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Significance of routine preoperative prone computed tomography for predicting intractable cases of inguinal hernias treated by transabdominal preperitoneal repair

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Abstract
Physical examination is the standard diagnostic approach for adult inguinal hernias. We aimed to evaluate the clinical utility of routine preoperative computed tomography scans in the prone position for predicting intractable cases of inguinal hernias before performing transabdominal preperitoneal repairs. We retrospectively analyzed 56 lesions in 48 patients with inguinal hernias who underwent prone computed tomography scans prior to transabdominal preperitoneal repairs. To assess the ability of prone computed tomography to enable the accurate preoperative diagnosis of inguinal hernias, we compared preoperative hernia types as classified through hernia computed tomography and intraoperative diagnosis. We also analyzed the relationship between operation time and hernia type in unilateral cases (n = 40). The overall hernia computed tomography detection and classification accuracy rates were 81.0% and 83.9%, respectively, using the Japan Hernia Society classification system (2009 version) and 84.3% and 91.2%, respectively, using the European Hernia Society classification system. There were no differences in the hernia type frequencies between the shorter (n = 20) and longer (n = 20) operation time groups. Two patients had sliding inguinal hernias with prolapsing bladders, both of which were detectable using preoperative prone computed tomography. Although transabdominal preperitoneal repairs were completed in both cases, the operation times were exceptionally long (185 and 291 minute). Preoperative prone computed tomography is useful for predicting intractable cases of inguinal hernias. Prone computed tomography can play a significant role in not only typing and differentiating hernias from other diseases, but also in helping surgeons appropriately treat unexpected intractable cases with laparoscopic surgery.

Abbreviations: CT = computed tomography, EHS = European hernia society, F = femoral, IEA = inferior epigastric artery, JHS = Japanese hernia society, L = lateral, M = medial, TAPP = transabdominal preperitoneal.

Keywords: computed tomography, inguinal hernia, laparoscopy

1. Introduction

More than 20 million inguinal hernia repairs are performed worldwide each year.[1] Aside from the classical open repairs, laparoscopic repairs are increasingly preferred to treat inguinal hernias due to recent advances in laparoscopic surgical instruments and techniques.[2] The increase in these procedures is mainly aimed at reducing the rate of chronic pain and reducing recovery times without compromising recurrence rates.[3] Therefore, accurate preoperative diagnoses are mandatory to enable surgeons to perform the procedures appropriately and smoothly.

Inguinal hernias typically present as symptomatic (but reducible) inguinal bulges. The European hernia society (EHS) recommends that the standard diagnostic approach to adult inguinal hernias is physical examination.[4] However, further evaluation with imaging may be indicated when the physical examination findings are indeterminant and concerns about femoral hernias

Opt-out informed consent was obtained instead of written informed consent, and an opportunity to decline participation was also provided.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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or other tumorous lesions exist.[5] Although a herniography is a radiological technique that was developed for use in the diagnosis of inguinal hernias, it is rarely employed because of its invasiveness.[6] Ultrasonography is a noninvasive procedure that is useful for the detection of inguinal hernias; however, factors related to both the operator and patient can significantly affect the objectivity and reproducibility of the technique.[7] Presently, computed tomography (CT) and (occasionally) magnetic resonance imaging are used to detect inguinal hernias. Although it is difficult to predict the existence and characterization of inguinal hernias using conventional supine CT, a prone CT scan under decompression in the groin (hereafter referred to as hernia CT) exhibits improved diagnostic ability.[8]

During inguinal hernia surgery, surgeons sometimes encounter intractable cases that make the operation difficult to perform. A sliding inguinal hernia is a type of hernia in which the intra-abdominal organs prolapse.[9] Sliding hernias are estimated to account for 3% to 7% of all inguinal hernias.[10–12] Preoperatively diagnosing slipped and prolapsed hernias is difficult; therefore, these hernias are often initially diagnosed during surgery.[10,13,14] Prolapsed bladders are observed in 0.5% to 4% of slipped and prolapsed hernia cases, the majority of which are internal inguinal hernias.[15,16] However, some patients with sliding inguinal hernias and prolapsed bladders have an indirect form of inguinal hernia, and these cases are difficult to treat surgically.[17]

In our department, we perform transabdominal preperitoneal (TAPP) repairs as a first-choice procedure for inguinal hernias. To make the repair procedure safer, we routinely perform preoperative hernia CT scans for all inguinal hernia cases. In this study, we aimed to retrospectively evaluate the clinical utility of hernia CT scans for predicting intractable cases of inguinal hernias before performing TAPP repairs.

