Laparoscopic Surgical Training by 2D-Double Mirror Imaging Box with One Eye-Occluded Glass

Wuttichai Thanapongsathorn*
Burapa Kanchanabat*

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One of the major problems in laparoscopic surgery is training to gain laparoscopic skills because they are different from conventional surgical skills. This paper presents a new piece of equipment for laparoscopic training which uses two mirrors for a double reflection. This training box gives an indirect three-dimensional image which is not along the direct eye-instrument pathway. It simulates the two-dimensional picture seen on a laparoscopic monitor by using one eye-occluded glass, and simulates hand-eye coordination in laparoscopic surgery. The main advantages are that it is cheaper and is less complicated than other laparoscopic trainers which require a laparoscope and video equipment.

Index : Laparoscopic training box., 2D-double mirror imaging box., One eye-occluded glass.

Reprint request : Wuttichai Thanapongsathorn MD.
Department of Surgery, Faculty of Medicine,
Srinakharinwirot University, Bangkok 10300, Thailand.

** Department of Surgery, Faculty of Medicine, Srinakharinwirot University, Bangkok 10300, Thailand.*

Background

Video laparoscopic surgery is a major advanced procedure. It has become the standard treatment for cholecystolithiasis, inguinal hernia, especially in recurrent or bilateral cases, and for many other abdominal problems. There is also an established role for advanced laparoscopic surgery in CBD exploration, esophageal reflux surgery, gastric surgery, adrenal surgery and colorectal surgery. Laparoscopic training is, therefore, a major concern because different skills are required. Practising laparoscopic skill is necessary because it will minimize operative complications, decrease the learning curve, and decrease operative times and costs.

In conventional surgery, we use our own stereoscopic vision, and have direct manipulation of the instruments with both hands. But in laparoscopic surgery, we view a picture on a laparoscopic monitor which is magnified and is in only two dimensions. The monitor is away from the actual operative field, tactile sensation is indirect and propioception through long instruments is decreased.[1] We mainly use the visual perception to coordinate hand movement (hand-eye coordination).[2] Only with experience do we become acquainted with distance, and the relation between the hand and the position of the instrument tip. By these means we obtain some idea of three dimensional positions.

Laparoscopic instruments are handled with a fixed point as a fulcrum at the abdominal wall. This movement is primarily in a paradoxical direction. The same as rowing a boat.[3] If we want to move our laparoscopic instruments to the left we have to move our hand to the right, and we measure distance by trial and error.

It is very difficult to practice laparoscopic surgery. Before a surgical resident's first time suturing a bowel, he must take time to practice suturing skin and other simple tissues. But to practice laparoscopic surgery, proper training equipment is desirable and beneficial.

Training equipment

There are several types of training equipment available.

1. A box with a transparent covering and working channels [training box or pelvic box].[4] Despite its easy availability and relatively low cost, the skill acquired by this equipment still differs from actual laparoscopic skill. We see a three dimensional picture directly through the transparent covering. This is just like working with long instruments in conventional surgery.

2. A box connected with a laparoscopic camera and video monitor [bench trainer]. Although the skill gained from this equipment simulates actual laparoscopic skills, it requires an expensive laparoscopic camera and video monitor which are not usually easily available except in the operating room.[5] There is a modification using a home video camera connected to a television monitor but this gives less picture resolution than a laparoscopic monitor and is also not always available.[6,7]

3. Real laparoscopic operations on animals such as pigs. This is an ideal way to train laparoscopic skills. It gives a real sense of laparoscopic surgery, but it is very expensive and requires a complicated set up.

This paper presents a new, simple piece of equipment for training laparoscopic surgery, and using materials that are easily available. It is inexpensive and easily constructed. It is based on double reflection from two mirrors.[8] This gives a three-dimensional picture which is not along the direct eye instrument path, but by using one eye-occluded glass it is displaced the same as the simulated two-dimensional picture on a video monitor. This reflection is similar to the reflection of light transmitted through an optic fiber as used in laparoscopic equipment. Using laparoscopic instruments with this equipment gives the same tactile sensation as working with actual video laparoscopic equipment, hence practice with this equipment can produce essential basic laparoscopic skills.

Equipment construction

This equipment can be easily constructed from a thick cardboard box cut in the desired shape (Fig. 1). It consists of 6 parts.

