

# A Comparative Study on the Risk Factors of Musculoskeletal Disorders among Laparoscopic Surgical Technologists in Circulatory and Scrub Roles

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## Abstract

**Background:** Musculoskeletal disorders are of the most important occupational injuries and diseases, in which the work environment and individual activities play an essential role in their prevalence. Since laparoscopy has become a preferred approach to treating many of the actions, the aim of this study was to determine the risk factors of musculoskeletal disorders among laparoscopic surgery technologists and comparing them between circulatory and scrubbing roles.

**Materials and Methods:** In this descriptive-analytical cross-sectional study, 49 participants were evaluated by REBA method in Al-zahra Hospital, Isfahan, Iran, 2017. Data was collected through REBA form and analyzed using SPSS software version 20. Results: 94% of our samples were women mostly married with an age range of 32/17 years. The prevalence of musculoskeletal disorders was 98.87% with a mean overall risk of  $7.2 \pm 0.75$  in the role of circulatory and  $5.31 \pm 0.63$  in the role of scrub.

**Conclusion:** Considering the fact that surgical technologists are at risk due to the nature of their job and to promote their health, ergonomic interventions are critically suggested for equipment, tools and environments as well as including ergonomics in their educational curriculum and regular exercise programs.

**Keywords:** Musculoskeletal Disorders; Risk Factors, Postures; Laparoscopy; Circulatory and Scrub.

## 1. Introduction

Laparoscopic techniques for minimally invasive surgery (MIS) are rapidly developing (Janki et al., 2017; Bartnicka et al., 2013) so that it might have been considered as the first choice for many surgeries such as cholecystectomy And has become a golden standard for removal of the gallbladder (Janki et al., 2017; Bartnicka et al., 2018; Kramp et al., 2014). Although there are many advantages in laparoscopic procedures such as less pain after surgery, shorter recovery time and better results for patients (Janki et al., 2017; Bartnicka et al., 2018; Choi et al., 2018), they require a fixed port position contributing to different awkward postures (El-Badry et al., 2018) and certain technical constraints (Sánchez-Margallo et al., 2017). There may be ergonomic problems, therefore,

with techniques or tools (Bartnicka et. al., 2018). Among health workers, especially nurses, Work-related Musculoskeletal Disorders (WMSDs) are a major global concern (Nur Azma et. al., 2016) and the number of cases has risen since 1980 (Athena et. al., 2014). For example, the number of WMSDs complaints in Taiwanese nurses, has gone up from 28.35% in 2006 to 33.65% in 2010 (Chung et. al., 2013). Also, based on the statistics, the reported complains among nurses who experienced WMSDs symptoms at least in one region of their body were 88% in Malaysia, (Nur Azma et. al., 2016), 48% in the United States (Zhang et. al., 2018), 85% in Saudi Arabia (Attar., 2014), 66% in Switzerland (Nützi et. al., 2015), 80.8% in Africa 80.8% (Munabi et. al., 2014), 100% in Iran (Zamanian et. al., 2017). The cost of these disorders is estimated about 4% of the world's gross domestic product. For instance, back injuries among the operating room staff have caused direct costs of \$ 37,000 and indirect costs of \$ 147,000 (King, 2011). In addition, ignoring the risk factors and injuries of musculoskeletal disorders over time, it may result in increasing absenteeism, medical expenses, pre-retirement, and reducing the working quality and productivity, as well as the lack of workforce, abundant economic effects on individuals, organizations, and societies or even in more severe cases the death of a person (Ballester Arias & García, 2017; Taghinejad et. al., 2015). Therefore, by assessing the WMSDs risk factors, high risk tasks can be identified and it may be possible to eliminate or reduce these risk factors through ergonomically designing the layout (Choobineh et. al., 2013; Choobineh et. al., 2012), tools and equipment (Choobineh et. al., 2012) contemporary with an organized educational intervention (Copenhaver et. al., 2017; Epstein et. al., 2018) with the aim of adopting suitable work postures (El-Badry et. al., 2018; Abdollahzade et. al., 2016), exercise (Stolt et. al., 2018; Heba et. al., 2018) aerobics and physical strength training (Szeto et. al., 2013; Wang et. al., 2017) prevented the spread of it (Dana et. al., 2013; Wang et. al., 2017). As previously mentioned, laparoscopic approach encompasses unique ergonomic challenges compared to open surgery (Wang et. al., 2017). Although, some studies have shown a relationship between laparoscopy and more musculoskeletal pain in surgeons (Dalager et. al., 2018; Choi, 2015), some other studies like Wang Robert et. al. (2017) a reduction of ergonomic stress was observed in some muscles among surgeons doing laparoscopic practice compared with that of open surgery (Wang et. al., 2017). However, there is no detailed ergonomic information on the impact of this new technology on the activities of surgical technologists during laparoscopic surgery since so far few studies have been conducted specifically on these people, especially in the role of Circulatory. In the surgical team, surgical technologists are only part of the team with two different roles of circulatory and scrub among surgical operations. They in surgical procedures of most medical centers, the surgical technologists would act as a circulatory, the interface between the surgical sterilization team and the non-sterile environment (Choobineh et. al., 2010) and in the role of scrub, they act simultaneously as scrubs and as the first assistant throughout the entire course of surgery which means, ergonomically working in worse situation than even nursing.