2. Methods

2.1. Patients

After receiving approval to conduct this study from the Gunma University Hospital Clinical Research Review Board (approval no. HS2019-197), we retrospectively analyzed 56 lesions in 48 patients who underwent hernia CT and subsequent laparoscopic inguinal hernia repair at Gunma University Hospital from April 2015 to December 2018. The mean age of the patients was 68.7 years (range, 47–90 years), and the male to female ratio was 43:5 (89.6%:10.4%). Opt-out informed consent was obtained instead of written informed consent, and an opportunity to decline participation was also provided.

2.2. Hernia CT

The hernia CT portion of the study was performed as follows: to begin, the patient was placed in the prone position. Two 60 × 120 cm towels were rolled up as bolsters that were approximately 60 cm in length and 20 cm in diameter. The bolsters were placed beneath the patient transversely, approximately 20 cm apart; one bolster was placed at the umbilicus and the other at the thigh, thereby lifting the patient's body above the table. This was done to decompress the structures on both sides of the inguinal region. Once the patient was properly positioned, a non-contrast, lower abdominal CT was performed.

2.3. TAPP operative procedure

We used either a 5 mm or a 10 mm trocar at the umbilicus for the flexible laparoscope and two 5 mm trocars to aid in performing the TAPP repair. A peritoneal incision was made from the outside of the hernial orifice. For patients with indirect inguinal hernias, a circular incision around the peritoneum of the hernia orifice was made, and complete dissection of the myopectineal orifice was performed. For those with direct inguinal hernias, a peritoneal incision was started from the lateral side of the internal inguinal ring to dissect the preperitoneal space, and the myopectineal orifice was dissected off between the hernia sac and the transverse fascia without making an annular incision around the hernial orifice. A polypropylene mesh (3DMax™ Light Mesh; Bard, Murray Hill, NJ) was inserted into the dissection cavity and placed such that it completely covered the myopectineal orifice. It was then fixed with an absorbable tacker (AbsorbaTack™; Medtronic, Minneapolis, MN).

2.4. Interpretation of the CT images

For each patient, the CT image was used to diagnose the hernia definitively and classify it according to both the Japanese hernia society (JHS) inguinal hernia classification system (2009 version, Table S1, Supplemental Digital Content, http://links.lww.com/MD/H992) and the EHS inguinal hernia classification system (Table S2, Supplemental Digital Content, http://links.lww.com/MD/H993). The interpretation of all the images was performed collaboratively by at least one gastrointestinal surgeon and one radiologist who was certified by the Japan Radiological Society for at least 10 years. 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 and identified these vessels as continuous with the external iliac artery and vein, respectively. An inguinal hernia was defined as a protrusion of a portion of the bowel and/or intraperitoneal fat through the abdominal wall and a separation of ≥ 5 mm between the peritoneum and abdominal wall.

Each hernia was classified into one of the following types of inguinal hernias using the JHS inguinal hernia classification system (2009 version): Type I- indirect inguinal hernia (the hernia sac or its contents are lateral to the IEA); Type II- direct inguinal hernia (the prolapse is medial to the IEA); Type III- femoral hernia (the hernial sac or its contents are medial to the femoral vessels and caudal to the inguinal ligament); Type IV- complex (combined) hernia (any two of the Type I–III hernias coexisting); Type V- unclassified (hernias that are difficult to classify). A type I hernia was recognized by identifying the lateral crescent sign, which refers to a CT depiction of the altered course of the inferior epigastric vessels when they are displaced into the hernial sac. Each hernia was further classified as a lateral (L), medial (M), or femoral (F) inguinal hernia using the EHS inguinal hernia classification system.

2.5. Comparison of the classification of inguinal hernias using hernia CT and intraoperative diagnosis

To assess whether hernia CT scans can be used to accurately diagnose inguinal hernias preoperatively, we compared preoperative inguinal hernia types, as classified using both hernia CT and intraoperative diagnosis. To obtain the intraoperative findings, the patients' records were retrospectively reviewed. Although we classified all the patients using both the JHS and EHS systems, the diameter of the orifice was not considered because it is difficult to measure using CT. The accuracy of the preoperative classifications, as identified using both the JHS (Types I, II, III, IV, and V) and EHS (L, M, and F) systems, was evaluated based on a comparison of the results from the 2 systems. Combined types (as classified using the JHS system), such as coexisting indirect and direct hernias, were counted as separate types in the EHS system.

