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Evaluation of Ergonomics in Laparoscopic Appendectomy Technique

Mohamed S. Kharoub[1], Emad M. Abdelrahman[1], Ehab M. Oraby[1], Yasser H. Metwally and Mohamed O. El-Shaer[1]

[1]General Surgery Department, Faculty of Medicine, Benha University, Egypt

[2]General Surgery Department, Al-Azhar University Hospitals, Egypt

Corresponding Author: Emad M. Abdelrahman **Email:** emadshan301@gmail.com

Tel: O1226763986, **ORCID** https://www.orcid.org/0000-0001-6066-2215

ABSTRACT

Background: Ergonomics in laparoscopy involve some terms as manipulation angle, Azimuth angle, elevation angle, and eye target axis. These parameters are determined after distribution of ports in relation to target organ. Laparoscopic appendectomy doesn't have a standard approach. Many variations are available in port placement and mostly dependent on surgeon's preference. Different port distribution will result in different ergonomics that will positively or negatively affect the task performance.

Objective: The aim of this study was to evaluate the ergonomics in laparoscopic appendectomy technique in terms of working angle, elevation angle, Azimuth angle and eye- hand- target axis.

Patients and Methods: This retrospective study included 55 consecutive patients presented with acute appendicitis who were eligible for laparoscopic appendectomy. Azimuth angle and elevation angles were measured intraoperatively, while images captured from video records of each operation were used to measure manipulation angles. Surgical team discomfort or complaint also had been reported.

Results: In this described technique, manipulation angle was 61 ± 8.3°, elevation angles were 38.9 ± 7° and 34 ± 7°, Azimuth angles were 21.3 ± 5.4° and 63.1 ± 7.3° for right and left surgeon's hand respectively. Operative time was 33.5 ± 9.7 minutes. Smooth performance was achieved in 94.5%.

Conclusion: Surgeons' orientation of ergonomic rules is a must to accomplish a smooth laparoscopic task performance. This proposed technique of laparoscopic appendectomy offers a good ergonomics and excellent cosmetic results.

Keywords: Laparoscopic appendectomy, Ergonomics, Manipulation angle, Azimuth angle.

INTRODUCTION

Acute Appendicitis (AA) is the commonest emergency in abdominal surgery. Laparoscopic appendectomy (LA) is a feasible and safe procedure with worldwide acceptance [1]. Laparoscopic appendectomy offers short hospital stay, less wound complications, less morbidity, and better cosmetic results [2, 3].

Tactile sensation, and binocular vision are missed items in laparoscopic surgery. The fixed portal of entry restricts surgeon's freedom that often be compensated with musculoskeletal burden [4, 5]. Therefore, optimal laparoscopic performance is more likely to be achieved when a surgeon achieves appropriate triangulation of the instrument and camera ports [6].

The "ergonomics" is defined as "the concept of arranging working environment to fit the worker, instead of pushing the worker to fit the environment" [7]. Ergonomics target the human benefits, improve workplace efficiency, reduce cost, decrease waste of materials, and increase work team satisfaction [8].

The port locations in minimally invasive surgery that can affect the surgical performance, surgical outcomes and affect the surgeon's working positions [9, 10]. Ergonomics in laparoscopy involve some terms as manipulation angle, Azimuth angle, elevation angle, and eye target axis. These parameters are determined after distribution of ports in relation to target organ.

Manipulation angle is defined as the angle created between the two working ports in a horizontal plain. Ideally to be 60° (45-75°). Extremes of this angle below 30 or above 90 degrees will have a profound drawback on task performance [11].

Azimuth angle is defined as the angle between the telescope and each single working port in a horizontal plain. Ideal situation is to put the telescope in a central position between the two working ports (contralateral port position) to create an equal Azimuth angle for each port (30°). This ideal arrangement is not usually available as in appendectomy operations in which case the ipsilateral port position is more suitable [12, 13].

Elevation angle is defined as the angle between each single working port and the target tissues in a vertical plain. In general words, the elevation angle should be equal to the manipulation angle i.e., in cases with manipulation angle is 60 °, the elevation angle should be 60° [11, 14].

