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ORIGINAL ARTICLE

Prone "computed tomography hernia study" for the diagnosis of inguinal hernia

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Abstract

Purpose To improve diagnostic accuracy in cases of a suspected inguinal hernia, we perform a "CT hernia study," with the patient lying prone to allow decompression of the structures in the inguinal region.

Methods We reviewed the records of 914 patients with a suspected inguinal hernia who underwent prone non-contrast lower abdominal CT with two rolled-up towels, 20 cm in diameter, placed transversely beneath them, at the umbilicus and hips, respectively.

Results The CT hernia study yielded a diagnosis of inguinal hernia in 861 (94.2%) patients and a condition other than inguinal hernia in 43 (4.7%) patients. Hernia was not detected preoperatively but found intraoperatively in 10 patients (1.1%). Surgery was performed for a collective total of 1029 hernias in 873 patients, and the CT hernia study-based hernia detection rate was 98.3%. We compared the preoperative diagnoses of various types of hernia (Japanese Hernia Society Types I–V) against the intraoperative diagnoses and found that the CT hernia study yielded 95.8% accuracy.

Conclusion The CT hernia study appears to provide a high detection rate and makes differentiating the various types of inguinal hernia possible. We believe our CT hernia study adds a level of objectivity that is diagnostically beneficial.

Keywords Inguinal hernia · Diagnostic imaging · Computed tomography · Prone position

Introduction

Together, preoperative diagnosis and classification of adult inguinal hernias are important for deciding whether surgical repair is indicated and for selecting the appropriate surgical technique. Physical examination (inspection and palpation) is the standard diagnostic approach to adult inguinal hernia, as recommended by the European Hernia Society [1]. However, in obese patients, swelling in the inguinal region may not be easy to recognize, making hernia diagnosis difficult. Moreover, a femoral hernia often coexists with an inguinal hernia in women, and this too must be diagnosed for selection of the appropriate surgical procedure.

Diagnostic imaging, such as herniography and/or ultrasonography, is performed to overcome the limitations of physical examination when an inguinal hernia is suspected. However, herniography involves inserting a needle through the abdominal wall to inject contrast medium into the peritoneal cavity, making the procedure invasive. There is also a risk of perforation of the bowel or bleeding and even subsequent infection [2–4]. Ultrasonography is useful for diagnosing inguinal hernia, but its accuracy depends on the skill of the ultrasonographer, and objectivity and reproducibility are lacking [5]. Neither herniography nor ultrasonography-based diagnosis of inguinal hernia is standardized. The ideal clinical scenario would be one in which the preoperative diagnosis is always accurate and comprehensive so that treatment decisions can be made with confidence. Thus, we devised a computed tomography (CT) procedure, named "CT hernia study", for adult patients when physical examination suggests an inguinal hernia. The key to this CT hernia study is decompression of the structures in the inguinal region. We conducted a retrospective study to establish whether our CT

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hernia study is useful for classifying inguinal hernias and for selecting the appropriate treatment.

Patients and methods

Patients

From a review of departmental records, we identified 914 patients who presented with pain and/or swelling in the inguinal region and were examined in the St. Marianna University School of Medicine Department of Gastrointestinal and General Surgery, Tokyo, between April 2006 and December 2014. Patients in whom an inguinal hernia was suspected underwent our CT hernia study after providing informed consent. The CT hernia study was not performed for any patient who required emergency treatment for hernial incarceration or who could not tolerate being placed in the prone position.

CT hernia study

The CT hernia study is performed as follows: the patient is placed in the prone position. Two 60 × 120 cm towels are rolled up as bolsters, approximately 60 cm in length and 20 cm in diameter. These bolsters are placed beneath the patient transversely, about 20 cm apart: one at the umbilicus and the other at the thigh, lifting the patient's body away from the table. This is done to decompress the structures in the inguinal region on both sides. Once the patient is properly positioned, we obtain a non-contrast, lower abdominal CT image (Fig. 1).

Interpretation of the CT images

In each case, the CT image obtained was used to diagnose the hernia definitively and classify it according to the Japanese Hernia Society (JHS) inguinal hernia classification system (Table 1) [6]. Interpretation of all images was done collaboratively by at least one gastrointestinal surgeon and one radiologist who had been certified by the Japan Radiological Society for 10 years or more. In viewing the images, the examiners traced the inferior epigastric artery (IEA) and inferior epigastric vein running dorsally to the caudal half of the rectus abdominis muscle. They identified these vessels as continuous with the external iliac artery and vein, respectively. An inguinal hernia was recognized by a protrusion through the abdominal wall of a portion of bowel and/or intraperitoneal fat and a separation of 5 mm or more between the peritoneum and abdominal wall.

