

## Significance of ultrasonography in the assessment of patients with a groin mass: a large, single-center case series

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### Abstract

**Aim:** There is a concern that the differential diagnosis of a groin mass depends on a physicians' subjective judgment and experience. We aimed to clarify the significance of US in the diagnosis of a groin mass. **Material and methods:** This retrospective study included 1,898 patients who underwent US examination of a groin mass. Physicians' diagnoses were compared with US-based diagnoses. Furthermore, the incidence of asymptomatic contralateral hernia was analyzed. The frequency of unnecessary surgery in patients with and without preoperative US was compared. In 1,451 patients who underwent surgery with preoperative US, the preoperative US classification was compared with surgical diagnosis. **Results:** Of 1,805 patients diagnosed with an inguinal hernia by physicians, 190 (10.5%) exhibited no US findings of inguinal hernia. US revealed asymptomatic contralateral hernia in 13.3% of the 1,543 patients in whom a physician detected unilateral inguinal hernia. The frequency of unnecessary surgery was significantly associated with preoperative US (1/1451; 0% vs. 2/351, 0.6%;  $p=0.0382$ ). The overall US diagnostic accuracy for the inguinal hernia type was 92.7%. **Conclusions:** US imaging of a groin mass can help avoid unnecessary surgery, detect latent inguinal hernia, and guide surgical planning.

**Keywords:** inguinal hernia; ultrasonography; herniorrhaphy; femoral hernia; groin mass

### Introduction

Inguinal hernia is one of the most common conditions encountered in routine surgical practice, and more than 140,000 surgeries are performed for inguinal hernia annually in Japan [1]. However, it is usually diagnosed based on patient history, clinical examination, and palpation by a surgeon. The guidelines of the Japanese Hernia Society indicate that pretreatment diagnosis is based only

on physical examination findings in cases with typical bulging, and the guidelines recommend additional diagnostic modalities in cases with atypical findings or in cases requiring an accurate preoperative diagnosis [2]. In Europe, the gold standard for hernia diagnosis is clinical examination [3-5]. Van den Berg et al reported a sensitivity of 74.5% and a specificity of 96.3% for physical examination, 92.7% and 81.5% for ultrasonography (US), and 94.5% and 96.3% for magnetic resonance imaging (MRI) [3]. The European Association for Endoscopic Surgery and International Guidelines for Groin Hernia Management do not recommend additional imaging studies [4,5]. However, there is a concern regarding the fact that the differential diagnosis of a groin mass depends on physicians' subjective judgment and experience. Moreover, unnecessary surgery is performed in some cases due to erroneous diagnosis [6-11]. Therefore, the lack of an objective diagnostic modality is a major concern.

Imaging modalities such as herniography, computed tomography (CT), MRI, and US provide an objective ba-

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sis for the diagnosis of inguinal hernia. However, imaging is often considered an auxiliary diagnostic tool, and few facilities perform routine imaging tests because of limited medical resources. Recently, US imaging was reported to be useful for musculoskeletal disorders in patients with sarcopenia and painful shoulder syndromes [12,13]. The usefulness of US for diagnosing inguinal hernia has been reported for a few decades; however, there are few reports on the significance of US in the diagnosis of a groin mass, with no large case series comparing physicians' diagnosis to US diagnoses, and inguinal hernias types between US diagnosis and surgical diagnosis [14-29]. In 2010, our institute introduced US for the differential diagnosis of a groin mass; since then, we have been validating US diagnosis with surgical diagnosis on a case-by-case basis. The objectives of this study were to 1) compare US diagnosis with physician diagnosis; 2) determine the incidence of asymptomatic contralateral hernia; 3) compare the frequency of unnecessary surgery in patients with and without preoperative US; and 4) compare the accuracy of preoperative US diagnosis (hernia type) with that of surgical diagnosis.

**Material and methods**

In 2010, we introduced in our department US for the objective diagnosis of inguinal hernia. Between June 2010 and December 2019, 1,898 patients who underwent US for a groin mass were included for comparison of US diagnosis and clinical examination, while patients who did not undergo surgery were excluded from the study of the hernia type (fig 1). A total of 1,451 patients with preoperative US underwent herniorrhaphy were included for comparison of US diagnosis and surgical findings (fig 1).

US diagnoses were classified as “inguinal hernia”, “other diseases”, or “non-specific findings”. When pro-

lapse of abdominal organs from the abdominal wall into the groin was identified with increased abdominal pressure, the diagnosis was “inguinal hernia”. When a mass in the abdominal wall was observed without prolapse of abdominal organs, the diagnosis of “other diseases” was determined based on the size, shape, margin, echogenicity, and color Doppler signal of the mass. When prolapse of abdominal organs or a mass in the intra-abdominal wall was not identified, the diagnosis was “non-specific findings”.

