Article published online: 2022-09-29

Ultrasound Changes of Postoperative Adhesion Types Over Time in Children

Seyed Ali Alamdaran[1] Seyed Hamidreza Vahed[2] Golnaz Seyedin[3]

[1] Clinical Research Development Unit, Akbar Hospital, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
[2] Radiologist, Mashhad University of Medical Sciences, Mashhad, Iran
[3] Surgen, Mashhad University of Medical Sciences, Mashhad, Iran

Address for correspondence Seyed Ali Alamdaran, MD, Clinical Research Development Unit, Akbar Hospital, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran (e-mail: Alamdarana@mums.ac.ir).

J Child Sci 2022;12:e138–e143.

Abstract

Postoperative fibrotic band formation is a common complication that causes bowel obstruction, chronic pain, and especially reoperation problems. We tried to evaluate the ultrasound signs of different adhesions over time in children. This descriptive study was performed in children hospital of Mashhad University of Medical Sciences. Sixty-five children aged 4 months to 15 years (mean age of 7.2 ± 6.5 years) were enrolled in the study. Complete abdominal sonography using 5 to 12 MHz multifrequency probes was performed by a pediatric radiologist. The sonographic findings and data analysis were performed. In first week after surgery, the fibrinous exudates are seen as hypoechoic shadows. It has uneven thickness and usually encases the bowel loops in a circular shape. In second week, they gradually become straighter with uniform thickness. In this period, in 68% of cases, a hyperechoic line is formed in the center of hypoechoic fibrinous exudates, which is usually placed between the bowel loops (interloop fibrosis). The omentum or mesentery entrapment in the fibrinous exudates was occurred in ∼50% and 25% of these cases, respectively. In this state, echogenic omentum or mesentery was seen simultaneously with the hypoechoic fibrinous exudates. After 1 month from surgical procedure, One of the following four sonographic patterns are seen: attachment hyperechoic omentum to retroperitoneum (50%), attachment hyperechoic mesentery to anterior abdominal wall (26%), interloop fibrosis (39%), and severe hypoechoic fibrotic band (30%). Absence of visceral sliding was seen in 65 to 80% of patients. Overall, there are five morphologic patterns of adhesion on ultrasound: fibrinous exudates, interloop fibrosis, fibrotic band, fixed omentum to retroperitoneum, and fixed mesentery to abdominal wall.

Keywords
- adhesion band
- sonography
- children

Introduction

Postoperative fibrotic band formation is the most frequent complication after abdominal or pelvic surgeries.[1] Although this process is a normal response to the inflammation caused during the injury in the pathway of wound healing process, it can cause several complications such as bowel obstruction, infertility, chronic pain, and especially reoperation problems due to the anatomical changes.[2] Unfortunately, the lifetime risk of postoperative complications is even higher in children, especially neonates and infants,[3] and the reoperation rate for children with adhesions is reported to be 6.2 to 12.6% through the literature.[4]

Despite this high rate of complication, there is little imaging evidence for diagnosis of these adhesions in children in literature. One of the methods that can be used with an

received
October 4, 2021
accepted after revision
July 14, 2022

DOI https://doi.org/10.1055/s-0042-1757152.
ISSN 2474-5871.

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

acceptable accuracy (around 90%) in detecting visceral adhesions is cine magnetic resonance imaging (MRI)[5–7]; however, this method is expensive and time consuming.

Another inexpensive and accessible modality used for detecting postoperative adhesions is ultrasonography. The use of the ultrasound sign "visceral sliding" as a marker for these adhesions is the most important basis for these studies. However, this sign has variety of specificities and sensitivities,[8,9] and most studies were conducted on adults. The sensitivity of 75% and the specificity of 80% for this sign were reported in only children population research.[10] Smereczyński et al presented their experience about the possibilities of intraabdominal adhesion diagnostics by means of the ultrasound morphologic findings.[11]

Therefore, further investigations are needed to specify postoperative adhesions in ultrasound for better treatment planning. In addition, the postoperative adhesions have different sonographic signs that change over time. The aim of this study was to assess ultrasound changes of postoperative adhesions over time in children.

