Evaluation of the diagnostic potential of trans abdominal ultrasonography in detecting intra-abdominal adhesions: A double-blinded cohort study

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ABSTRACT

Background: Intra-abdominal adhesion is one of the most important complications of abdominopelvic surgery. It increases morbidity and mortality for patients. Although laparoscopy is the gold standard of adhesion diagnosis, it can cause visceral damage during the operation. Therefore, surgeons prefer to use non-invasive methods for planning the operation. We designed this study to evaluate transabdominal ultrasonography (TAU) accuracy for diagnosing Intra-abdominal Adhesions

Material & methods: This double-blinded cohort study was conducted on 47 patients with previous laparotomy who undergo another surgery. Spontaneous visceral slide (SVS) and induced visceral slide (IVS) were measured during TAU.

Results: The mean age and BMI of 47 patients were 43.21 ± 10.3 and 27.545 ± 5.76. The majority of the patients were female (76%). Mean SVS and IVS in patients with intra-abdominal adhesion were 8.73 ± 1.60 and 44.84 ± 11.60. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of TAU in intra-abdominal diagnosis were 83.33%, 51.72%, 51.72%, 83.33%, 63.83%.

Conclusions: Although TAU is an appropriate method for detecting the intra-abdominal adhesion, it isn't good enough for diagnosing free adhesion area. We recommended further researches with greater sample size and other non-invasive techniques.

1. Background

Intra-abdominal adhesion is consisted of abnormal fibrotic tissue. It is one of the most important complications which can be caused by previous abdominopelvic surgery, gynecologic and obstetric disorders such as pelvic inflammatory disease, endometriosis, abortion, peritonitis, radiation in abdominopelvic area and etc. [1–4]. The severity of adhesion is related to type and number of previous surgeries and their complications [1].

Abdominal adhesion is estimated in 20–50% of patients with history of abdominal operation. Although adhesions can occur between all intra-abdominal organs and damaged serosal membranes, it most occurs between omentum and scar sites [3,5,6].

Abdominal adhesion can cause abdominal pain, intestinal complications, infertility and it increases the risk of damages to internal organs, urinary system, vessels, omentum, leading to more bleeding, hematoma, infection, fistula formation, length of hospitalization and risk of reoperation [1,2,6]. These complications augment post-operative morbidity and mortality.

Adhesiolysis is used for management of intestinal obstruction, ileus and chronic abdominal pain. During adhesiolysis, complications can occur, too. One-third of patients undergo adhesiolysis might experience intestinal perforation. Hence, mapping the adhesions and severity should be evaluated before reoperation [2,7].

Laparoscopy is the gold standard diagnostic approach of intra-abdominal adhesion. Surgeon reports the pattern and severity of adhesions in the same abdominal segments [1]. During the entrance of first trocar in laparoscopy procedure, surgeon does not have vision for protecting organs [1,6,8]. However some surgeons start their operations from left upper quadrant or umbilical area as a safe place for

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Table 1
Demographic Data of the subjects.

		Total N = 47	Without Adhesions	With Adhesions	P-value
Age		43.21 ± 10.3	45.03 ± 8.95	41.39 ± 11.64	0.23
Gender	Male	11	9(18.2%)	2(81.8%)	0.22
	Female	36	20(44.4%)	16(55.6%)	
BMI		27.545 ± 5.76	27.75 ± 5.69	27.33 ± 5.41	0.80
Number of previous surgery	1	40			
	2	6			
	3	1			
SVS		10.07 ± 4.23 (5.00–24.00)	10.89 ± 5.11	8.73 ± 1.60	
IVS		46.38 ± 11.33 (17.00–71.00)	47.34 ± 11.26	44.84 ± 11.60	0.47
SVS	≤1 cm	29(61.7%)	14(48.3%)	15(51.7%)	
	> 1 cm	18(38.2%)	15(83.3%)	3(16.7%)	

entrance of first trocar, but the risk of complications have not been reduced [9]. Therefore, Surgeons prefer planning before operation for preventing probable injuries. Transabdominal ultrasonography (TAU) and cine magnetic resonance imaging (Cine MRI) have been suggested as non-invasive methods to diagnose abdominal adhesions [1,10,11].

