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Reliability of port entry techniques applied in laparoscopic surgery and their effects on post-operative outcomes

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ABSTRACT

Introduction: The aim of this study is to show the reliability of three different access techniques (Hasson Technique [HT], Veress Needle Technique [VNT], and Direct Trocar Technique [DTT]) commonly used in laparoscopic surgery and to investigate their effects on the early and late outcomes.

Materials and Methods: This single-center cohort study was designed as a retrospective study (between May 2019 and July 2020) at a tertiary health center with 290 patients. Pre-operative, operative, and post-operative parameters were gathered from hospital archive system. Post-operative outcomes were divided into two categories: Early outcomes and late outcomes. Early outcomes were defined as complications detected within the first 30 days after surgery, while late outcomes were defined as complications occurring between 30 days and 1 year. The differences of the investigated parameters in the three insertion techniques were evaluated statistically.

Results: HT was used in 113 (39%) patients, VNT in 104 (35.9%), and DTT in 73 (25.2%) patients. DTT was a preferred method at younger ages (P<0.001). Twelve (4.1%) patients had complications during the first trocar insertion. While both operative complications and visceral injury were higher in the DTT group, the rate of vascular injury was the same between all groups. The early outcomes were seen in 34 (11.7%) patients.. The rates of both subcutaneous emphysema and ecchymosis were significantly lower in the HT group, P=0.011 and P=0.008, respectively. On the other hand, late outcomes were seen in 9 (3.1%) patients. The rates of late outcomes were similar between all groups.

Conclusion: HT is a reliable method for the first trocar insertion due to the low rates of operative complications, and low incidence of early complications.

Keywords: Complication, Laparoscopy, Surgical instruments

Introduction

The first laparoscopic procedure in human history was performed by Hans Christian Jacobaeus in 1910.[1] Since then, there have been continuous advances in the laparoscopic procedure and techniques. Compared to open surgery, laparoscopy has numerous benefits such as less post-operative pain, early return to normal activities, and fewer post-operative complications.[2]

The basic step in laparoscopic surgery is to enter the abdominal cavity and create a pneumoperitoneum. Despite the numerous advantages of laparoscopic surgery, many complications may develop during the insertion of the

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first trocar into the abdomen.[3] Complications related to trocar insertion occur in 2% of patients. The rates of major vascular and abdominal organ injuries were reported as 0.03–0.1% and 0.08–0.14%, respectively.[4,5] Although iatrogenic abdominal organ injuries or major vascular injuries are rarely encountered at the time of entry, they are potentially life-threatening complications when they develop.

Many modalities of laparoscopic access methods have been developed over the years. The most commonly used ones today consist of closed entrance (with Veress needle), open entrance (Hasson technique [HT]), direct trocar insertion, disposable shielded trocars, and visiports.[6] Each of these entrance methods used has its own advantages and disadvantages. The HT refers to the open method, in which an incision (usually periumbilical) is made under direct vision of the abdominal wall.[7] The advantage of the HT is that all layers of the abdomen are directly visualized during insertion, and it significantly reduces the rate of iatrogenic complications. On the other hand, Veress needle technique (VNT) refers to the method, in which a Veress needle is used to puncture the layers of the abdominal wall, introduced by Janos Veres, but is a technique that must be applied with caution due to slow insufflation rates and potentially life-threatening complications.[8] Direct trocar technique (DTT) has been described as the blind insertion of the trocar without creating pneumoperitoneum.[6]

In our study, we aimed to show the reliability of three different access techniques (HT, VNT, and DTT) commonly used in laparoscopic surgery and to investigate their effects on early and late outcomes.

Materials and Methods

Patient Selection

This single-center cohort study was designed as a retrospective study after ethical committee approval from Erzurum Regional Training and Research Hospital (Decision number: 2021/13-224). The study was conducted in General Surgery Clinic of Erzurum Regional Training and Research Hospital, Erzurum, Turkey between May 2019 and July 2020. Patients aged 18 years and older who were operated on by laparoscopy were included in the study, while pediatric patients under the age of 18, and pregnant patients were not included in the study. After all filtering, the study was conducted with 290 patients.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Clinical Evaluation

Patients' demographic features (age and gender), body mass index (weight/height^2), operative complication during insertion, operation room time, and post-operative outcomes were gathered. While calculating the body mass index, height in meters and weight in kilograms were used. Post-operative complications were divided into two categories: Early outcomes and late outcomes. Early outcomes were defined as complications detected within the first 30 days after surgery, while late outcomes were defined as complications occurring between 30 days and 1 year. Hospital records, consultation and operation notes, and clinical charts of the patients were evaluated to collect the researched parameters and early outcomes. To confirm the presence of late outcomes, patients were telephoned. Moreover, their hospital admissions were confirmed using the data system of the Ministry of Health, Republic of Turkey.

