World Journal of Laparoscopic Surgery, January-April 2008;1(1):49-55

Role of OT Table Height on the Task Performance of Minimal Access Surgery

Gurvinder Kaur

Western Coalfields Ltd, Coal Estate, Civil Lines, Nagpur 44001

Abstract: The advent of laparoscopic surgery has changed the concept of surgery from prolonged painful to painless, cosmetically satisfying and short stay. In the past few years many instruments have been developed and introduced into the operating room (OR), but there has been ongoing debate about the optical ergonomic posture of the operating surgeon.

One of the main ergonomic problem in our currently available operating room table is that they are designed for the open surgery and are not ideal (suitable) for the laparoscopic surgery. Since laparoscopic surgery requires the use of longer instruments than open surgery, thus changing the relation between the height of the surgeon and the desirable height of the operating room table.

This study aims to understand an ergonomically optimal operating table height required for the particular height of the surgeon from the floor so that they can perform their surgery comfortably.

The operating table height was defined as the upper level of the table from the floor. The study was undertaken keeping all other variables fixed (Elevation angle, Manipulation angle, Azimuth angle, Distance of monitor.) Coaxial alignments were maintained. The only variable was the operating room (OR) table height.

Keywords: Ergonomics, Laparoscopy, Operation Table Height.

Definitions

Elevation angle: It is an angle between the instrument and the body of the patient.

Manipulation angle: It is an angle between the two working instruments.

Azimuth angle: It is an angle between the one side of instrument and the telescope.

Coaxial alignment: The axis joining the eye of the surgeon, target of dissection and the center of monitor.

INTRODUCTION

Ergonomics is the study (or science) of the interaction between human and their working environment in terms of equipment design, work place layout the working environment, safety, productivity and training. Often called the "human factors" in the United States, it is the psychological and physical interaction between the user (e.g. surgeon, assistants or nurse) and their tools.[1]

Since the past fifteen years laparoscopic surgery has become part of the visceral surgery, providing the patient short painless and a quick recovery. In the literature laparoscopic surgery is in many cases associated with ergonomics problems.[2-4] Infact poor ergonomics has always been one of the major drawbacks of endoscopic surgery. In the last decade or so, many new instruments and devices have been developed for the laparoscopic surgery. The handling of these tools has a sizeable impact on the length of the procedure in terms of time and the overall morbidity. The relationship between the surgeon and the tools also determine how much effort is expended by the surgeon.

The fatigue and discomfort of the surgeon's complaints during laparoscopy have led to several studies which investigate the origin of the physical problems.[5-9]

A comparative study of the surgeon's posture during open and laparoscopic surgery[6] showed more upright head and back posture with less body movements during laparoscopic surgery. There were significant musculoskeletal complaints of neck and arms. One study has shown that laparoscopy instruments causes excessive flexion and ulnar deviation of the surgeon's wrist with abduction of arm during manipulation.[7-10] This ergonomic problem results from the combined effect of the fixed point of insertion of the laparoscope through the body wall, a large external arc of the arm movement due to greater length of the instrument and the poorly adjusted operating table height.

The Society of American Gastrointestinal Endoscopic Surgeons (SAGES) realized the importance and established a study group for improving the ergonomics in the operating room.[11-13] DeQuervain pointed out the importance of adjusting of the table for the positioning of the patients in relation to the surgeon for open surgery.[14-15] In laparoscopic surgery the situation differs, since the table cannot be lowered sufficiently for precise and relaxed work. To overcome this problem the surgeon compensates by elevating their arms which is fatiguing.[16]

Guidelines for the height of the work surfaces for standing workers in industry or offices have existed for many years.[17] In medical literature, there has been, however, less focus on the ergonomics problem of operating table height during laparoscopy. Only recently a paper has been published dealing with the ergonomic problem of incorrect operating table height.[18]

This aim of the study was to find out the ergonomically optimal operating table height required for the particular height of the surgeon for laparoscopic surgery in order the surgeon can perform their task comfortably without the extreme upper limb joint movements. The approach of this study can be extended as guidelines for designing of the ergonomically optimal operating table.

