

Comparative study among cine-magnetic resonance imaging, ultrasound, and periumbilical ultrasound-guided saline infusion in high-risk patients for subumbilical adhesions before laparoscopic entry

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Abstract Abdominal entry at the time of laparoscopy remains the most critical step in laparoscopic surgery. Transabdominal ultrasound (TAU) and cine magnetic resonance imaging (cine-MRI) are both non-invasive tools in the preoperative prediction of adhesions. Ultrasound is effective in detecting abdominal wall adhesions, but MRI is the best for intra-abdominal adhesions. Periumbilical ultrasound-guided saline infusion (PUGSI) is an excellent method for detecting subumbilical adhesions. Evaluate the most effective and rapid method for diagnosis of subumbilical adhesions before laparoscopic interference in gynecological practice. This study was carried out on 90 high-risk patients for subumbilical adhesions. All patients were subjected to medical history, physical examination, laboratory investigations, and three techniques for subumbilical adhesions detection before laparoscopic entry including cine-MRI, TAU, and PUGSI. PUGSI for detection of subumbilical adhesions showed that the sensitivity of 94.7 % and a specificity of 90.1 %. With preoperative TAU, a sensitivity of 89.5 % and a specificity of 88.7 % were obtained. With cine-MRI, a sensitivity of 78.9 % and a specificity of 84.5 % were obtained. PUGSI is a more sensitive and rapid method than TAU and cine-MRI for detection of subumbilical adhesions before laparoscopic gynecological surgery.

Keywords Adhesions · Laparoscopy · TAU · PUGSI and cine-MRI

Introduction

Prevalence of adhesions after abdominal surgery between tissue and organ reached up to 93 % following laparotomy [1].

Intra-abdominal adhesions between the previous abdominal scar and the underlying viscus such as the bowel or omentum are common sequelae of laparotomy. Prevalence of abdominal wall adhesions after abdominal surgery is estimated between 68 and 82 %. Patients with midline abdominal incisions had more adhesions (59 %) than did patients with Pfannenstiel incisions (27 %) [2, 3]. Accurate diagnosis of intra-abdominal adhesions would be highly valuable [4].

Abdominal entry is the most risky step during laparoscopic surgery, because laparoscopy begins with a trocar or Veress needle insertion into the abdomen with subsequent risk of injury to the underlying viscera that may be adherent to the anterior abdominal wall [5].

Preoperative detection of adhesions is difficult. However, previous abdominal and pelvic surgery, endometriosis, peritonitis, and pelvic inflammatory disease can help to predict the probability of adhesions during laparoscopy [2].

Today, there are different methods to predict abdominal wall adhesions including transabdominal ultrasound (TAU), cine magnetic resonance imaging (cine-MRI), and periumbilical ultrasound-guided saline infusion (PUGSI).

Visceral slide test is the movement of intra-abdominal viscera either spontaneously or as the result of breathing movements, manual compression, or Valsalva. Normal movement of intra-abdominal viscera is 2–5 cm longitudinally and 1 cm transversely. It is useful only for detection of adhesions to the

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abdominal wall. This test is used either with TAU or cine-MRI. Restricted sliding as a result of adhesions is less than 1 cm in either direction [6].

Transabdominal ultrasonography and cine-MRI are both non-invasive tools in the preoperative prediction of intra-abdominal adhesions. Ultrasound is less expensive and more acceptable for patients, but MRI may be better at detecting particular types of adhesions [7].

TAU can be used in high-risk patients scheduled for laparoscopy to rule out spontaneous adherences or vascular abnormalities in order to plan a safe approach to the abdominal cavity, reduce visceral and vascular complications, and extension of operative time [8].

Transabdominal ultrasonography may be less accurate in the lower one third of the abdomen because the degree of visceral slide is hampered by the lack of respiratory force transmitted to this area. However, all the trocar sites evaluated were above the umbilicus [9].

Cine-MRI has been evaluated for the detection of intra-abdominal adhesions. Cine-MRI is particularly useful at detecting adhesions between intra-abdominal organs, whereas TAU is effective in detecting adhesions involving the abdominal wall [10].

PUGSI technique improves preoperative prediction of both the presence and absence of subumbilical adhesions during laparoscopy in patients with previous abdominal operations and infection [11].