The inguinal hernia type was determined according to the Japanese Hernia Society classification for inguinal hernia [2]: indirect inguinal hernia, direct inguinal hernia, femoral hernia, and combined type. Preoperative US findings were compared with surgical diagnoses, and the overall diagnostic accuracy and detection rate of US for each inguinal hernia type were calculated. The study period was divided into the early (60 months—June 2010 to May 2015, n = 710 lesions) and late (55 months—June 2015 to December 2019, n = 827 lesions) phases, and the diagnostic accuracy and detection rates were compared between the two phases.

The study protocol was approved by the ethics committee of our hospital, which waived the need for informed consent due to the retrospective nature of the study (No. 2019-315).

**US method**

The US equipment used in this study included Canon Medical Systems Co., Ltd. Applio500 and XarioXG with a PLT-805AT 8.0-MHz linear probe. The US depth was basically 6 cm, and sensitivity time control was increased as the US depth was risen. US examination was performed with patients in the supine and upright positions according to the standardized steps followed at our laboratory by five and six sonographers of medical technologists in the early and late phases, respectively.

**Step 1:** Prolapse of abdominal organs, such as the greater omentum, intestine, and urinary bladder, from the abdominal wall into the groin was identified with increased abdominal pressure (Videos 1–3 on the journal site). Furthermore, the largest diameter of the hernia orifice was measured (fig 2).

**Step 2:** The inferior epigastric artery (IEA) behind the rectus abdominis muscle was identified, and the bifurcation from the external iliac artery (EIA) was depicted in a long-axis view. Using the long-axis image of the IEA as an index, the probe was tilted laterally and medially, and indirect and direct inguinal hernias were distinguished depending on the side of the IEA on which the hernia orifice was located (fig 3; Videos 4 on the journal site). When a direct inguinal hernia was diagnosed, it was determined whether the hernia orifice was located medial or lateral to the posterior wall of the inguinal canal.

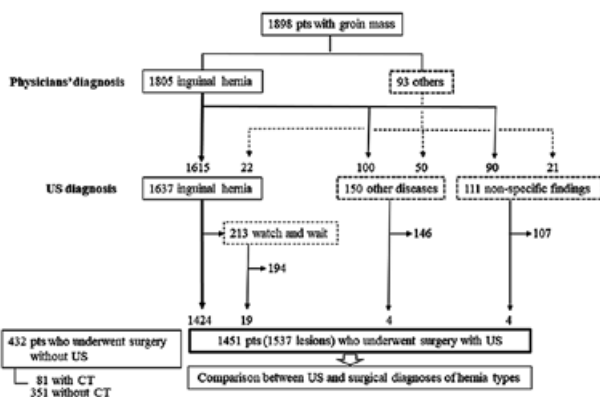


Fig 1. Flow chart for selecting the study patients.

**Step 3:** A transverse scan was performed caudally from the inguinal ligament using IEA bifurcation from the EIA as an index. Prolapse of intra-abdominal organs medial to the femoral vein (into the femoral canal) was identified in cases of femoral hernia (fig 4; Video 5 on the journal site).

**Step 4:** The contralateral groin, irrespective of whether symptoms were present, was also examined. If there was no prolapse of intra-abdominal organs into the groin in the standing position, US findings were considered as suggesting no inguinal hernia.

**Step 5:** If US showed no inguinal hernia findings, the differential diagnosis of other diseases was made according to the shape, margin, echogenicity, movement, and Doppler US blood flow signal of the inguinal mass.

The US diagnosis was determined by an attending physician (NY) who knew clinical information and reviewed US videos obtained by sonographers. Comparison between US and surgical diagnosis (hernia type) was performed by the discussion between an attending physician (NY) and a surgeon who supervised all herniorrhaphy performed in our surgical department (HN).

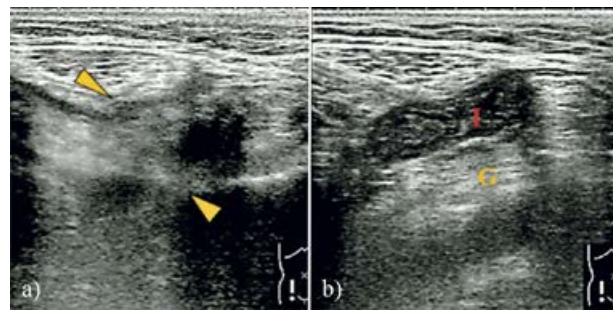
#### Statistical analysis

Continuous variables were expressed as the mean  $\pm$  standard deviations. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. The overall diagnostic accuracy and the detection rate of US for the inguinal hernia types were calculated by dividing the number of concordant diagnoses by the total number of cases and by the total number of surgical diagnoses, respectively. Statistical analyses were performed using the JMP software program (version 10.0; SAS Institute Inc., Cary, NC, USA). Statistical significance was set at  $p < 0.05$ .