1. Two mirrors. The first mirror reflects an object, for example an artificial gallbladder. This first reflection gives a picture of the surgical object as though it is behind the mirror and at the same distance. The second mirror reflects the first mirror image, and it appears as an object behind the second mirror by the sum of the distance between the two mirrors plus the distance of the object from the first mirror. It can be seen that the final apparent distance of the object depends on the distance between the surgical object and the first mirror and the distance between the two mirrors. The larger the picture we want, the closer we have to place the object to the two mirrors. This is limited only by the angle required for visualisation, and the working space required. Both mirrors should be adjustable in position and angle to match any individual is eyesight, and to match both standing and sitting working positions (Fig. 2).

2. Surgical training object. It should be positioned behind the second mirror to avoid direct reflection of the surgical object by the second mirror, but direct reflection from the shafts of the laparoscopic instruments will still occur and may cause some confusion for the beginner, but after a short training period he/she will adjust to this automatically.

3. Surgical object arena. This should be constructed as an angled stage because the camera in laparoscopic surgery is looking downward but the mirror in this box is looking forward so that the contrast between the surgical object stage has to be angled up to compensate, and it should be painted dark to enhance the contrast between the surgical object and the background.

4. Instruments. We use laparoscopic instruments through the ports which are constructed by drilling holes at various desired positions. The distance from various ports to the surgical object arena should be 15-20 cm because the length of most laparoscopic instruments is about 30 cm.

5. Light source. It is necessary to have adequate illumination because the picture quality gains from this and instruments appear further away if inadequately illuminated. Illumination can be easily provided by incorporation of a simple electric bulb. This light source should be properly shielded from direct reflection in the second mirror so as to avoid glare that may cause poor visual acuity.

6. One eye-occluded glass (Fig. 3). Two-eye visualization provides three-dimensional perception. Using one eye-occluded glass, we can perceive only a two-dimensional picture, which is the same as using an endoscope with one eye. However, single eye visualization is an eccentric view but there is no effect on surgical skills.

The unique characteristics of this image are:

1. A real reflected color picture.
2. A high resolution image.
3. A three-dimensional picture. We can test this by putting the tips of pencils held by both hands together while looking at the reflection in a mirror. But one eye-occluded glass makes it seem as two dimensional, similar to what we see on a laparoscopic video monitor.
4. The picture in this equipment is not magnified because there is no lens. However, the picture seems to be further away and smaller because the mirror reflects the object before it as though the object is behind the mirror at an equal distance.
5. The image is devoid of a mirror image reversal effect because of the double reflection from the two mirrors.
6. The image seen on the second mirror is away from the actual operative site. We can't look directly in the same way as real laparoscopic surgery.

Skill training

There are two steps for training the beginner.

1. First step - 3D training. This step familiarizes the surgeon with laparoscopic instruments, laparoscopic

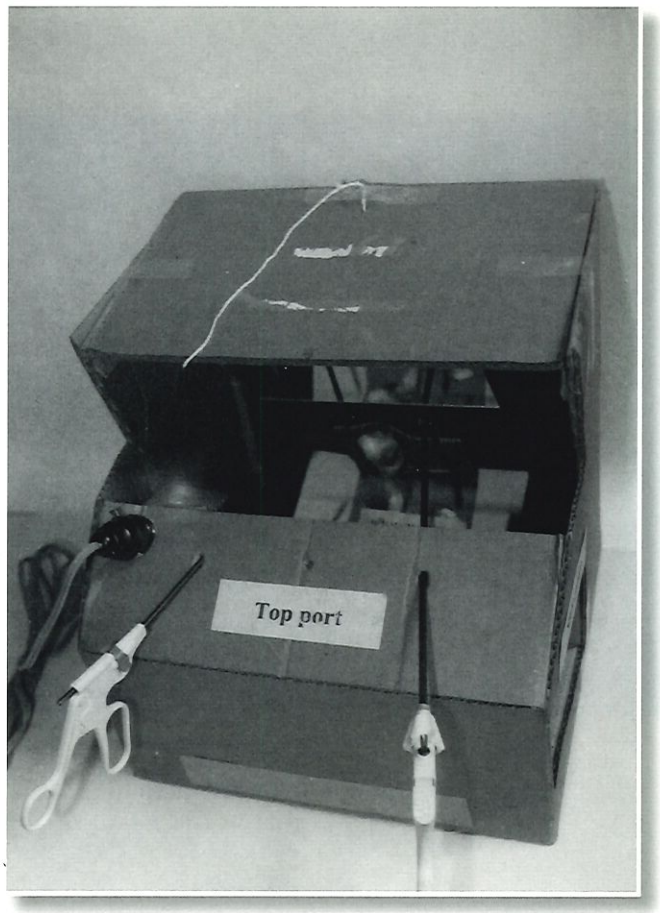

Figure 1: Laparoscopic training box.

