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ORIGINAL ARTICLE

Usefulness of transabdominal ultrasonography in excluding adnexal disease

Toru Kameda[1] · Fukiko Kawai[1] · Nobuyuki Taniguchi[2] · Yasuyuki Kobori[3]

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Abstract
Objectives To investigate the final diagnoses and examine the rate of detection of normal ovaries in patients with negative results for adnexa on transabdominal ultrasonography (TAUS) using current machines.
Methods Of 188 eligible patients who underwent TAUS to assess lower abdominal pain, 158 were subsequently evaluated using other imaging modalities, surgical procedures, follow-up, or questionnaire data. Of these patients, 135 patients with negative results for adnexa on TAUS were included in the investigation of the final diagnoses. The rate of detection of normal ovaries on TAUS was calculated on a per-ovary basis in these patients.
Results One hundred thirty-three (98.5 %) and two (1.5 %) patients were finally diagnosed with non-adnexal diseases and adnexitis, respectively. The rate of detection of 270 ovaries in 135 patients was 38.9 %, while that of 148 ovaries in 74 patients between 16 and 45 years of age was 66.2 % and that of 122 ovaries in 61 patients over 45 years of age was 5.7 % ($P < 0.001$).
Conclusions TAUS appears to be the first step for ruling out adnexal disease in patients with lower abdominal pain. The rate of detection of normal ovaries is good in younger patients.

✉ Toru Kameda
kamekame@pb3.so-net.ne.jp

[1] Department of Clinical Laboratory Medicine, Saiseikai Utsunomiya Hospital, 911-1 Takebayashi, Utsunomiya, Tochigi 321-0974, Japan

[2] Department of Clinical Laboratory Medicine, Jichi Medical University, Shimotsuke, Japan

[3] Department of Clinical Laboratory, Saiseikai Utsunomiya Hospital, 911-1 Takebayashi, Utsunomiya, Tochigi 321-0974, Japan

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Introduction

Several studies published between 1985 and 1990 demonstrated that transvaginal ultrasonography (TVUS) was superior to transabdominal ultrasonography (TAUS) for evaluating adnexal disease [1–5]. Since then, TVUS has generally been accepted as the initial technique of choice among gynecological imaging modalities [6], while TAUS continues to be required for scanning large pelvic masses due to the limited field of view of TVUS [7].

TAUS, which is readily available to clinicians, rather than obstetricians and gynecologists, is typically utilized to detect the causes of lower abdominal pain in females in primary and acute care settings. Clinicians must always keep the possibility of adnexal disease in mind when interpreting the TAUS results and consider whether TVUS or other modalities are subsequently required.

Over the past two decades, the performance of ultrasound (US) has rapidly improved. In particular, tissue harmonic imaging has been reported to exhibit enhanced resolution compared with conventional US [8–11]. For instance, TAUS is now capable of visualizing the normal appendix due to these technological advances, thus allowing physicians to rule out acute appendicitis [9, 12]. As for visualization of the adnexa, Oktar et al. reported that, in their study, TAUS with advanced technology provided better image quality compared with conventional TAUS in 13 cases of ovarian cysts [8]. However, the utility of TAUS for evaluating the adnexa has rarely been assessed in more recent studies with a large series of patients. The aims of this study were to investigate the final

diagnoses and to examine the rate of detection of normal ovaries in patients with negative results for adnexa on TAUS using the currently available machines in a laboratory setting.