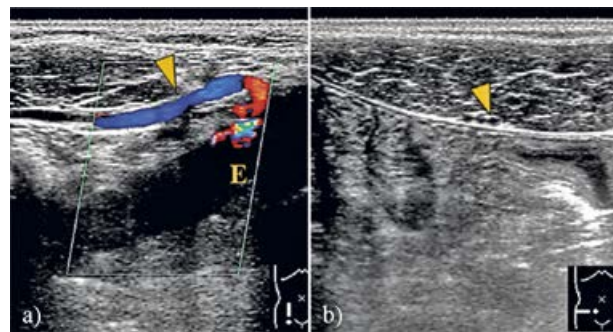
## Results

### Comparison of US diagnosis and clinical examination

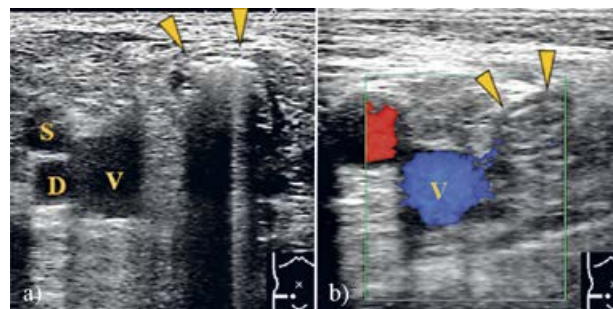
Among a total of 1898 patients (1,584 men; mean age,  $65.6 \pm 16.0$  years) with groin mass, physicians diagnosed them as inguinal hernia or other conditions in 1,805 and 93 patients, respectively. US revealed inguinal hernia in the majority of patients with a groin mass (1,637/1,898; 86.2%). Furthermore, US revealed other diseases ( $n=150$ ) and non-specific findings ( $n=111$ ). The other diseases included hydrocele of the canal of Nuck (spermatic cord) (fig 5a, Video 6 on the journal site), lymphadenopathy (fig 5b, Video 7 on the journal site), round ligament varicosities (spermatic varicocele) (fig 5c,d, Supplementary Figure 1, Videos 8 and 9 on the journal site), ectopic endometriosis (fig 5e, Video 10 on



**Fig 2.** Inguinal hernia. Longitudinal scan showing a small abdominal wall defect (a: arrow heads) and prolapse of the greater omentum (G) and intestine (I) (b).



**Fig 3.** Identification of the inferior epigastric artery (IEA); a) longitudinal scan showing the IEA (arrowhead) branched from the external iliac artery (E); b) Transverse scan showing the IEA runs behind the rectus abdominis muscle. When a hernia orifice is located lateral to the IEA by longitudinal scan using the IEA as an index, US diagnosis is indirect inguinal hernia.



**Fig 4.** Femoral hernia, transverse scan along the inguinal ligament showing prolapse of the intestine (arrow heads) medial to the femoral vein (V). S: Superficial femoral artery, D: Deep femoral artery. (a): B-mode, (b) color Doppler mode.

the journal site), and hematoma (fig 5f; Video 11 on the journal site, Table I). Among 1,805 patients with physicians' diagnosis of inguinal hernia, US revealed inguinal hernia ( $n=1615$ , 89.5%), other diseases ( $n=100$ ) and non-specific findings ( $n=90$ ). Among 93 patients with physicians' diagnosis of other conditions, US revealed inguinal hernia ( $n=22$ ), other diseases ( $n=50$ ) and non-specific findings ( $n=21$ ).

Table I. Comparison between physicians' and US diagnosis

Physicians' diagnosis US diagnosis	Inguinal hernia	Other conditions					Inguinal mass	Un- described	Total
		Hydrocele of the canal of Nuck	Lymph- adeno- pathy	Round ligament varicosities	Ectopic endo- metriosis				
Inguinal hernia	1615	2		1		18	1	1637	
Other diseases	100	9	13	6	2	20		150	
Hydrocele of the canal of Nuck (spermatic cord)	67	5				5		77	
Lymphadenopathy	3		13			3		19	
Round ligament varicosities (Spermatic varicocele)	10			6				16	
Ectopic endometriosis	4				2	2		8	
Spigelian hernia	2	1				2		4	
Hematoma	1					1		3	
Foreign body	2							2	
Cryptorchidism	1					1		2	
Lipoma	1					1		2	
Cyst	1	1						2	
Subcutaneous edema	1							1	
Swollen aponeurosis		1						1	
Fluid retention	1							1	
Undiagnosed inguinal mass	6	1				5		12	
Non-specific finding	90	1				20		111	
Total	1805	12	13	7	2	58	1	1898	

Among 1,637 patients with US diagnosis of inguinal hernia, 213 patients were followed up as per surgeons' watch-and-wait policy because of small, asymptomatic hernias, patient preference or general condition. Among them, 19 patients subsequently decided to undergo hernia surgery. Among 150 patients with US diagnosis of other diseases, inguinal hernia was detected in 4 patients by subsequent US which was performed 3-36 months later. They underwent herniorrhaphy. The initial US diagnosis of the 4 patients was hydrocele of the canal of Nuck (spermatic cord). Among 111 patients with US diagnosis of non-specific findings, inguinal hernia was observed in 4 patients by subsequent US which was performed 12-48 months later. They underwent herniorrhaphy. Consequently, 1,451 patients underwent surgery based on the US diagnosis of inguinal hernia.