When the adhesions are created, the intra-abdominal organ movements during respiratory cycles are restricted. TAU detects these movements as visceral slides. Normal visceral movements define motions between 2 cm and ≥5 cm and 1 cm in transverse. In presence of abdominal adhesion these movements are reduced to less than 1 cm [1,11,12].

The goal of our study is to evaluate accuracy of TAU for diagnosis of intra-abdominal adhesions after the abdominopelvic surgery. Correlation between TAU and surgeon observations is used for determining the accuracy of this technique in diagnosis of intraabdominal adhesions.

2. Materials and methods

2.1. Study design and participants

This is a prospective double blinded cohort study which the study protocol was approved by institutional review board of Tehran University of Medical Science (TUMS). Written informed consent was obtained from all participants of the study. This study has been reported in line with the STROCSS criteria: Strengthening the Reporting of Cohort Studies in Surgery [13], and has been recorded in the Research Registry (UIN: research registry 3525). The study population was patients referred to Imam Khomeini hospital during 6 months in 2016 who had previous laparotomy more than 10 days prior to admission with midline incision and subsequent laparotomy was performed on them. Patients with the history of peritonitis, radiotherapy in abdominopelvic area, peritoneal seeding, history of laparoscopy were excluded.

Patients underwent TAU especially in healed surgical scar site by GE logiq5 expert (3.5–5 and up to 10 MHz) one day before upcoming surgery. Patients were examined by ultrasound in supine position. After several normal breathing cycles, a specific site of omentum or intestine beneath healed surgical scar was detected for evaluation. This site movement during each breathing cycle was recorded as spontaneous visceral slide (SVS). Also, the distance was measured during the deep breathing as induced visceral slide (IVS) [11]. the distance less than 1 cm was known as intra-abdominal adhesion.

The single radiologist determined the content of intra-abdominal adhesions. Also, the single surgeon recorded surgery date, type of surgery (laparotomy or laparoscopy), causes of surgery, type of incision and complications during surgery (e.g. perforation, bleeding, …). Then the surgeon reported the adhesion status of scar site in 4 categories: 1) without adhesions, 2) thin adhesions, 3) thick adhesions with omentum, 4) thick adhesions with intestinal loops. Thus, we considered first and second categories as without adhesion and third and fourth

categories as adhesions of scar site. The surgeon was unaware of the radiologic findings at the time of operation.

2.2. Statistical analysis

Two by two tables were used for calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio(LR+), and negative likelihood ratio (LR-). OpenEpi software was used for statistical analysis and p value of less than 0.05 was considered significant. For comparison of categorical data, Fisher's exact and Chi-Square tests were used.

3. Results

We included 47 subjects in our study and we made the comparison based on having or not having adhesions after laparotomy. Mean age was 43.21 ± 10.3 years old with BMI of 27.54 ± 5.76 and majority were female (76%). There was no significant difference between demographic distribution of subjects in groups (p = 0.23). All subjects had prior history of laparotomy with midline incision which 40 of them had just one surgery and 7 of them had history of more than one operation. Iatrogenic complications were not reported during the surgeries. Median SVS and IVS in the study were 10.07 mm (IQR = 5–24) and 46.38 mm (IQR = 17–71) respectively. About 60% of the subjects had SVS of less than 1 cm and the same for IVS less than 1 cm. Detailed report of comparison between groups is summarized in Table 1.

Thirty six percent of the patients were without adhesions, 25% with thin adhesions and the rest with thick adhesions. Value of median SVS and also its range decreased from 11.13 (5–24) to 8.33 (6.3–10.8) by increasing size of adhesion. Simultaneously value of IVS increased from 46.97 (17–71) to 48.85 (24–66).

After drawing two by two tables for two groups, for SVS, true negative, true positive, false negative and false positive rates were 83.3%, 51.7%, 16.7%, and 48.3%, respectively (Fig. 1). Sensitivity of the test was 83.3% (95% CI = 60.78–94.16), specificity was 51.72% (95% CI = 34.43–68.61) and accuracy was 63.83% (95% CI = 49.54–76.03). The rest of the parameters are described in Table 2.

4. Discussion

The purpose of this study is to evaluate the accuracy of TAU in diagnosis of intra-abdominal adhesions in healed scar sites of previous surgery in comparison with surgical observations as gold standard. We observed a high rate of sensitivity and negative predictive value but modest rate of specificity which means the test can be used to rule out the presence of adhesion bands.

