High Accuracy of Ultrasound in Diagnosing the Presence and Type of Groin Hernia

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ABSTRACT: *Background.* To evaluate the accuracy of ultrasound (US) in diagnosing the the presence and type of groin hernia.

Methods. We retrospectively studied the results of 172 US examinations of the groin in 151 patients (101 men and 50 women; mean age, 59 years) who had undergone US examination for suspected groin hernia. In total, 119 of the groin hernias had been diagnosed on US, and 108 (91%) had required subsequent surgery. All patients who had had positive results for hernia on US and did not undergo surgery ($n = 11$) and most of the patients whose US results had been negative for hernia ($n = 48$) underwent limited MRI or CT scanning. We determined the sensitivity, specificity, and accuracy of US in diagnosing the presence and type of groin hernia. To identify any change in the accuracy of US over time at our institution, we compared the sensitivity, specificity, and accuracy of its use from January 2002 through December 2010 ($n = 54$ groins) with those from January 2011 through December 2012 ($n = 118$ groins).

Results. The overall rates of sensitivity and specificity of US for diagnosing the presence of groin hernia were 96% and 96%. These rates reflect improvements from 92% and 88% prior to 2011 to 98% and 100% beginning in 2011. In addition, the overall accuracy of US for diagnosing the type of groin hernia was 96%. This also improved over time at our center from 91% prior to 2011 to 98% beginning in 2011.

Conclusions. US is highly accurate at diagnosing the presence and type of groin hernia. © 2015 Wiley Periodicals, Inc. *J Clin Ultrasound* **43**:538–547, 2015; Published online in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/jcu.22271

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INTRODUCTION

The term "groin hernia" encompasses inguinal (both direct and indirect subtypes) and femoral hernias. In most patients, groin hernias are clinically apparent and no imaging is needed.[1–6] However, in some patients, a groin hernia may not be clinically palpable, or the clinical signs may be inconsistent. These patients are increasingly being referred for imaging to determine whether a hernia is present and, if so, its type.

CT and MRI are highly accurate established modalities for diagnosing both the presence and the type of groin hernia with sensitivities, specificities, and accuracies approaching 100%.[1–6] Ultrasound (US) has been advocated as an alternative to CT or MRI for assessing groin hernia[7] because it has distinct practical advantages in that it is more readily available, relatively less expensive, and more accessible; it allows a dynamic assessment; and, unlike CT, it requires no use of ionizing radiation. In many less-developed areas of the world, US is the only modality available to diagnose hernias. US is, however, more operator dependent, requiring a thorough knowledge of both examination technique and practical experience. A small number of recent studies have shown improved accuracy of US in the detection of both the presence and the type of groin hernia, with its accuracy in some centers now approaching that of CT or MRI.[2,3,5,6]

In this study, we retrospectively evaluated our results on the diagnostic accuracy of US in determining the presence and location of groin hernia, and the type of the hernia present, over an 11-year period at our center. This article also

describes in detail the US technique used and looks at the trend over time in the accuracy of US diagnosis of groin hernia at our institution.

PATIENTS AND METHODS

This study was approved by our institutional ethics committee. All patients referred for US examination for suspected groin hernia in our institution were identified from January 2002 through December 2012 and were included if they had undergone either subsequent groin surgery or imaging with CT or MRI. All electronic clinical, imaging, and surgical records were reviewed by a single investigator (R.L.K.L.), and data relating to clinical presentation, imaging investigations, and outcome of suspected groin hernia were collated. Those patients with no surgery or follow-up CT or MRI were excluded from the study cohort. US findings were compared with those of surgery, CT, and MRI.

US Examinations

All US examinations had been performed by one of five fellowship-trained musculoskeletal radiologists, all of whom had undergone musculoskeletal US training at the same center (ranging from 6 to 17 years) on one of two scanners (Siemens Sonoline Elegra, Issaquah, WA, or Philips iU22, Bothell, WA) using linear-array transducers ranging from 9 to 17 MHz depending on each patient's body habitus.

US Technique

The same US technique was used by all readers for diagnosing groin hernia. The affected groin and upper thigh region were routinely examined in both longitudinal and transverse planes in all patients. In men, the upper scrotal area was also examined. Patients were examined both at rest and while straining (ie, on Valsalva maneuver, cough, or straight leg raise). Patients were also examined in a standing position if clinical symptoms or signs were more prevalent in the standing position. Light pressure on the transducer was used to avoid obscuring or reducing any hernia. The US transducer was always initially placed on the site of clinical swelling or pain and to look for any abnormal fatty or bowel mass present. Fat within the hernial sac had an echotexture similar to that of subcutaneous fat, whereas the bowel was recognized as a tubular structure with striated walls, luminal gas or fluid, and often, but not always, peristalsis on real-time imaging. If an abnormal mass was present, it was traced proximally to determine whether it entered the peritoneal cavity. The mass was then examined during a straining maneuver, looking for any accentuation or movement of the mass. The relationship of the hernial neck, if present, to the inferior epigastric arteries and the inguinal ligament was also assessed.