2.6. Relationship between operation time and hernia type

To align the condition, we limited the analysis of the relationship between operation time and hernia type to unilateral cases (n = 40). The hernia type was determined using the intraoperative findings.

2.7. Intraoperative/postoperative complications, postoperative hospital stay length, and recurrence

The intraoperative and postoperative complications, length of postoperative hospital stay, and recurrence rates were analyzed. Complications were assessed using the Clavien-Dindo classification system.[18] The period between the day of the operation and the cutoff day (January 4, 2021) ranged from 787 to 1944 days. Regular follow-ups usually ended with the first visit after discharge (usually approximately one month after surgery) unless there were specific problems.

2.8. Statistical analyses

The data are expressed as the mean ± standard deviation or the number and percentage of patients or hernias. The data were analyzed using Fisher's exact test. EZR10 version 1.36 (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria), was used for all the statistical analyses, and $P < .05$ was considered significant.

3. Results

3.1. Classification using hernia CT scans and intraoperative diagnosis

The comparisons of the preoperative CT evaluations and intraoperative findings are shown in Table 1 (JHS classification system) and Table 2 (EHS classification system).

Using the JHS classification system, the hernia CT detection rate was 97.2% for Type I hernias, 81.8% for Type II, 100% for Type III, and 25% for Type IV. The hernia CT classification accuracy was 94.6% for Type I hernias, 60% for Type II, 100% for Type III, 100% for Type IV, and 0% for Type V. The overall hernia CT detection rate and classification accuracy using the JHS classification system were 81.0 % and 83.9%, respectively.

Using the EHS classification system, the hernia CT detection rate was 90.2% for L type hernias, 88.2% for the M type, and 50% for the F type. The hernia CT classification accuracy was 97.3% for L type hernias, 88.2% for the M type, and 100% for the F type. The overall hernia CT detection rate and classification accuracy using the EHS classification system were 84.3% and 91.2%, respectively.

3.2. Type of hernia and operation time

The average operation time for unilateral cases was 111 minutes (Fig. 1). We divided these 40 patients into a shorter operation time group (n = 20) and a longer operation time group (n = 20) and compared the distributions of the hernia types, as determined using both the JHS and EHS classification systems, between the 2 groups. There were no differences in the hernia type frequencies between the shorter and longer operation time groups (Table 3, $P = 1.0$ for the JHS classification system and $P = .663$ for the EHS classification system).

In the series of 40 unilateral cases, case #39 and case #40 were both sliding inguinal hernias with prolapsing bladders (case #40 was a recurrent case). Among all the patients in the study, the longest surgery time (291 minute) was for case #40, and the second longest time (185 minute) was for case #39. The intraoperative findings for both patients showed that the bladder prolapsed and slipped off the outside of the inferior epigastric artery and vein. Case #39 is representatively shown in Figure 2 and Video, Supplemental Digital Content, http://links.lww.com/MD/H994. In both cases, these findings were also detectable using the preoperative hernia CT.

3.3. Intraoperative/postoperative complications, postoperative hospital stay length, and recurrence

There were no intraoperative complications or complications of grade II or higher related to the surgical procedures. The mean postoperative hospital stay was 2.65 days (1–10 days), and there were no cases of recurrence within the observation period of approximately 2 to 5 years after the surgery.

4. Discussion

An accurate preoperative inguinal hernia diagnosis is important, as it helps to form the basis for treatment decisions. The clinical significance of preoperative inguinal hernia evaluations using CT is viewed negatively in Europe and the United States.[1] Notably, Suzuki et al found that only 48% of inguinal hernias were detected using supine CT imaging, and the prolapse was not visible in more than 50% of these cases.[19] However, the introduction of prone CT scans has markedly improved the ability of clinicians to detect and classify inguinal hernias, as well as evaluate occult hernias.[8] Kamei et al reported a high detection rate and ability to differentiate the inguinal hernia types using prone CT based on an analysis of 1029 hernias.[20] Hernia CT scans can also be performed without contrast, alleviating concerns about contrast agent allergies. Therefore, we routinely perform hernia CT scans for all patients with inguinal hernias.

Table 1

Comparison of inguinal hernia type by the Japanese hernia society classification (2009 version) between prone computed tomography and intraoperative diagnosis.

