Original Article
Application of transabdominal and transvaginal sonography for diagnosis of gynecological acute abdominal disease

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Abstract: The aim of the current study was to investigate the diagnostic value of transabdominal sonography (TAS) combined with transvaginal sonography (TVS) in gynecological acute abdominal disease (GAAD). One-hundred and twenty cases of GAAD, between January and December in 2015, confirmed by surgical pathology or clinical final diagnosis, were enrolled. Diagnostic accuracy by single or combined sonography was evaluated and the causes of missed diagnosis were analyzed. The 120 patients with GAAD included 12 cases of ovarian cyst torsion, 18 cases of corpus luteum ruptures, 22 cases of acute pelvic inflammatory disease, 18 cases of placenta previa, 14 cases of placental abruption, and 36 cases of ectopic pregnancies, confirmed by pathology, operations, and follow-ups. The coincidence rate of TAS combined with TAS (91.67%) was higher than that of TAS (75.00%). Differences were significant (P < 0.05). Taken together, the combination of TAS and TVS significantly improved diagnosis accuracy for GAAD. However, clinical history and other examination data are necessary to avoid occurrence of missed diagnosis.

Keywords: obstetrics and gynecology, acute abdominal disease, transabdominal sonography, transvaginal sonography, misdiagnosis

Introduction

Gynecological acute abdominal disease (GAAD), one of the more common emergency diseases, is characteristics by rapid onset, quick development, and obvious symptoms [1]. Delays in diagnosis and treatment of GAAD can be life-threatening. Sonography examinations are non-invasive, painless, and easily implemented. Thus, sonography is the preferred auxiliary examination method for diagnosis of GAAD [2].

Transabdominal sonography (TAS) is characterized by a wide field of vision and high flexibility. It is performed by placing the probe in the abdominal area, aiming to observe the shape of pelvic organs [3]. However, the bladder should be filled before the examination. Quality is affected by many factors that result in decreased diagnostic specificity and increased misdiagnosis, including abdominal fat accumulation, intestinal gas, organ overlap, bladder multiple reflections, and so forth. Compared with TAS examinations, preparation times are shorter with transvaginal sonography (TVS), without the essential condition of bladder-filling. Additionally, the higher frequency probe is placed into the anterior fornix of the vagina, fitting better with part of the pelvic organs and avoiding occlusion caused by other organs or the abdominal wall [4]. More details in reproductive organs, especially in small lesions or lesions with unclear boundaries, can be observed [5]. Li et al. suggested that complementary advantages are achievable in diagnosis of GAAD using the combination of TAS and TVS [6]. However, this viewpoint is not conclusive and requires further investigation.

The current study investigated the effects of the combination of TAS and TVS for diagnosis of GAAD, analyzing misdiagnosis accuracy. The combination of TAS and TVS was found to be effective in improving diagnosis accuracy.

Table 1. Results of TAS scans

Disease	Cases	Confirmed (%)	Misdiagnosis (%)	Missed diagnosis (%)
Ovarian cyst torsion	12	8 (66.67)	4 (33.33)	0 (0)
Corpus luteum rupture	18	12 (66.67)	6 (33.33)	0 (0)
Acute pelvic inflammatory disease	22	18 (81.82)	4 (18.18)	0 (0)
Placenta previa	18	16 (88.89)	2 (11.11)	0 (0)
Placental abruption	14	10 (71.43)	0 (0)	4 (28.57)
Ectopic pregnancy	36	26 (72.22)	6 (16.67)	4 (11.11)
Total	120	90 (75.00)	22 (18.33)	8 (6.67)