Laparoscopic appendectomy doesn't have a standard approach. Many variations are available in port placement and mostly dependent on surgeon's preference. Different port distribution will result in different ergonomics that will affect the task performance either positively or negatively [9, 15, 16]. And this had motivated the authors to conduct this study.

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PATIENTS AND METHODS

Study design and subjects: This retrospective study was conducted at Department of General Surgery, Benha University Hospital and Al-Azhar University Hospitals after obtaining approval from local ethical committee and after fully informed written consent was signed by patient. This study included 55 consecutive patients. 48 cases presented with acute appendicitis, while 7 cases were diagnosed as subacute appendicitis through the period from December 2020 to March 2023.

Inclusion criteria: All patients presented with clinical manifestations of AA with RIPASA score more than 7.

Exclusion criteria: Patients with ASA score more than 3 or who had contraindications for laparoscopic surgery. Also, patients presented with appendicular mass or abscess.

Patient data (age, sex, and complaint) were recorded. Other data as comorbidities, BMI, operative time, simple or difficult case, hospital stay, and postoperative outcomes also were noted.

Procedure: All patients were prepared to general anesthesia by routine lab investigations and pelviabdominal Ultrasound. Preoperative administration of 3rd generation cephalosporin plus metronidazole infusion. All cases received gastric care medications (proton pump inhibitor plus Metoclopramide hydrochloride 10 mg).

Operating room (OR) setup was implemented (Figure 1)**.** After induction of anesthesia, abdominal wall antiseptic application, and standard toweling. Abdominal examination under anesthesia was carried out to palpate any masses. Extended index and thumb fingers of left surgeon's hand were used to locate position of first port. Tip of index finger was placed on McBurney's point while the tip of thumb was drawing the arc line for port positions (telescope port and first working port). Telescope port is located on that arc opposite or just higher than the umbilical level towards the left midclavicular line **(Figure 1)**.

In this study, 3 ports sized 5 mm were used and abdominal insufflation started. Telescope (30°- and 5-mm diameter) was used. Possible injuries after blind port insertion were routinely ruled out. Abdominal exploration and confirmation of appendicitis were carried out.

Putting the table in the Trendelenburg position and tilting up the right side were taken to benefit from the gravity to take bowel and omentum away from the operative field. First working port (P_1 = Surgeon's right hand) was inserted somewhere lateral to inferior epigastric vessels at or below the level of left anterior superior iliac spine along the previously determined arc. Also, the second working port (P_2 = Surgeon's left hand) was inserted lateral to the right inferior epigastric vessels, related to right anterior superior iliac spine, and below the cecum level. The second working port position is obligating the surgeon's left hand to cross over the patient midline. The left working instrument (P_2) was better to be grasped in a reversed manner to put the left surgeon's wrist in a slight dorsiflexion, which is better functional position instead of the locking palmar flexion position.

Two bowel graspers were used to mobilize the omentum and small bowel towards left upper abdominal quadrants. Grasping of appendix and retracting it upward and medially was carried out by left working port. This step can be accomplished directly or after release of lateral peritoneal attachment of the cecum **(Figure 2).** This important step helped to shift the operative field upwards and medially and this step brought the target tissues and working instruments in better ergonomic situation.

Devascularization of the appendix mostly was completed by the monopolar hook. The aim of this step was to get the appendix completely bared from the fatty tissues for easier specimen extraction. Handmade Endo-loop was used to control the appendicular stump **(Figure 3)**. Division of appendix, peritoneal toilet and ensuring hemostasis was accomplished. Specimen was taken out through the left port site after minimal dilatation. Skin was closed by simple stitches for better final aesthetic outcome **(Figure 4)**. Regimen of early and gradual oral intake was applied successfully in all cases. Patients routinely discharged after 8-36 hours (12.76 ± 4.9). Patients were scheduled to first post-operative outpatient visit on fifth day for checking wound status and then wound exposure.

Methods for ergonomic evaluation: Azimuth angle and elevation angles were measured intraoperatively. While images captured from video records of each operation were used to measure manipulation angle **(Figure 5)**. Any surgical team discomfort or complaint also had been reported.