MATERIAL AND METHOD

The study was carried out in the Laparoscopic Laboratory of Laparoscopy Hospital, New Delhi. A literature search was also performed using Medline and the search engine Google to find out for any such related article. The following search terms were used "ergonomics, ergonomics in surgery, ergonomics in laparoscopy".

The tests were performed on endo-trainer using the six different table heights for a particular surgeon for task performance. All the other variables were kept fixed or constant (Elevation angle, Manipulation angle, Azimuth angle, Distance of the Monitor). The coaxial alignments were maintained. The only variable studied was the OR Table Height. The neutral zone of joint movements is shown in Table 1.

The ports were introduced keeping in mind the "baseball diamond" concept.[19]

1. The telescope was fixed in between the working instruments.
2. Level 1 lever system was used for the insertion of the instrument through the ports, i.e. half the instrument was inside and half the instrument was kept outside maintaining the Elevation angle of 30 degree.
3. Manipulation angle was fixed to 60 degree.
4. Azimuth angle was fixed to 30 degree.

TABLE 1: Neutral zone of joint movement (VAN VEELEN)

Joint	*Movement*	*Neutral zone (degree)*
Shoulder	Abduction	< 30
	Adduction	< 30
Elbow	Flexion	> 30 < 130
	Extension	0
Wrist	Ulnar abduction	< 15
	Radial abduction	< 15
	Palmer flexion	< 15
	Dorsal flexion	< 15

Fig. 1: Abduction of the shoulder were measured

Fig 2: Flexion of the wrist and elbow were measured

Fig 3: Operating table height

The joint movement and the angles (abduction of the shoulder and flexion of the wrist) of the shoulder elbow and wrist were measured by video recording and snap shots during the task performance (Figs 1 and 2).

The results were evaluated by a questionnaire and snap shots. The optimum operating table height was defined for the

different height of surgeon. The girth of the patient was kept constant during the study as the task was performed on the endo-trainer.

Task

The subject had to perform the task of tying the intracorporeal knot. The operating table height was adjusted to six different height for a particular surgeon. The monitor was placed in front of the surgeon at a height of 170 cm from floor.

Subjects

Consisted of surgeon and laparoscopic trainees. The total numbers of subjects were twenty-five out of which five were females and the rest twenty were. They worked mostly with right hand.

Operation Table Height (Fig. 3)

Six different heights of the operating table was adjusted varying from 65 to 90 cm.

Duration of Each Observation

The duration of each observation was for five minutes for each height of operating room table. For six different heights of the table the total observation duration was of 30 minutes for the task performance with respect to the position of shoulder, elbow and wrist movements.

Video Analysis

The camera was used to record the position of the shoulder, hand arm and wrist joint and videos snaps were taken during the task performance at different operating table height.

Questionnaire

The subjects were asked for the particular level of discomfort of the operating table height during their task performance.

Level of comfort (from best to worst) was graded:

A. *Comfortable:* When the subject's upper extremities were in neutral zone posture.

B. *Less comfort:* When there was minimum deviation from the above posture (Abduction of shoulder joint and flexion of wrist joint).

C. *Discomfort:* When there was increasing abduction of shoulder joints with increasing flexion of wrist joint to perform the task.

D. *Uncomfort:* When there was complementary increased abduction of shoulder joint with increased flexion of wrist joint to perform the task.

RESULTS

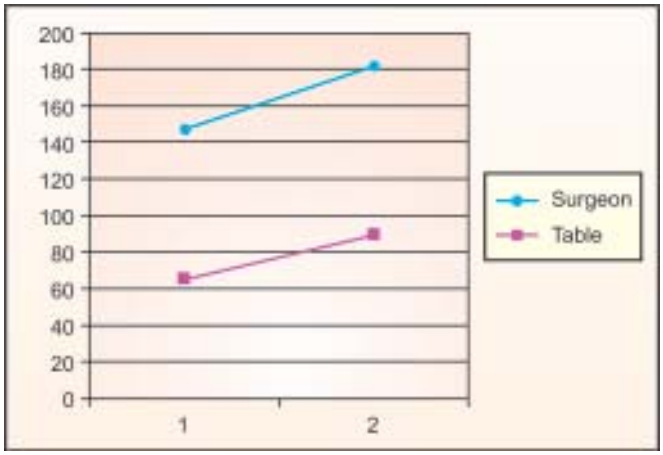
The results of the level of comfort of OR table during task performance with respect of the height of the surgeon is shown in Table 2. The short stature subjects (147 to 151 cm) were comfortable at 65 cm table height while the tall subjects (178 to 182 cm) experienced comfort at 90 cm OR table height.