	Intraoperative diagnosis						
Hernia CT findings	Type I	Type II	Type III	Type IV	Type V	None	Total
Type I	35	1	0	1	0	0	37
Type II	0	9	0	4	0	2	15
Type III	0	0	1	0	0	0	1
Type IV	0	0	0	2	0	0	2
Type V	0	0	0	1	0	0	1
None	1	1	0	0	0	0	2
Total	36	11	1	8	0	2	

CT = computed tomography.

Table 2

Comparison of inguinal hernia type by the European hernia society classification between prone computed tomography and intraoperative diagnosis.

	Intraoperative diagnosis				
Hernia CT findings	**L**	**M**	**F**	**None**	**Total**
L	37	1	0	0	38
M	0	15	0	2	17
F	0	0	2	0	2
None	4	1	2	0	7
Total	41	17	4	2	

Combined types, such as the coexistence of indirect and direct hernias, were counted separately.
CT = computed tomography, F = femoral, L = lateral, M = medial.

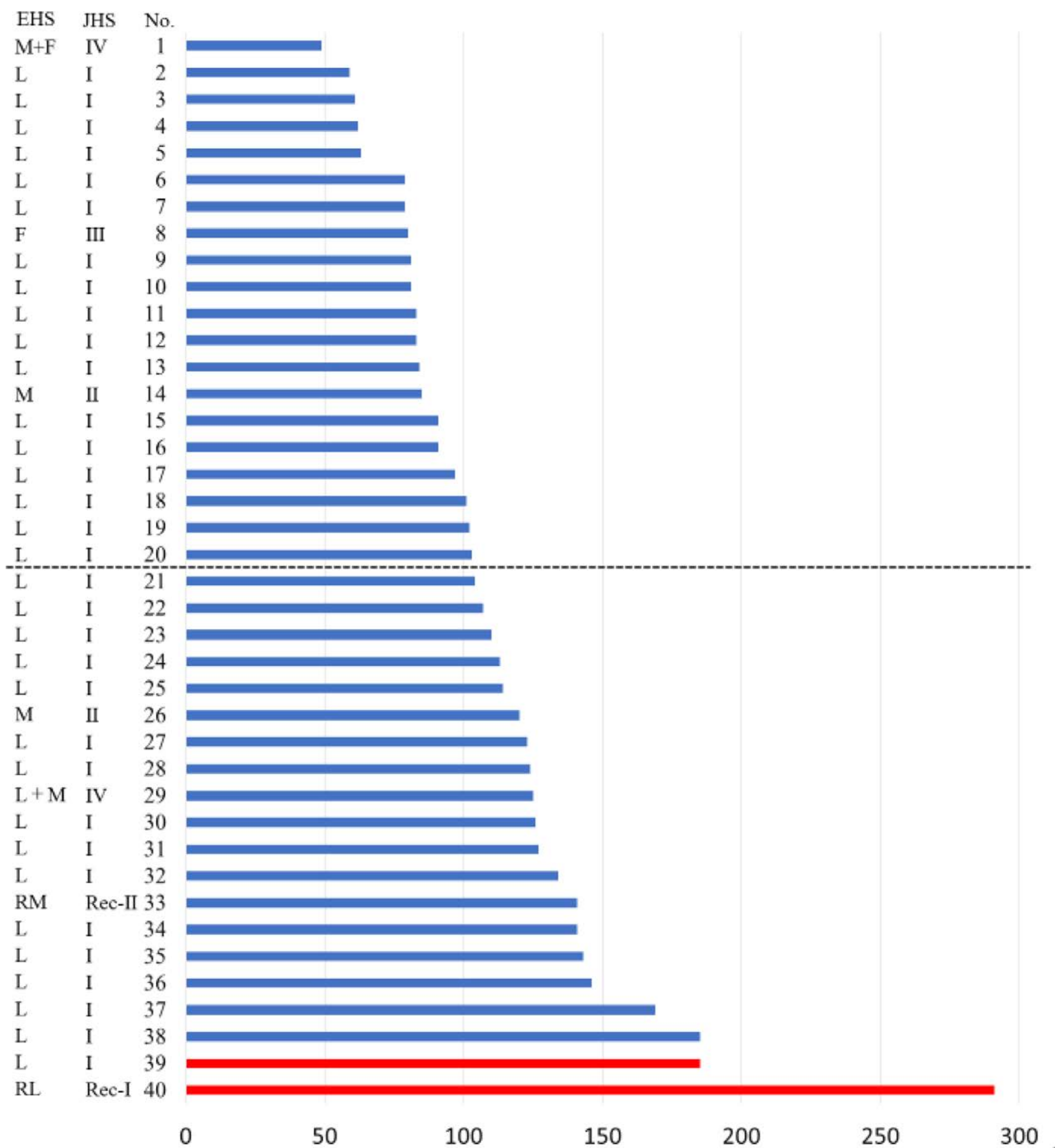

Figure 1. Diagram of the operation time, JHS classification, and EHS classification for the unilateral surgery cases. Two of the cases (case #39 and case #40) with sliding inguinal hernia prolapsing bladders are indicated by the red bars. EHS = European hernia society, JHS = Japanese hernia society.