Materials and Methods

This descriptive cross-sectional study was performed in the radiology and surgery departments of Akbar Children's Hospital, Mashhad, Iran from 2018 to 2022. The Ethics Committee of Mashhad University of Medical Sciences approved this study with the approval code IR.MUMS.fm.REC.1396.282.

A total of 65 children aged 4 month to 15 years, referring to the radiology department with postoperative compliant were enrolled in the study. Patients with postoperative collection and cases with incomplete documentation of medical records were also excluded from the study. Complete abdominal sonography was performed using 5 to 12 MHz multifrequency probes (Voluson E6, Samsung WS80 and Esaote class C, ultrasound machines). Targeted ultrasound examination of bowels was performed by an expert pediatric radiologist focusing on the signs of adhesion. The ultrasound scans were done assessing for the presence of the following signs: fluid-filled dilated loops, tubular or sausage-shaped dilatation of bowels, valvulae conniventes (stack of coins sign), to-and-fro motion of bowel contents, collapsed loops, the transition zone between the dilated proximal and collapsed distal loops, fixed bowels, visceral sliding, the fibrinous exudates, organized exudates, fibrotic band, fixed omentum to retroperitoneum, and the fixed mesentery to abdominal wall. Although both mesentery and omentum are echogenic, mesenteric vessels and deep bulk of mesentery differentiate it from superficial and nonvascular omentum. The absence of visceral sliding is used for movement restriction of the omentum and/or bowel due to their adhesions to the abdominal wall.

As histological changes (from fibrinous exudates until permanent fibrotic bands) occurred over time in inflammatory exudates, we divided them into two groups: less than 1 month and more than one month (persistent) groups. The fibrinous exudates are defined as extra-luminal hypoechoic tissue with a non-uniform thickness that usually encases the bowel loops.

After sonographic assessment of adhesion and bowel obstruction, the patients underwent appropriate medical or surgical procedures such as contrast study, observation, or surgical treatment. Then, they were followed up until a final definite diagnosis was made for them. Results of sonographic findings and data analysis were performed using statistical package for social science (SPSS; version 16 for Windows; IBM Statistics, Chicago, Illinois, United States).

Results

In the current study, 65 cases with sonographic signs of postoperation adhesion were studied (40 males and 25 females). The subjects had a mean age of 7.2 ± 6.5 years (range: 4 month–15 years). Postoperative period of our patients was 2 days to 4 years. Appendicitis was the most common cause of adhesion in our patients ($n = 46$, 71%). Right lower quadrant and hypogastric region are the most common location of adhesion ($N = 61$, 94%). ►**Table 1** shows the causes and location of adhesion in the study sample.

Sonographic signs of obstruction including loop distention, sausage appearance, to-and-fro movement, transitional zone, and absence of visceral sliding were seen in ~65 to 80% of patients.

Thirty-seven of our patients (57%) were in the group with a history of less than 1 month after surgery. In first week after surgery, the fibrinous exudates are seen as hypoechoic shadows. It has variable and nonuniform thickness, and usually encases the bowel loops. In second week, they gradually become straighter with uniform thickness. In some cases, organization, and cystic changes and septation appear in fibrinous exudates. Organized exudates may rarely (two cases) persist for 3 to 4 months (►**Fig. 1**). In this period in 68% of cases; a hyperechoic line forms in the center of hypoechoic fibrinous exudates, which lies between the bowel loops (interloop fibrosis) (►**Fig. 2**). The omentum or mesentery entrapment in the fibrinous exudates was occurred in ~50 and 25% of these cases, respectively. In this state, echogenic omentum or mesentery was seen associated with the hypoechoic fibrinous these cases. In this state,

Table 1 The causes and location of adhesion

Feature		*N* (%)
Cause of adhesion	Appendicitis	46 (71)
	Obstruction	11 (17)
	Perforation	4 (6.1)
	Malrotation, pancreatitis, mass, ...	4 (6.1)
Location of adhesion	RLQ	37(57)
	Hypogastric region	24 (37)
	Others	4 (6)

Abbreviation: RLQ, right lower quadrant.

