Historical changes in recurrence forms and their mechanisms after laparoscopic transabdominal preperitoneal inguinal hernioplasty, as assessed by video review

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Abstract

Background: Technical factors leading to hernia recurrence after transabdominal preperitoneal (TAPP) repair include insufficient dissection, inadequate prosthetic overlap and prosthetic size, improper fixation and folding or crinkling of the prosthesis. However, which of these can intraoperatively determine if a case will go on to develop recurrent hernias remains unclear.

Methods: We reviewed operation videos for 27 control cases and primary laparoscopic hernioplasty of 13 lesions where the patient suffered recurrence after TAPP repair. Five surgeons blindly reviewed the videos to assess surgical techniques such as adequate dissection, mesh coverage, and folding or crinkling of the mesh. We explored the association of the technique with development of recurrence across our policy change, and hernia type before and after recurrence.

Results: After implementing a TAPP repair policy of covering myopectineal orifice (MPO) with sufficiently overlapped mesh, 79% of the rating were satisfactory, whereas 34% were satisfactory prior to the policy. The recurrence rate decreased to 0.7% (5/678) compared with 6.2% (10/161) before the policy (p <0.001). Although various types of recurrences were noted in the earlier period, only primary indirect and recurrent indirect hernias were observed in the later period (p =0.006). With univariate analysis, the scores of posterior prosthesis overlap to the MPO in the recurrent cases were significantly lower than controls in the later period (p =0.019).

Conclusions: Fully covering the MPO with mesh is essential for preventing direct type recurrence. Prosthesis overlap posterior to the MPO in a large indirect hernia is important for preventing recurrence.

Background
The number of cases of laparoscopic hernioplasty (LH) for groin hernia in Japan has been increasing since the medical fee was revised under the National Health Insurance System in 2012. In the 13th nationwide survey of endoscopic surgery in 2015, LH accounted for 41.3% of all groin hernia repair surgeries (1). However, unacceptable recurrence rates of 3.0% with the transabdominal preperitoneal (TAPP) approach and 3.4% with the total extraperitoneal approach were reported in the 2014 and 2015 surveys, possibly due to an uptick in the number of inexperienced surgeons newly performing the surgery.

Technical factors leading to hernia recurrence include insufficient dissection, inadequate prosthetic overlap, insufficient prosthetic size, improper fixation, folding or crinkling of a prosthesis, and missed hernias (2). These factors were found responsible for nearly all cases of recurrence, and covering Fruchaud’s MPO entirely by a prosthetic mesh with adequate overlap was reported to be essential for preventing hernia recurrence (3). Indeed, the use of a large mesh sheet resulted in a decrease in hernia recurrence (4, 5).

These techniques should be assessed during surgery for determining whether or not the lesion went on to develop a recurrent hernia (i.e. future recurrence). However, which of these techniques helps predict future recurrence remains unclear.

The purpose of this study was to identify a surgical technique that predicts future hernia recurrence in TAPP repair and to clarify the mechanisms associated with the technique. For this, we conducted a video review assessment of control cases and also primary LH videos in patients who went on to develop recurrent hernias after TAPP repair and control cases. A multiple-evaluation method by plural reviewers was employed to increase the integrity and objectivity of the evaluation. We assessed the surgical techniques, such as adequate dissection, mesh coverage, and folding or crinkling of the mesh, at the time of primary repair and the type of hernia in primary and recurrent cases, according to the Japan Hernia Society (JHS) classification (Supplemental Table 1) (6).
Methods

Selection of recurrent and control cases

Recurrent cases were based on voluntary visits by the patient or a referral visit from a cooperating doctor. Two or three controls per case were selected from among the individuals who were matched according to categorical variables, such as the gender, type of hernia, operation date, and surgeon. The control patients were examined or interviewed to confirm that there had been no hernia recurrence. The primary LH videos of future recurrent cases and controls were edited to around 15-minute digests by M. S. Our criteria and the operative procedure used to perform TAPP have been previously described (7).

Video review assessments

Five surgeons, aside from M. S., reviewed the primary LH video digests, which were anonymized and blinded, for relapse. Four of the surgeons, aside from H. W., did not participate in any of the surgeries. The surgery experience of the reviewers were 5 years for A.M., 30 years for H. W., and from 10 to 13 years for the other three reviewers. The items for assessment are shown in Figure 1 A to L. The distance of the overlaps was referenced in previous reports (5, 8). The reviewers assessed these items with three multiple-choice responses, as follows: satisfactory, unsatisfactory, or undeterminable (uncounted). An average score of the countable choices was used for the analysis. A score of 1.0 meant all five reviewers assessed as satisfactory, while a score of 0.0 meant they assessed as unsatisfactory. Secondary videos were reviewed by M. S. to identify the location of the prosthesis and to assess the type of recurrent hernia. For cases repaired with an anterior approach, the written operation records were used to assess the type of recurrence.