Materials and methods

Patients

A total of 120 GAAD cases from the Linyi Central Hospital, between January and December in 2015, were enrolled in this study. Ages of the patients ranged from 21 to 44, with a mean age of 21.3 ± 4.6. The duration of abdominal pain ranged from 1 to 20 hours, with a mean value of 8.3 ± 2.5 hours. Inclusion criteria: 1) Subjects were in line with the diagnostic criteria of GAAD [7], including varying degrees of lower abdominal pain, vaginal bleeding, shock, and other symptoms; 2) Subjects got married or had a sexual life history; and 3) Subjects underwent TAS and TVS with complete imaging data. Exclusion criteria: 1) Subjects did not meet the diagnostic criteria of GAAD; 2) Subjects were unmarried; 3) Subjects had neuropsychiatric disorders and could not complete this study; 4) Subjects had advanced cancer; and 5) Imaging data of the subjects were incomplete. GAAD was confirmed by surgical pathology or clinical final diagnosis. Prior written and informed consent were obtained from every patient. The study was approved by the Ethics Review Board of Linyi Central Hospital.

Sonography

Both TAS and TVS were performed in all patients using a GE Voluson 730 Expert series (GE Healthcare, Milwaukee, WI, USA). TAS was first performed using a TAS probe set to 3.5 MHz. During the process of TAS, patients were in the supine position with bladder-filling. TVS was then carried out within a few minutes after TAS. The patients were asked to empty their bladder and assume the lithotomy position. A TSV probe was then set to 6.5 MHz. The uterus, annex area, ovary and pelvic cavities, and abnormal masses were observed carefully.

Ultrasound physicians focused on the size, internal echo, and boundary condition of the mass. Color doppler flow imaging (CDFI) was used to determine blood flow in the lesion.

Evaluation standards

Ultrasonography results were compared, with a final diagnosis by surgical pathology or clinician analysis. Diagnostic coincidence rates of TAS and TVS were calculated and compared.

Statistical analyses

Data was analyzed using SPSS 17.0 software. Count data are expressed as percentages (%). Chi-square tests were used to compare differences between the two sonography examinations. *P*-values < 0.05 indicate significant differences.

Results

Comparison of diagnostic coincidence rates of ultrasonography

Analyzing diagnostic coincidence rates of ultrasonography, TAS and TVS were performed in 120 patients with GAAD, confirmed by pathology, operations, and follow-ups. These patients included 12 cases of ovarian cyst torsion, 18 cases of corpus luteum ruptures, 22 cases of acute pelvic inflammatory disease, 18 cases of placenta previa, 14 cases of placental abruption, and 36 cases of ectopic pregnancies (**Tables 1**, **2**). Of these, there were 8 cases of ovarian cyst torsion, 12 cases of corpus luteum rupture, 18 cases of acute pelvic inflammatory disease, 16 cases of placenta previa, 10 cases of placental abruption, and 26 cases of ectopic pregnancies diagnosed by TAS, with diagnostic coincidence rates of 66.67%, 66.67%, 81.82%, 88.89%, 71.43%, and 72.72%, respectively (**Table 1**).

Table 2. Results of TAS combined with TVS scans

Disease	Cases	Confirmed (%)	Misdiagnosis (%)	Missed diagnosis (%)
Ovarian cyst torsion	12	10 (83.33)	2 (16.67)	0 (0)
Corpus luteum rupture	18	17 (94.44)	1 (5.56)	0 (0)
Acute pelvic inflammatory disease	22	21 (95.45)	1 (4.55)	0 (0)
Placenta previa	18	16 (88.89)	2 (11.11)	0 (0)
Placental abruption	14	12 (85.71)	0 (0)	2 (14.29)
Ectopic pregnancy	36	34 (94.44)	2 (5.56)	0 (0)
Total	120	110 (91.67)	8 (6.67)	2 (1.67)

Table 3. Comparison of diagnostic coincidence rates of TAS and TAS combined with TVS