So, Although new technology may yield credible advantages for surgical team like improving patient surgery outcomes (Dalager et. al., 2017) or even reducing the risk of transmitting biological agents; it is unclear in terms of ergonomics what impacts would have on the person with the role(s) of the circulatory and/or scrub. Based on the mentioned points, the need for a study with regard to the risk factors leading to WMSDs is felt among these people. Therefore, this study aimed at comparing the WMSDs risk factors among laparoscopic surgery technologists with the two roles of circular and scrubbing.

### **Laparoscopic History**

Laparoscopy goes back to 1901 (Supe et. al., 2010), the first laparoscopy in Alzahra hospital, however, dates back to 1995, firstly done by attend Thorax on laparoscopic cholecystectomy.

Today's other operations such as herniorrhaphy, bariatric, diagnostic laparoscopy, hysterectomy, cystectomy, thymectomy, pulmonary, nephrectomy, and diagnostic Infertility have also been developed. Cholecystectomy in the studied hospital is performed based on the American method, i.e. the surgeon standing on the left side of the patient (Kramp et. al., 2014), through 4

separate ports with Trendelenburg reversal of the patient after pneumoperitoneum with an average time of 103 minutes (from patient arrival to departure).

### **Ergonomic Problems**

The advent of Minimal Invasive Surgery (MIS) has changed the environment of today's operating rooms (Wasielowski et. al., 2017). These operating rooms, which are originally designed for open surgical operations, are not responsive to large equipment used in laparoscopic devices. Although the laparoscopic method has currently become a preferred approach to many practices, the shortage of laparoscopic equipment is critically felt as in the 11 rooms where laparoscopic surgery takes place; only 7 tray Carts exist containing laparoscopic equipment (monitor, insufflator, cold light source, DVD and CCD drawer). These carts are, inevitably, kept outdoors and away from the operating room contributing to personnel's obligation to relocate, reconnect, and reassemble these equipment for each operation. The 6 monitors available include one very low qualified 14 inch, two ordinary 20 inch and four fairly good qualified flat monitors permanently located on the highest floor of each card. The heights of the monitor center to the ground are 1640, 1665, 1680, 1750 mm in the ordinary and flat ones, respectively. The CCD drawer is also placed on the lowest floorboard with a height of 280 and 230, 470, 490 mm from the floor. despite open operations through which only a pack and a set are required, laparoscopic cholecystectomy needs more widespread sets and dishes Including at least one pack cloth (6900 kg) or disposable (approx. 200 g), a small set (2700 g) or a large general (3900 g) dish of homolog handhold (6200 g) laparoscopic dish (6200 g) dish hook and lens (3900 g) and sometimes also dishes of advance (6900 g), the trocar dish (3600 g) and the additional instrument dishes (6100 g). These dishes are also kept in the workroom at a height of 1880 mm from the ground floor and at 5 floors away from the main operating room.

Sets (small and general) and packs (fabric and disposable) are also located in the hall away from the rooms and have the heights of 1040, 830 and 1150,230 mm from the floor, respectively, (Figure 1).



*Figure 1. Sets and packs are located in the hall away*

The hospital surgical beds are of the two types of manual and automatic with the minimum and maximum adjustable heights of 750- 970mm and 700-1000 mm, respectively, adjusted to the surgeon.