If no mass was present, a standardized examination of the deep inguinal ring, Hesselbach's triangle, and the femoral canal was performed. This latter technique involved first spending a few minutes identifying the following groin anatomy: (1) the inferior epigastric artery and vein were identified beneath the lateral border of the rectus abdominis muscle and traced distally in a transverse plane to the femoral vessels; (2) the inguinal ligament was identified on both transverse and longitudinal planes running between the origin of the anterior superior iliac spine (ASIS) and the pubic tubercle; and (3) in men, the spermatic cord was identified in the upper scrotal area and followed along a transverse plane from medial to lateral to the deep inguinal ring, often aided by color Doppler imaging. Particular attention was then paid to three areas in turn for the presence of hernia: the deep inguinal ring, Hesselbach's triangle, and the femoral canal. The deep inguinal ring was identified just above the inguinal ligament and lateral to the inferior epigastric vessels and further identified in men as that area where the spermatic entered the peritoneal cavity. Hesselbach's triangle is bordered by the rectus abdominus muscle medially, the inferior epigastric vessels laterally, and the inguinal ligament inferiorly. The femoral canal lies medial to the femoral vein; the mnemonic used to remember the femoral canal contents is NAVeL (ie, nerve, artery, vein, lymph node).

A groin hernia was diagnosed by identifying a hernial sac communicating with the peritoneal cavity containing fat or the bowel protruding though a fascial defect at one of these three locations.[7–9] The sac was assessed to determine the presence of peritoneal fat, mesenteric vessels, or bowel. Movement of the sac or its contents was a useful but not absolute criterion for the diagnosis of a hernia. Especially in obese patients, the subcutaneous fat of the abdominal wall moves on a strain maneuver, so tissue movement per se was not used as an absolute criterion.

Noting the site of a fascial defect (eg, the hernial neck) allowed identification of the type of

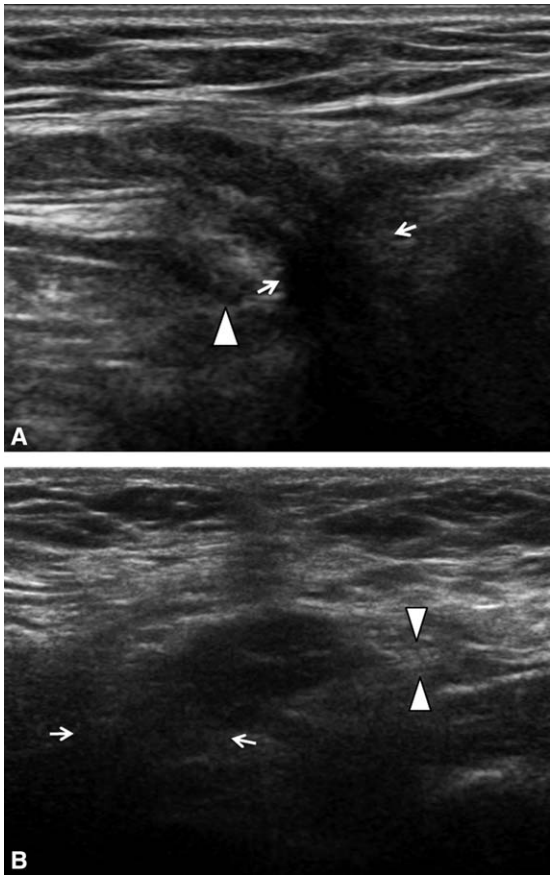

FIGURE 1. **(A)** Transverse sonogram of a left groin shows an indirect inguinal hernia. The neck (arrows), arising from the deep inguinal ring, lies lateral to the inferior epigastric artery (arrowhead). **(B)** Longitudinal sonogram from the same patient shows the neck of the indirect inguinal hernia arising from the deep inguinal ring (arrows) superior to the inguinal ligament (arrowheads).