Surgical Technique

All operations were performed by the same well-trained surgical team. A single laparoscopic access technique was applied to each patient. The choice of entrance technique is left to the surgeon. Three main entry techniques were applied at the entrance of the first trocar: HT, Veress needle insertion, and direct trocar insertion. CO_2 insertion was made only through the first trocar in all cases.

Statistical Analysis

The differences of the investigated parameters in the three insertion techniques were evaluated statistically. Quantitative variables were expressed as mean ± standard deviation (SD), median, minimum-maximum, interquartile range, and interval. Qualitative variables were reported as numbers and percentages. Statistical analyses were performed using the IBM Statistical Analyses for the Social Sciences (SPSS) ver. 21.0 for Windows. In the evaluation of distribution of normality, Kolmogorov–Smirnov test was used. Due to Kolmogorov–Smirnov test results, Kruskal Wallis test was used to compare groups. Chi-square tests (Pearson and likelihood ratio) were used to compare qual-

itative variables. P-value below 0.05 was considered statistically significant.

Results

There were 290 patients who met all study criteria. The mean age of all patients was 43.43 ± 16.21 (19–83), and 150 (51.7%) patients were male. Three different first port entry techniques were used: HT in 113 (39%) patients, VNT in 104 (35.9%), and DTT in 73 (25.2%) patients. The most common performed surgery was cholecystectomy with 35.2%. Although DTT was a preferred method at younger ages (P<0.001), gender distribution and mean rank for body mass index were similar between all groups. Table 1 shows clinical parameters of all patients.

HT was mostly preferred in the first trocar entry in cholecystectomy, while DTT was preferred in appendectomy. Twelve (4.1%) patients had complications during the first trocar insertion: Visceral injury in 8 (2.8%) patients, and vascular injury in 4 (1.4%) patients. Visceral injuries were as follows: Small bowel mesentery injury in four patients, small bowel serosal injury in three patients, and spleen injury in one patient. All small bowel mesenteric injuries were repaired with simple sutures and energy devices to prevent bleeding and herniation, while small bowel serosal injuries were repaired with serosal sutures. On the other hand, first degree splenic capsule rupture occurred in a patient with splenomegaly and the bleeding stopped spontaneously. Vascular injuries were left common iliac artery injury in one patient, middle colic vein injury in two patients, and jejunal artery injury in one patient. In one of the patients with small bowel injury and in the patient with left common iliac artery injury, the injury was repaired with a midline incision. All middle colic vein injuries and jejunal artery injury were repaired with laparoscopy. While both operative complications and visceral injury were higher in the DTT group, the rate of vascular injury was the same between all groups. The median value of operation room time was significantly shorter in the HT group (P<0.001). Comparison of pre-operative and operative parameters between entry technique groups is shown in Table 2.

Early outcomes were seen in 34 (11.7%) patients, and the most common early outcome was hematoma with 3.8%. Four (1.4%) patients had both ecchymosis and subcutaneous emphysema. All hematomas and infections/collections were managed with drainage and daily wound cleaning. No intervention was made in subcutaneous emphysema cases and emphysema resolved spontaneously within 1 week. Mucopolysaccharide polysulfide gel (every 8 h) was used for the treatment of patients with abdominal wall ecchymosis. The rate of both subcutaneous emphysema and ecchymosis was significantly lower in the HT group, P=0.011 and P=0.008, respectively.