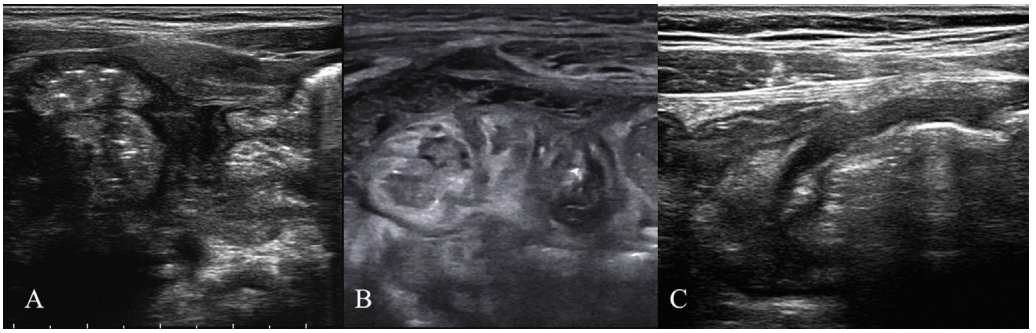

Fig. 1 (**A**) The fibrinous exudates are seen as a hypoechoic, nonuniform shadow between the bowel loops. (**B**) The cystic changes and septation in organized fibrinous exudates (**C**) straight uniform hypoechoic shadow of fibrotic band.

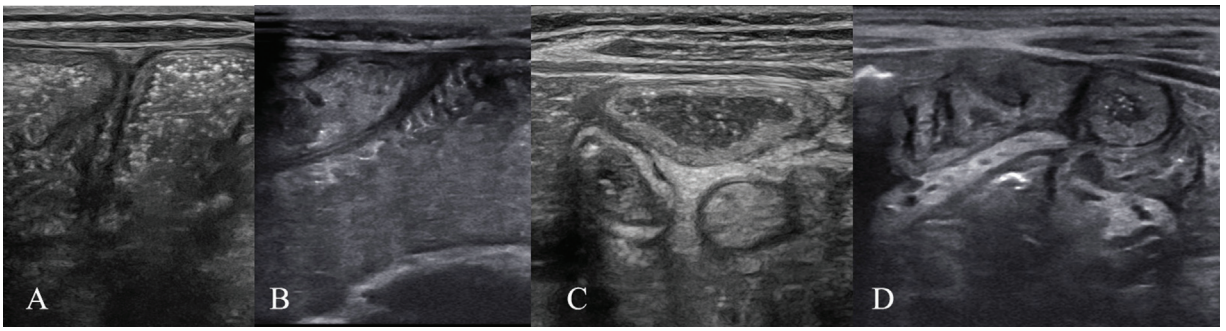

Fig. 2 (**A, B**) Three-layer appearance in interloop fibrin/fibrosis. The fibrinous exudates are associated with entrapped omentum (**C**) and mesentery (**D**).

echogenic omentum or mesentery was seen within the hypoechoic fibrinous exudates. Then, overall, the fibrinous exudates are seen either as hypoechoic shadow or mixed with hyperechoic shadows (►**Fig. 2**).

After 1 month from surgical procedure (persistent group), four sonographic patterns are seen: attachment hyperechoic omentum to retroperitoneum (50%), attachment hyperechoic mesentery to anterior abdominal wall (26%) (►**Fig. 3**), interloop fibrosis (39%), and severe hypoechoic fibrotic band (30%). Severe hypoechoic fibrotic bands may be straight or enveloped the bowel loops in a circular shape (►**Fig. 4**). Over time, uneven thickness hypoechoic fibrinous exudates change to thin three-layer appearance and eventually severe hypoechoic fibrotic band.

Overall, based on morphologic patterns of adhesion on ultrasound, there are five appearances: fibrinous exudates as uneven hypoechoic shadow, interloop fibrosis as a hypoechoic shadow with three-layer appearance between the bowel loops, fibrotic band as severe hypoechoic band, fixed hyperechoic omentum to retroperitoneum, and fixed hyperechoic mesentery to abdominal wall. ►**Table 2** summarizes prevalance and sonographic findings of adhesion types.