The maximum subjects were in the height group 165 to 170 cm which is the average height of the Indian masses, were comfortable during their task performance at 80 cm OR table height.

There was a parallel steady rise in trend (Graph 1). As the height of the surgeon increased there was proportionate increase in the vertical height of the OR table.

TABLE 2: Subjects height versus table height (comfort level)

Subject (surgeon height cm)	*Comfort of the level of OR Table height (cm)*
147	65
150	65
151	65
155	70
156	70
160	75
160	75
161	75
163	75
164	75
165	80
165	80
166	80
167	80
167	80
168	80
168	80
170	80
171	85
172	85
173	85
174	85
178	90
180	90
182	90



Graph 1: Relation between surgeon and OR table height (cm)

The results of the video analysis are shown in Table 3. For 155 cm subject height was comfortable at 70 cm in the neutral zone posture showing shoulder joint was abducted at 15 degree and elbow joint showed extension at 125 degree abduction of wrist joint.

At 65 cm OR table height there was less comfort experienced by the subject as the shoulder joint was abducted to zero degree and the elbow joint extended to more than 130 degree (i.e. 150 degree). On further raising the table height to 75 cm there was the same less comfort. The shoulder joint was abducted to 40 degree with extension of the elbow joint to 120 degree to perform the task.

When the OR table height was further raised to 85 cm there was discomfort experienced by the subject since the abduction of shoulder joint had increased further to 45 degree combined with the increasing flexion of wrist joint to perform the task. At

TABLE 3: Subjects Height versus Table Height

OT Table Height (cm)	*Abduction Angle of Shoulder*	*Flexion of Elbow and wrist*	*Observation*
65	 0°	 150°	B = Less comfort minimal deviation from neutral zone posture.
70	 15°	 125°	A = Comfortable-neutral zone posture shoulder joint abducted 15° elbow extended 125° wrist joint extended.
75	 40°	 120°	B = Less comfort minimal deviation from neutral zone posture.

Contd...

Contd...

OT Table Height (cm)	*Abduction Angle of Shoulder*	*Flexion of Elbow and wrist*	*Observation*
80	 45°	 115°	C = Discomfort starting of abduction of shoulder joint, increasing flexion of elbow joint, flexion and ulnar deviation of wrist joint
85	 60°	 105°	C = Discomfort starting of abduction of shoulder joint, increasing flexion of elbow joint, flexion and ulnar deviation of wrist joint
90	 75°	 Angle cannot be calculated from side (awkward position)	D = Uncomfort complementary increased abduction of shoulder joint 75° increased flexion and ulnar deviation of wrist joint

90 cm for the particular surgeon height there was uncomfort felt by surgeon during task performance. This was compensated by the complementary increased abduction of shoulder joint (75 degree) and then elbow joint was straightened, also there was increased flexion and ulnar deviation of wrist joint.

The different grades of comfort level as stated by the surgeon during the task performance at the six different OR table height is shown in (Table 4). The result of the objective evaluation with video analysis co-relate with the subjective assessment of the comfort level of the subjects (questionnaire) working at the particular vertical height of the OR table.

The height of the operating table varies in relation to the surgeon's level of comfort for task performance.

DISCUSSION

The operating room (OR) table height is one of the important factors deciding the ergonomics of the laparoscopic surgery. The height of the table has an effect on the upper joint movements of the shoulders, arms and wrist during laparoscopy. The fixed position of the trocars and the scope in the abdominal wall require the surgeon to move the upper extremities into making longer external arc of movements with long awkward positions manipulating the tissues at different angles inside the abdomen.[3]

This study was carried out to define the ergonomically optimal OR table height which will suit the particular height of the surgeon performing laparoscopic surgery. Unfortunately most of the OR table available in the laparoscopic theater is made for open surgery and it becomes inconvenient to use during laparoscopic surgery. The endo-trainer used during the study represents the manipulation done in the dissection phase of an operation.