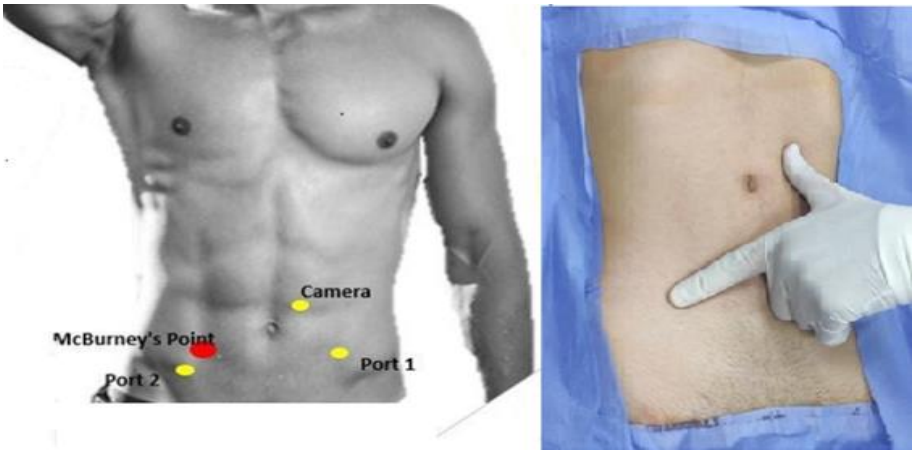

Figure 1: Operation set up and localizations of the port sites

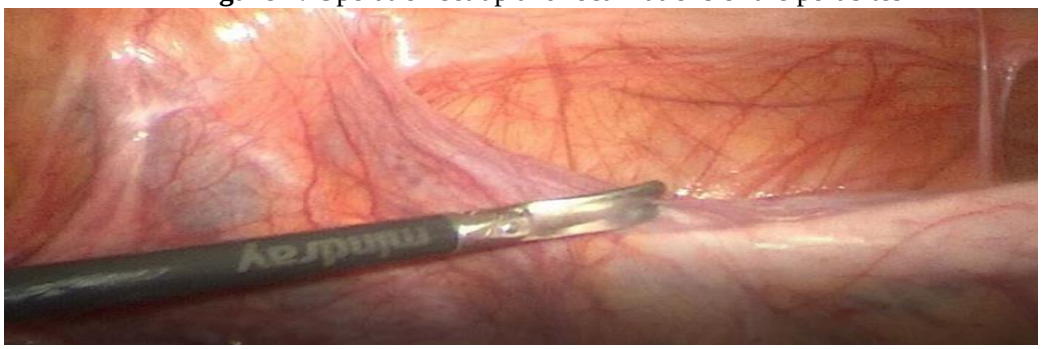

Figure 2: Release of peritoneal reflexion

Figure 3: Devascularization an end-loop application.

Figure 4: closure of the port sites with simple stitches

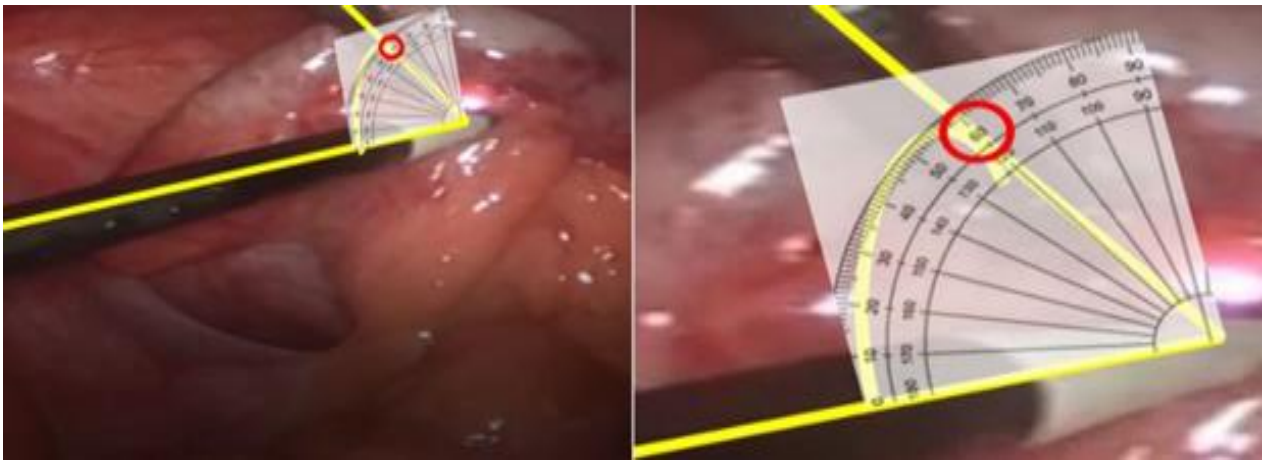

Figure 5: Azimuth angle and elevation angles.