Discussion

The fibrotic bands are occurred in 63% of the patients who underwent major abdominal or pelvic surgeries, within the first year.[12] Most of adhesion bands are formed as a postsurgical sequel (90%). They also occurred on postinflammatory or infectious processes such as endometriosis, Crohn's disease, and so on and/or after radiation.[1,12,13]

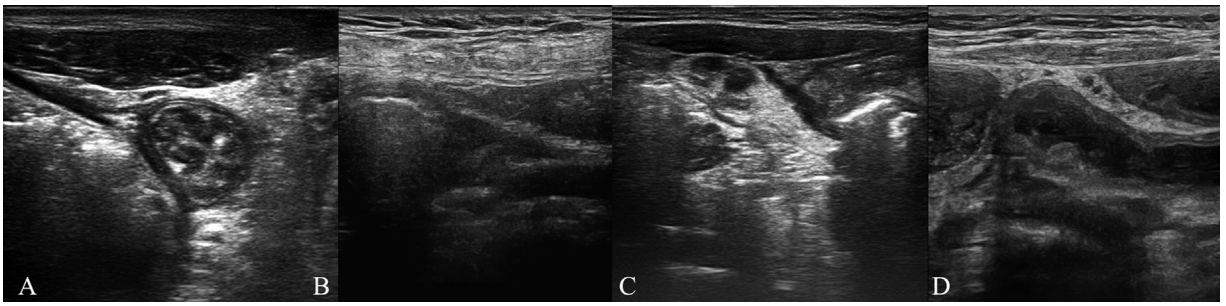

Fig. 3 (**A**) Persistent fibrotic band and fixed attachment of omentum to posterior abdominal wall. (**B**) Echogenic band due to omental attachment to posterior abdominal wall enveloped by exudates. (**C, D**) Fixed attachment mesentery to anterior abdominal wall. Superficial and nonvascular omentum helps differentiate it from mesentery with its mesenteric vessels and deep bulk.

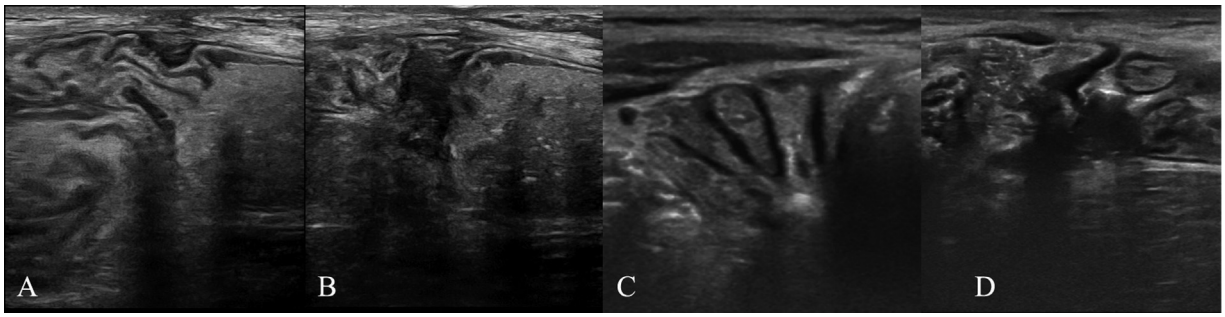

Fig. 4 (**A, B**) A fibrotic band as severe hypoechoic band envelopes a bowel. (**C, D**) The severe hypoechoic fibrotic bands in two other patients.

Table 2 Prevalence of ultrasound features and percentages of adhesion types (Some types of adhesion exist simultaneously)

Type of adhesion	Ultrasound feature	Percentage
Fibrinous exudates	Uneven hypoechoic shadow	59
Inter-loop fibrosis	Hypoechoic shadow with three-layer appearance between the Bowel Loops	39
Persistent Fibrotic band	Severe hypoechoic band	30
Fixed omentum	Fixed hyperechoic Omentum to Retro-peritoneum.	50
Fixed mesentery	Fixed hyperechoic Mesentery to Abdominal wall.	26

Although postoperative adhesions are the most common cause for small bowel obstruction, other symptoms attributable to them are nonspecific.[14,15] Imaging findings are usually minor and the patients are often undiagnosed due to the paucity of sensitive/accurate diagnostic tests and patients occasionally can develop psychosomatic disorder, or they may be confused with bowel dysfunction, such as irritable bowel syndrome.[1,16] In addition, ultrasonic demonstration of bowel adhesion can be used for the precise localization and mapping of abdominal wall adhesions prior to abdominal surgery. This may be particularly useful in providing and selecting a safe access (adhesion-free site) in patients undergoing laparoscopy who are at increased risk for instrumental injury of viscera due to abdominal wall adhesions.[17]

It is usually difficult to identify the adhesion band as the cause of the obstruction, and abdominal imaging is usually done to rule out other causes. Based on movement restriction of bowel, some studies have been done to diagnose adhesions with MRI and ultrasonography.