Materials and methods

This prospective observational study was performed at a regional general hospital. From January 2010 to December 2011, TAUS was performed a total of 21,072 times in the laboratory. During this two-year period, 303 consecutive patients 16 years of age or older referred from departments other than obstetrics and gynecology to undergo TAUS for evaluation of lower abdominal pain were candidates for this study. Of the 303 patients, 115 were excluded due to a history of gynecological surgery ($n = 55$), a known diagnosis causing the pain ($n = 56$), or being in the second or third trimester of pregnancy ($n = 4$). In 48 of the remaining 188 patients, outpatient follow-up was either not performed or the follow-up ended before identification of the cause of pain, despite the fact that the symptoms persisted. For these 48 patients, questionnaires were sent to their homes or other institutions by mail three months or more after the TAUS examination in order to confirm the resolution of their symptoms or obtain the final diagnosis. Thirty of the 48 patients were excluded due to missing responses; therefore, 158 patients in total were eligible for this study. Of the 158 eligible patients, 23 with positive results for the adnexa on TAUS were finally diagnosed with adnexal disease ($n = 21$, 91 %) and nonspecific abdominal pain ($n = 2$, 9 %). In the two patients diagnosed with nonspecific abdominal pain according to a chart review, a simple cyst with a major axis larger than 25 mm had been defined as a positive finding on TAUS in the US laboratory, but it was not considered to be clinically significant. The remaining 135 patients with negative results for the adnexa on TAUS were ultimately included in this study.

The patients were not asked to present with a full bladder before undergoing TAUS. The TAUS procedures were performed by one of 12 experienced sonographers. The acquired images and findings reported by the sonographers were then interpreted by one of two board certified fellows of the Japan Society of Ultrasonics in Medicine (T.K., F.K.). Each organ, including the adnexa and uterus, was scanned systematically. The finding of normal ovaries was defined as the detection of a clear, elliptic-shaped structure with or without follicles or cysts, the major axis of which was no larger than 25 mm. The definition of adnexal disease on TAUS was as follows: a cyst with a major axis larger than 25 mm, a tumor, or an abnormal tubular structure in the presumed adnexal position, in which the lesions were not connected with or related to the uterus or digestive tract [7, 13, 14]. The presumed position was scanned within several minutes for the purpose of excluding adnexal lesions and detecting normal ovaries. For reference, the bladder volume was calculated on the TAUS images using the following formula: bladder volume = transverse width × sagittal depth × sagittal height × 3.14/6 [15]. If the amount of urine in the bladder was too small to be measured, the bladder volume was defined as 0 ml. Each examination was performed using one of four US systems, the EUB-7500 device (Hitachi Medical Corporation, Tokyo, Japan) with 3-MHz convex and 10-MHZ linear transducers or the SSA-770A, SSA-780A, or SSA-790A device (Toshiba Medical Systems, Tochigi, Japan) with 3.5-MHz convex and 7.5-MHz linear transducers. Convex transducers were used in all patients, while linear transducers were used to examine precisely the intestinal system when necessary.

We also investigated the methods selected for further assessments, such as TVUS, computed tomography (CT), magnetic resonance imaging (MRI), and surgical procedures including laparotomy and laparoscopy, which are useful for evaluating the adnexa and other regions in the female pelvic cavity. TVUS was performed on patients with the SSA-640A device (Toshiba Medical Systems, Tochigi, Japan) using a 6-MHz transducer by experienced gynecologists who had just evaluated them by means of a pelvic bimanual examination. CT was performed on a multidetector scanner (SOMATOM Definition AS; Siemens Healthcare, Forchheim, Germany) with or without the intravenous administration of iodinated contrast material. MRI was performed on a 1.5-T scanner (MAGNETOM Aera or Avanto; Siemens Healthcare, Erlangen, Germany) with or without the intravenous administration of gadolinium contrast agent. The CT and MRI results were interpreted by experienced radiologists.

The final diagnosis was made according to a chart review at our hospital or the responses to the questionnaires received from other institutions. Diagnoses of adnexal disease were made by detecting adnexal lesions with the above-mentioned methods and/or adnexal tenderness with a pelvic bimanual examination performed by a gynecologist. In patients diagnosed with pelvic inflammatory disease (PID), adnexal disease or adnexitis was defined as the presence of adnexal tenderness, regardless of the detection of an adnexal lesion using these methods.