Post- operative evaluation:

Early postoperative complications including, postoperative nausea and vomiting (PONV), ileus, wound infection, intraperitoneal abscess, or peritonitis were documented. All patients were evaluated for postoperative pain by visual analogue scale (VAS) [17] within the first 24 hours. Also, the hospital stay was reported. Cosmetic outcome of the surgical scars was evaluated 1 month postoperatively subjectively (by the patient) and objectively through Manchester scar scale (MSS)[18].

Ethical approval:

The current retrospective study was conducted after approval of The Ethical and Research Committee, Benha University (RC 25-3-2023). This study was executed according to the code of ethics of the World Medical Association (Declaration of Helsinki). Every patient signed a written informed consent.

Statistical analysis

SPSS (version 20) was used for the statistical analysis of the data. Statistics were considered significant if $P \leq 0.05$. As AUC 0.7 was regarded as good, the ROC curve was also utilized to calculate the AUC, sensitivity, and specificity of all markers.

RESULTS

This current retrospective study included 55 consecutive patients with a mean age at presentation was 32 ± 5.7 years, 48 patients (87.3%) presented with acute appendicitis and 7 patients with subacute appendicitis (12.7%), 16 males (29.1%) and 39 females (70.9%) (Table 1).

Table 1: Sociodemographic data

Patients	**N=55**
Age Mean± SD	**32± 5.7 years**
Sex	
Male N (%)	**16 (29.1%)**
Female N (%)	**39 (70.9%)**
BMI Mean± SD	**24.12±4.2 Kg/m²**
Presentation	
Acute Appendicitis N (%)	**48 (87.3%)**
Subacute appemdicitis N (%)	**7 (12.7%)**

In this study, 49 (89.1%) cases were found to be simple operative cases**.** These cases showed minor adhesions, mobile appendix and minimal peritoneal reaction. On the other hand, 6 (10.9%) cases proved to be difficult with considerable omental and/or bowel adhesions and significant peritoneal and pelvic purulent exudate. Two cases of these (3.6%) were perforated at tip with limited peri appendicular localized abscess formation. Cases with pelvic collection required copious suction irrigation.

This step was completed with some struggling in 3 (5.5%) cases, which showed thick purulent pelvic collection. Struggling was attributed to disturbed hand eye display axis alignment. This situation was corrected by moving the display monitor toward foot of the patient. All these difficult cases required insertion of pelvic drain through the site of right port. No case required conversion to open surgery (Table 2).

Table 2: Intraoperative data

Ergonomics		
Manipulation angle	**Mean± SD**	**61°±8.3°**
Elevation angle		
Angle 1*	**Mean± SD**	**38.9° ± 7°**
Angle 2*	**Mean± SD**	**34°± 7°**
Azimuth angle		**21.3° ± 5.4°**
Azimuth 1**	**Mean± SD**	**63.1° ± 7.3°**
Azimuth 2 **	**Mean± SD**	
Operative duration	**Mean± SD**	**(33.5 ± 9.7)**
Presentation		
Acute not complicated A	**N (%)**	**49 (89.1%)**
Complicated A	**N (%)**	**6 (10.9%)**
Feasibility of procedure		
Smooth performance	**N (%)**	**52 (94.5%)**
Struggling	**N (%)**	**3 (5.5%)**
Open conversion	**N (%)**	**0(0%)**
Team\discomfort	**N (%)**	**0(0%)**

*Elevation angle 1= angle between right working instrument and patient body in vertical plain, *Elevation angle 2= angle between left working instrument and patient body in vertical plain, **Azimuth angle 1= angle between telescope and right working port, **Azimuth angle 2= angle between telescope and left working port.

