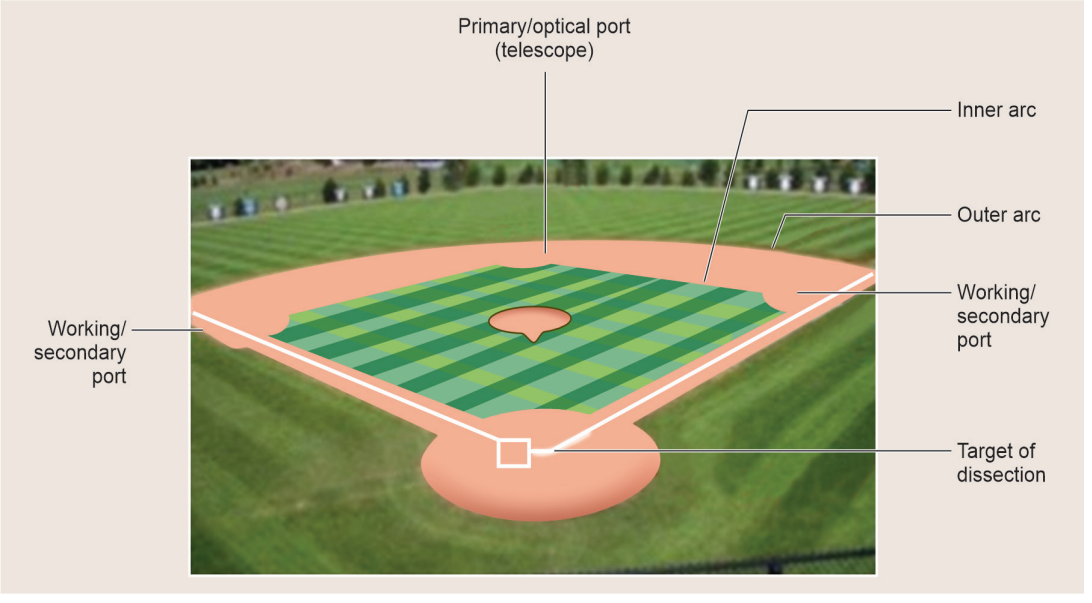


Fig. 1.14: Ergonomic port positioning using baseball diamond concept

junction is the target. After marking the target, two arcs are drawn, 18 cm and 24 cm away from the target area, all the working ports should be between these two arcs for the instrument to behave like type 1 lever.

In real-time situation after marking the target area and drawing two arcs, the camera port is placed in straight line with the target organ, now the right and left ports are placed between the two arcs in such a way that the instruments when placed from these ports form an angle of 60° with each other. 'Triangle law' states that the distance of the working ports from the camera depends on the length of the instrument used. If a pediatric instrument of 28 cm length is used, the distance of the working port from the camera port should be 5 cm to make manipulation angle of 60°, this distance is 7.5 cm when standard 36 cm adult instruments are used and becomes 10 cm when 45 cm bariatric instruments are used.

In real time the above can be achieved in an adult by making a diamond with your both index fingers and thumb. The tip of both the index fingers should be placed at the target organ, the confluence of both the thumbs will give us the camera position and the working ports will be in at the level of anatomical snuffbox. The distance from tip of the thumb to the snuffbox is roughly 7.5 cm.

Depth Cues

As laparoscopes are monocular scope there is a loss of depth perception. Placing camera between both the working instruments gives a better depth perception. Surgeon progressively learns to understand these depth cues and hence is able to say which structure is deep and which one near.

- *Occlusion:* The structure in front will occlude the one behind and cast a shadow, therefore, one may be able to conclude that the structure which is occluding is nearer as compared to the structure which is being occluded.
- *Relative size:* The structures closer to camera appear bigger and the structures which are farther off appear smaller.

- *Ariel gradient:* The structures which are nearer have sharper edges as compared to structures which are farther off.
- *Linear parallax:* Two parallel lines appear to meet each other at a distance and appear parallel to each other at a closer distance.
- *Motion parallax:* Structures near appear to move more as compared to deeper structures.
- *Texture gradient:* Nearer structures appear bright when compared to deeper structures which appear dark.

Mirror Imaging (Fig. 1.15)

It is important to understand the concept of mirror imaging in laparoscopy. When an assistant is standing opposite to the operating surgeon and assisting, though he would be seeing the same image as the surgeon all his movements will be opposite to the surgeon's movement as seen on the screen.

Summary of instrument characteristics

- Head should be straight, in axis of trunk, without rotation or extension of the cervical spine.
- Shoulders in relaxed and in neutral position.
- Arms should be along the side of the body
- Elbows should be bent to 70° to 90°
- Forearms in horizontal or in a slightly descending axis
- Hands pronated
- Hands and fingers lightly grip the handles/handpiece
- Gaze should be down
- Neck slightly flexed and in straight line with the monitor.

Ergonomic posture of operating surgeon is shown in **Fig. 1.16**.

Co-axial Alignment (Fig. 1.17)

It is an important ergonomic consideration in laparoscopic surgery, the surgeon, target organ and the monitor should be in the same line. The monitor should be slightly lower than the eye level of the surgeon, so that the surgeon has a 15°–20° downward gaze.

Fig. 1.15: Mirror imaging for the 1st assistant surgeon

Fig. 1.16: Ergonomic posture of operating surgeon

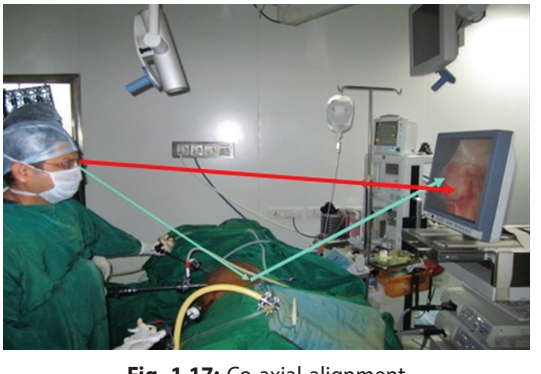


Fig. 1.17: Co-axial alignment