With respect to interventions that may affect the final diagnosis, we also investigated the use of antibiotics after TAUS in order to reassess the diagnosis. In patients with pain of unknown origin in which the resolution of their symptoms was subsequently confirmed, the final diagnosis was defined as nonspecific abdominal pain, regardless of the prescription of antibiotics.

Each of the final diagnoses of the 135 patients was investigated. Among these patients, the rate of detection of normal ovaries on TAUS was calculated on a per-ovary basis, and the differences between age groups were investigated. In addition, the mean body mass index (BMI) values were compared between the visualized and non-visualized ovaries on a per-ovary basis.

For the statistical analyses, 95 % confidence intervals (CIs) were calculated on a binomial distribution. The Chi-square test was used to compare the rate of detection of normal ovaries between the age groups. The Mann–Whitney *U* test was used to compare the mean BMI values between the age groups on a per-patient basis and between the visualized and non-visualized ovaries on a per-ovary basis. A P value of less than 0.05 was considered to be statistically significant. The statistical analyses were performed using the STATA version 13.0 software program (StataCorp LP, College Station, TX).

Results

The mean and median ages of the 135 included patients with negative results for the adnexa on TAUS were 45.5 and 43 years, respectively (range 16–90 years). The mean and median BMI (in kilograms per square meter) were 21.7 and 20.7, respectively (range 16.0–33.4), and the BMI values were greater than or equal to 25 in 22 patients (16.3 %). The median estimated bladder volume was 35.8 ml (range 0–722 ml). TUVS, CT (enhanced CT), MRI (enhanced MRI), and surgical procedures were performed in 25, 43 (36), 3 (1), and 13 patients, respectively. The median intervals between TAUS and TVUS, TAUS and CT, TAUS and MRI, and TAUS and surgical procedures were 2 (range 0–136), 0 (0–144), 2 (2–30), and 0 days (0–64 days), respectively. TVUS, CT, MRI, and/or surgical procedures were performed in 58 of the 135 patients (43.0 %). In 36 of these 58 patients, a lesion was detected using these evaluation methods. Of the 77 patients who did not undergo an assessment with one of these methods, resolution of the patient's symptoms without the need for further evaluation was confirmed during the clinical follow-up at the outpatient clinic in 64 patients, while resolution of the patient's symptoms was confirmed according to the responses to the questionnaire in 13 patients. Antibiotics were prescribed in 29 of the 58 patients who underwent one of the above evaluation methods and 17 of the 77 patients treated without these modalities.

The location of the lesion and final diagnosis in the 135 patients are shown in Table 1. Table 2 shows the final diagnoses in the 36 patients in whom lesions were detected using TAUS (Fig. 1). Of the 73 patients ultimately diagnosed with nonspecific abdominal pain, 19 underwent TVUS, CT, MRI, and/or surgical procedures and 54 did not. Antibiotics were prescribed in two of the 19 patients who underwent the above evaluation methods and four of the 54 patients treated without these modalities. Six patients prescribed antibiotics did not undergo pelvic bimanual examinations and TVUS performed by gynecologists during the symptomatic period.

One hundred thirty-three (98.5 %) and two (1.5 %) patients were ultimately diagnosed with non-adnexal diseases and adnexitis, respectively. In the two patients with adnexitis (Fig. 2), adnexal tenderness was subsequently detected by a gynecologist; however, any lesions in the presumed adnexal position were not detected on TVUS. In these patients, contrast-enhanced CT also did not show any lesions in the genital, gastrointestinal, urinary, or vascular