Table 1. Clinical parameters of all patients

Parameters	n (%) or Value
Preoperative parameters	
Age (mean±sd)(range)	43.43±16.21 (19-83)
Gender	
Male	150 (51.7)
Female	140 (48.3)
BMI (mean±sd) (range)	29.06±6.19 (17-57)
Operative parameters	
Operation type	
Cholecystectomy	102 (35.2)
Appendectomy	97 (33.4)
Inguinal hernia	60 (20.7)
Sleeve gastrectomy	25 (8.6)
Nissen fundoplication	6 (2.1)
Entry technique	
Hasson technique	113 (39)
Veress needle technique	104 (35.9)
Direct trocar technique	73 (25.2)
Complications during insertion	
Yes	12 (4.1)
Visceral injury	8 (2.8)
Vascular injury	4 (1.4)
No	278 (95.9)
Conversion during port entry	2 (0.7)
Operation room time (mean±sd)(range)	107.75±45.28 (30-219)
Postoperative parameters	
Early outcomes	
Yes	34 (11.7)
Hematoma	11 (3.8)
Infection/Collection	9 (3.1)
Subcutaneous emphysema	8 (2.8)
Ecchymosis	10 (3.4)
No	256 (88.3)
Late outcomes	
Yes	8 (2.8)
Trocar side hernia	6 (2.1)
Prolonged infection	3 (1)
No	282 (97.2)

Table 2. Comparison of preoperative and operative parameters between entry technique groups

Parameters	Entry techniques			p
	Hasson technique (n=113)	Veress needle technique (n=104)	Direct trocar technique (n=73)	
Preoperative parameters				
Age				
Median (IQR)	45 (IQR=23)	43.5 (IQR=28)	31 (IQR=25)	<0.001*
Gender				0.014**
Female	50 (35.7%)	44 (31.4%)	46 (32.9%)	
Male	63 (42%)	60 (40%)	27 (18%)	
BMI				
Median (IQR)	27 (IQR=11)	28 (IQR=4)	28 (IQR=4)	0.241*
Operative parameters				
Operation type				<0.001*
Cholecystectomy	52 (46%)	32 (30.8%)	18 (24.7%)	
Appendectomy	22 (19.5%)	37 (35.6%)	38 (52.1%)	
Inguinal hernia	20 (17.7%)	30 (28.8%)	10 (13.7%)	
Sleeve gastrectomy	13 (11.5%)	5 (4.8%)	7 (9.6%)	
Nissen fundoplication	6 (5.3%)	0 (0%)	0 (0%)	
Complications during insertion				0.002***
Yes	0 (0%)	7 (6.7%)	5 (6.8%)	
No	113 (40.6%)	97 (93.3%)	68 (93.2%)	
Visceral injury				0.016***
Yes	0 (0%)	4 (4.8%)	4 (5.5%)	
No	113 (100%)	100 (96.2%)	69 (94.3%)	
Vascular injury				0.108***
Yes	0 (0%)	3 (2.9%)	1 (1.4%)	
No	113 (100%)	101 (97.1%)	72 (98.6%)	
Conversion during port entry				0.127***
Yes	0 (0%)	2 (1.9%)	0 (0%)	
No	113 (100%)	102 (98.1%)	73 (100%)	
Operation room time Median (IQR)	70 (IQR=41)	110 (IQR=44)	133 (IQR=73)	<0.001*

*Kruskal Wallis test; **Pearson Chi-square test; ***Likelihood ratio test.

Late outcomes were seen in 8 (2.8%) patients and the most common late outcome was trocar site hernia with 2.1%. One patient's delayed wound infection was completely cured on the 42nd day, and the patient was diagnosed with trocar site hernia at the 4th month of follow-up. All patients with trocar site hernia underwent herniorrhaphy with a prosthetic material. In addition, the patients with prolonged infection had diabetes mellitus and received daily wound cleaning with rifamycin 250 mg (one vial per day). The rate of both trocar site hernia and prolonged infection was similar between all groups. Comparison of entry techniques in terms of post-operative outcomes is shown in Table 3.