US findings suggested contralateral hernia in 205 (13.3%) of 1,543 patients diagnosed with a unilateral inguinal hernia by physicians.

#### **Comparison of US diagnosis and surgical findings**

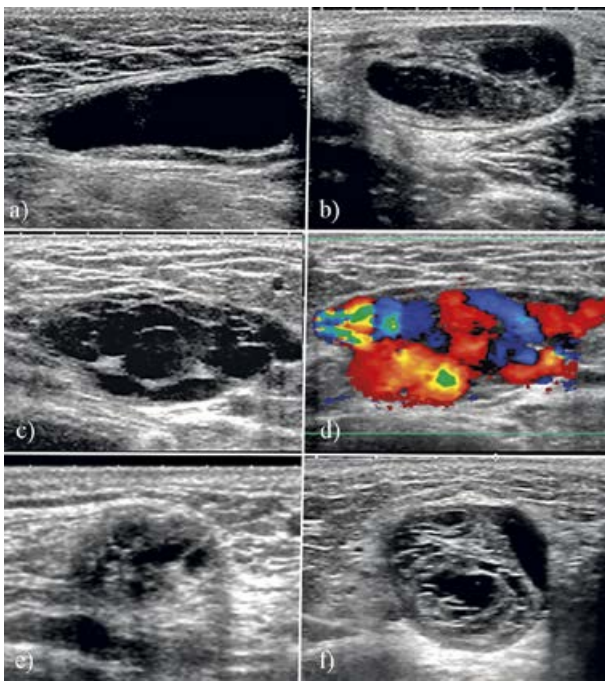
A total of 1,451 patients with preoperative US underwent herniorrhaphy based on the preoperative diagnosis of inguinal hernia. They included 71 patients who had undergone previous hernia surgery. On the other hand,

432 patients without preoperative US underwent surgery based on the preoperative diagnosis of inguinal hernia during the same period. They did not undergo preoperative US because of the US introduction period, emergent setting, or undergoing alternative CT for an accurate preoperative diagnosis (n=81). Herniorrhaphy was performed in most cases using the anterior approach, whereas the laparoscopic approach was applied in 10 (0.5%) cases.

None of the 1,451 patients with preoperative US underwent unnecessary surgery, whereas 2 (one with non-communicating hydrocele and another with hematoma) of the 351 patients without US or CT underwent unnecessary surgery. The frequency of unnecessary surgery was significantly associated with preoperative US (0/1451; 0% vs. 2/351; 0.6%; p=0.0382).

Among 1,451 patients with preoperative US who underwent herniorrhaphy, surgical diagnoses included indirect inguinal hernia (n=1126), direct inguinal hernia (n=330), femoral hernia (n=39), and combined type (n=42) (direct and indirect inguinal hernia, 39; indirect inguinal hernia and femoral hernia, 2; and direct inguinal hernia and femoral hernia, 1). The overall diagnostic accuracy (the concordance rate between US diagno-





**Fig 5.** a) Hydrocele of the canal of Nuck, oblique scan along the inguinal ligament showing a well-demarcated tear drop-like anechoic cystic lesion, enlarged with increased abdominal pressure; b) lymphadenopathy: longitudinal scan showing a well-demarcated ovoid hypoechoic mass with central echogenicity; c) round ligament varix: oblique scan along the inguinal ligament showing a nodular ovoid multicystic mass; d) round ligament varix: color Doppler US showing hypervascularity with engorgement at increased abdominal pressure; e) ectopic endometriosis: transverse scan showing an irregular hypoechoic mass with cystic and solid contents. Repeated US showed a periodical change of the size; f) hematoma: transverse scan showing a spherical mass with ramified echogenicity and clear border.

sis and surgical diagnosis) was 92.7%; furthermore, the diagnostic accuracy was significantly higher in the late phase than in the early phase (early vs. late phase: 90.1% vs. 94.9%;  $p < 0.001$ ; Table II). The detection rates (the number of concordant cases divided by the number of surgical diagnoses) of indirect inguinal hernia, direct inguinal hernia, femoral hernia, and combined hernia were 94.6%, 92.7%, 82.1%, and 52.4%, respectively. The detection rate for indirect inguinal hernia was significantly higher in the late phase than in the early phase (early vs. late phase: 91.1% vs. 97.7%;  $p < 0.0001$ ).