The results of study show that subject height in the range of 147 to 151 cm were comfortable at 65 cm OR table height while subjects of 152 to 156 cm expressed their comfort at 70 cm. For 160 to 164 cm surgeon height the comfort level of OR table height was 75 cm. The maximum number of subjects ranged

TABLE 4: Comfort levels as stated by surgeons

Height of subject (cm)	*OR table height (cm) and grade of comfort level*					
	65	70	75	80	85	90
147	A	B	B	C	D	D
150	A	B	B	B	C	D
151	A	B	B	C	C	D
155	B	A	B	C	C	D
156	B	A	B	B	C	D
160	B	B	A	B	C	D
160	B	B	A	B	C	D
161	C	B	A	B	C	D
163	C	B	A	B	C	D
164	C	B	A	B	C	D
165	C	C	B	A	B	C
165	C	C	B	A	B	C
166	C	C	B	A	B	C
167	C	B	B	A	B	C
167	C	C	B	A	B	C
168	C	C	B	A	B	C
168	C	C	B	A	B	C
170	B	B	B	A	B	C
171	C	C	B	B	A	B
172	C	C	B	B	A	B
173	C	C	B	B	A	B
174	C	C	B	B	A	B
178	D	C	C	B	B	A
180	D	C	C	B	B	A
182	D	C	C	B	B	A

from 165 to 170 cm height were comfortable during the task performance at 80 cm OR table height. For 171 to 178 cm subject height the comfortable height was defined at 85 cm. While (180-182 cm height of subjects observed comfort level at 90 cm OR table height. For lower table height many subjects had to tilt on one side and bend forward to compensate the low instrument position. At this height the flexion of the spinal column shows higher discomfort and difficulty though the upper arm muscle is working at low level. Thus, the optimum working height of a surgeon is a compromise between the position of the spinal column and the arm position with the resultant fatigue of the respective antagonist muscle. A higher OR table is also not good because then is increased abduction of shoulder combined with flexion and ulnar deviation of the wrist. This causes fatigue of the wrist joints.

Berguer recently recommended adjusting the operating table so that the height of the prone patient is at the level of the surgeon's upper thigh. The minimum vertical range of the operating table was not specified. Further more the hands should be positioned at the level of the elbow with the forearm in a horizontal position.

Secondly, the video stills taken during the task performance for the joint movements of the upper extremities is a reliable method as the interpretation of the abduction angle of shoulder joint and angle of elbow joint, the flexion and ulnar deviation of wrist joint during the task performance and examined jointly by the two persons and the angles are measured using the set square scale. The result show that at lower OR table height for corresponding height of the surgeon there was less comfort with abduction of shoulder joint (0 degree) and flexion of elbow joint 150 degree.

At higher OR table height in respect to the surgeon height there was discomfort of the upper extremities with the starting of abduction of shoulder joint (> 45 degree) with flexion of elbow joint < 30 degree and ulnar deviation of wrist joint. At still higher OR table height there was uncomfort when the task

could be done with complimentary increased abduction of shoulder joint 75 degree and increased flexion and ulnar deviation of the wrist joint.

The comfortable height of the OR table was from 65 to 90 cm for short and tall stature subjects respectively. For the mean height of the subjects 165 to 170 the comfortable OR table height was 80 cm. These OR table height were considered comfortable for the corresponding subject height because they had more freedom in movement and had less discomfort in the backs shoulder and wrist.

Tendick et al[20] were the first investigators to show the manipulation problems in laparoscopic surgery emphasizing the negative effect on the surgeon's dexterity of the narrow degree of freedom with use of laparoscopic instruments. Patkin and Isabel[21] further reviewed human interface problems in laparoscopic surgery and identified the need for a human engineering (ergonomic) approach to the design of the laparoscopic operating environment. A 1997 survey conducted by the Society of American Gastrointestinal Endoscopic Surgery (SAGES) found an 8-12% incidences of pain or numbness in the upper extremities following laparoscopic surgery.