Lienemann et al performed a cine MRI for 27 patients at risk for intra-abdominal adhesions. Preoperative data were compared with operative findings for 13 patients. The authors found an overall sensitivity of 88% and a specificity of 93%.[5] Katayama et al evaluated the lower abdomen adhesions in 52 women with gynecologic disorders with cine MRI. They divided movement restriction into four different subgroups. After abdominal surgery in all the patients, they found an overall accuracy of 85% in the lower abdomen for cine MRI.[6] Buhmann-Kirchhoff et al also performed preoperative cine MRI for 90 patients with history of abdominal or pelvic surgery and had experienced acute or chronic abdominal pain. They reported an overall accuracy of 89%.[7]

Several studies have also assessed the applicability of sonography in detecting intra-abdominal adhesions based on movement restriction of bowel. All of them are used from viscera slide sign as the sonographic sign of abdominal adhesion. Abdominal wall adhesions produce a restriction of viscera slide. The examination is based on the demonstration of movement of abdominal viscera during real-time imaging, which is called viscera slide sign. These movements either occur spontaneously because of respiratory movement or may be caused by manual compression. This sign is assessed by a deep breathing test, a change in the patient's condition, or by probe pressures. The ultrasonic examination of the abdominal wall was done using convex or linear probes.[17,18]

Kodama et al studied visceral sliding as a sonography marker. They found spontaneous or induced visceral slide restriction to less than 1 cm in 58% of patients. Larciprete et al observed the absence of the "sliding visceral" sign in 64% of patients with adhesion. Kolecki et al reported high accuracy (91%) for this sign.[19–21]

Caprini et al and Kothari et al assessed sonography as a tool for mapping adhesions before laparoscopic adhesiolysis surgery. They determined normal movement during longitudinal scanning; 2 to 5 cm for spontaneous viscera slide and 1 cm or more for induced viscera slide. They found all adhesions by ultrasound preoperatively. They conclude that examination of the abdominal wall with spontaneous and induced viscera slide, using ultrasound scanning, can reliably detect intra-abdominal adhesions.[22,23]

Wani et al also assessed sonography as a tool for evaluating adhesions in patients who had gallbladder stone and were candidate for laparoscopy to assess an easy access. Their study revealed that ultrasonography has more than 70% sensitivity, more than 80% specificity, and more than 76%

accuracy in predicting pericholecystic adhesions which is the major cause of conversion from laparoscopic to open cholecystectomy.[24]

Only one study was conducted in children population that was conducted by Tan et al. They assessed visceral sliding as a marker of visceroparietal adhesion. Their reported sensitivity and specificity in predicting adhesions were 75 and 80%, respectively.[10]

We found one article in literature about morphological changes in intra-abdominal adhesion; Smereczyński et al explained hypoechoic band or heterogeneous or hyperechogenic change in adhesions and four types of morphological changes in the ultrasound caused by adhesions: viscera-peritoneal adhesions, intraperitoneal adhesions, adhesive obstructions, and adhesions between the liver and abdominal wall.[11,18]

This study was performed to assess the ultrasound changes of postoperative adhesions over time in children. To better understand the subject, we first describe the postoperative tissue changes. The mesothelial cells (layer) of the serous membranes of peritoneum can be detached by slightest trauma.[25] This damage leads to increased vascular permeability and exudation of inflammatory cells that is followed by formation of a fibrin matrix called fibrinous exudates (stage 1).[26] However, these fibrinous exudates are usually removed by the fibrinolysis process. When the fibrinous exudate is large and cannot remove, it stimulates the ingrowth of fibroblasts (organization) and produces fibrous tissues called adhesion fibrotic bands (stage 3) in the second week onward. Both fibrinous exudates and fibrotic bands lead to connect two injured peritoneal surfaces and interfere on the normal intestinal motility and transit processes.[16,27,28]

Sonographically, the fibrinous exudates of early phase are seen as uneven hypoechoic shadows. Exudates thickness is variable and nonuniform and usually envelopes the bowel loops in a circular shape. Gradually, they become straighter with uniform thickness and a three-layer pattern appeared between bowels loop as a hyperechoic line in center of hypoechoic fibrinous exudates, which are visible with high-resolution probes. Severe hypoechoic fibrotic band is ultimate outcome.