Therefore, this study was performed to evaluate the most effective method for prediction of subumbilical adhesions in high-risk patients before laparoscopic entry.

Patients and methods

This study was conducted in the Department of Obstetrics and Gynecology, Faculty of Medicine, Zigazag University, Egypt, from May 2012 to October 2014. The present study was carried out on 90 women with risk factors for intra-abdominal subumbilical adhesions. Inclusion criteria were age 18 years or older, previous surgery as Cesarean delivery, ovarian cystectomy, myomectomy, or exploratory laparotomy and history of pelvic inflammatory disease. Participants were interviewed for medical history, physical examination, and laboratory investigations.

Functional cine-MRI

Cine-MRI was performed 24 h before laparoscopic interference with a 1.5-T system (Sonata/Avanti; Siemens Erlangen, Erlangen, Germany). No pre-medication or contrast media was administered. The abdomen was screened by using single-section true-fast imaging with a steady-state precession sequence (field of view, 400 mm; matrix, 256 × 256; flip angle, 50°; section thickness, 5 mm) [12]. One cycle consisted

of 10 consecutive measurements in the same position, with one frame acquired every 1.3 s. The patients were asked to increase intra-abdominal pressure and then to relax. Transverse images covering the abdomen in a craniocaudal direction and sagittal images covering the abdomen from right to left were taken. The mean distance between two cycles was 1.5 cm. Depending on patient body dimensions, 300 to 400 images were acquired. The mean examination time was 25 min.

Two experienced radiologists evaluated both the transverse and the sagittal cycles of cine-MRI blinded to the intra-operative findings. Distortion of adjacent organs, a missing separation between them, and a missing normal excursion along the peritoneal layer within the section orientation were used as MRI criteria for diagnosis. The depicted adhesions on MRIs were classified according to the location on the abdominal map; nine abdominal segments divided by two vertical lines along the borders of the rectus abdominis muscle, a transverse line across the inferior costal margins, and another transverse line across the iliac crest and according to the involved structures. The transverse and sagittal images were integrated in a movie of cine-MRI findings.

Transabdominal ultrasound

It was performed in the operating room with a senior radiologist, without anesthesia with the patients in supine position. Portable ultrasound with a 7-mHz real-time abdominal probe (convex type) was used in the periumbilical region along the sagittal plane to measure the displacement of viscera more than 1 cm beneath the umbilicus through several cycles of inspiration. The diagnostic criterion for predicting subumbilical adhesions by TAU was a visceral slide of less than 1 cm.

Periumbilical ultrasound-guided saline infusion

Under general anesthesia, tenting up the abdominal wall with lateral towel clips was performed. Then, a sterile 22-gauge spinal needle on a syringe was advanced through the skin and the subcutaneous layers under the ultrasonic guidance; once beyond the peritoneum, 10 mL of sterile normal saline was infused and monitored with TAU to assess for dispersion or loculations. The diagnostic criterion for predicting subumbilical adhesions by PUGSI was negative dispersion of saline or presence of loculations or both.

Before pneumoperitoneum, if there was any concern regarding subumbilical adhesions, either an alternative site of entry was chosen which is the left upper quadrant entry (Palmer's point entry) or open laparoscopy method for port placement. Otherwise, direct trocar entry at a 90° angle was performed using a 10-mm port. Adhesions under the umbilicus were categorized as obliterating or non-obliterating.

Obliterated adhesions were defined in accordance with the operative laparoscopy group as adhesive, thick tissues including intra-abdominal organs such as the small or large bowel that would prevent a safe laparoscopic entry at the site of the umbilicus [13].

All data were analyzed using statistical software package for social science (SPSS/version 17, Inc., Chicago, IL, USA). Mean (\bar{x}) and standard deviation (SD) of the data were calculated. Prevalence rate, sensitivity, specificity, PPV, NPV, and diagnostic accuracy were calculated using the laparoscopic findings as the gold standard.

Results

The distribution of patients according to indications of laparoscopy was shown in Table 1. In Table 2, the sensitivity and specificity for MRI are 78.9 and 84.5 %, respectively. In Table 3, the sensitivity and specificity for TAU are 89.5 and 88.7 %, respectively. In Table 4, the sensitivity and specificity for PUGSI are 94.7 and 90.1 %, respectively..