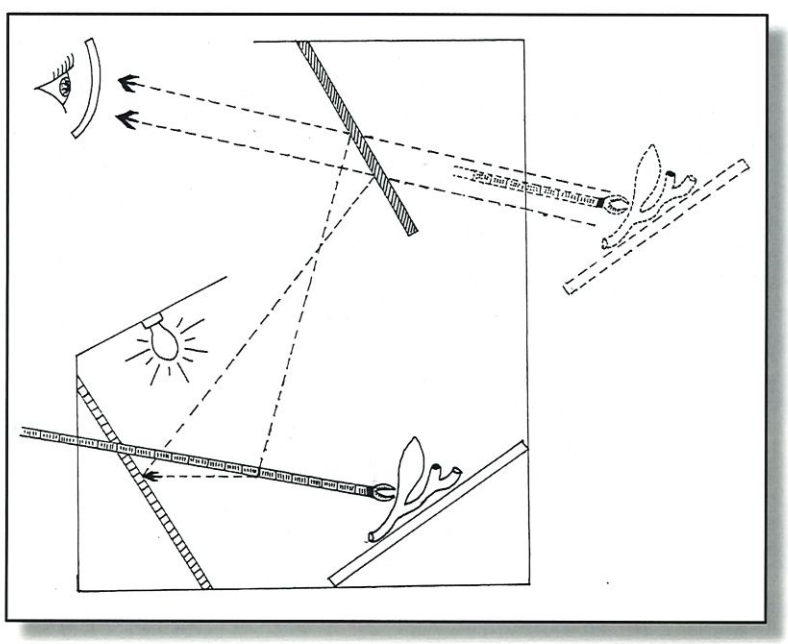

Figure 2: Two mirror imaging system.

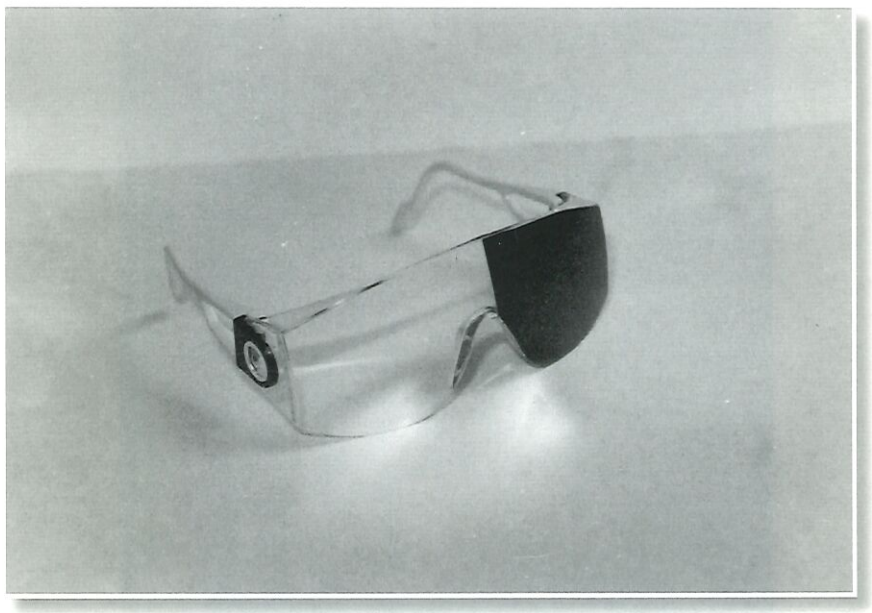

Figure 3: One eye occluded glass.

Figure 4: Training with one eye occluded glass.

manipulation and remote visual perception. It should start with grasping, cutting and dissecting skills, followed by suturing and knot tying (Extracorporeal and intracorporeal techniques).

2. Second step - 2D training. Wearing one eye-occluded glass, the surgeon practices the same procedures as in first step. This will shorten laparoscopic training time and provide effective skills for laparoscopic surgery (Fig. 4).

Conclusion

The double-mirror laparoscopic training box with one eye-occluded glass can simulate the monitor view and sensation of actual laparoscopic surgery. It can be built easily, inexpensively and cost-effectively for training laparoscopic surgery. A controlled trial of the effectiveness between this equipment and a laparoscopic bench training box will be conducted in the near future.

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