Groups	Cases	Pathological examination		
		Confirmed (%)	Misdiagnosis (%)	Missed diagnosis (%)
TAS combined TVS	120	110 (91.67)	8 (6.67)	2 (1.67)
TAS	120	90 (75.00)	22 (18.33)	8 (6.67)
X^{2a}			12.133	
P			0.002	

a, Chi-square tests were used to compare diagnostic coincidence rates between TAS and TAS combined with TVS.
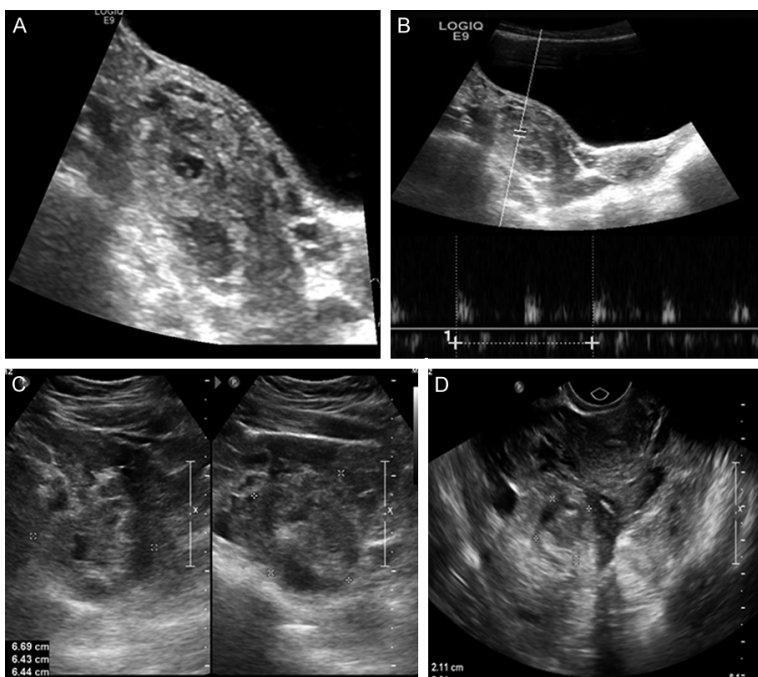
Figure 1. Sonographic imaging in the diagnosis of ectopic pregnancies. (A) Gestational sac within the mass was detected in the right ovary; (B) Embryonic heartbeat and germ within the mass were detected out; (C, D) Ruptured ectopic pregnancy. Masses with small sac-like echo in the annex and its surrounding were detected by TAS and TVS in (C) and (D), respectively.

There were 10 cases of ovarian cyst torsion, 17 cases of corpus luteum ruptures, 21 cases of acute pelvic inflammatory disease, 16 cases of placenta previa, 12 cases of placental abruption, and 34 cases of ectopic pregnancies diagnosed by TAS combined with TVS, with diagnostic coincidence rates of 83.33%, 94.44%, 95.45%, 88.89%, 85.71%, and 94.44%, respectively (**Table 2**). The total diagnostic coincidence rate detected by TAS combined with TVS (91.6%) was significantly higher than that detected by TAS (75%) (p < 0.05, **Table 3**). Results suggest that TAS combined with TVS significantly reduced missed diagnosis and misdiagnosis rates, compared with TAS alone.