The laparoscopic instrument used in cholecystectomy, including Scissor (length 470 and 455 mm), Clip applier (455, 460 and 470 mm), Grasper 470 mm, hook 355 mm, lens and CCD altogether were (395+1353 = 530 mm) (Figure 2).



*Figure 2. The laparoscopic instrument used in cholecystectomy*

To use electro cautery and Ligasure for a dissection, cut and coagulate tissues, a foot pedal should be placed on the floor where the surgeon is standing.

To make an appropriate lighting of the operation field, before and after using the camera, the ceiling-connected siliatic lights are applied. Depending on the presence of one or two residents, the scrub can be placed either on the left or right side of the patient. Since the monitor is adjusted to be placed on the right side of the patient depending on the surgeon location, the distances between the surgical technologist's eye to the center of the image on the right or left are 774 and 1372 mm, respectively, and the average distance between the elbow of the scrub to the ground floor is 1005 mm. The minimum distance traveled by a surgical technologist in each operation include: 18 surgical room to a stoke Set and Pack 42 steps, patient admission 172steps, the pharmacy 118 steps, workshop 148 steps, Recovery for sample delivery 282 steps, record patient profile in the book 20 steps and computer out of the room 32 steps, scrub sink 116 steps, computer in the room 10 steps, set Sialtic light 12 steps, the cautery and the suction device 20 steps, Connect the serum 12 steps, pouring formalin solution 22 steps and unpacking the inside of the commode each is 18 steps

## **2. Methods**

### **2.1. Participants and Procedures**

This study is descriptive analytical and cross-sectional performed after obtaining the code of ethics from Isfahan University of Medical Sciences from March2017 to July 2018, at al-Zahra Hospital ,Isfahan, Iran. A written consent was given to the participants to partook in the study for 5 months.

The study population included 57 (50 females and 7 males) of laparoscopic technologists in the hospital voluntarily enrolled in the study. After considering inclusion criteria (participation in laparoscopic cholecystectomy in scrub and circulatory roles, voluntary and satisfactory partaking in the research, not having any musculoskeletal disorder and history of bone or joint surgery and no pregnancy) and exclusion criteria(The participants dissatisfaction with continuing cooperation, inactivity in the laparoscopic field, reluctance to take photos, leaving and death), 8 people were excluded from the study and 49 people partook in this study to be evaluated at least 2 times and up to 4 times(139 scrub role and 149 circular role).

### **2.2. Data Collection and Procedure**

Initially, the researcher made a list of the most important tasks performed by the circular [bringing pack and surgical sets, opening sterile instruments on the surgical table, pushing or pulling equipment, attaching the delivery of scrub connectors to the corresponding devices(cautery pen, cord, serum set , etc.), Delivery of instrumentation and materials to the surgical team (Cautery Pedal and CCD), patient relocation] and scrub [delivering sterile instruments from the circulatory,

surgical table setup, pulling up the surgical table, helping the surgeon in the field of operation and delivery of dirty tools used to operate the workroom] pre prepared.

In the following days, a two-part general Nordic questionnaire was used containing demographic information (age, gender, weight, height, dominant hand, regular exercise, level of education, work experience, marital status, ergonomic awareness, job satisfaction, visual requirement, satisfaction from the monthly program and the operating room's agent).

The following tool were used to evaluate the persons:

- REBA: An observational method validated and verifiable used to assess the health jobs work statuses.

To evaluate the circulatory (by the researcher) and the scrub (by the occupational health professional) in the tasks determined by rapid entire body assessment, with a digital camera Sony HX1, One or more photos of each task are provided. Then the REBA checklist was scored; also, force exertion rating score (less than 5 kg = 0, 10 kg = 1 and more than 10 kg = 2), hand pairing with load score (load with proper handle = 0, acceptable with hand = 1, unacceptable with hand = 2 and load without handle with inappropriate postures = 3) and activity type (static or dynamic = 1) were involved. Finally, the other person who did not know the details of the checklist for interpretation in the course of the work and the research objectives entered the REBA software. Score 1: negative level of risk that no corrective action is required. 2 to 3: low risk level, further studies are required. 4 to 7: moderate level of risk and corrective action is required.