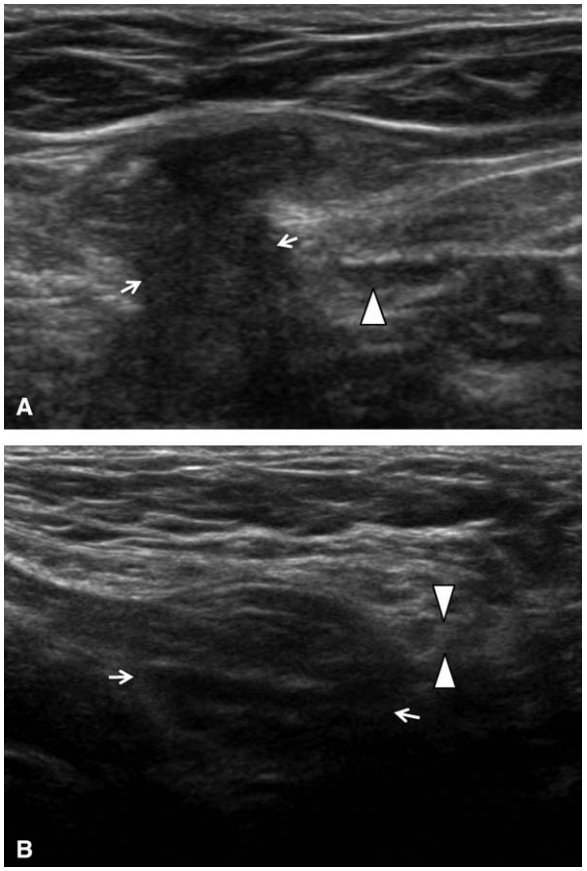

FIGURE 2. **(A)** Transverse sonogram of a left groin shows a direct inguinal hernia. The neck (arrows) of the hernia is arising medial to the inferior epigastric artery (arrowhead). **(B)** Longitudinal sonogram from the same patient shows the neck (arrows) of the direct inguinal hernia arising superior to the inguinal ligament (arrowheads).

hernia present. In the case of an indirect inguinal hernia, the hernia's neck is at the deep inguinal ring (Figure 1A and 1B). In a direct inguinal hernia, the hernia's neck is at the transversus abdominis fascia (Hesselbach's triangle) (Figure 2A and 2B); in a femoral hernia, the hernia's neck lies at the femoral canal (Figure 3A and 3B). Identification of a hernia at one location does not preclude the occurrence of a hernia at another location, so all three areas were routinely examined.

Follow-Up and Comparison with Reference Standard (Surgical, CT, or MRI Findings)

Hernia surgery was performed by more than 20 different surgeons (with 1 to 20 years of experience) on the majority of patients with positive results for hernia on US and some patients with negative US findings on account of continued clinical suspicion of hernia. The operative records of all surgical cases were reviewed and the presence of a groin hernia and type of hernia were recorded. The remainder of the patients with US-negative results was followed up with either CT or MRI scanning, in accordance with our routine imaging practice of undertaking limited groin CT or MRI examinations in patients with hernia symptoms but no hernia evident on US examination. Also, some patients with a positive US who had not undergone surgery (either refused it or were unfit for operation) were recalled for either CT or MRI evaluation.

CT and MRI Technique

Low-dose noncontrast CT through the groin region from the ASIS to the upper thigh was performed by using a multidetector CT scanner (Lightspeed 64 VCT; GE Healthcare, USA, Milwaukee) using a standard clinical CT protocol (20 acquisitions at 0.625 mm, 80 mA, 120 kV, and 1:1 pitch).

MRI examinations were performed by using a 3.0-T whole-body scanner (Achieva TX series;

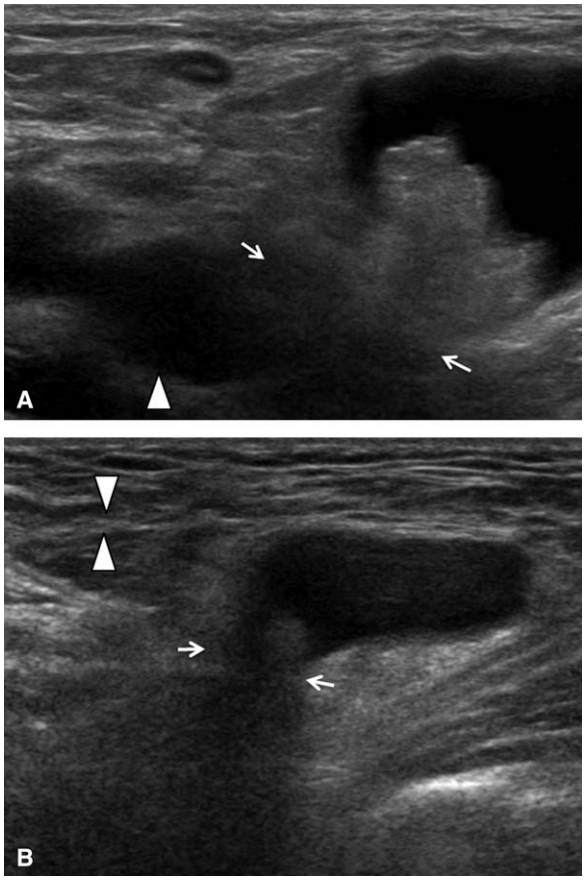

FIGURE 3. **(A)** Transverse sonogram of a right groin shows a femoral hernia. The neck (arrows) of the hernia is arising from the femoral canal medial to the femoral vein (arrowhead). Mild medial indentation of the femoral vein is present. **(B)** Longitudinal sonogram from the same patient shows the neck (arrows) of the femoral hernia arising inferior to the inguinal ligament (arrowheads).