Discussion

Laparoscopic surgery has developed rapidly in recent years and have become the gold standard in many surgical fields. Laparoscopic surgery provides advantages such as shorter hospital stay, earlier return to daily activities, good cosmetic results, less post-operative pain, and minimal morbidity. The first step in laparoscopic surgery is to create the pneumoperitoneum. Methods used to create

Table 3. Comparison of entry techniques in terms of postoperative outcomes

Parameters	Entry techniques			p
	Hasson technique (n=113)	Veress needle technique (n=104)	Direct trocar technique (n=73)	
Early outcomes				0.002*
Yes	4 (3.5%)	17 (16.3%)	13 (17.8%)	
No	109 (96.5%)	87 (83.7%)	60 (82.2%)	
Hematoma				0.062**
Yes	1 (0.9%)	5 (4.8%)	5 (6.8%)	
No	112 (99.1%)	99 (95.2%)	68 (93.2%)	
Infection/Collection				0.159**
Yes	2 (1.8%)	6 (5.8%)	1 (1.4%)	
No	111 (98.2%)	98 (94.2%)	72 (98.6%)	
Subcutaneous emphysema				0.011**
Yes	0 (0%)	6 (5.8%)	2 (2.7%)	
No	113 (100%)	98 (94.2%)	71 (97.3%)	
Ecchymosis				0.008**
Yes	1 (0.9%)	2 (1.9%)	7 (9.6%)	
No	112 (99.1%)	102 (98.1%)	66 (90.4%)	
Late outcomes				0.764**
Yes	4 (3.5%)	2 (1.9%)	2 (2.7%)	
No	109 (96.5%)	102 (98.1%)	71 (97.3%)	
Trocar side hernia				0.131**
Yes	4 (3.5%)	2 (1.9%)	0 (0%)	
No	109 (96.5%)	102 (98.1%)	73 (100%)	
Prolonged infection				0.164**
Yes	1 (0.9%)	0 (0%)	2 (2.7%)	
No	112 (99.1%)	104 (100%)	71 (97.3%)	

*Pearson Chi-square test; **Likelihood ratio test.

pneumoperitoneum were HT, VNT, and DTT. In the HT, all layers of the abdominal wall are passed, and the abdomen is reached under direct vision. The trocar is bluntly placed into the abdominal cavity, and then, gas insufflation is started. In the VNT, the Veress needle is inserted into the abdomen blindly and the trocar is inserted blindly after gas insufflation. In the DTT, on the other hand, trocar entry is made directly blindly without creating gas insufflation. This technique is not a reliable method because it is formed by placing the sharp-tipped trocar into the abdomen blindly and is the least used method today.[6,9] In terms of reducing the risks that may occur in blind entry techniques, the open entry technique is a more widely used method. However, the debate on the most appropriate method still continues. In this study, the most frequently used technique was HT with 39%, which is compatible with the literature. The least used technique was DTT with 25.2%.

Complications from trocar insertion occur in approximately 2% of patients undergoing laparoscopic surgery, and more than half of these occur during initial insertion.[10] Injuries can be seen in visceral organs or vascular structures in the abdominal wall. In the HT, passing the anterior abdominal wall layers under direct vision and then placing a blunt-tipped trocar minimizes possible vascular and visceral injuries. With VNT or DTT, there are potential damages that can be caused by both a sharp-tipped trocar and a Veress needle. In the study of Molloy et al., the highest rate of vascular injury was seen

at the entrance with Veress needle, and vascular injury was seen the least in the HT. In addition, visceral injury was most frequently seen in the DTT.[11] In a meta-analysis including 7,389 cases, in which laparoscopic access techniques were evaluated, no significant difference was found between the techniques in terms of preventing vascular or visceral organ damage from the first trocar insertion.[12] In another meta-analysis comparing HT and VNT, the rate of vascular injury was 0.44% in VNT and 0% in HT. In the same meta-analysis, the incidence of intestinal injury was 0.7% in VNT and 0.5% in HT.[13,14] In the study of Pryor et al., the rate of major vascular injury was reported as 0.03–0.1%, and the rate of abdominal visceral injury was reported as 0.08–0.14%. However, no statistically significant difference was observed between the techniques in terms of complications in the same study.[4] On a non-randomized comparison, the bowel and major vessel injury rates were 0.04% and 0.01% in VNT and 0.19% and 0% in HT, respectively.[15] Among the patients included in the present study, no vascular injury was observed in the HT group, while vascular injury was observed in one patient in the DTT, and in three patients in the VNT. Although not statistically significant, the absence of vascular injury in the HT technique is consistent with the literature. In addition, while visceral injury was not observed in any patient in the HT group, serosal injury was observed in four patients in each of the VNT group and DTT group, which did not require additional surgical intervention.