There are 8 to 10 levels of risk that corrective actions should be implemented in the near future. 11 to 15 levels are very high and immediate ergonomic action is required (Pazouki et. al., 2017).

### **2.3. Data Analysis**

The research data were both quantitative (continuous and consecutive) and qualitative (nominal) and were analyzed using SPSS 20 software. In order to determine the overall risk score of musculoskeletal disorders in the role of scrub and circulatory, descriptive statistics (Mean, standard deviation, percentage and frequency) was applied. For comparing the scores of the two tasks, paired t-test was used. A repeated measure of variance analysis was applied to determine the average risk score in each of the tasks by separating the circular and scrub roles (after assuring that the assumption of sphere was determined by the Makhli test). Then, using the LFB test, two tasks were compared. Finally, we used independent T-test to determine the distribution of musculoskeletal disorders and the comparison of the mean overall risk score of circulatory and scrub.

## **3. Results**

### **3.1. Sample Characteristics**

Approximately 94% of the research population was women (46 women, 3 men). The participants aged 23 to 48 years (mean  $32.17 \pm 6.6$ ) with mean height and weight was 163.8 and 61.8, respectively. Most of the participants were right-handed (83.7%) and job tenure ranged from 1 to 25 years ( $9.26 \pm 6.2$ ). 68.8 % of them were married and 79.6% had no regular exercise.

### **3.2. Working Postures**

The average RBA score for all of the evaluated activities was obtained higher than 6 (Table 1).

Also, the task of the instrument delivery to the surgical team (foot pedal) had the highest score of  $9.29 \pm 1.25$  ( $P < 0.001$ ) and the task of patients transfer had the lowest score of  $6.4 \pm 1.43$  ( $P < 0.001$ ). Based on the score obtained from the scrub tasks shown in Table (2); It was found that the RBA score was between 4 and 6. The lowest score for surgical operation was  $4.3 \pm 1.11$  ( $P < 0.001$ ), and the highest score for delivery of the surgical instrument used in the work room was  $6.1 \pm 1.2$  ( $P < 0.001$ ). Based on the results, (Tables 1 and 2), it was found that the average risk score was significantly different between some tasks of circular and ( $P < 0.001$ ) in a way that the greatest

difference was observed between pedal delivery and patient displacement tasks ( $P < 0.001$ ). Also, the results (table 3) showed that the average overall risk score in the circulatory tasks was higher than that of the scrub ( $P < 0.001$ ).

Table 1. Determining and comparing frequency distribution gender in two groups

Duties	Average RBA score	Standard deviation	F- value	P- value	Difference between two tasks	
1. Bringing Surgery Set and Pack Surgery	6.55	1.43	46.8	< 0.001	1	
					2	0.2
					3	-2.67
					4	0.81
					5	-1.1
2. Open sterile instruments	6.35	1.14	46.8	< 0.001	6	0.41
					2	
					3	-2.87
3. Delivery of tools to the team Surgery	9.22	1.25	46.8	< 0.001	5	-1.32
					6	0.21
					3	
4 Equipment relocation	7.4	1.12	46.8	< 0.001	4	-1.86
					5	-1.55
					6	3.1
5. Attach serum set	7.67	1.25	46.8	< 0.001	4	
					5	-0.31
					6	1.23
6. Patient relocation	16.14	1.43	46.8	< 0.001	5	
					6	1.54

Table 2. Comparison of average risk score in different tasks of scrub role and difference between tasks

Duties	Average RBA score	Standard deviation	F- valu	P- valu	Difference between two tasks	
1. The surgical table set up	5.0	1.2	18.01	< 0.001	1	
					2	0.47
					3	-0.86
					4	0.71
					5	-1.2
2. Prevent the surgical table	4.43	1.1	18.01	< 0.001	2	
					3	-1.33
					4	-1.2
					5	-1.63
3. Delivery of tools from Circulator	5.8	1.1	18.01	< 0.001	3	
					4	0.15
					5	-0.3
4. Help the surgeon	5.61	1.3	18.01	< 0.001	4	
					5	-0.45
5. Deliver tool to work room	6.1	1.2	18.01	< 0.001		

Table 3. Level of risk and priority level of corrective actions based on REBA score in different tasks