Philips Medical Systems, Best, The Netherlands) with a SENSE torso/cardiac coil. The protocol consisted of a single axial T1-weighted sequence (slice thickness, 3 mm; repetition time, 573 ms; echo time, 10 ms; field of view, 257 × 247 mm; matrix, 512 × 512) from the ASIS to the upper thigh.

The Valsalva maneuver was not used during CT and MRI examinations. All CT and MRI scans were reviewed for the presence or absence of groin hernia by two musculoskeletal radiologists (R.L.K.L. and A.W.H.N., who have, respectively, 7 and 17 years of experience in musculoskeletal imaging); any disagreement was resolved by consensus. The radiologists were blinded to both the clinical data and the US results. Some of the US examinations had been performed by these two radiologists, but the CT or MRI review was performed at least 4 weeks after the US examination.

To investigate changes in US accuracy over time, the overall sensitivity, specificity, and accuracy of the US examinations performed from January 2002 through December 2010 were compared with those performed from January 2011 through December 2012. A separate analysis of the results from patients who had suspected recurrent hernia was also performed to determine the accuracy of US in this subgroup.

Statistical Analysis

Results are expressed as means ± standard deviations. The rates of sensitivity, specificity, and accuracy of US for diagnosing the presence and type of groin hernia were determined. For this study, we defined sensitivity as the proportion of study patients with groin hernia verified on surgery, CT, or MRI who also tested positive for hernia on US. Specificity was the proportion of study patients without groin hernia verified on surgery, CT, or MRI but who tested negative on US. We defined accuracy as the proportion of true results (both true positives and true negatives) in the study cohort.

RESULTS

Patients

The final study cohort consisted of 172 groins in 151 patients (101 men, 50 women; mean age, 59 years, range, 20–89 years) who had undergone US examination. On clinical examination, 21 of the patients were found to have bilateral groin hernias. The initial clinical symptoms and signs were obtained from the electronic records in our database. The dominant presenting symptoms were a groin mass ($n = 58$), groin pain ($n = 54$), groin discomfort ($n = 29$), or symptoms that had recurred after prior repair of inguinal or femoral hernia ($n = 31$). Clinical palpation revealed an equivocal hernia in 135 (78%) and no hernia in 37 (22%) of the groins. Patients with a definite hernia clinically had not been referred for imaging assessment and were not included in the study cohort.

Of the 172 groins included in the study, 92 (53%) suspected hernias were located on the right side and 80 (47%) were located on the left side. Twenty patients who had undergone US assessment but not surgery or follow-up CT or MRI were excluded from the study cohort.

Findings on US

Over the period studied, 172 groins in 151 patients were assessed for the presence of hernia (Figure 4). A total of 119 groins in 107

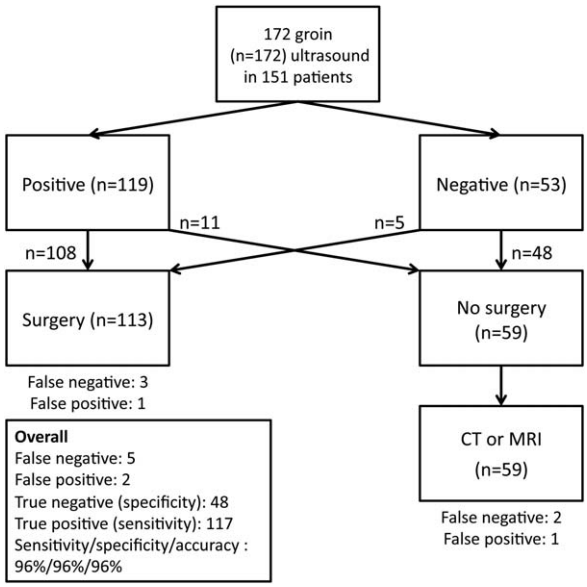

FIGURE 4. Flowchart illustrates the results of our 172 groin sonographic examinations with respect to the presence and absence of any groin hernia.