If the omentum and mesentery entrap in the fibrinous exudates, echogenic omentum or mesentery can be seen within the hypoechoic fibrinous exudates. Over time, fibrinous exudates disappear and fixed omentum to posterior abdominal wall or fixed mesentery to anterior abdominal wall is seen as echogenic band.

Overall, based on morphologic patterns of adhesion on ultrasound, there are five appearances: fibrinous exudates as uneven hypoechoic shadow, interloop fibrosis as hypoechoic shadow with three-layer appearance between bowel loops, fibrotic band as severe hypoechoic band, fixed hyperechoic omentum to retroperitoneum, and fixed hyperechoic mesentery to abdominal wall. In addition, the signs of bowel obstruction such as loop distention, sausage appearance, to-and-fro movement, and transitional zone are seen in most patients.

Unlike visceral sliding, these morphologic changes are visible objectively and are easily seen with looking for these signs were done under surgical scar. In addition, the visceral sliding sign was absent in 25% of patients with the morphologic signs of adhesion.

The main limitation of our study is nonperformance of surgery in all patients as the best gold standard to match the sonographic and surgical findings. Further research is needed to determine the clinical significance especially in treatment planning, correlation with surgical findings, and prognostic value of these findings.

Conclusion

There are five types of adhesion in ultrasound: fibrinous exudate, interloop fibrosis, persistent fibrotic band, fixed omentum to retroperitoneum, and fixed mesentery to abdominal wall. The ultrasound appearance of postoperative adhesions changes over time; in first week, the fibrinous exudates are seen as uneven extraluminal hypoechoic shadows. After 1 week, they gradually become straighter with uniform thickness with three-layer appearance in interloop space. Sometime, these fibrinous exudates are associated with omentum entrapment, which is seen as mixed hypoechoic and hyperechoic shadows. After 1 month, following sonographic patterns are seen: interloop fibrosis as three-layer shadows between the bowel loops; severe hypoechoic fibrotic band; and hyperechoic fixed omentum to retroperitoneum or hyperechoic fixed mesentery to abdominal wall.

Conflict of Interest
None declared.

Acknowledgments
We appreciate the assistance of clinical research development unit of Akbar Hospital related to Mashhad University of Medical Sciences in performing this research.

References

1 Tabibian N, Swehli E, Boyd A, Umbreen A, Tabibian JH. Abdominal adhesions: a practical review of an often overlooked entity. Ann Med Surg (Lond) 2017;15:9–13
2 van den Beukel BA, de Ree R, van Leuven S, et al. Surgical treatment of adhesion-related chronic abdominal and pelvic pain after gynaecological and general surgery: a systematic review and meta-analysis. Hum Reprod Update 2017;23(03): 276–288
3 Al-Salem AH, Oquaish M. Adhesive intestinal obstruction in infants and children: the place of conservative treatment. ISRN Surg 2011;2011:645104
4 Fredriksson F, Christofferson RH, Lilja HE. Adhesive small bowel obstruction after laparotomy during infancy. Br J Surg 2016;103 (03):284–289
5 Lienemann A, Sprenger D, Steitz HO, Korell M, Reiser M. Detection and mapping of intraabdominal adhesions by using functional cine MR imaging: preliminary results. Radiology 2000;217(02): 421–425
6 Katayama M, Masui T, Kobayashi S, et al. Evaluation of pelvic adhesions using multiphase and multislice MR imaging with kinematic display. AJR Am J Roentgenol 2001;177(01):107–110