Sonographic features of ectopic pregnancy

A total of 36 patients were diagnosed as ectopic pregnancies and underwent surgeries, including 15 cases of unruptured tubal, 13 cases of ruptured tubal, and 8 cases of obsolete tubal. Ultrasound characteristics were as follows: Endometrium with mild thickening; No significant intrauterine gestational sac; Heterogeneous mass shadow in the annex area (**Figure 1**). Pregnancy patterns were regular and a gestational sac within the mass was detected in unruptured tubal. In addition, yolk sac, embryonic heartbeat, and embryos or germs within the mass were detected in a small number of patients (**Figure 1A**, **1B**). CDFI demonstrated
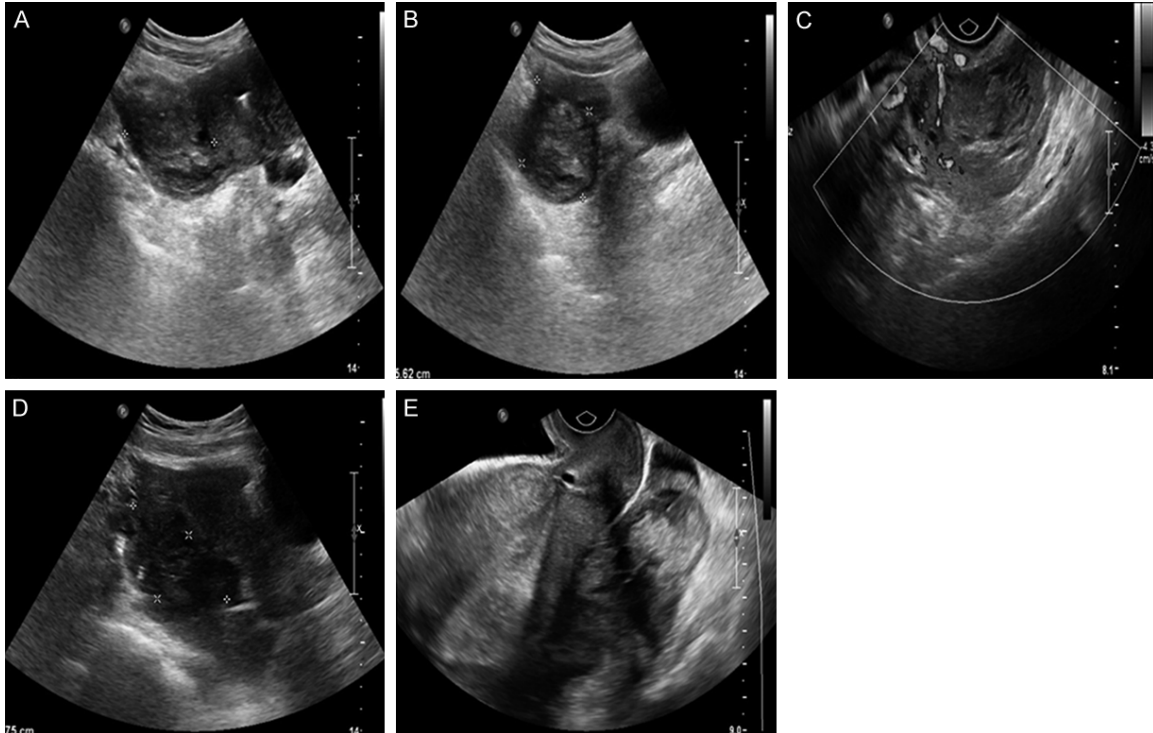
Figure 2. Sonographic imaging in the diagnosis of corpus luteum ruptures. (A, B, C) Corpus luteum rupture of mass type. Irregularly shaped hypoechoic mass with unknown ovarian shape was detected by TAS in (A); Mass boundary was detected by TAS in (B); Mass boundary with a few blood flow signals was detected by TVS in (C); (D, E) Corpus luteum rupture of cystic mass. Different sizes of cystic mass with an unclear boundary, irregular shape, and heterogeneous internal echo were detected by TAS and TVS in (D) and (E), respectively. Free dark areas were found in the pelvic cavity.

blood flow signals in the hyperechoic mass. Irregular hyperechoic masses with unclear boundaries were detected in ruptured (**Figure 1C**, **1D**) and obsolete tubal cases. No blood flow was found within the mass, which was possible rather than specific. Pelvic fluid was detected as well.

A total of 4 cases of ectopic pregnancies were misdiagnosed as corpus luteum ruptures by TAS. This was due to the similar performance of corpus luteum ruptures and ectopic pregnancy ruptures regarding clinical manifestations and sonography. In the following TVS examinations, half of the 4 cases were corrected. The other 2 were still misdiagnosed, indicating that the two diseases need to be diagnosed by combining sonography with patient history and clinical examination data.

Sonographic features of corpus luteum ruptures

A total of 18 patients were diagnosed with corpus luteum ruptures, including 7 cases of the mass type and 11 cases of the cyst type.