Table 3

Comparison of inguinal hernia type and operation time.

	Operation time				
Hernia CT findings	**Shorter group (n = 20)**		**Longer group (n = 20)**		***P* value**
Japanese Hernia Society classification (2009 version)					
Type I	17	(85.0)	17	(85.0)	1
Type II	1	(5.0)	2	(10.0)	
Type III	1	(5.0)	0	(0)	
Type IV	1	(5.0)	1	(5.0)	
Type V	0	(0)	0	(0)	
European Hernia Society classification					
L	17	(81.0)	18	(85.7)	.663
M	2	(9.5)	3	(14.3)	
F	2	(9.5)	0	(0)	

The data in parentheses indicate percentages.
CT = computed tomography, F = femoral, L = lateral, M = medial.

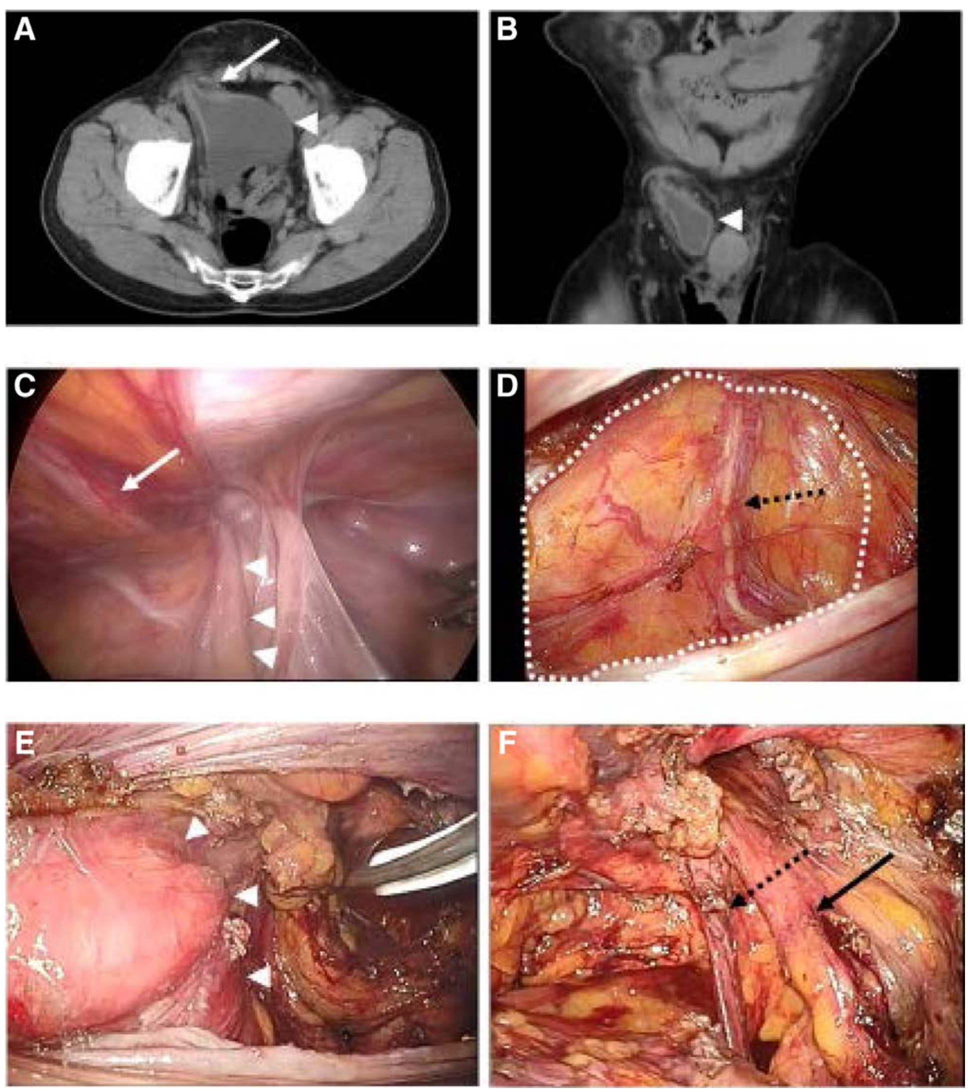

Figure 2. Preoperative and intraoperative findings for case #39. (a), (b) The hernia CT scan shows that the bladder slides into the inguinal canal from the outside of the inferior epigastric artery and vein. (c) Intraoperative findings. The bladder was sliding from the outside of the inferior epigastric artery and vein. (d) When the preperitoneal cavity was dissected from the outside, the bladder appeared in a partition-like shape, making it difficult to dissect off the Retzius space. The spermatic code was found on the bladder. (e) After the dissection, the bladder was returned from the inguinal canal into the preperitoneal space. (f) The post-dissection findings were similar to those of a typical indirect inguinal hernia. White arrow: inferior epigastric artery and vein. White arrowhead: bladder. White dotted area: bladder. Black arrow: testicular artery and vein. Black dotted arrow: spermatic code. CT = computed tomography.

In this study, we analyzed the relationship between hernia CT scans and intraoperative findings. The overall hernia CT detection rate and classification accuracy were 81.0% and 83.9%, respectively, using the JHS classification system and 84.3% and 91.2%, respectively, using the EHS classification system. Our analysis of each hernia type revealed that the hernia CT detection rate for Types IV and F and the classification accuracy for Types II and V were < 80%. These results were relatively inferior to those from Kamei et al (detection rate and accuracy: 98.3% and 95.8%, respectively).[20] There are 2 possible reasons for this discrepancy. The first is the number of subjects in the current study might have been too small to adequately evaluate the hernia CT detection rate and classification accuracy for each type. The other potential reason is the operative procedure. We performed TAPP repairs for all the patients in this study. TAPP repairs are particularly advantageous because the laparoscopic images allow detailed observations of the bilateral inguinal regions, leading to more accurate diagnoses.[21] We believe that TAPP repairs might contribute to more accurate intraoperative diagnoses, potentially resulting in inferior hernia CT detection rates and classification accuracies.