Each patient's hernia was further classified as one of five types: indirect inguinal hernia (Type I), when the hernia sac or its contents were lateral to the IEA (Fig. 2a); direct inguinal hernia (Type II), when prolapse was medial to the IEA (Type II) (Fig. 2b); femoral hernia (Type III), when the hernial sac or its contents were medial to the femoral vessels and caudal to the inguinal ligament (Fig. 2c); or complex (combined) hernia (Type IV), when any two of the Type I–III hernias coexisted. Hernias that were difficult to classify were referred to as unclassified (Type V). A Type I hernia was recognized by the lateral crescent sign (Fig. 2a), which refers to CT depiction of the altered course of the inferior epigastric vessels when they are displaced into the hernia sac.

Fig. 1 Computed tomography imaging is performed with the patient prone for decompression of the inguinal region

Table 1 The Japan Hernia Society inguinal hernia classification system

Type I: Indirect (lateral) inguinal hernia
I-1: Indirect (lateral) inguinal hernia (small)
Diameter of the orifice is less than 1 cm (one finger-breadth); provided that less than one finger-breadth means that the fifth finger cannot be inserted
I-2: Indirect (lateral) inguinal hernia (medium)
Diameter of the orifice is equal to or larger than 1 cm (one finger-breadth) and less than 3 cm (two finger-breadths); provided that less than two finger-breadths means that the second and third finger cannot be inserted
I-3: Indirect (lateral) inguinal hernia (large)
Diameter of the internal ring is equal to or larger than 3 cm (two finger-breadths)
Type II. Direct (medial) inguinal hernia
II-1: Direct (medial) inguinal hernia (supra-vesical)
Diameter of the orifice is less than 3 cm (two finger-breadths), and the center of the orifice is within the medial half of the posterior wall of the inguinal canal
II-2: Direct (medial) inguinal hernia (localized type)
Diameter of the orifice is less than 3 cm (two finger-breadths), and the center of the orifice is within the lateral half of the posterior wall of the inguinal canal
II-3: Direct (medial) inguinal hernia (diffuse type)
Diameter of the orifice is equal to or larger than 3 cm (two finger-breadths)
Type III: Femoral hernia
Type IV: Combined type
Coexisting indirect (lateral) inguinal hernia, direct (medial) inguinal hernia, or femoral hernia (describe each type)
Type V: Unclassified
Not classified as one of the above types

See Reference 6

Recurrent hernia is described according to the classification of the primary hernia

Evaluation of the CT hernia study

To assess our CT hernia study as a means of accurately diagnosing inguinal hernia preoperatively, we reviewed the patients' records and calculated both the number and percentage of patients with a hernia detected by our prone CT examination and the number and percentage of patients whose hernia was accurately classified by the examination. Accuracy of the preoperative classifications was based on the intraoperative classifications.

The study was approved by our hospital's ethics committee (approval no. 106), and informed consent was obtained from all patients for anonymized use of pertinent information from their medical records for study purposes.

Statistical analyses

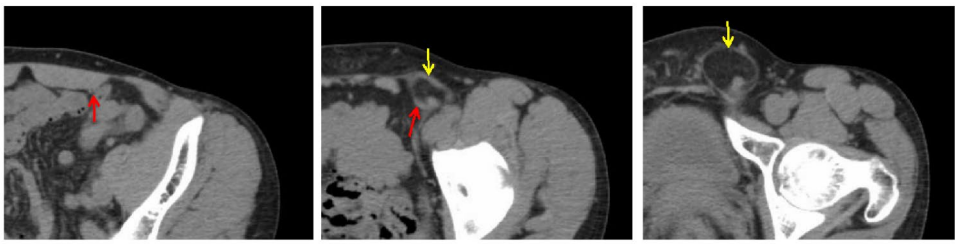
Values are expressed as means ± SD or the number and percentage of patients or hernias. Data were analyzed by Fisher's exact test. JMP Pro 13.0.0 was used for all statistical analyses, and $p < 0.05$ was considered significant.