Ultrasonographic features included a mass-like structure with different sizes. It was ill-defined with an irregular contour (**Figure 2A-C**). The cyst types presented were cystic mass-like structures with different sizes, clear boundaries, discontinuous wall, and sound permeable in turbid liquid (**Figure 2D**, **2E**). Surrounding blood flow signals with low-speeds and low-impedance were detected around the corpus luteum by CDFI. Hypoechoic fluid was detected in the pelvic cavity.

A total of 5 cases of corpus luteum ruptures were misdiagnosed as ectopic pregnancy ruptures, while 1 case was misdiagnosed as ovarian cyst torsion by TAS. This was due to a lack of sonographic specificity. After TVS, the misdiagnosed cases were corrected. Results showed that TVS explored the relationship between the lesions and surrounding structure better, improving diagnostic accuracy.

Sonographic features of ovarian cyst torsion

Sonographic features of the 12 patients with ovarian cyst torsion included unclear morphol-
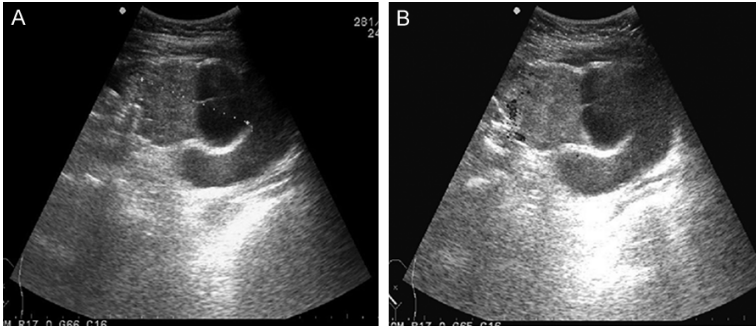
Figure 3. Sonographic imaging in the diagnosis of ovarian cyst torsion. A. TAS scans showed abnormal cystic solid mass in the right annex with a clear boundary, irregular shape, bad sound transmission, and heterogeneous internal echo; B. Color Doppler ultrasound showed that a small amount of blood flow signals was detected around the mass. No obvious blood flow signal was detected in the solid mass.
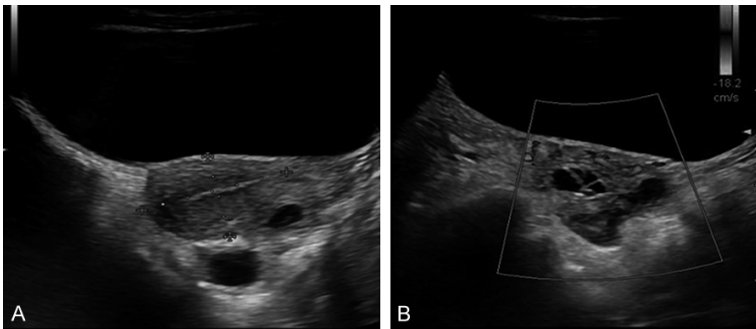
Figure 4. Sonographic imaging in the diagnosis of pelvic abscess. A. TAS scans showed a mass in the pelvic cavity with thickened and incomplete wall and bad sound transmission; B. Color Doppler ultrasound showed that ovarian with heterogeneous internal echo and abundant blood supply was detected.

cians to diagnose correctly. After TVS, half of the 4 detected no significant blood flow in the torsion site and were corrected. The other 2 cases were still misdiagnosed. Results suggest that sonography, at times, provides partial indirect signs. Thus, other examinations should be carried out for correct diagnosis.