All the team members reported no musculoskeletal fatigue or undesired physical contact between team members. All cases passed through smooth post-operative course. Seven cases (12.7%) complained of post-operative nausea and vomiting (PONV). Post-operative pain was easily controlled by combination of nonsteroidal analgesics and paracetamol (Table 3).

Table 3: Post-operative data

Post operative follow up	
Pain (VAS) Mean± SD	**3 ± 1.2**
PONV N (%)	**7 (12.7%)**
Wound infection N (%)	**0 (%)**
Other morbidity (intra- peritoneal abscess, peritonitis) N (%)	**0 (%)**
Aesthetic outcome	
Subjective cosmetic satisfaction	**Excellent**
Manchester scar scale Mean ± SD	**4.8 (± 0.5)**

DISCUSSION

Introduction of laparoscopy instead of ordinary open surgery put the surgeons in front of great limitations to their free movements. These restrictions were attributed to working through ports with fixed positions. Unplanned port position may enforce surgeons to face great difficulties in even simple tasks [19, 20]. Previous situations raise the importance of ergonomics in laparoscopic world. Ergonomic rules involve every piece of OR structures even where to put the diathermy pedals and how to arrange cables [21, 22].

Reviewing the literature for different techniques in laparoscopic appendectomy, there were no standard technique for this operation. Different techniques were described with different ports' arrangement. All of them, according to authors' knowledge, described the camera port to be in the peri-umbilical region. Authors believe that this location for camera port offers a better cosmetic result but has some disadvantages as being very close to operative field. This proximity to target tissues results in limited space for telescope and frequent contact with tissues and repeated fogging of telescopic lens.

Arrangement of surgical team members around the operative table in this discussed technique offer no physical contact between team members; surgeon, camera holder and nurse. On the other hand, other techniques with ports are closely related to each other mostly associated with some physical contact between surgeon and camera holder [15, 16, 23, 24]. Direct entry of first port was found to be rapid, safe, and feasible approach. This concept matches with what reported by **Vilos *et al.*** [25] that one blind step is better than 3 blind steps: Verres needle insertion, insufflation, and trocar insertion.

In this study, the two working ports were placed in the lower abdomen at or below the level of anterior superior iliac spines. This location offers a mostly hidden site for small scar of 5 mm ports. Moreover, widely spaced ports offer more ergonomic environments for meticulous dissection and smooth performance. Measured manipulation angle, Azimuth angles (1 & 2), and elevation angles (1 & 2), were 61 ± 8.3°, 21.3 ± 5.4°, 63.1 ± 7.3°, 38.9 ± 7° and 34 ± 7° respectively**.** On the other hand, other techniques mostly with crowded ports, not sufficiently spaced, create a narrow manipulation angle. According to authors' knowledge, no previous studies measured these angles in their proposed techniques.

In this study, the suprapubic inferior location of working ports, offer the inferior attack of the appendix and the whole right colon. In this perspective, the precise safe dissection of the appendix is smoothly feasible. On the other hand, attacking the appendix from above downwards, usually facing the appendix partially hidden behind the bulky cecum and terminal ileum. In situations necessitating cecal mobilization, usually not a simple task if attacking from above downwards. The difficulty in this approach appeared when the operation required more pelvic manipulation as pelvic collection. Dealing with pelvic viscera through this arrangement of ports and monitor display creates a misaligned eye hand target axis. This disturbance makes the task so difficult. This difficulty can be solved either by second monitor or moving the available monitor toward the patient foot.

In this study, no musculoskeletal fatigue was documented by any team member. This status of comfort can be attributed to the ergonomic arrangement of OR machines and instruments. Also, due to relatively short operative time. No difficulty was noted in relation to the changes in BMI. This finding matches with those reported by **Liang *et al.* [26]**.

CONCLUSION

Surgeons' orientation of ergonomic rules is a must to accomplish a smooth laparoscopic task performance. Also, this ergonomics orientation makes the surgeon to avoid undesired difficulties. This proposed technique of laparoscopic appendectomy offered a good ergonomics that enables the surgery team to complete the task with smooth performance and low musculoskeletal burden. Moreover, this approach gave the patient less pain, potentially hidden scars with excellent cosmetic results.

Conflict of interest: NIL
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