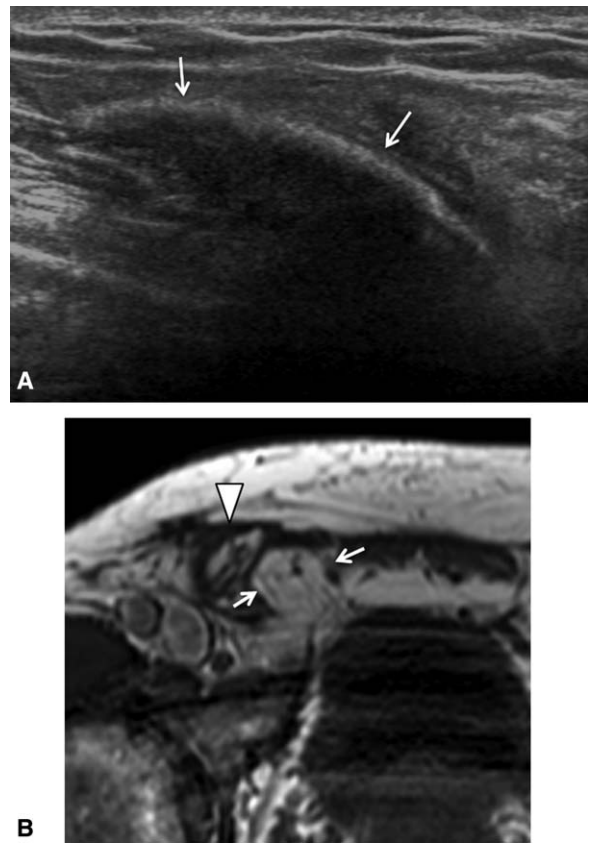

FIGURE 5. **(A)** Transverse sonogram of the right groin of a patient who had previously undergone repair of a direct inguinal hernia. Acoustic shadowing from the surgical mesh (arrows) largely obscures the assessment of any residual or recurrent hernia located deep to the mesh. **(B)** Axial T1-weighted MRI from the same patient shows a recurrent direct-type inguinal hernia (arrows) located deep to the surgical mesh (arrowhead). This hernia contains fat and no bowel.

patients were positive for hernia on US. Among these were 119 groin hernias, 71 (60%) indirect inguinal hernias, 23 (19%) direct inguinal hernias, 22 (18%) femoral hernias, and 3 (3%) combined hernias (direct + indirect inguinal hernia). Of the 119 groin hernias identified on US, 59 (50%) were on the right side, and 60 (50%) were on the left side. In addition, 110 (92%) contained fat (extraperitoneal or mesenteric), and 36 (30%) contained bowel.

US images were negative for hernia in 53 groins. Among these, US revealed normal findings in 28 (53%) patients; postoperative complications (eg, hematoma, seroma, lymphocele) in 10 (19%); subcutaneous masses (eg, lipoma, epidermoid cyst) in 6 (11%); lymphadenopathy in 4 (8%); canal of Nuck cyst in 3 (6%); and hydrocele in 2 (3%).

US Findings Compared with Surgical Results

Of the 119 groin hernias identified on US, 108 (91%) had proceeded to surgery (Figure 4). Five patients whose US findings had been negative nevertheless underwent surgery because of high clinical suspicion of hernia. The average time between US examination and surgery was 9.0 ± 7.8 months. Compared with surgical findings, there were one false-positive and three false-negative US findings. The false-positive case was a spermatic cord lipoma found on surgery that had originally been identified on US as an indirect inguinal hernia. The three false-negative cases were two small (sac < 2 cm) indirect and one direct inguinal hernia that had been missed on US but found during surgery. These three patients had had suspected hernia clinically, although the US results were negative. Surgery had been performed because these patients had experienced persistent pain.

On surgery, 67 indirect inguinal, 20 direct inguinal, 17 femoral, and 3 combined (direct + indirect inguinal) hernias were found. Five indirect inguinal hernias had been identified on US as direct ($n = 2$), femoral ($n = 2$), and combined ($n = 1$). Three direct inguinal hernias had been identified on US as indirect ($n = 2$) and femoral ($n = 1$); in addition, one femoral hernia and one combined hernia had been identified on US as indirect hernias.

Follow-up of Groins in Patients Who Did Not Undergo Surgery

Of the patients who had not undergone surgery, 11 had had positive and 48 had had negative

results on US. All of these patients had undergone follow-up with either CT ($n = 39$) or MRI ($n = 20$) examinations within 3.4 ± 4.8 months of the US examination.

Comparing US findings with those of CT and MRI revealed two false negatives and one false positive on US. The two patients with false-negative results had been deemed unfit for surgery; both patients had surgical mesh obscuring a recurrent indirect hernia on US that was subsequently found on MRI (Figure 5A and 5B). The patient with false-positive results on US had been considered to have an indirect inguinal hernia, but on CT, it was identified as a spermatic cord lipoma (Figure 6A and 6B).