*Sonographic features of acute pelvic inflammatory disease*

A total of 22 patients were diagnosed with acute pelvic inflammatory disease. Sonography presented the following: Inflammatory edema of the uterus with unclear boundaries, ovarian enlargement with heterogeneous echogenic form, and tubal inflammation (**Figure 4**). Specifically, sonographic signs associated with tubal included thickened fallopian tubes, uneven thickening of the wall, and adhesion with the surrounding tissue. Pelvic fluid was detected in most patients. In addition, abscess masses with thickened walls and a rough edge in the pelvic cavity and disordered punctate echoes in the pelvic empyema were detected in some patients.

ogy and structures in diseased ovaries. There were abnormal cystic dark areas in the ipsilateral pelvic cavity with clear boundaries, smooth or rough walls, and bad sound transmission (**Figure 3**). Torsion of the cysts was heterogeneous and slightly echogenic. Little or no blood flow was detected by CDFI.

Of these, 2 cases of ovarian cyst torsion were misdiagnosed as corpus luteum ruptures and 2 cases were misdiagnosed as pelvic abscess by TAS. Sonographic features of the 4 included heterogeneous mass, atypical sonograph, blurry echo, and disordered lesions. Simultaneously, the clinical manifestations were short for specificity and all expressed as right lower quadrant pain with no obvious menopause, no vaginal bleeding, and other medical history. These made it difficult for ultrasound physi-

After TAS, 2 cases of acute pelvic inflammatory disease were misdiagnosed as obsolete ectopic pregnancies and 2 cases were misdiagnosed as acute appendicitis. Sonographic features of both acute pelvic inflammatory disease and obsolete ectopic pregnancy included pelvic mass. HCG of some patients with obsolete ectopic pregnancies was also normal. These made the 2 cases more difficult to identify. After subsequent examinations with TVS, the 2 misdiagnosed cases were corrected. The location and sonography of the pelvic mass, as well as the abnormal appendiceal abscess, were similar. They were shown as disordered
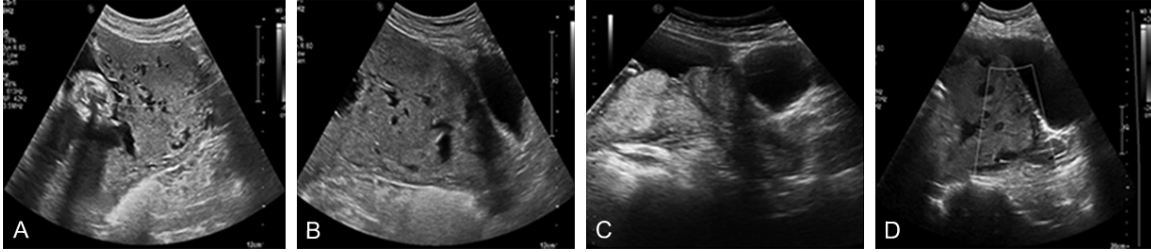
Figure 5. Sonographic imaging in the diagnosis of placenta previa. A, B. Previa placenta in which placenta completely covering the internal cervical os; C. Marginal previa in which placental tissue reaches the margin of the internal cervical os without covering it; D. A complete placenta previa with placenta accreta.
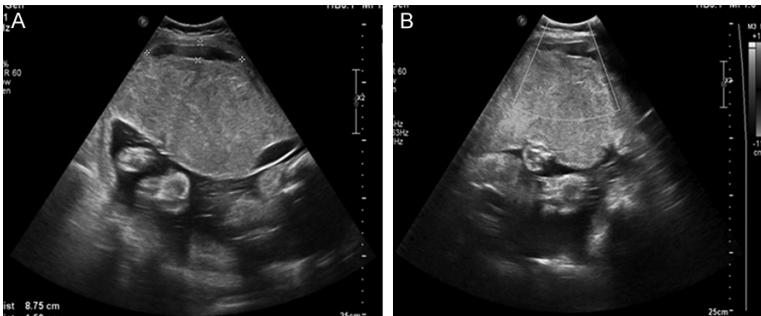
Figure 6. Sonographic imaging in the diagnosis of placental abruption. A. Thickened placenta decidua, echo enhancement, liquid dark areas between the uterine wall, and placenta decidua shown by TAS scans; B. No obvious blood flow signal was detected in placenta shown by Color Doppler ultrasound.

peripheral structures and blurred echo. Symptoms of the patients were similar, including metastatic right lower abdominal pain. One of the 2 cases misdiagnosed as acute appendicitis was still misdiagnosed by the combination of TAS and TVS. Results suggest that detailed patient histories and abdominal CTs may be important in some situations.