Table 1 Location of the lesion and final diagnosis in the 135 patients

Locations	*n*	(%)	Final diagnoses
Genital system	8	(5.9)	Adnexitis (2), myoma uteri (2), perihepatitis associated with PID (1), cervical cancer (1), placental site trophoblastic tumor (1), first trimester pregnancy (1)
Gastrointestinal system	33	(24.4)	Appendicitis (16), colonic diverticulitis (6), enterocolitis (6), ischemic colitis (1), mesenteric adenitis (1), colonic carcinoma (1), intussusception with colonic carcinoma (1), constipation (1)
Urinary system	17	(12.6)	Urolithiasis (12), cystitis (4), pyelonephritis (1)
Abdominal vascular system	2	(1.5)	Aortic aneurysm (1), thrombosis of superior mesenteric artery (1)
Retroperitoneal space	1	(0.7)	Actinomycosis (1)
Unknown origin	74	(54.8)	Nonspecific abdominal pain (73), chronic pain of unknown origin (1)[a]

PID pelvic inflammatory disease

[a] Enhanced computed tomography did not show any abnormal findings related to lower abdominal pain

Table 2 Final diagnosis in the 36 patients in whom lesions were detected on TAUS

Locations	*n*	Final diagnoses
Genital system	2	Myoma uteri (2)
Gastrointestinal system	21	Appendicitis (11), colonic diverticulitis (3), enterocolitis (4), ischemic colitis (1), mesenteric adenitis (1), intussusception with colonic carcinoma (1)
Urinary system	11	Urolithiasis (11)
Abdominal vascular system	1	Aortic aneurysm (1)
Retroperitoneal space	1	Actinomycosis (1)

Among these 36 patients, 15 patients with urolithiasis ($n = 9$), acute appendicitis ($n = 2$), colonic diverticulitis ($n = 1$), enterocolitis ($n = 1$), mesenteric adenitis ($n = 1$), and an aortic aneurysm (n = 1) were diagnosed based on the TAUS findings without undergoing TVUS, CT, MRI, or surgical procedures

TAUS transabdominal ultrasonography

systems, although light inflammatory changes in the pelvic fat were noted.

Table 3 shows the rates of detection of normal ovaries on TAUS and the mean BMI values by age group. The rate of detection of 270 ovaries in 135 patients was 38.9 % (105 of 270; 95 % CI: 33.0–45.0 %). The mean BMI values in 105 visualized ovaries and 165 non-visualized ovaries were 21.2 and 22.1, respectively ($P = 0.013$). The rate of detection of 148 ovaries in 74 patients between 16 and 45 years of age was 66.2 % (98 of 148; 95 % CI: 58.0–73.8 %), while that of 122 ovaries in 61 patients over 45 years of age was 5.7 % (7 of 122; 95 % CI: 2.3–11.5 %) (Fig. 3) ($P < 0.001$). The mean BMI values of the former and latter age groups were 21.0 and 22.6, respectively ($P < 0.001$). In the 148 ovaries of the patients between 16 and 45 years of age, the mean BMI values in 98 visualized ovaries and 50 non-visualized ovaries were 21.0 and 21.0, respectively ($P = 0.98$).