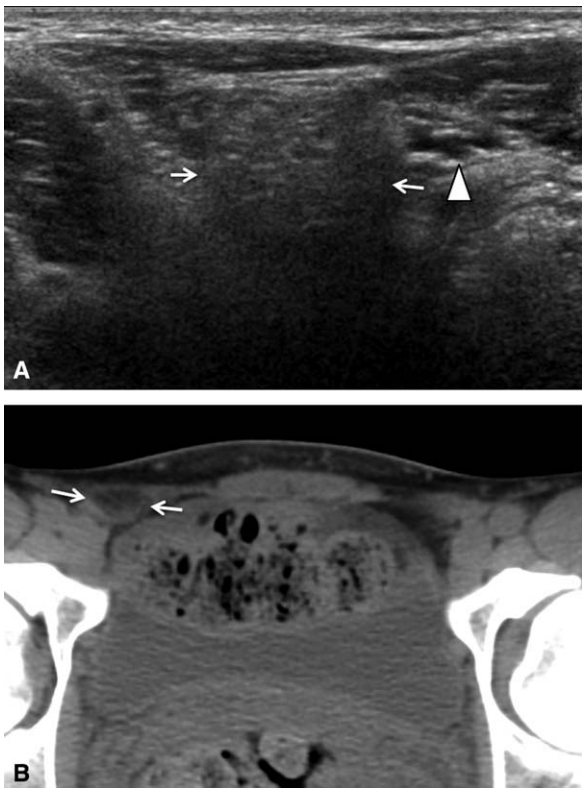

FIGURE 6. (A) Transverse sonogram of a right groin shows a suspected indirect inguinal hernia arising from the deep inguinal ring (arrows) lateral to the inferior epigastric artery (arrowhead). **(B)** Axial CT image from the same patient shows an inguinal canal lipoma (arrows). No hernia was present.

Performance of US in Detecting the Presence of Groin Hernia

Among the total of 172 groins that had undergone US examination, the overall sensitivity, specificity, and accuracy of US for diagnosing the presence of groin hernia were each found to be 96% (Table 1) when we used the follow-up CT or MRI findings as the reference standard. The rates of diagnostic accuracy improved over time from 92%, 88%, and 91% during the period 2002–2010 ($n = 54$) to 98%, 100%, and 98% during the period of 2011–2012 ($n = 118$).

Among the patients who had undergone surgery, the sensitivity, specificity, and accuracy of US for diagnosing the presence of groin hernia were 97%, 67%, and 96% when we used the surgical findings as reference standard, and those rates were 83%, 98%, and 95% when we used the follow-up CT or MRI findings as the reference standard.

Performance of US in Identifying the Type of Groin Hernia

Among the total of 108 groins that had undergone US examination and been found to be positive for hernia, 107 were verified on surgery as being true positives (Figure 7). The overall rates

TABLE 1
Rates of Chromosomal Abnormalities and Overall Poor Outcome in a Cohort Study of 90 Cases of Prenatally Diagnosed Clubfoot Classified as Complex or Isolated and as Unilateral or Bilateral

Laterality	Characteristic	Complex Clubfoot	Isolated Clubfoot	Total
Bilateral	No. of cases	25	37	62
	Karyotyping performed, *n* (%)	25/25 (100)	32/37 (86.5)	57/62 (91.9)
	Abnormal karyotype detected, *n* (%)	6/25 (24)	1/32 (3.1)	7/57 (12.3)
	Corrected rate of chromosomal abnormalities, *n* (%)*	6/25 (24)	1/37 (2.7)	7/62 (11.3)
	Poor outcome, *n* (%)	23/25 (92)	4/37 (10.8)	27/62 (43.5)
Unilateral	No. of cases	9	19	28
	Karyotyping performed, *n* (%)	8/9 (88.9)	13/19 (68.4)	21/28 (75)
	Abnormal karyotype detected, *n* (%)	4/8 (50)	0/13 (0)	4/21 (19)
	Corrected rate of chromosomal abnormalities, *n* (%)*	4/9 (44.4)	0/19 (0)	4/28 (14.3)
	Poor outcome, *n* (%)	8/9 (88.9)	1/19 (5.3)	9/28 (32.1)
Total	No. of cases	34	56	90
	Karyotyping performed, *n* (%)	33/34 (97)	45/56 (80.4)	78/90 (86.7)
	Abnormal karyotype detected, *n* (%)	10/33 (30.3)	1/45 (2.2)	11/78 (14.1)
	Corrected rate of chromosomal abnormalities, *n* (%)*	10/34 (29.4)	1/56 (1.8)	11/90 (12.2)
	Poor outcome, *n* (%)	31/34 (91.2)	5/56 (8.9)	36/90 (40)

*Prenatal karyotyping was not performed, but absence of neonatal abnormalities suggested normal karyotype.