Sonographic features of placenta previa

A total of 18 patients with placenta previa included two major sonographic features: 1) Increased placental thickness; and 2) Placenta partially or completely covered by the internal cervical os. Placenta previa is divided into three grades depending on the relationship and distance to the internal cervical os. In detail, there were 6 cases of complete previa, in which the placenta completely covered the internal cervical os (**Figure 5A**, **5B**). There were 7 cases of marginal previa, in which placental tissues reached the margin of the internal cervical os, without covering it (**Figure 5C**). There were 5 cases of low-lying placenta, in which the

lower edge of placenta was less than 20 mm from the internal cervical os. Of these, one patient had a complete placenta previa with placenta accreta (**Figure 5D**).

After examination by sonography, 2 cases of placenta previa diagnosis were not accurate. They should have been asymmetric placenta previa. The 2 patients were diagnosed during the second trimester. The state of placenta previa did not last to the late pregnancy confirmed by late follow-up. This should not have been diagnosed as placenta previa. This indicates that ultrasound physicians need to pay attention to gestational age.

Sonographic features of placental abruption

Sonographic features of the 14 patients with placenta previa included separation of the uterine wall and placenta decidua, blood in the placenta decidua, and rounding of anechoic hematoma between the uterine wall and placenta decidua, with unclear boundaries (**Figure 6**). Various shaped masses with a messy echo in the placental edge inserted into the amniotic cavity.

After TAS, 4 cases of placental abruption were missed. In these cases, the liquid anechoic area between the placenta and uterine were not detected out. After subsequent examination with TVS, the thin strip of the anechoic area in 2 cases of the 4 were detected out. However, the other 2 cases still missed due to the abruption located in the posterior wall of

the uterus. Results suggest that less sensitive ultrasounds, coupled with a lack of experience of ultrasound physicians, occasionally result in misdiagnosis.

Discussion

GAAD is a group of diseases with lower abdomen pain due to bleeding, inflammation, and other causes [8]. It mostly occurs in women of childbearing age, with a variety of clinical manifestations. Most patients have menopause, vaginal bleeding, and other medical histories [9]. Due to unclear illness history and symptoms in the diagnosis process, identification of GAAD and surgical gastrointestinal acute abdomen becomes difficult to distinguish [10]. Sonography, which is simple and non-invasive, has been commonly used as an emergency auxiliary examination method [11].

In this study, the application of TAS and TVS in GAAD diagnosis was analyzed. Results showed that the total diagnostic coincidence rate detected by TAS combined with TVS (91.6%) was significantly higher than that detected by TAS (75%). Especially in the diagnosis of ovarian cyst torsion, ectopic pregnancies, ruptures of corpus luteum, and acute pelvic inflammatory disease, coincidence rates by TAS combined with TVS were increased from 66.67%, 72.72%, 66.67%, and 81.82% to 83.33%, 94.44%, 94.44%, and 95.45%, respectively. Results suggest that TAS combined with TVS provides better diagnostic results, with reduced missed diagnosis and misdiagnosis rates, compared to TAS alone. Results are consistent with previous results [6, 12]. TVS can avoid the impact of the abdominal wall and other organs, improve the quality of sonography, and improve diagnostic coincidence rates. In combined examinations, TVS can be used on the abnormal location revealed by TAS to improve accuracy [6].