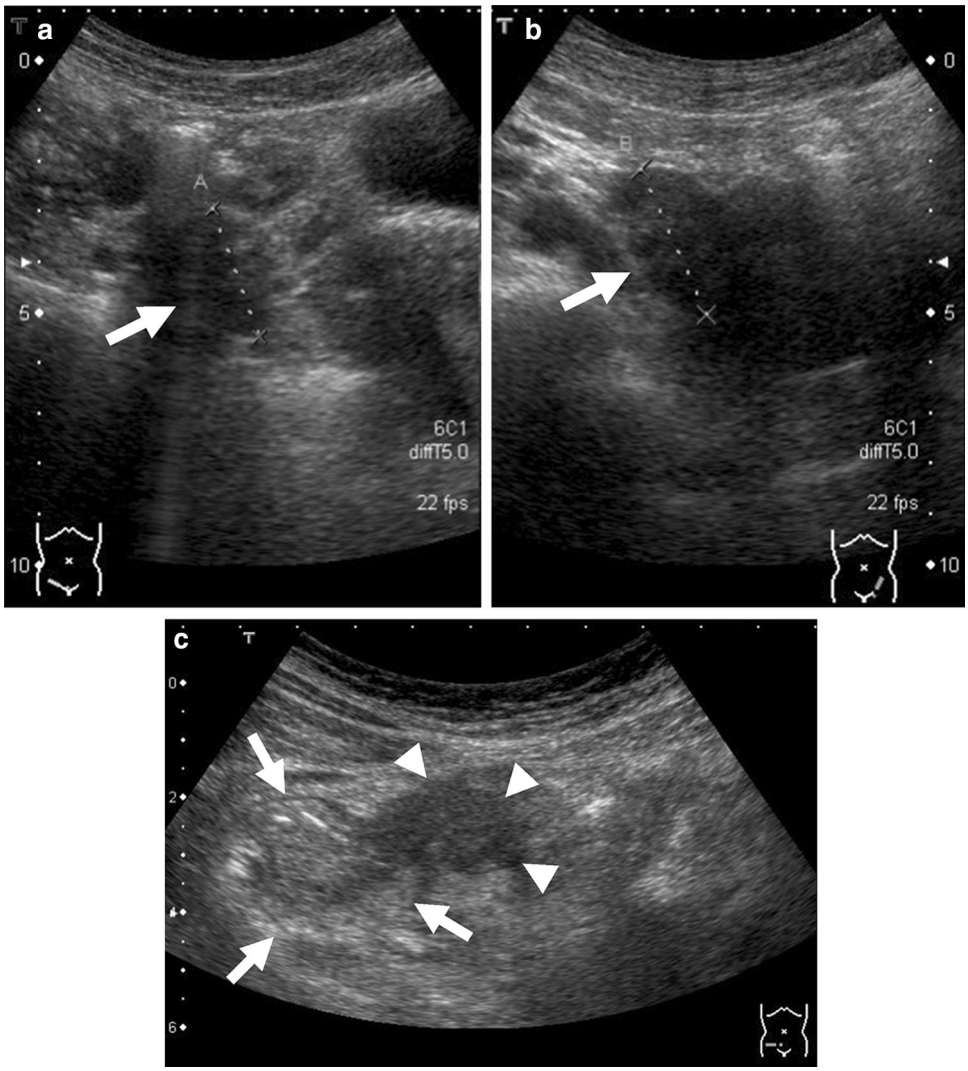

Fig. 1 Transabdominal ultrasound images in a 40-year-old woman who presented with right lower abdominal pain. The right (**a**, *arrow*) and left (**b**, *arrow*) ovaries are clearly shown. **c** The ascending colon has a markedly thickened wall (*arrows*) with an adjacent inflamed diverticulum (*arrowheads*). She was ultimately diagnosed with colonic diverticulitis

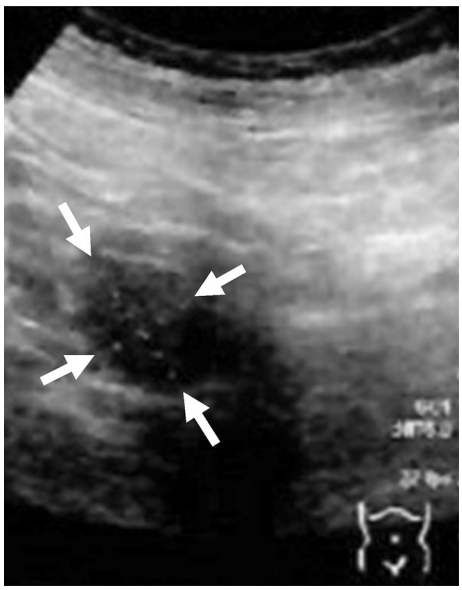

Fig. 2 A transabdominal ultrasound image showing the right elliptic-shaped ovary (*arrows*) in a 34-year-old woman with right adnexal tenderness. She was diagnosed with adnexitis by a gynecologist

Discussion

Although the methods used for further evaluation of lower abdominal pain were not uniform, and each of the final diagnoses was made according to a chart review or questionnaire, only two (1.5 %) of the 135 patients who had demonstrated negative results for adnexa on TAUS were finally found to have adnexal disease. The adnexal lesions in these two patients, who were diagnosed with adnexitis, were not visible on TVUS. US generally has a limited ability for diagnosing PID, such as mild salpingitis [16].