## Discussion

In this study, 10.5% of the 1,805 patients diagnosed with inguinal hernia by physicians exhibited no US findings of inguinal hernia. US revealed an asymptomatic contralateral hernia in 13.3% of the 1,543 patients with

a physician diagnosis of a unilateral inguinal hernia. The frequency of unnecessary surgery was significantly associated with preoperative US (0/1451; 0% vs. 2/351; 0.6%). The overall diagnostic accuracy of US for the inguinal hernia types was 92.7%.

There is a concern regarding the fact that the differential diagnosis of a groin mass depends on physicians' subjective judgment and experience. There are cases where unnecessary surgery was performed due to erroneous diagnosis [6-11] or a femoral hernia is treated based on the preoperative diagnosis of a direct or indirect inguinal hernia. The surgical procedure performed using the anterior approach for a femoral hernia is different from that performed for a direct or indirect inguinal hernia. Recently, the laparoscopic approach has been frequently selected for herniorrhaphy; however, it requires general anesthesia and is not indicated for patients with a poor performance status. Conversely, the anterior approach using local anesthesia is preferred for elderly patients with multiple comorbidities. These observations demonstrate the importance of accurate preoperative diagnosis for patients with a groin mass.

Before the study period (between January 2000 and May 2010), of 1,506 patients without preoperative US, 6 (0.4%) patients underwent surgery in our surgery department, revealing a non-communicating hydrocele ( $n=4$ ), round ligament varicosities ( $n=1$ ), and lymphadenopathy ( $n=1$ ). Although the incidence was low, we had major concern regarding unnecessary surgery and introduced US for the objective diagnosis of inguinal hernia in 2010. During the study period, unnecessary surgery was performed in two (0.6%) patients (non-communicating hydrocele and hematoma in one patient each) among 351 patients who did not undergo preoperative US and CT. The frequency of unnecessary surgery was significantly lower in patients who underwent preoperative US (0/1451, 0%). To the best of our knowledge, there has been no study reporting the frequency of unnecessary surgery in patients with a clinical diagnosis of inguinal hernia.

Herniography, CT, MRI, and US enable an objective diagnosis of inguinal hernia. Herniography is a highly reliable diagnostic modality; however, invasiveness and potential complications, such as intestinal puncture, limit its use [2,26]. Miyaki et al and Kamei et al reported CT detection rates of 100% and 98.3%, respectively [27,28]. Although CT diagnosis of hernia has an excellent objectivity, the use of CT is limited by radiation exposure and medical economy. US diagnosis offers several advantages: it is noninvasive and repeatable, it can discriminate the prolapsing abdominal organs from the surrounding structures, and it is suitable for evaluating circulatory dis-

Table II. Hernia types by US diagnosis compared with surgical diagnosis

		Phases / accuracy					Total	Overall accuracy
<b>(a) Early phase (2010-/06-2015/05)</b>		<i>Surgical diagnosis</i>						
		Indirect	Direct	Femoral	Combined	Unclassified		
<i>US diagnosis</i>	Indirect	481	7	0	3	0	491	90.1%
	Direct	37	136	3	6	0	182	
	Femoral	2	1	15	0	0	18	
	Combined	1	2	0	8	0	11	
	Unclassified	7	0	1	0	0	8	
	Total	528	146	19	17	0	710	
<b>(b) Late phase (2015/06-2019/12)</b>		<i>Surgical diagnosis</i>						
		Indirect	Direct	Femoral	Combined	Unclassified	Total	Overall accuracy
<i>US diagnosis</i>	Indirect	584	8	0	4	0	596	94.9%
	Direct	9	170	2	6	0	187	
	Femoral	0	1	17	1	0	19	
	Combined	2	4	0	14	0	20	
	Unclassified	3	1	1	0	0	5	
	Total	598	184	20	25	0	827	
<b>(c) Overall</b>		<i>Surgical diagnosis</i>						
		Indirect	Direct	Femoral	Combined	Unclassified	Total	Overall accuracy
<i>US diagnosis</i>	Indirect	1065	15	0	7	0	1087	92.7%
	Direct	46	306	5	12	0	369	
	Femoral	2	2	32	1	0	37	
	Combined	3	6	0	22	0	31	
	Unclassified	10	1	2	0	0	13	
	Total	1126	330	39	42	0	1537	

turbances in the prolapsing organs using the color Doppler method [29]. However, it has several limitations, such as high dependence on the sonographer's skill and interpretation of reviewers, the sensitivity for detecting inguinal hernia ranging from 67% to 100% (Table III) [14-18,20-24].

The finding that 10.5% of the 1,805 patients with a physician diagnosis of inguinal hernia exhibited no US findings of an inguinal hernia implies that unnecessary surgery might have been performed in one-tenth of the patients had US not been performed. In particular, 10 of the 16 patients with round ligament varicosities had been misdiagnosed with an inguinal hernia by physicians because the groin bulge was enlarged due to increased abdominal pressure or on standing [6,8,30]. Round ligament varicosities are frequently found in pregnant women and they usually regress spontaneously after delivery; therefore, unnecessary surgery during pregnancy should be avoided [31].