According to typical sonographic performance, common GAAD is easy to diagnosis by sonography, combined with clinical history and laboratory data [13]. However, changes and the specificity deficiency of the sonography in atypical cases are likely to cause misdiagnosis or missed diagnosis [14]. In this study, 8 cases (6.67%) were missed by TAS and 2 cases (1.67%) were missed by combined examinations. Of these, 4 cases of ectopic pregnan-

cies were missed by TAS. They were corrected in the following TVS. The main reasons for missed diagnosis were as follows: 1) Two cases of patients were younger and in early pregnancy; 2) The time of menopause was short; 3) Human chorionic gonadotropin (HCG) was negative; and 4) No obvious mass in the annex area was detected. The rate of misdiagnosis was 0% in diagnosing ectopic pregnancies after the combination of TAS and TVS. This indicates that TVS is significantly important in diagnosing ectopic pregnancies, especially in early pregnancy. In recent years, incidence of ectopic pregnancies has increased year by year, especially in some patients with IVF, in which pregnancies may occur in intrauterine and extrauterine at the same time [15]. This should alert ultrasound physicians and TAS combined with TVS should be used in future examinations. A total of 4 cases of placental abruption were missed with TAS. Half of the 4 cases were corrected with the following TVS, while the other 2 cases were still missed. In this case, patients should be followed-up in a timely manner, aiming to reduce occurrence of accidents.

A total of 22 cases (18.33%) were misdiagnosed by TAS, while 8 cases (6.67%) were misdiagnosed via the combination of TAS and TVS. The combination of the two methods significantly reduced the rate of misdiagnosis. Of these, 4 cases of ectopic pregnancies were misdiagnosed as corpus luteum ruptures and 5 cases of corpus luteum ruptures were misdiagnosed as ectopic pregnancy ruptures by TAS. After the following TVS examinations, 6 of the 9 cases were corrected. Corpus luteum ruptures and ectopic pregnancy ruptures have similar performances in clinical manifestations and sonography. Although TVS combined with TAS can improve diagnosis accuracy, clinical examination and patient history data are still needed. In addition, HCG is a good measure of determining pregnancies [16]. Additionally, 2 cases of acute pelvic inflammatory disease were misdiagnosed as obsolete ectopic pregnancies and 2 cases were misdiagnosed as acute appendicitis by TAS. After TVS, the 2 cases misdiagnosed as obsolete ectopic pregnancies and 1 of the 2 misdiagnosed as acute appendicitis were corrected. Pelvic abscesses are generally characterized by fevers, increased white blood cells, and no

obvious history of menopause [17]. Considering the similar sonographic features between acute pelvic inflammatory disease and obsolete ectopic pregnancies, detailed patient histories are important. For identification of acute appendicitis and pelvic inflammatory disease, sonography combined abdominal CT scans may be carried out. Two cases of placenta previa, diagnosed during the second trimester, did not last to late pregnancy. These cases should not have been diagnosed as placenta previa. Placenta previa generally occurs in the third trimester or during labor. Most cases occur in mid-pregnancy can be self-recovered [17]. This indicates that ultrasound physicians need to pay attention to the gestational age, aiming to avoid misdiagnosis. Ultrasound physicians should also pay attention to the placenta accrete. If the liquid dark area in the placenta was found within cloud-like echo area (placental vortex sign), placenta accreta is possible [18]. One patient with complete placenta previa with placenta accreta was found in the current study. Sonography and clinical examinations should be combined. History of cesarean sections and dangerous placenta previa should be closely monitored to avoid major bleeding [19, 20]. After TAS, 2 cases of ovarian cyst torsion were misdiagnosed as corpus luteum ruptures and 2 cases were misdiagnosed as pelvic abscess by TAS. After TVS, half of the 4 cases were corrected. The other 2 cases were still misdiagnosed. Studies have shown that tenderness of the diseased annex area in some patients with ovarian cyst torsion was obvious [21,22]. Analysis of misdiagnosed cases indicates that sonography only provides partial indirect signs. Therefore, clinical examinations combined with other checks should be carried out.

In conclusion, sonography is fast, easy, and repeatable. Importantly, TAS combined with TAS, which has significantly improved diagnosis coincidence rates of GAAD, may the preferred auxiliary examination method for GAAD diagnosis.

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Disclosure of conflict of interest

None.

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