The most common early post-operative complications after the first trocar injury were bleeding/hematoma, infection/collection, subcutaneous emphysema, ecchymosis, pneumothorax, and pneumomediastinum, while the most common late complications were prolonged infection, port site hernia, and delayed wound healing. [16] Trocar site bleeding and associated abdominal wall ecchymosis are common in patients with thick abdominal wall due to obesity, increased adipose tissue, large trocar entrances, and in cases, where the incision is widened for exploration. In the study of Karthik et al., the incidence of trocar entry site bleeding was reported as 0.7%.[17] On the other hand, hematoma/ecchymosis rate after DTT was 0.36% in the study of Ulusoy et al.[18] Bleeding at the first port of entry is mostly associated with tissue damage resulting from repeated attempts. On the other hand, it is recommended that trocars be placed under direct vision by illuminating the abdominal wall (transillumination), since trocar entry site bleeding is often caused by injury to the epigastric vessels at the secondary trocar entry. Bleeding may not be asymptomatic until the trocar is removed due to the tissue buffering effect of the trocar. For this reason, the entry sites should be carefully evaluated even after the trocar is removed. Studies show that trocar entry site hematoma is more common in VNT and DTT. [12] The reason for this may be due to seeing the abdominal layers in HT and repetitive trials in other techniques. In the present study, hematoma due to trocar entry site bleeding was observed in a total of 11 patients (3.8%), and it was found at a higher rate than the literature. One of the patients was in the HT group, and the other five patients were in both DTT group and VNT group.

CO_2 is used to create the pneumoperitoneum during laparoscopic surgery. It is important to know, where the gas goes when performing the pneumoperitoneum, otherwise subcutaneous emphysema may occur. Gas insufflation without entering the abdominal cavity, inconsistency of incision-trocar size, large number of inserted trocars, multiple attempts at trocar entry, high gas volume, and long surgical procedures increase this risk. For subcutaneous emphysema, the rate in the literature is 0.43–2.3%.[19] Considering the literature data in terms of entry techniques, although there was a slight increase in VNT, no statistically significant difference was observed in terms of techniques.[19,20] In this study, although no emphysema was observed in HT, subcutaneous emphysema was observed in a statistically significant total of eight patients, six in the VNT technique, and two in the DTT technique.

Trocar site hernia seen after laparoscopic surgery occurs due to the inability of the fascia to be closed properly during the operation. In addition, risk factors for trocar site hernia such as obesity, trocar size (>10 mm), malnutrition, and age have also been defined. The overall incidence of trocar site hernia is 1%, but the actual rate is higher since the incidence is detected with symptomatic cases admitted to the hospital.[21] In various series, trocar site hernia was seen less frequently in the open technique.[13] The reason for this is that more reliable closure is made by seeing the layers while entering the abdominal cavity and during closure. On the other hand, prolonged infection is a late outcome of first trocar insertion. Diabetes mellitus is the most important etiological factor. Daily wound cleaning is the main treatment. However, negative pressure wound therapy is a useful but costly procedure used to accelerate wound heal-

ing. In this study, trocar site hernia was observed with a prevalence of 2.1 in a 1-year follow-up, while prolonged infection was observed with a prevalence of 1%. In addition, all patients with prolonged infection had diabetes mellitus.

Limitations and Suggestions

The most important limitation of the present study is that it was conducted on a retrospective basis. Since the time to reach the abdominal cavity from the skin incision cannot be evaluated retrospectively, it is an important shortcoming of the study. In addition, we believe that comparing entry techniques in the same operation type will yield more accurate results. There is a need for prospective studies, especially for the close follow-up of the post-surgical outcomes.

Conclusion

Creating a pneumoperitoneum is a critical step in laparoscopic surgery. Although the open access technique is generally recommended in the literature, there is no consensus, on which trocar entry technique is the most appropriate to reduce complications. From the results of the study, it is found that HT is a reliable method for the first trocar insertion due to the low rate of operative complications, shortening the operation time, and low incidence of the early complications. Awareness of potential complications, their early detection and treatment are essential elements of high-quality surgery. Complications can be seen even under direct vision, and surgeons must work with great care and diligence.

Disclosures

Ethichs Committee Approval: Ethics committee approval was received from Non-invasive Clinical Research Ethics Committee of Erzurum Regional Education and Research Hospital, Erzurum, Turkey (Decision number: 2021/13-224).

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