We encountered 2 cases of sliding inguinal hernias with prolapsing bladders. Patle et al found no recurrence of laparoscopy-related sliding inguinal hernias in 27 cases of TAPP repairs and 19 cases of totally extraperitoneal approaches, which they argued was evidence for the usefulness of laparoscopic surgery.[22] Conversely, Andresen et al reported that the sliding inguinal hernia recurrence rate for laparoscopic surgery was 6.1%, which is slightly higher than the 4.5% rate for the Lichtenstein method.[13] For the 2 cases of sliding inguinal hernias with prolapsing bladders in the present study, hernia CT detected that the bladders had escaped from within the inferior epigastric arteries and veins. Eventually, these 2 cases were successfully treated with TAPP repairs; however, it took a substantially longer time to perform these operations compared with the other cases, indicating the difficulty of the surgical procedures in these cases. In fact, in case #40, the original surgeon had to be replaced by a senior surgeon during the operation due to operator disorientation. During laparoscopic surgery, misidentification of the dissection layer makes subsequent anatomical recognition extremely difficult; therefore, it is important to make diagnostic predictions before surgery whenever possible. In such cases, a senior doctor familiar with TAPP repair may be able to perform the surgery more safely. We believe that hernia CT can play a key role in accurately evaluating the degree of surgical difficulty in cases requiring TAPP repair.

There are some limitations to this study. First, this study was based on a small number of cases from a single institute. Second, the operators were not fixed during the study period. Additionally, at our institute, the residents tend to perform the inguinal hernia operations, which likely affected the operation time variability. Third, we did not consider the diameter of the orifice when classifying the types of hernias because the information provided in the medical records was inadequate. A more detailed analysis of the orifice diameter is required for future studies.

In conclusion, routine preoperative prone CT is useful for predicting unexpected intractable cases of inguinal hernias before treatment with TAPP repair. We believe that hernia CT scans play a significant role, not only in the typing of hernias and differentiating them from other diseases, but also in appropriately managing unexpected intractable cases using TAPP repair. With the wider availability of the robotic platform, the utilization of robotic inguinal hernia repair has recently increased.[23] We believe that further development of preoperative diagnostic abilities is also needed, accompanied by a requirement for more advanced surgical techniques. In the future, multi-institutional investigations on the diagnosis of inguinal hernias will aid in the development of an appropriate preoperative evaluation methodology for this common disease.

Author contributions

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