We assumed that the detection of normal ovaries would be useful for excluding the possibility of lesions in the ovaries and/or the contiguous fallopian tubes. However, the rate of detection in 270 ovaries in 135 patients was 38.9 % on a per-ovary basis, while the number of patients with adnexal disease was very small. Therefore, we were unable to evaluate whether the detection of normal ovaries was useful for excluding adnexal disease in the present study.

The rate of detection of normal ovaries on TAUS was good among the younger patients between 16 and 45 years of age, whereas it was quite low in the older subjects. The main reason for this finding is believed to be the significant decrease in ovarian volume that occurs with age. Pavlik et al. reported a mean ovarian volume on TVUS of 6.6, 6.1, 4.8, 2.6, 2.1, and 1.8 cm^3 in females less than 30, 30–39, 40–49, 50–59, 60–69, and ≥70 years of age, respectively [17]. In addition, the presence of ovarian cysts including the follicles, which appears to be useful for identifying the ovaries on TAUS, is less frequent in postmenopausal females [18].

To the best of our knowledge, there are currently no precise studies concerning the relationship between detection of the adnexa on TAUS and body composition based on the BMI. In the current study, the differences in the mean BMI values between visualized and non-visualized ovaries, among all age groups, were small but significant, whereas the mean BMI values of these groups among the patients 16 and 45 years of age were the same in this population, in which the majority of patients had a normal BMI. Unfortunately, the influence of BMI could not be fully evaluated in this study. Therefore, further studies of populations including more overweight and obese patients are needed to clarify this issue.

In reports from the late 1980s, TAUS was performed through a full bladder as an acoustic window to view the pelvic organs [1–5]. Since that time, patients have come to the US laboratory with a full bladder for the initial

Table 3 Rates of detection of normal ovaries on TAUS and the mean BMI values by age group

Age	N (patients)	Ovary visualized			Detection rate (%) 2a + b/2(a + b + c)	Mean BMI (kg/m^2)
		Both (a)	Right or left (b)	Neither (c)		
16–20	17	6	6	5	18/34 (52.9 %)	20.5
21–25	13	9	2	2	20/26 (76.9 %)	21.1
26–30	9	5	2	2	12/18 (66.7 %)	22.2
31–35	12	10	1	1	21/24 (87.5 %)	21.3
36–40	12	7	2	3	16/24 (66.7 %)	20.9
41–45	11	4	3	4	11/22 (50.0 %)	20.3
46–50	6	0	1	5	1/12 (8.3 %)	25.9
51–55	6	0	0	6	0/12 (0.0 %)	23.9
56–60	13	1	0	12	2/26 (7.7 %)	22.6
61	36	1	2	33	4/72 (5.6 %)	21.8
	135	43	19	73	105/270 (38.9 %)	21.7