Statistical analyses

The Heml software program (The CUCKOO Workgroup, China) was used for heat mapping
and hierarchical clustering with average linkage and the Manhattan distance similarity metric (9). The Fisher–Freeman–Halton exact test was performed using the EZR software program (Jichi Medical University Saitama Medical Center, Japan) (10). The other statistical analyses were performed using IBM SPSS software (IBM Corp., Armonk, NY, USA). With the nonparametric Mann–Whitney U test, the null hypothesis was that “the distribution of scores for the two groups is the same”. A p-value of <0.05 was considered to be statistically significant.

Results

Future recurrent cases and video materials to be reviewed

Between April 1992 and July 2017, 839 TAPPs in 711 patients were performed at Hamamatsu University School of Medicine. Fifteen patients subsequently suffered recurrence after we performed TAPP repair. Of the 15 recurrent cases, 12 underwent reoperation with TAPP repair, while two were repaired with an anterior approach (Table 1). The remaining one was treated conservatively because of refusal to undergo another operation. Thirteen videos of the primary LH were used for the review in this study; of the remaining two videos, one was missing, and a second operation was not performed on the other. Eleven videos of the reoperations and the two written operation records were used to assess the types of recurrence.

[Insert Table 1 Here.]

We reviewed the primary LH videos of future recurrence and control cases. The basic characteristics, including the surgeon’s degree of experience, were not significantly different between the groups (Table 2).

[Insert Table 2 Here.]

Internal consistency reliability among the reviewers
To determine the feasibility of the assessments by multiple evaluators, we tested the internal consistency among the reviewers. There were 480 questions in which 12 assessment items for 40 videos were included. When even one undeterminable response was included in a question, it was excluded for the reliability statics. With the exclusion of 118 questions, 362 questions were used for the test. The Cronbach’s $\alpha$ co-efficient was 0.816. Thus, the internal consistency among the reviewers was deemed to be good.

**Division into two periods: Before and after the policy changed**

To see how all the cases were grouped according to the differences of the video assessment scores, the cases were shown on a heat map and then rearranged by hierarchical clustering (Figure 2). There were two main branches on the y-axis. The two groups were largely divided by the period of operation, but not based on whether or not they were recurrent cases. The upper branch comprised cases 17 to 118, except for case 167, while the lower branch comprised cases 136 to 528, except for case 119. Our surgical policy was changed in April 2003 to require covering of the whole MPO, with the size of the mesh decided after measuring the dissected area to secure a mesh overlap of more than 2 cm. The date of implementation of the policy was between cases 136 and 161 and close to a boundary of the above grouping between cases 118 and 136. It was deemed appropriate to stratify the cases by time series. We therefore subsequently analyzed the data for the two periods separately: the earlier period (April 1992 to March 2003) and the later period (April 2003 to July 2017).

To determine whether or not the policy had been followed properly, we assessed the mesh area in all LH cases and compared the areas before and after the new policy was implemented (Figure 3). The mesh area tended to increase in size during the earlier period and the average size of the prosthesis was 9.9×7.2 cm, while the average size of the
prosthesis was 13.3 × 9.4 cm in the later period. The area was significantly different before and after the policy changed (Student’s t-test, \( p<0.001 \)). Thus the policy had been thoroughly adhered to.

Differences in recurrence rate and their forms before and after the policy change

In the earlier period, 175 (58%) of the 300 questions were scored less than or equal to 0.4, indicating unsatisfactory scores were predominant. Conversely, in the later period, 143 (79%) of the 180 questions were scored greater than or equal to 0.6, indicating satisfactory scores in general. Because these scores were regarded as examples of all TAPP repairs in each period, we compared the recurrence rate for the two periods. It is noteworthy, that the recurrence rate drastically dropped to 0.7% (5/678) after the policy was implemented, compared with 6.2% (10/161) before the policy was adopted (chi-squared test, \( p<0.001 \)).

We explored the differences in the types of hernia recurrence before and after the policy changed. Both Type I and Type II recurrences were observed in the earlier period (Table 3), where six of the nine cases in the earlier period relapsed with Type II, while three relapsed with Type I. In contrast, the five cases that relapsed in the later period were all primary Type I and recurrent Type I (\( p<0.006 \)). Furthermore, when reviewing the reoperation videos in the five observed cases, the meshes shifted anteriorly and/or medially to the hernia orifices, but not posteriorly in any of them. The sizes of the orifices were more than 30 mm in the three most recent cases, which were all classified as JHS Type I–3.

[Insert Table 3 Here.]

Surgical techniques intraoperatively predict hernia recurrence after TAPP repair
To determine which techniques could predict hernia recurrence after TAPP repair, we assessed the differences in the item scores between future recurrence and control cases in each period.

In the earlier period, no items were significantly different between the future recurrence and control cases in a univariate analysis (Supplemental Table 2). As unsatisfactory scores were predominant also in controls, no techniques would predict future recurrence in the period.