Our study just evaluates the patients with previous laparotomy. Manipulation in laparoscopy is less than laparotomy. So, inflammation responses and risk of adhesion creation are reduced in laparoscopy [1]. Laparoscopic adhesiolysis is preferred but the risk of intestinal loop perforation during entrance of first trocar is reported about 31.5% [6].
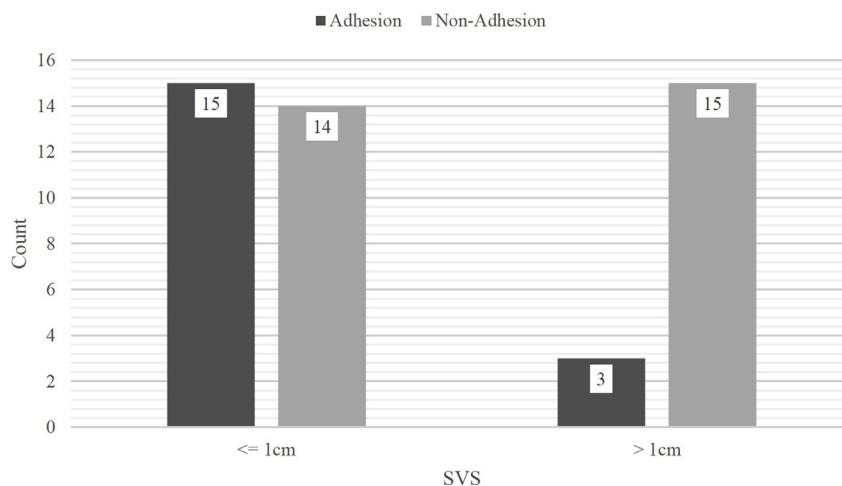
Fig. 1. SVS prediction for intra-abdominal adhesion.

Table 2
Statistical analysis of the procedure.

Parameter	Estimate	Lower	Upper
Sensitivity	83.33%	60.78	94.16
Specificity	51.72%	34.43	68.61
Positive predictive value (PPV)	51.72%	34.43	68.61
Negative predictive value (NPV)	83.33%	60.78	94.16
Accuracy	63.83%	49.54	76.03
positive likelihood ratio(LR +)	1.72	1.46	2.03
Negative likelihood ratio (LR-)	0.32	0.14	0.69

TAU was validated by Marin et al. in 1987 for diagnosis of adhesions [14]. While using visceral slide movements during TAU was introduced for adhesion diagnosis in 1991 by sigel et al. [11].

Several studies considered both spontaneous and induced visceral slide less than 1 cm for abdominal adhesion detection and visceral slide movements between 2 cm and ≥ 5 cm as reported normal [1,5,11,15–18]. We consider SVS < 1 cm as normal evaluation and SVS ≥ 1 cm as intra-abdominal adhesion. Moreover, there is not the similar IVS measurement between studies. Although siegel et al. and Kodema et al. pointed out IVS usually is more than 1 cm in adhesion diagnosis, caprine et al. demonstrated IVS less than 3 cm as abnormal findings [11,12,17]. other studies defined both IVS and SVS the same [1,15,18].

We designed a prospective double blinded cohort study. The surgeons did not have any information about the ultrasonography results and surgeon and radiologist filled separate checklists according to their observations. Among various studies performed on TAU evaluation, only Kothari et al. have conducted their study blinded [19].

According to our study mean patient BMI was higher than 27 in both groups without significant relation with adhesion. Kothari et al. and Aubé et al., had evaluated patients with mean BMI of 48 and 28. Although Aubé and colleagues emphasized that obesity can affect the diagnosis, but also Kothari et al. study shows that omental adhesion was diagnosed more easily in patients with significantly higher BMI [7,20]. The other study in 2010, referred to limitations of TAU in patients with severe obesity and intestinal gas [1].

In present study, we find sensitivity and NPV to be 83.33%. But the specificity and PPV were not high enough and obtained at 51.7% for both. Overall, we measured the accuracy of TAU in detection of adhesion to be 63.83%. It demonstrates TAU is not an accurate test for diagnosis of adhesion free areas.