Type of duty	RBA score	Danger level	Priority level corrective actions	The need for action Correction and time
Bringing Surgery set and Pack	7	Medium	2	Necessary
Opening sterile instruments	6	Medium	2	Necessary
Deliver the tool to the surgical team	9	Top	3	Essential (sooner)
Equipment relocation	7	Medium	2	Necessary
Attach serum set	8	Top	3	Essential (sooner)
Patient relocation	6	Medium	2	Necessary
the surgical table set up	5	Medium	2	Necessary
Prevent the surgical table	4	Medium	2	Necessary
Delivery of tools from the circulator	6	Medium	2	Necessary
Help the surgeon	6	Medium	2	Necessary
Deliver tool to work room	6	Medium	2	Necessary

#### 4. Discussion

The new method of laparoscopy threatens the ergonomic conditions of surgical technologists working as circulator and scrub. Based on the results, the level of risk for Circulator role was obtained medium and high in each of its tasks. Therefore, implementing ergonomic interventions as well as corrective actions should be taken into account. In a study carried out by Murty et. al. (2010) on 12 endoscopic nurses working in five different tasks, using method, and after 26 observations it was found that the scores related to the back and neck regions in each task were high or very high among the participants (Murty et. al., 2010). In another study in 2017, 62 surgeons, first assistant and scrubs were evaluated by the RUIA method, and it was found that during the surgery almost 95% of people had ergonomic problems among which 37.1% were at high risk (Pazouki et. al., 2017). In our study, the highest risk score of 9.22 was for those participants working with foot pedal. The reason is that foot pedal is located on the floor requiring the person bending trunk and legs more than 90 degrees inducing a high risk of WMSDs (Figure 3). Although the patient transplantation task allocated score of 6/14 which means being at a moderate level it received the lowest score compared to the other tasks.



Figure 3. Participants working with foot pedal



When transferring, the greatest amount of force exertion is concentrated on patient Transferor. Most of the time, circulator holds only the patient's legs with a relatively acceptable posture. However, if the Circulator is positioned on the patient's side, the arms are bent up to 45 to 90 degrees forward and the trunk is also bent more than 60 degrees which impose a high level of risk to the person (Figure 4).



*Figure 4. Transferring, the greatest amount of force exertion is concentrated on patient Transferor*

The average risk score difference between the two tasks of pedal delivery and patient's transferring was the highest ( $P < 0.001$ ). After pedal delivery, CCD used by surgery team had the highest risk score as the CCD was placed at the bottom of the laparoscopic cart slot at less than 500 mm from the floor that required the participants awkward postures to do the task (Figure 5).



*Figure 5. CCD used by surgery team*

Serum attachment is also associated with a high level of high serum holder (7.67 grade) and an unpleasant postures of extension and neck rotation, deviation to the front of the arm exceeds 90 degrees, shoulder height, rotation, and extension of 0 to 20 degrees of trunk (Figure 6).





*Figure 6. Serum attachment is also associated with a high level of high serum holder*

In front of the device, such as the setting of sialtic light (7/4 grade) Surgical technologist has to raise more than 90 degrees of arm, Shoulder up, neck extension and the trunk and the unbalanced position of the legs. This posture can be justified by the attachment of the light to the ceiling and its height from the ground floor (Figure 7).



*Figure 7. The setting of sialtic light*



*Figure 8. To remove cloth pack from the lower floor of the hallway*

If using cloth pack (6900 g) the surgical technologist will have to remove it from the lower floor of the hallway at an altitude of 230 mm from the floor which in this case faces a significant change in posture (Figure 8).

The displacement of heavy dishes (6200 g) stored at high altitudes of the work room encasement (1880 mm) is considered as one of the other ergonomic issues that the circulators were encountered with (Figure 9).