TAUS transabdominal ultrasonography, *BMI* body mass index

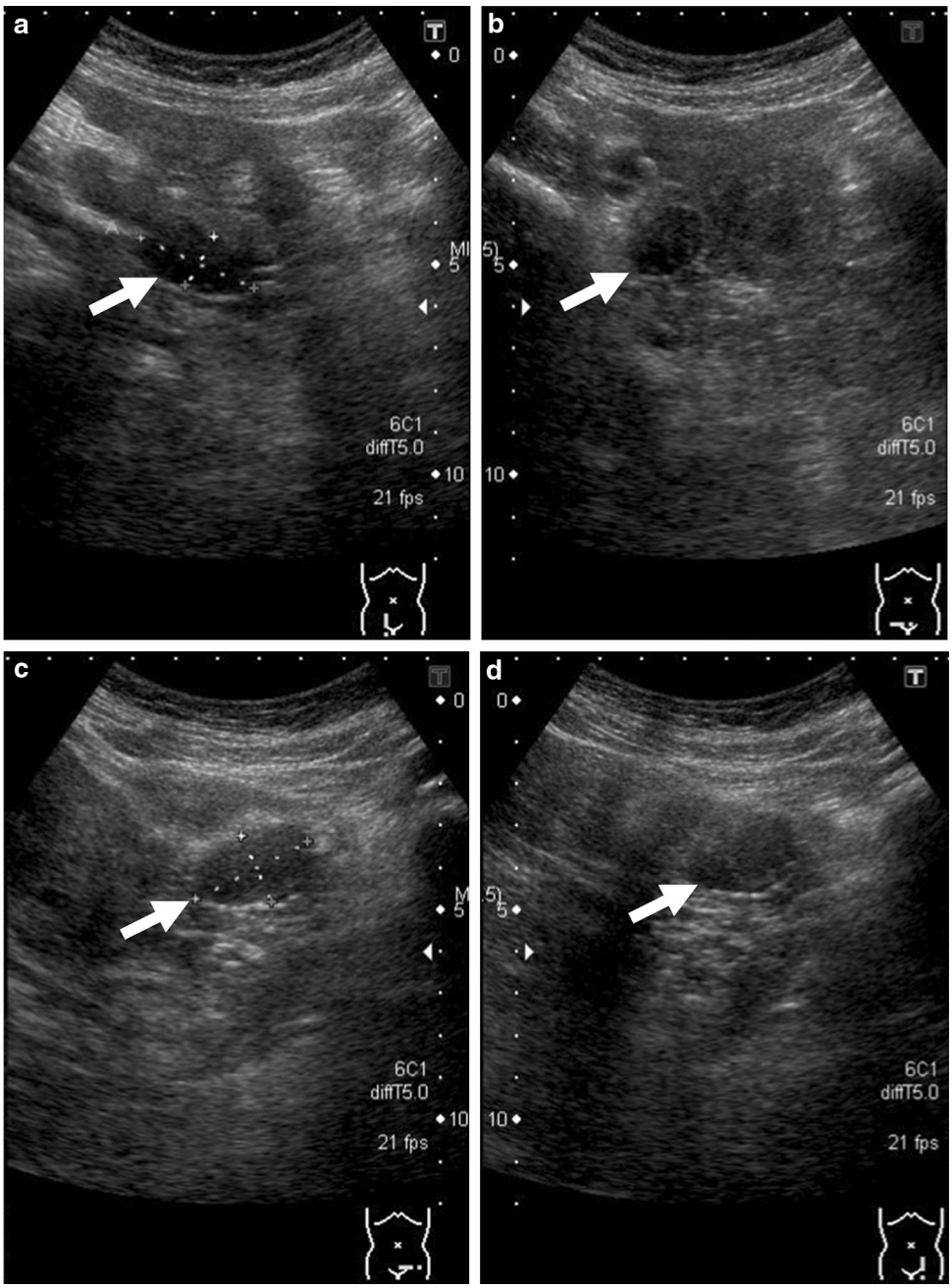

Fig. 3 Transabdominal ultrasound images showing the right (**a**, **b**) and left (**c**, **d**) ovaries in a 62-year-old woman who presented with left lower abdominal pain. She was ultimately diagnosed with nonspecific abdominal pain

transvesical scan [6]; however, they often complained about having to fill their bladder prior to the procedure. Benacerraf et al. reported that it is no longer reasonable to subject all female patients undergoing TAUS to bladder distention [19]. In the present study, patients with lower abdominal pain were not asked to present with a full bladder before undergoing TAUS with the goal of preventing further discomfort. For reference, we measured the transverse width, sagittal depth, and sagittal height of the bladder in order to calculate the bladder volume for the semi-quantitative assessments. Consequently, the median estimated bladder volume was as low as 35.8 ml. The rate of detection of normal ovaries on TAUS was not high in this study. Therefore, further studies are needed to evaluate the differences in the rate of detection of the ovaries between patients with an empty versus full bladder using current US machines in order to clarify the validity of evaluating the ovaries and fallopian tubes without a full bladder.