There were 8 patients in whom initial US showed other diseases or non-specific findings and developed inguinal hernia during subsequent US. The results suggest

the hernia development after initial US or misdiagnosis of initial US. The incidence of possible false negative result was low (8/261, 3%); however, it may indicate the imperfection of US diagnosis. Follow-up is recommended in case of hydrocele of the canal of Nuck (spermatic cord).

US revealed a contralateral latent inguinal hernia in 13.3% of the 1,543 patients with a physician diagnosis of a unilateral inguinal hernia. This incidence is similar to that reported using laparoscopic exploration (10-22%) [32-34]. Although the International Guidelines for Groin Hernia Management recommend not to repair asymptomatic contralateral hernias [5], the diagnosis of a contralateral occult hernia is clinically significant because it presents pertinent information on the potential future symptomatology and offers the option of simultaneous bilateral herniorrhaphy to patients.

Preoperative classification of the inguinal hernia types would help in surgical procedure selection and contribute to an accurate intraoperative diagnosis, especially in cases of femoral and combined type hernias [35]. Several studies have compared preoperative hernia

Table III. Accuracy of US diagnosis of inguinal hernia in English and Japanese literature

Author	Country	Year	Presence of inguinal hernia			Type of inguinal hernia	
			n	Sensitivity	Specificity	n	Accuracy
Yamaguchi [14]	Japan	2001	109	na	na	101	71.3%
Bradley [15]	UK	2003	118	100%	100%	120	93.3%
Kraft [16]	Germany	2003	220	97%	87%		na
Watanuki [17]	Japan	2007	93	na	na	86	91.9%
D-stefanovic [18]	Serbia	2008	125	100%	100%	124	96.0%
Kim [20]	UK	2015	267	96%	na		na
Lee [21]	Hongkong	2015	172	96%	96%		na
Niebuhr [22]	Germany	2017	4951	97.6%	100%		na
Maisenbacher [23]	Germany	2018	326	97%	77%		na
Duarte [24]	Brazil	2019	232	67%	na		na

na: not applicable

classification using imaging modalities with intraoperative findings. Kamei et al reported 95.8% accuracy using prone non-contrast CT for 1,011 hernias [28]. Conversely, US diagnostic accuracy for distinguishing the inguinal hernia types is 71.3-96.0% [14,15,17,18]. The diagnostic accuracy in this study was 92.7%, which was higher than that reported in previous studies. The better accuracy (94.9%) in the late phase is attributable to the principles of our US laboratory: reviewing the US video, discussion with surgeons, standardizing the US procedure, and following up patients with US diagnosis of other diseases and non-specific findings.

In this study, indirect inguinal hernia was occasionally misdiagnosed as direct inguinal hernia and vice versa. The possible cause was the misjudgment of the IEA or misjudgment of a part of the orifice of the hernia sac. It is important to appreciate the positional relationship between the IEA and the hernia orifice (abdominal wall defect). The detection rate for femoral hernias was relatively low (82.1%). Since both femoral and direct inguinal hernias were located medial to the IEA, a femoral hernia was occasionally misdiagnosed as a direct inguinal hernia. However, the detection rate was improved owing to a recently increased recognition of femoral hernias via the identification of the hernia contents medial to the femoral vein in the transverse scan.

We acknowledge the criticism against preoperative US for patients with a groin mass from a viewpoint of medical resources. However, unnecessary surgery should be avoided. Accurate diagnosis can be achieved by combining physical and US findings. In particular, US is useful for prompt diagnosis and appropriate management of patients in an emergent situation and point of care setting [36,37].

This study has several limitations. First, a learning curve is necessary for a fresh sonographer to perform the

standardized US procedure for diagnosing a groin mass and appreciating the US findings. Our US clinical laboratory has ten sonographers, who have learned US skill, interpretation and hernia anatomy through discussions with an attending physician and surgeons. As a result, diagnostic accuracy was significantly improved in the late phase compared with that in the early phase. Secondly, the two groups with and without US were not randomly allocated because of the retrospective nature of the study. Patients who underwent preoperative CT could have had the necessity to obtain a prompt and accurate diagnosis. Third, some patients with an US diagnosis of inguinal hernia were merely followed up without an intervention, such as hernia surgery (watch-and-wait). We did not completely follow up the study patients; therefore, the true detection rate and diagnostic accuracy of US might have been miscalculated. Additionally, patients with negative US findings did not undergo surgery; therefore, the true negative rate of US could not be determined. Fourth, most surgical procedures were performed using the anterior approach; thus, a combined type hernia including femoral hernia might not have been identified intraoperatively. Despite these limitations, this study shows the significance of US for diagnosing inguinal hernia in a large, single-center case series.

**In conclusion,** US imaging of a groin mass can help avoid unnecessary surgery and can contribute to the detection of a latent inguinal hernia, the planning of surgical treatment, and the selection of surgical procedures.