Lienemann et al. in 2000, identified cine MRI features in diagnosis and mapping of abdominal adhesions for the first time. They reported a sensitivity of 87.5% and a specificity of 92.5% in comparison with intra-abdominal operation. Also, they demonstrated differentiation of adhesion diagnosis in different abdominal segments [10]. Also Lang et al., in 2008 reported the sensitivity and accuracy of cine MRI to be 93% and 90% respectively [21]. Although some studies validate the cine MRI as a non-invasive method, they did not report the cine- MRI accuracy and describe the development of this method [22,23].

Zinther et al., compared TAU and cine MRI as non-invasive methods for detection of intra-abdominal adhesions. There was no significant difference between TAU and Cine MRI. TAU can rule out adhesions significantly better than cine MRI. Accuracy of TAU was reported higher than cine MRI. Sensitivity, specificity, and accuracy of TAU were reported 24%, 97.9%, and 81.3% [1].

Randell et al. identified shaegram technique in cine MRI during respiration. They evaluated 52 patients among 106 patients with suspected dynamic MRI. The shaegram was reported by two groups of radiologists which were expert radiologists for reporting the shaegram and other radiologists. So, the sensitivity of shaegram in expert group and another group were 96% and 93%. Specificity was 81% in both groups. This study showed shaegram technique with high sensitivity is a suitable technique for adhesion diagnosis [24].

In various studies, authors evaluated the features of TAU for detecting the abdominal adhesions. The highest sensitivity of TAU is demonstrated 100% among 24, 130, 323 patients [12,16,25]. The highest specificity is reported 100% among 24 and 124 patients [12,26]. Among these studies, only kodama and colleagues evaluated TAU between two groups of patients with and without history of abdominal operation. Moreover, TAU was considered with no false negative and positive diagnosis. The patients have high BMI and authors pointed out it help to diagnosis easily [12]. Steitz et al. found highest accuracy among other studies (97%) [26]. Table 3 shows the results of studies used TAU for detection of abdominal adhesions.

5. Conclusion

As conclusion, our study shows high level of sensitivity, NPV and accuracy for TAU which can be helpful subsequently for detecting the intra-abdominal adhesions with higher degree of reliability. But due to low specificity and PPV, TAU is not a useful test to diagnose free adhesion areas especially in patients with SVS ≤ 1 cm. So, we can consider TAU is an appropriate diagnostic test in patients with history of abdominal operation who are more probable to have intra-abdominal adhesions. It's necessary for further studies to compare various non-invasive diagnostic tests in different surgical procedures with larger sample sizes. Moreover, we suggest additional researches in IVS cut-off point for adhesion diagnosis. Also, for increasing the accuracy of study and considering the inter-observation bias, future studies with

Table 3
Characteristics of the studies with TAU evaluation for abdominal adhesions detection.

Author	Year	Blinded	NO	Visceral sliding	Sensitivity	Specificity	Accuracy
Kodama et al. [11]	1992	No	24	≤ 1 cm	100	100	NA
Kolecki et al. [13]	1994	No	84	≤ 1 cm	90	92	91
Uberoi et al. [25]	1995	No	48	≤ 1 cm	24	94	NA
Steitz et al. [24]	1997	No	124	≤ 1 cm	96	100	97
Borzellino et al. [14]	1998	No	30	≤ 1 cm	100	32	89
Tan et al. [16]	2003	No	17	≤ 1 cm	75	80	NA
Tu et al. [4]	2005	No	60	< 0.8	57	96	NA
				< 1.0	86	91	
				> 1.5	86	79	
Hsu et al. [23]	2006	No	512	≤ 1 cm	100	4	NA
Kothari et al. [17]	2006	Yes	50	Chaotic movement	43	90	83
Zinther et al. [1]	2010	No	60	≤ 1 cm	24	97.9	81.3

ultrasonography by two radiologists for every patient recommend.

Ethical approval

The study protocol was approved by institutional review board of Tehran University of Medical Science. Written informed consent was obtained from all participants of the study.

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None to declare.

Author contribution

MMDF& AA & HA & MR designed the study. All evaluation and assessments (Ultrasonography and surgery) were done with supervising or performing by MR and AA. MMDF & HA & SZ collect the data and follow the patients during the hospitalization. RN analyzed the data. SZ & RN & MMDF wrote the article with supervising by MR.

Conflict of interest

The authors have no conflict of interest.

Research registration number

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2018.09.013.

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