Although the primary aim of the operation is not the comfort of the surgeon, the data reported by Hanna et al show that inefficient working postures directly affect the working efficiency of the surgeon.

The study shows that OR table height is less than that used for open surgery. The surgeon should adjust his/her OR table height corresponding to his own height according to the table and graph which we have discussed.

After analyzing the ration of surgeon's height with the OR table height we hypothesized that the OR table height should be Surgeon's Height into 0.49.

$$\text{OR Table Height} = \text{Surgeon's Height} \times 0.49$$

CONCLUSION

In this study it was observed laparoscopic OR table height has an effect on the upper joint movements. The laparoscopic OR table height should vary from 65 to 90 cm from the floor. The surgeon should be able to adjust the OR table corresponding to his/her height in order to bring upper joint movements to the minimum position with the resultant less discomfort in the shoulder, back elbow and the wrist.

REFERENCES

1. Salvendy G. Handbook of Human Factor and Ergonomics, New York: Wiley, 1997.
2. Berguer R. Surgical technology and the ergonomics of laparoscopic instruments. Surg Endosc 1998;12:458-62.
3. Berguer R, Forkley DL, Smith WD. Ergonomic problems associated with laparoscopic surgery. Surg Endosc 1999;13:466-8.
4. Schurr MO, Buess GF, Witcth F, Saile HJ, Botsch M, Ergonomic surgeons' chair for use during minimally ergonomic invasive surgery. Surg Laparosc Percutan Tech 1999;7:244-7.
5. Berguer R, Gerber S, Kilpatrick G, Beckley D. An ergonomic comparison of in-line vs pistol grip handle con-I, figuration in a laparoscopic grasper. Surg Endosc 1997;12:805-8.
6. Berguer R, Rab GT, Abu-Ghaida H, Alarcon A, Chung J. A comparison of surgeon's posture during laparoscopic and open surgical postures. Surg Endosc 1996;11:139-42.
7. Matern U, Waller P. Instruments for minimally invasive surgery: Principles of ergonomics-handles. Surg Endosc 1999;13:174-82.
8. Van Veelen MA, Meijer DW. Ergonomics and design of laparoscopic instruments: Results of a survey among laparoscopic surgeons. J Laparoendosc Adv Surg Tech A 1999;6:481-9.
9. Van Veelen MA, Meijer DW, Goossens RHM, Snijders CJ. New ergonomic design criteria for handles of laparoscopic dissection forceps. J Laparoendosc Adv Surg Tech A 2001;11:17-26.
10. Van Veelen MA, Meijer DW, Goossens RHM, Snijders O, Jakimowicz N. Improved usability of a new handle design for laparoscopic dissection forceps. Surg Endosc 2002;16:201-7.
11. Berguer R. The application of ergonomics in the work environment of general surgeons. Rev Environ Health 1997;12:99-106.
12. Bergure R. Surgical technology and the ergonomics of laparoscopic instruments. Uurg Endosc 1998;12;458-62.
13. Laparoscopic Surgery update. Reduced fatigue and discomfort: tips to improve operating room setup. Laparoscopic Surgery Update. 1997;5;97-100.
14. De Quervain F. Zur Operationstischfrage. Zentrabl Chir 1906;11;321-3.
15. De Quervain F. Weiteres zur Operationstischfrage. Zentralbl Chir 1909;19:686-8.
16. Grandjean E. Ergonomie in der Praxis. Kaln: Schriftreihe Arbeitswissenschaftdes Arbeitgeberverbandes der Metallindustrie; 1982.
17. Ayoub MM. Work place design and posture. Hum Factors 1973;15:265-8.
18. Matern U, Waller P, Giebmeyer C, Ruckauer KD, Farthmann EH: Ergonomics: Requirements for adjusting the height of laparoscopic operating tables. JSLS 2001;5:7-12.
19. RK Mishra. Textbook of Laparoscopic Surgery.
20. Tendik F, Jennings RW, Tharp G, Strak L. Sensing and manipulation problems in endoscopic surgery: experiment, analysis, and observation. Presence 1993;2:66-80.
21. Patkin M, Isabel L. Ergonomics, engineering and surgery of endosurgical dissection. J R CoIl Surg Edinb 1995;40:120-32.