**Conflict of interest:** none

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## References

1. Japan surgical society [homepage on the Internet]. National clinical database 2016. Available from: <https://www.jssoc.or.jp/other/info/info20170811-02.pdf>. Published August 11, 2017.
2. Japanese Hernia Society [homepage on the Internet]. Inguinal hernia practice guidelines 2015. Available from: [http://jhs.mas-sys.com/pdf/sokeibuhernia\\_guideline2015.pdf](http://jhs.mas-sys.com/pdf/sokeibuhernia_guideline2015.pdf). Published February 1, 2016.
3. van den Berg JC, de Valois JC, Go PM, Rosenbusch G. Detection of groin hernia with physical examination, ultrasound, and MRI compared with laparoscopic findings. *Invest Radiol* 1999;34:739-743.
4. Poelman MM, van den Heuvel B, Deelder JD, et al. EAES Consensus Development Conference on endoscopic repair of groin hernias. *Surg Endosc* 2013;27:3505-3519.
5. HerniaSurge Group. International guidelines for groin hernia management. *Hernia* 2018;22:1-165.
6. Guillem P, Bounoua F, Duval G. Round ligament varicosities mimicking inguinal hernia: a diagnostic challenge during pregnancy. *Acta Chir Belg* 2001;101:310-311.
7. Narci A, Korkmaz M, Albayrak R, et al. Preoperative sonography of nonreducible inguinal masses in girls. *J Clin Ultrasound* 2008;36:409-412.
8. Ijpma FF, Boddeus KM, de Haan HH, van Geldere D. Bilateral round ligament varicosities mimicking inguinal hernia during pregnancy. *Hernia* 2009;13:85-88.
9. Husain F, Siddiqui ZA, Siddiqui M. A case of endometriosis presenting as an inguinal hernia. *BMJ Case Rep* 2015;2015:bcr2014208099.
10. Wolfhagen N, Simons NE, de Jong KH, van Kesteren PJM, Simons MP. Inguinal endometriosis, a rare entity of which surgeons should be aware: clinical aspects and long-term follow-up of nine cases. *Hernia* 2018;22:881-886.
11. Lucas JW, Shete KC, Schermer C, Perosio P, Sterious S. Canal of Nuck hydrocele in an adult female. *Urol Case Rep* 2019;23:67-68.
12. Han DS, Wu WT, Hsu PC, Chang HC, Huang KC, Chang KV. Sarcopenia is Associated with increased risks of rotator cuff tendon diseases among community-dwelling elders: A cross-sectional quantitative ultrasound study. *Front Med (Lausanne)* 2021;8:630009.
13. Wu WT, Chen LR, Chang HC, Chang KV, Özçakar L. Quantitative ultrasonographic analysis of changes of the suprascapular nerve in the aging population with shoulder pain. *Front Bioeng Biotechnol* 2021;9:640747.
14. Yamaguchi H, Iwashita K, Takeyama S, et al. Usefulness of preoperative ultrasonographic diagnosis for the inguinal hernia –Evaluation of image feature and diagnosis method–. *Japanese Journal of Medical Ultrasound Technology* 2001;26:4-9. doi:10.11272/jss.26.4.
15. Bradley M, Morgan D, Pentlow B, Roe A. The groin hernia - an ultrasound diagnosis? *Ann R Coll Surg Engl* 2003;85:178-180.
16. Kraft BM, Kolb H, Kuckuk B, et al. Diagnosis and classification of inguinal hernias. *Surg Endosc* 2003;17:2021-2024.
17. Watanuki Y, Kaiami Y, Matui T, et al. Usefulness of preoperative ultrasonographic diagnosis for the inguinal hernia. *Japanese Journal of Medical Ultrasound Technology* 2007;32:613-620.
18. Djuric-Stefanovic A, Saranovic D, Ivanovic A, et al. The accuracy of ultrasonography in classification of groin hernias according to the criteria of the unified classification system. *Hernia* 2008;12:395-400.
19. Robinson A, Light D, Nice C. Meta-analysis of sonography in the diagnosis of inguinal hernias. *J Ultrasound Med* 2013;32:339-346.
20. Kim B, Robinson P, Modi H, Gupta H, Horgan K, Achuthan R. Evaluation of the usage and influence of groin ultrasound in primary and secondary healthcare settings. *Hernia* 2015;19:367-371.
21. Lee RK, Griffith JF, Ng WH. High accuracy of ultrasound in diagnosing the presence and type of groin hernia. *J Clin Ultrasound* 2015;43:538-547.
22. Niebuhr H, König A, Pawlak M, Sailer M, Köckerling F, Reinhold W. Groin hernia diagnostics: dynamic inguinal ultrasound (DIUS). *Langenbecks Arch Surg* 2017;402:1039-1045.
23. Maisenbacher T, Kratzer W, Formentini A, et al. Value of Ultrasonography in the Diagnosis of Inguinal Hernia - A Retrospective Study. *Ultraschall Med* 2018;39:690-696.
24. Duarte BHF, Iamarino APM, Gabor S, et al. Accuracy of the ultrasound examination in patients with inguinal hernia. *Rev Col Bras Cir* 2019;46:e2108.
25. Kwee RM, Kwee TC. Ultrasonography in diagnosing clinically occult groin hernia: systematic review and meta-analysis. *Eur Radiol* 2018;28:4550-4560.
26. Fumimoto Y, Inoue Y, Katsura H, et al. S. Usefulness of herniography in latent groin hernia. *Surgical Therapy* 2004;91:360-372.
27. Miyaki A, Yamaguchi K, Kishibe S, Ida A, Miyauchi T, Naritaka Y. Diagnosis of inguinal hernia by prone- vs. supine-position computed tomography. *Hernia* 2017;21:705-713.
28. Kamei N, Otsubo T, Koizumi S, Morimoto T, Nakajima Y. Prone “computed tomography hernia study” for the diagnosis of inguinal hernia. *Surg Today* 2019;49:936-941.
29. Cavigli E, Mastrorosato M, Danti G, Addeo G, Cozzi D, Miele V. Ultrasound diagnosis of acute appendicitis complicating De Garengot’s hernia. *J Ultrasound* 2021;24:205-209.
30. Yonggang H, Jing Y, Ping W, et al. Forty-one cases of round ligament varicosities that are easily misdiagnosed as inguinal hernias. *Hernia* 2017;21:901-904.
31. Maeoka E, Yamagishi H, Setta M, et al. Two cases of round ligament varicosities diagnosed by color Doppler ultrasonography. *Japanese Journal of Medical Ultrasonics* 2012;39:471-476.
32. Tiwary SK, Kumar S, More R, Shankar V, Kumar S, Dwivedi AND. A study of contralateral occult inguinal hernia in adult male patients undergoing total extraperitoneal herniorrhaphy. *J Family Med Prim Care* 2020;9:2975-2979.