*Figure 9. The displacement of heavy dishes*

Scrub was another role that the surgical technologist was responsible for. According to our findings, the technologists in this role face a medium-risk (4-6) level. Abdullah Zadeh et. al. (2016) also found similar results in his study so that the average score of RBA was 7.7 in three scrub activities (Abdollahzade et. al., 2016). The greatest difference here was between the average risk scores obtained for pulling the table and delivering the tool to the work room as the lowest score was related to the task of pulling the surgery table. This finding can be due to the participants' relatively better postures. In a way that most participants try to approach to the surgical bed (arm deviation forward up to 20 degrees) with holding up trunk in a right posture (straight or bending 0 to 20 degrees) and sometimes slightly bent (0 to 20 degrees) holding the hand in the middle of the table (no abduction of the arms before surgery beginning. In this situation, the worst posture was observed in the wrist (abduction and extensions up to 15 degrees). Noteworthy, sometimes the participants would approach to the table from the side of the surgical bed requiring trunk to be twisted and bent 20 to 60 degrees, following by an unbalanced position of the legs, abduction of the arms, an angle of less than 60 degrees for forearms and the awkward posture of the wrists (Figure 10).



*Figure 10. The displacement of heavy dishes*

In the delivery of tools to the work room although the level of risk is moderate but the highest score is (6/1). At the end of surgery the scrub should put the tool in the sink of the work room. Since the height of these sinks is low individual puts inside the sink one single instrument on the surgical table with a rotating posture and bending 20 to 60 degrees trunk, unbalanced position of the legs, deviation 45 to 90 degrees of arm (Figure 11).



*Figure 11. At the end of surgery the scrub should put the tool in the sink of the work room*

In the help to the surgeon as well although the trunk is almost in perpendicular position but with an average risk level (5.61), it encounters ergonomic problems. Janki also believes in Laparoscopy the neck and back are in the vertical position and static state (Janki et. al., 2017). In the process of tools delivery to the work room, although the level of risk was moderate, the highest score was obtained (6/1). At the end of surgery, the scrub was responsible for putting the tool in the sink of the work room. Since the height of these sinks is low for most of the individuals, they put the devices one by one inside the sink with a rotating posture with a 20 to 60 degree trunk bending, unbalanced position of the legs, and an arm deviation of 45 to 90 degree (Figure. 11). Also, when helping to the surgeon although the trunk was almost in perpendicular position, the average risk level was obtained relatively high (5.61) Janki also believed that in Laparoscopy process the neck and back may be in the vertical position and static state (Janki et. al., 2017). This can be explained by the fact that surgical technologists simultaneously play the both roles of scrub and first assistant. Pazuki also pointed out this issue in his study (Pazouki et. al., 2017). In case of presence only one resident or surgeon, the technologist had to use simultaneously both the right and left hands, respectively, to keep and adjust the camera to accurately transfer the field of surgery image to the monitor with an average time of 4380 seconds and maintaining and tension tightening the grasper for a good exposure for bile bladder with an average time of 2640 seconds. This condition caused the technologist to get an unpleasant static posture due to ports limit which would increase the range of motion to degree 4 (Bartnicka et. al., 2013). The grasper held the right or left hand with tensing it on the right side of the patient where the monitor was located. In this case, two inappropriate ergonomic conditions occur including to reduce the distance to the monitor (mm770) and neck rotation and extension (Figure 12).



*Figure 12. Surgical technologists simultaneously play the both roles of scrub and first assistant*

Previous studies also showed that if the monitor was not in the proper position, extension, bending and static neck rotation may occur. To deliver the tool to the surgeon may mostly require a worse posture. Holding the camera with a hand or grasper and availability of the device on the Mayo table forced the participants to rotate, bend trunk up to 20 to 60, stretching and abduction of the arms, unbalanced position of the legs and the neck rotation and extension (Figure 13).



*Figure 13. To deliver the tool to the surgeon may mostly require a worse posture*

### **Research Constraints**

In this study, the participation of male surgical technologists was very small as a result, the results cannot be safely attributed to the male society. One of the advantages of this research is the evaluation of individuals in a completely real and alive surgical condition and the imaging of a point that is visible to all the angles.

### **5. Conclusion**

The study was conducted for concern about the rapid growth of laparoscopy and the lack of knowledge of ergonomic conditions in surgical technologists. Polling data and observations indicate that there is a real problem in this population with a high level of prevalence of disorders. The roles of both roles raise people with a moderate level of risk. Perhaps this risk is more in the role of a circulatory. As a result, some challenges require new engineering solutions in equipment, Tools and environment, and integration of ergonomics in educational curriculum to adapt the working



conditions to the individual's abilities and characteristics with the aim of increasing the safety, productivity and job satisfaction of the employees.

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