Results

The study group comprised 795 men and 119 women, aged 65.2 ± 14.9 years, with a collective total of 1029 lesions. Inguinal hernia was diagnosed using the CT hernia study in 861 (94.2%) of the study patients (1017 lesions), and one or more conditions other than hernia (no hernia present) were diagnosed in the remaining 43 patients (Table 2). These other conditions comprised hydrocele of the canal of Nuck ($n = 17$), inguinal lymphadenopathy ($n = 8$), scrotal hydrocele ($n = 6$), funicular hydrocele ($n = 3$), spermatic varicocele ($n = 4$), lipoma ($n = 3$), funiculitis ($n = 1$), and cryptorchidism ($n = 1$). Surgery was performed for eight of the patients with another condition diagnosed. The preoperative and intraoperative diagnoses were consistent in four of the patients with a hydrocele of the canal of Nuck and in two of the patients with a scrotal hydrocele, whereas the suspected inguinal lymphadenopathies for which surgery was performed were revealed to be an inguinal ganglion in one patient and a malignant lymphoma in one patient. An inguinal hernia was also found intraoperatively in one of the patients with a hydrocele of the canal of Nuck and one with a scrotal hydrocele.

A Indirect hernia (Type I)

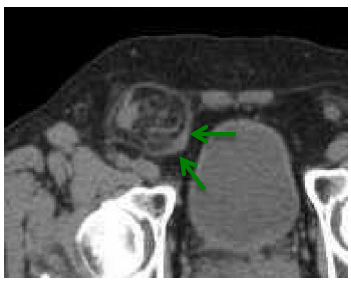
A-1



Red arrow: Inferior epigastric vessels

Yellow arrow: Hernial sac

A-2



Green arrow: Lateral crescent sign

B Direct hernia (Type II)

Red arrow: Inferior epigastric vessels

Yellow arrow: Hernial sac

C Femoral hernia (Type III)

Blue arrow: Femoral vein

Yellow arrow: Hernial sac

Fig. 2 Computed tomography hernia study-based diagnosis of the various hernia types

Table 2 Computed tomography hernia study-based diagnoses of disorders other than inguinal hernia

Hydrocele of the canal of Nuck	17 (4) patients
Inguinal lymphadenopathy	6 (2) patients
Scrotal hydrocele	6 (2) patients
Funicular hydrocele	3 patients
Spermatic varicocele	4 patients
Lipoma	3 patients
Funiculitis	1 patient
Cryptorchidism	1 patient
Total	43 patients

Numbers in parentheses are the number of patients treated surgically

A total of 1029 inguinal hernias in 873 patients were treated surgically. Of those hernias, 1011 were detected by the CT hernia study, and 18 were not. Thus, the CT hernia study detection rate was 98.3%. The surgically treated hernias were left-sided in 404 patients, right-sided in 313 patients, and bilateral in 156 patients. Table 3 shows the intraoperative diagnoses vs. the preoperative diagnoses. Of the 628 hernias diagnosed preoperatively as Type I, 609 (96.8%) were diagnosed intraoperatively as Type I, 12 (2.0%) as Type II, and 7 (1.2%) as Type IV (combination of Types I and II). Of the 331 hernias diagnosed preoperatively as Type II, 316 (95.4%) were diagnosed intraoperatively as Type II (95.4%), 3 (1%) as Type III, and 12 (3.6%) as Type IV (combination of types I and II). All 28 hernias diagnosed preoperatively as Type III were also diagnosed intraoperatively as Type III. Four of the 20 hernias diagnosed preoperatively as Type IV were diagnosed intraoperatively as Type V (unclassified). Thus, the preoperative CT hernia study-based diagnoses were correct for 969 hernias, for a preoperative diagnostic accuracy of 95.8%.

There were 791 patients with only unilateral symptoms and positive physical examination findings. Of these patients, 160 were found to have a subclinical hernia, for a CT hernia study detection rate of 20.2%. Bilateral hernia was identified and repaired in 74 of these 160 patients.

Discussion

Palpation is generally carried out to detect and diagnose adult inguinal hernia. Herniography and ultrasonography are often used to confirm the diagnosis, but herniography is invasive, and these imaging modalities do not always yield satisfactory results. An accurate preoperative diagnosis is important because it becomes the basis for treatment decisions. Reports on the diagnosis of hernias include a study by Suzuki et al. [7] on diagnosing femoral and inguinal hernias on supine CT images. They reported that inguinal hernias were detected on only 48% of supine CT images ($p < 0.001$) and that the prolapse disappeared in more than 50% of cases during CT imaging. Although the CT hernia study entails radiation exposure, the study is performed without contrast, so venipuncture is not required, and there is no risk of an allergic reaction. Although no contrast is used during the study, the inferior epigastric vessels are easily identified, as is the positional relation between these vessels and the hernial orifice in patients with a detectable hernia. We found the sensitivity and specificity of our CT hernia study to be 98.3% and 100%, respectively, indicating that this technique is effective for detecting inguinal hernia. Moreover, it is an easy and non-invasive form of diagnostic imaging for inguinal hernias.