33. Griffin KJ, Harris S, Tang TY, Skelton N, Reed JB, Harris AM. Incidence of contralateral occult inguinal hernia found at the time of laparoscopic trans-abdominal pre-peritoneal (TAPP) repair. *Hernia* 2010;14:345-349.
34. van den Heuvel B, Beudeker N, van den Broek J, Bogte A, Dwars BJ. The incidence and natural course of occult inguinal hernias during TAPP repair: repair is beneficial. *Surg Endosc* 2013;27:4142-4146.
35. Sherman V, Macho J, Brunicardi F. Inguinal Hernias. In: Brunicardi F, Andersen D, Billiar T, et al. Editors. *Schwartz's principles of surgery*, Ninth Edition. New York: McGraw Hill Medical, 2009;1305-1342.
36. Biggs D, Patwa A, Gohsler S. Hydroceles-Not Just For Men. *J Emerg Med* 2017;53:388-390.
37. Scheier E. Inguinal ovarian hernia on point of care ultrasound: case reports and review of the literature. *Emerg Radiol* 2022;29:215-217.

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### Captions for the movies uploaded to the journal site

**Movie 1.** Prolapse of the greater omentum: Longitudinal scan of the left groin showing a mass with fine linear echogenicity.

**Movie 2.** Prolapse of the intestine: Longitudinal scan of the right groin showing an ellipsoid mass with internal linear high echoes suggesting air.

**Movie 3.** Prolapse of the urinary bladder: Oblique scan of the right groin showing a cystic organ with thick stratified wall tapered within the abdominal wall.

**Movie 4.** Indirect inguinal hernia: Color Doppler image of the longitudinal scan of the left groin showing the inferior epigastric artery (IEA). When the probe was tilted laterally, prolapse of the greater omentum was found, which indicated that the hernia orifice was located on the lateral side of the IEA.

**Movie 5.** Femoral hernia: A transverse scan caudal from the inguinal ligament showing prolapse of the intestine medial to the femoral vein.

**Movie 6.** Hydrocele of the canal of Nuck: Oblique scan along the inguinal ligament showing a well-demarcated elongated anechoic cystic lesion, shrunked with compression using a probe.

**Movie 7.** Lymphadenopathy: Longitudinal scan showing several well-demarcated ovoid hypoechoic masses with central echogenicity.

**Movie 8.** Round ligament varix: Oblique scan using B-mode along the inguinal ligament showing a nodular ovoid multicystic mass.

**Movie 9.** Round ligament varix: Color Doppler US showing a nodular ovoid multicystic mass with hypervascularity with engorgement at increased abdominal pressure.

**Movie 10.** Ectopic endometriosis: Transverse scan showing an irregular hypoechoic mass with cystic and solid contents.

**Movie 11.** Hematoma: Transverse scan showing a spherical mass with ramified echogenicity and clear border.