There are several limitations associated with this study. First, the selection of the patients must be taken into consideration. If patients initially presented with lower abdominal pain to a gynecologist, then they subsequently underwent TVUS with or without TAUS at the outpatient

clinic. Therefore, these patients did not have a chance to undergo TAUS at our US laboratory where this study was performed, whereas other patients who initially saw different specialists, such as emergency physicians, internists, surgeons, or urologists, had a chance to undergo TAUS in the laboratory. In addition, the rate of adnexal disease in the 158 eligible patients was only 14.6 %, as the final diagnoses included two and 21 cases of adnexal disease among the 135 total study patients and 23 patients with positive results for the adnexa on TAUS, respectively. Second, the detection of a cyst with a major axis over 25 mm was defined as a positive result for the adnexa. Dominant follicles can normally become enlarged to 25 mm; however, they may further increase, progressing to follicular cysts, if they fail to expel the oocyte [18, 20]. Therefore, patients with physiological cysts exhibiting a diameter exceeding 25 mm may have been excluded in this study. Third, the methods used to further evaluate lower abdominal pain were not uniform in this observational study, and TVUS, CT, MRI, and/or surgical procedures, which are very useful for assessing the adnexa and other regions in female patients with lower abdominal pain, were not performed in 77 of the 135 patients (57.0 %). Moreover, a long duration of time passed between TAUS and the other methods in some of the 58 patients who underwent at least one of these evaluation methods. During this period, resolution may have occurred in some patients. Finally, of the 73 patients ultimately diagnosed with nonspecific abdominal pain, the majority did not undergo TVUS, CT, MRI, or any surgical procedures in the short period of time after TAUS. Although resolution of the patients' pain was confirmed, some causes of adnexal disease, such as a corpus luteum hematoma and ovarian neoplasms, may have been overlooked. In this sense, normal ovaries must be studied using TAUS. On the other hand, antibiotics were prescribed, taking into consideration the possibility of infection as a differential diagnosis in six of the 73 patients. Hence, adnexitis may have been overlooked in some of the six patients whom a gynecologist did not evaluate using a pelvic bimanual examination and TVUS during the symptomatic period after TAUS.

Considering these limitations, it is possible that the percentage of patients with adnexal disease would thus increase if all patients were to undergo a gynecological examination in the symptomatic period after TAUS. However, our results indicate that TAUS appears to be the first step for ruling out the presence of adnexal disease in patients with lower abdominal pain. In the future, the efficacy of point-of-care TAUS, performed and interpreted by the clinician at the bedside, for assessing lower abdominal pain in females must also be evaluated, as the use of point-of-care US is rapidly growing, with wide application in various settings [11].

Conclusions

TAUS using modern technologies appears to be the first step for ruling out the presence of adnexal disease in patients with lower abdominal pain who are referred from departments other than departments of obstetrics and gynecology to US laboratories. The rate of detection of normal ovaries with TAUS was good in relatively younger subjects who did not present with a full bladder.

Compliance with ethical standards

Conflict of interest Toru Kameda, Fukiko Kawai, Nobuyuki Taniguchi, and Yasuyuki Kobori declare that they have no conflicts of interest in association with this study.

Ethical statements The adnexa was routinely evaluated using TAUS in females with lower abdominal pain in our laboratory. Approval from our ethics committee was obtained with a waiver for the need for written informed consent.

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