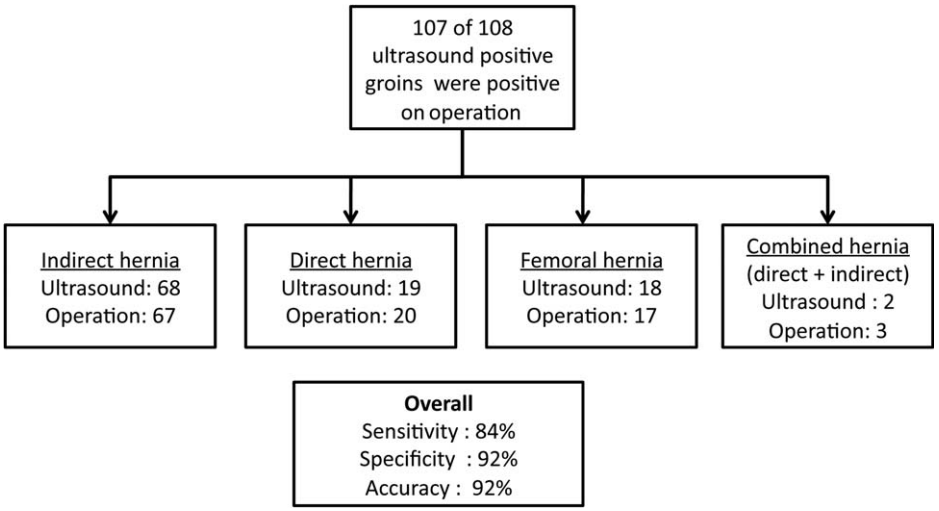

FIGURE 7. Flowchart illustrates that 107 of the 108 groins that had positive results for hernia on ultrasound were true positives on surgery. The types of the hernias and our final rates of sensitivity, specificity, and accuracy are presented.

TABLE 2
Rate and Description of Chromosomal Abnormalities Identified in 90 Fetuses with Prenatally Diagnosed Clubfoot Classified as Complex or Isolated and as Unilateral or Bilateral

Laterality	Complex-Clubfoot Group	Isolated-Clubfoot Group
Unilateral	6 of 25 (24%) had chromosomal abnormalities*	1 of 32 (3.1%) had chromosomal abnormalities*
Bilateral	4 of 8 (50%) had chromosomal abnormalities*	0 had chromosomal abnormalities
	47,XY +18 ($n = 4$)	47,XXY
	47,XX +18 ($n = 1$)	
	46,XX der(8) t(8;11) ($n = 1$)	
	Triploidy ($n = 2$)	
	46,XY inv(4) ($n = 1$)	
	47,XYY ($n = 1$)	

*Chromosomal abnormalities identified.

of sensitivity, specificity, and accuracy of US in determining the type of groin hernia were 84%, 92%, and 92%. Those results improved over time from 80%, 90%, and 90% for the period 2002–2010 ($n = 30$) to 95%, 98%, and 97% for the period of 2011–2012 ($n = 77$) (Table 2).

Performance of US in Identifying Recurrent Hernia

Among the 31 groins in patients who had previously undergone surgery but had had symptoms and signs of hernia, 6 were identified on US as having a recurrence of the initial hernia (5 indirect and 1 direct), 4 were identified as having a different type of hernia (2 indirect, 1 direct, and 1 femoral), and 21 were identified as having no recurrence of hernia. Two of the recurrent hernias were missed on US because they were small and had been obscured from visualization by the surgical mesh. These were subsequently found on follow-up MRI.

The overall rates of sensitivity, specificity, and accuracy of US in diagnosing recurrent hernia were 80%, 100%, and 94%.

DISCUSSION

US is known to be highly accurate in patients with clinically unequivocal groin hernia, although in this setting it provides little if any added benefit over clinical assessment.[2,10] However, US is increasingly being used to evaluate patients who have equivocal clinical findings.[9,10] This change in clinical referral practice is readily apparent at our institution, where, on average, fewer than 10 patients were referred yearly for US examination from 2002 through 2010 and more than 50 were referred yearly beginning in 2011. This increase in number over the last few years reflects a lower clinical threshold for referring patients with ambiguous clinical findings for US examination.

Both CT and MRI have high rates of accuracy (up to 96%) in diagnosing the presence of groin hernia, approaching the accuracy of herniography or surgical exploration.[1–6] In some centers, including ours, the clinical demands on the CT and MRI service are so high that US has become the first line of evaluation for suspected groin hernia. Also, because access to CT or MRI is not that readily available in many developing countries, US is the main imaging modality

used to investigate groin pathology. Some recent studies have demonstrated that the accuracy of US for diagnosing the presence and type of groin hernia is comparable to that of CT or MRI[3,9,11–16] (Tables 3 and 4). In this study, we investigated the rates of accuracy of identifying both the presence and the type of groin hernia and also looked at the change in our diagnostic accuracy over an 11-year period.

Unlike the method used in most previous studies, we used cross-sectional images from either CT or MRI as a reference standard for the presence or absence of hernia in those patients who either did not undergo surgery or had negative findings on US examination for hernia. Surgical exploration was used as the reference standard for identifying the type of groin hernia because the accuracy of CT and MRI has not been fully validated in this respect.[1–6]

All patients in our study cohort had symptoms of groin hernia but equivocal clinical findings. A previous study of 18 patients evaluated the performance of US in clinically equivocal cases and showed high rates of sensitivity of 95% and specificity of 100%, which are similar to those we found for determining the presence or absence of groin hernia.[11] A recent meta-analysis of published studies that included both clinically obvious and occult hernias showed the rate of sensitivity of US for detecting groin hernia to range from 93% to 100% and that of specificity to range from 22% to 100% (Table 3), providing overall rates of sensitivity and specificity of 96.6% and 84.8%.[3,9–14] Our results are comparable to those findings; we found rates of sensitivity and specificity of US in detecting groin hernia of 95% and 96%. Our results thus emphasize the high rate of accuracy of US in diagnosing the presence or absence of groin hernia in patients with clinically equivocal findings.