Discussion

Visceral injury if bowel adherent beneath the umbilicus can occur when placing a blind trocar or gas insufflation needle through the umbilicus [14]. The majority of trocar-related injuries occur when the trocar penetrates too far into the abdominal cavity or when the viscera are too close to the abdominal wall, mostly due to adhesions from a previous abdominal surgery [15]. Therefore, assessment for the presence of adhesions before laparoscopy should be a key factor in planning the approach and hence minimizing the risk of visceral injury.

As regards TAU, our results are concordant with [3]) who showed that with TAU, a prevalence of subumbilical bowel adhesions was 12 %. A visceral slide threshold ≤ 1 cm to predict adhesions had sensitivity of 86 % and specificity was 91 %.

[8] studied 60 patients for visceroparietal adhesions by TAU and reported that 56 out of 60 patients (93.3 %) have abdominal wall adhesions. In 2 patients (3.3 %), subumbilical

Table 2 Preoperative MRI findings of subumbilical region for detection of adhesions

	Laparoscopic findings		
	Without adhesions	With adhesions	
MRI without adhesions	60	4	64
MRI with adhesions	11	15	26
	71	19	90

adherences were underestimated, and in 2 patients (3.3 %), they were overestimated.

[16] showed that TAU compared with cine-MRI for detection of abdominal wall adhesions is an easily available examination that can be performed preoperatively and highly predictive for bowel adhesions to the abdominal wall.

As regards cine-MRI technique, our results are in agreement with [17] who showed that with cine-MRI for adhesion detection, there is an accuracy rate of 90 %, a sensitivity of 93 %, and a specificity of 25 %. The low specificity of 25 % is explained by the very low number of patients found without adhesions. Other study showed that an accuracy rate of cine-MRI in predicting intraoperative adhesion findings was between 85 and 90 % [10].

In addition, [6] showed that with cine-MRI, it showed a sensitivity and specificity of 21.5 and 87.1 %, respectively. TAU showed a sensitivity and specificity of 24 and 97.9 %, respectively. Comparison of TAU and cine-MRI showed no significant difference in the detection of adhesions to the abdominal wall; however, TAU was significantly superior in depicting adhesion-free areas.

As regards PUGSI technique, our results are concordant with Nezhat et.al [5] who showed that preoperative TAU in high-risk patients before trocar insertion had an accuracy of 96.4 %, sensitivity of 50 % and specificity of 98.1 %, PPV of 50 % and NPV of 98.1 %, while PUGSI test had sensitivity and specificity of 100 %. Other study showed that with PUGSI, a prevalence rate of subumbilical adhesions was 93.3 % with sensitivity 93.8 %, specificity 93.2 %, PPV 83.3 %, and NPV 97.6 % [11].

Table 1 Distribution of patients according to indications of laparoscopy

Indications	Patients ($n = 90$)	Percent
Infertility	62	68.9
Chronic pelvic pain	8	8.9
Ovarian cystectomy	12	13.3
Ectopic pregnancy	8	8.9

Table 3 Preoperative transabdominal ultrasonography findings of subumbilical region using visceral slide test (distance ≤ 1 cm)

	Laparoscopic findings		
	Without adhesions	With adhesions	
U/S without adhesions	63	2	65
U/S with adhesions	8	17	25
	71	19	90

Table 4 PUGSI findings of subumbilical region

	Laparoscopic findings		
	Without adhesions	With adhesions	
PUGSI without adhesions	66	1	67
PUGSI with adhesions	5	18	23
	71	19	90

Conclusion

The three methods

Cine-MRI, TAU, and PUGSI are useful in diagnosing abdominal adhesions, but Cine-MRI is more diagnostic for intra-abdominal adhesions than abdominal wall adhesions in subumbilical region. PUGSI technique is more diagnostic for subumbilical adhesions during laparoscopy entry (trocar insertion). TAU is effective in detecting subumbilical adhesions during laparoscopy entry but less than PUGSI.

Using PUGSI technique for detection of subumbilical adhesions in high-risk patients before laparoscopic entry is beneficial, easy, not costly, minimizing the risk of visceral and omental injuries. However, further studies should be conducted with large number of patients to validate this technique and to determine its effect on informing laparoscopic port selection and decreasing trocar-related complications in comparison with TAU and cine-MRI.

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