A condition other than inguinal hernia was diagnosed in 43 of our patients, and although these conditions were difficult to differentiate based on physical examination findings alone, it was possible to diagnose these conditions from the CT hernia study findings, whereby surgery could be avoided for many patients.

The CT hernia study yielded a correct diagnosis of the hernia type in 95.8% of cases. Yamaguchi et al. [8] reported that ultrasonographic examination of the inguinal region resulted in accurate identification of the type of inguinal hernia in 68% of cases ($p < 0.001$), whereas Watanuki et al. [9] reported 91% accuracy ($p = 0.0961$). Difficulty in diagnosis based on ultrasonography, whether the inferior epigastric vessels lie medially or laterally when the hernial orifice is large, is reported to be a source

Table 3 Intraoperative diagnoses of inguinal hernia types in relation to preoperative diagnoses

Preoperative diagnosis[a]	Intraoperative diagnosis[a]					Total
	Type I	Type II	Type III	Type IV	Type V	
Type I	609	12	0	7	0	628
Type II	3	316	0	12	0	331
Type III	0	0	28	0	0	28
Type IV	2	2	0	16	0	20
Type V	1	3	0	0	0	4
Total	615	333	28	35	0	1011

[a]Based on the Japanese Hernia Society inguinal hernia classification system

of error [9]. Nakajima et al. [10] performed preoperative herniography in 24 of 26 patients who underwent inguinal hernia surgery and confirmed the hernia in all 24 patients. When they compared the preoperative diagnoses against the surgical findings, they found that the hernia type was correctly identified preoperatively in 92.3% of cases ($p = 0.3213$) [11]. Fumimoto et al. [11] classified inguinal hernias as internal, external, or coexistent internal and indirect hernias, and found that the correct hernia type was identified preoperatively by herniography in 93% of cases ($p = 0.4681$).

The preoperative and intraoperative diagnoses differed in 42 (3.8%) of our patients who underwent the CT hernia study. 12 hernias were diagnosed as Type I preoperatively, but Type II intraoperatively; and 3 hernias were diagnosed as Type II preoperatively but Type I intraoperatively. We think that diagnosis was difficult in these cases because of laxity of the posterior wall of the inguinal canal and the overall appearance of prolapse. 19 of the hernias in this study were diagnosed as Type I or II preoperatively but as Type IV (complex) intraoperatively.

The CT hernia study can be used not only to establish the JHS classification, but also to judge the vulnerability of surrounding tissues, which is important for deciding the appropriate surgical strategy. The various strategies are applied differentially, and according to Sakurai [12], even for Type I-1 hernias, if the posterior wall of the inguinal canal is firm, as in young people, high ligation and the Marcy method are appropriate. However, mesh repair is necessary if the posterior wall of the inguinal canal is weakened, as in elderly people. The Lichtenstein method is inappropriate for a Type III hernia.

Although not officially defined by the JHS, subclinical hernia is generally recognized as a symptomless bulge in the groin area. The incidence of and risk factors for clinical manifestation of subclinical inguinal hernia were investigated at our institution, based on our CT hernia study, and the 5-year incidence of symptoms developing was 23.3% [13]. A large, symptomatic hernia is a risk factor for clinical manifestation, and because clinical manifestation occurs most readily in patients in with a hernia $\geq 44.5\ cm^3$, these patients require careful follow-up. We also believe that single-stage or early surgery should be considered [13].

Preoperative diagnosis of a subclinical hernia should translate to prevention of a contralateral hernia after unilateral surgery, and operating on both sides simultaneously should reduce the number of surgeries required, without compromising the quality of life of elderly patients and patients with comorbidities. We hope that an accumulation of reports from multiple centers describing the diagnosis and treatment of inguinal hernia will pave the way to reliable preoperative evaluation of the relative curability of inguinal hernias.

Conclusion

Our preoperative CT hernia study, devised for adults with suspected inguinal hernia, provides a high detection rate, excludes disorders other than hernia, helps identify the type of inguinal hernia, and facilitates the detection of subclinical hernia. The CT hernia study is safe, and we believe that its continued application will confirm its clinical usefulness.

Compliance with ethical standards

Conflict of interest NK declares no conflict of interest. TO declares no conflict of interest. SK declares no conflict of interest. TM declares no conflict of interest. YN declares no conflict of interest.

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