US is also known to be effective in evaluating complications (eg, hematoma, seroma) after mesh repair of groin hernias[17,18] but less sensitive in diagnosing recurrent hernia because these may be deep to and thus obscured by the surgical mesh. We found false-negative results in two patients owing to the mesh's obscuring the visibility of the recurrent hernia. In another study, three recurrent inguinal hernias found at surgery were not seen on preoperative US.[11] In addition, recurrent hernias may have a greater propensity than initial hernias to be reduced when the patient lies supine, making recurrences more difficult to detect.[11] Three of the five patients with negative results for hernia on US but who nevertheless underwent surgery did in fact have a hernia. Therefore, according to our normal clinical practice, if the clinical suspicion of hernia is high, even if the results of the US examination are normal, one should consider performing CT or MRI.

In our study, we incorrectly identified two spermatic cord lipomas as indirect inguinal hernias on US. A lipoma of the cord has features similar to those of a hernia containing

TABLE 3
Poor Outcomes in the Complex- and Isolated-Clubfoot Groups, by Laterality*

Laterality	Complex Group	Isolated Group
Bilateral	$n = 17$ Spina bifida ($n = 7$) VACTERL association Arthrogryposis Dandy-Walker malformation Caudal-regression syndrome Fryns syndrome Moebius syndrome CHARGE syndrome	$n = 3$ CNS abnormalities ($n = 2$) Arthrogryposis
Unilateral	$n = 4$ Spina bifida Fowler syndrome Cystic hygroma and hydrocephaly Esophageal atresia without tracheoesophageal fistula	$n = 1$ Fetal alcohol syndrome

Abbreviation: CNS, central nervous system.
*Excluding chromosomal abnormalities.

TABLE 4
Comparison of Chromosomal Abnormality Rates and Poor Outcomes by Clubfoot Laterality ($n = 90$ Cases)

Laterality of Clubfoot	Associated Findings	Chromosomal Abnormalities	*p* Value	*p* Value	Overall Poor Outcome	*p* Value	*p* Value
Unilateral 28/90 (31%)	Isolated 19/28 (67.8%)	0/19	$p < 0.01$	$p = 0.73$	1/19	$p < 0.001$	$p = 0.36$
	Complex 9/28 (32%)	4/9			8/9		
	Total	4/28			9/28		
Bilateral 62/90 (69%)	Isolated 37/62 (59.6%)	1/37	$p < 0.01$		4/37	$p < 0.001$	
	Complex 25/62 (40.3%)	6/25			23/25		
	Total	7/62			27/62		

mesenteric fat, the main distinction being continuity with the peritoneal cavity, reducibility, and change in size or shape on performance of the Valsalva maneuver. Color Doppler imaging has also been shown to help differentiate herniated mesenteric fat, which may show vascularity, from lipoma of the cord, which does not show vascularity; however, although this sign is specific, it is unfortunately not that sensitive, because most hernias containing mesenteric fat do not have demonstrable vascularity.[2,10]

Besides detecting the presence of a groin hernia, determining its type is necessary. Clinical examination is often unreliable at differentiating the type,[1] but its preoperative identification is important because the surgical approach to hernia repair differs between inguinal and femoral hernias. Inguinal hernia repair typically requires an oblique incision along the inguinal ligament, whereas femoral hernia repair requires a vertical incision over the femoral triangle.[1] One study showed that CT was quite accurate in this respect,[1] but the accuracy of US in classifying groin hernias has varied from 45% to 100% in previous studies[9,11–16] (Table 4). However, one recent study of 18 patients showed that the type of hernia was correctly identified on US in all positive cases.[11] In our study, the sensitivity, specificity, and accuracy for determining the type of hernia were high on US when surgical verification was available. The main error that occurred was in differentiating indirect from femoral or direct hernias. The errors in our distinguishing hernia types on US improved in more recent years as we have gained more experience and a greater awareness of the standardized US technique learned during a presentation at a departmental conference.

The key to US diagnosis of groin hernia is to routinely follow a meticulous standardized protocol (as described above), first identifying all of the critical anatomic landmarks and then carefully assessing the hernial orifices before and after having the patient perform the Valsalva maneuver in the supine and, occasionally, in the standing position. This will ensure a high degree of accuracy in the ability of US to diagnose both the presence and the type of groin hernia.

In addition to its retrospective nature, there are several limitations to this study. First, CT or MRI results were used as the overall gold standard because surgery was not performed in all of our patients who had negative findings for hernia on US. Second, we did not require the patient do the Valsalva maneuver during CT or MRI examination, even though that does seem to increase the likelihood of detecting groin hernia on CT, compared with CT examinations performed without that maneuver.[19] Finally, we did not address the interobserver variability of US.

In conclusion, we found that US is highly accurate at diagnosing the presence and type of groin hernia in patients who have equivocal findings on clinical examination.

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