7 Buhmann-Kirchhoff S, Lang R, Kirchhoff C, et al. Functional cine MR imaging for the detection and mapping of intraabdominal adhesions: method and surgical correlation. Eur Radiol 2008;18 (06):1215–1223
8 Spens K, Bird L, Bright P. Transabdominal ultrasound: can it be used to detect and quantify adhesions/reported pain, following caesarean section? J Bodyw Mov Ther 2018;22(03):733–740
9 Dehghani Firoozabadi MM, Alibakhshi A, Alaeen H, Zand S, Nazemian R, Rahmani M. Evaluation of the diagnostic potential of trans abdominal ultrasonography in detecting intra-abdominal adhesions: a double-blinded cohort study. Ann Med Surg (Lond) 2018;36:79–82
10 Tan HL, Shankar KR, Ade-Ajayi N, et al. Reduction in visceral slide is a good sign of underlying postoperative viscero-parietal adhesions in children. J Pediatr Surg 2003;38(05):714–716
11 Smereczyński A, Starzyńska T, Kołaczyk K, et al. Intra-abdominal adhesions in ultrasound. Part II: the morphology of changes. J Ultrason 2013;13(52):93–103
12 Deogracias JMC, Almonte JR. Postoperative adhesions after abdominal surgery in children: a pilot study in the Philippines. World J Pediatr Surg 2019;2(02):e000049
13 Bittinger F, Schepp C, Brochhausen C, et al. Remodeling of peritoneal-like structures by mesothelial cells: its role in peritoneal healing. J Surg Res 1999;82(01):28–33
14 Liakakos T, Thomakos N, Fine PM, Dervenis C, Young RL. Peritoneal adhesions: etiology, pathophysiology, and clinical significance. Recent advances in prevention and management. Dig Surg 2001; 18(04):260–273
15 Ellis H. The clinical significance of adhesions: focus on intestinal obstruction. Eur J Surg Suppl 1997;(577):5–9
16 Catena F, Di Saverio S, Coccolini F, et al. Adhesive small bowel adhesions obstruction: evolutions in diagnosis, management and prevention. World J Gastrointest Surg 2016;8(03):222–231
17 Sigel B, Golub RM, Loiacono LA, et al. Technique of ultrasonic detection and mapping of abdominal wall adhesions. Surg Endosc 1991;5(04):161–165
18 Smereczyński A, Starzyńska T, Kołaczyk K, et al. Intra-abdominal adhesions in ultrasound. Part I: the visceroperitoneal bordeline, anatomy and the method of examination. J Ultrason 2012;12(51): 472–478
19 Kolecki RV, Golub RM, Sigel B, et al. Accuracy of viscera slide detection of abdominal wall adhesions by ultrasound. Surg Endosc 1994;8(08):871–874
20 Kodama I, Loiacono LA, Sigel B, et al. Ultrasonic detection of viscera slide as an indicator of abdominal wall adhesions. J Clin Ultrasound 1992;20(06):375–380
21 Larciprete G, Valli E, Meloni P, et al. Ultrasound detection of the "sliding viscera" sign promotes safer laparoscopy. J Minim Invasive Gynecol 2009;16(04):445–449
22 Caprini JA, Arcelus JA, Swanson J, et al. The ultrasonic localization of abdominal wall adhesions. Surg Endosc 1995;9(03):283–285
23 Kothari SN, Fundell LJ, Lambert PJ, Mathiason MA. Use of transabdominal ultrasound to identify intraabdominal adhesions prior to laparoscopy: a prospective blinded study. Am J Surg 2006;192 (06):843–847
24 Wani AM, Rastogi R, Pratap V, Joon P, Gupta Y. Role of ultrasonography (USG) in evaluation of pericholecystic adhesions in gallstone disease (GSD). Ann Int Med Dental Res 2017;3(04):28
25 Mutsaers SE. Mesothelial cells: their structure, function and role in serosal repair. Respirology 2002;7(03):171–191
26 DiZerega GS. Peritoneum, peritoneal healing, and adhesion formation. In: Peritoneal Surgery. Springer; 2000:3–37
27 Law N, Ellis H. Adhesion formation and peritoneal healing on prosthetic materials. Clin Mater 1988;3(02):95–101
28 diZerega GS, Campeau JD. Peritoneal repair and post-surgical adhesion formation. Hum Reprod Update 2001;7(06):547–555