In the later period, 143 (79%) of the 180 scores were >0.5, indicating mostly satisfactory scores when fully covering the MPO, except for case 167. Future recurrent and control cases were not distinguished in a multivariate analysis. To make the differences between future recurrent and control cases in each item conspicuous, we rearranged the colored score table according to score values (Figure 4). Regarding the score of the posterior prosthesis overlap (item J), three of the five recurrent cases were scored 0.4 to 0.6, which meant the assessments did not match among the reviewers, whereas eight of the 10 control cases were scored 1.0, indicating that all the reviewers assessed it as satisfactory, with a significant difference in a univariate analysis ($p = 0.019$). It can be said that the probability of recurrence is lower when the assessments were agreed to be sufficient for the posterior overlap.

Regarding the scores of prosthesis folding or crinkling posteriorly (item K), there was no significant difference between the two groups. However, unsatisfactory scores of 0.0 were observed in three of the five recurrent cases, and conversely, in none of the controls. An agreement of unsatisfactory among all reviewers for the item score of 0.0 indicated an apparent technical error leading to recurrence. Regarding the scores of prosthesis fixation (item L), four of the five future recurrent cases scored less than 0.40, while one of the 10 controls did. Four of the 10 control cases showed a score of 0.5 or 0.6, which meant there
were conflicting assessments among the reviewers. Nevertheless, the score in the future recurrent cases tended to be lower than control cases, but the difference was not significant ($p = 0.060$).

Discussion

Previous analyses of surgical techniques leading to recurrence were based on reviews of primary LH videos, findings on reoperation, or comparative studies (2, 5, 8, 11). Because it is important to distinguish what conditions lead to recurrence during primary surgery, we compared the primary LH videos of future recurrence and control cases in a blinded fashion. Given that an evaluation by a single inspector might become subjective despite their abundant experience, we employed a multiple evaluation method to increase the integrity and objectivity of the evaluation. This multiple evaluation method was feasible because the internal consistency was found to be good among the five reviewers.

Historical changes in techniques were the dominant factor in the hierarchical clustering analysis. We therefore deemed it necessary to divide the surgeries into two groups based on the time period and then analyze the techniques used in each period. We set the dividing point as when our institution adopted a policy to completely cover the MPO. The difference observed in the mesh size before and after this point suggested that adherence to the policy was quite good, resulting in a drastic reduction in the recurrence rate from 6.2% before the implementation to 0.7% after the implementation. Leibl et al. reported that a recurrence rate of 2.8% when using a 13 × 8-cm mesh with a slit decreased to 0.36% when using a 15 × 10-cm mesh without a slit (5). Kapiris et al. similarly found that a 5% recurrence rate with an 11 × 6-cm mesh decreased to 0.16% with a 15 × 10-cm mesh (4). The mesh sizes in our study, even in the later period, tended to be smaller than 15 × 10-cm, but this fact may be due to the physical characteristics of the Japanese population. Given the above, fully covering the MPO after our policy change resulted in
the usage of a larger prosthesis, which helped reduce the rate of hernia recurrence. The mesh size is clearly the most important factor in preventing recurrence (12).

It was difficult to detect differences in the scores of the items between future recurrence cases and control patients in the earlier period because most of the cases, including the controls, scored low in general. Combined with the fact that covering the full MPO reduced the recurrence rate, most of the items, though not any specific ones, should be responsible for preventing a recurrence of various types like those that existed in this period.

By contrast, in the later period, 79% of the choices were assessed as satisfactory. This is likely a consequence of the policy change requiring the full coverage of the MPO. Because there were no cases of Type II recurrence in the later period, fully covering the MPO appears to be intimately involved in preventing Type II recurrence. However, the fact that the five most recent recurrent cases experienced Type I recurrence with meshes located anterior and medial to the orifice highlights the existence of some particular mechanism that causes such recurrence. An insufficient overlap width of less than 2 cm in length posterior to the MPO is considered to play a role in the mechanism of Type I hernia recurrence, as the unsatisfactory scores observed in the recurrent cases. Because of contraindication to tacking in this area, securing the overlap width and increasing its friction resistance are crucial in preventing recurrence (13). Therefore, in the past seven years, we have made an effort to secure an overlap of ≥3 cm from the edge of the MPO in all directions. Nonetheless, a larger posterior overlap is required for large hernias, as seen in the last three cases, which had relatively larger orifices. Indeed, the International Endohernia Society guidelines recommend the use of a larger mesh (i.e., 12 × 17 cm or greater) for large hernia defects (14). Since concrete data regarding the defect size have yet to be obtained, how far inferior to the iliopubic tract we should secure the overlap for
a large indirect hernia remains an issue.

In this study, we assessed the presence, but not the degree, of folding or crinkling of the prosthesis. The fact that unsatisfactory scores of 0.0 for item K were observed only in the recurrent cases meant prosthesis folding or crinkling was obvious to any reviewer in such cases. Because the assessment of prosthesis fixation is very subjective, there were conflicting scores among the reviewers in the four control cases for item L, while the reviewers agreed it to be unsatisfactory in the four of the five future recurrent cases. These suggest that items K and L are still important factors in causing hernia recurrence when these technical errors are apparent.

In conclusion, the covering of the MPO with mesh during TAPP repair made it possible to effectively reduce the frequency of hernia recurrence, especially for Type II recurrence. Even when fully covering the MPO, a prosthesis overlap that occurred posterior to the MPO was found to be the most important factor leading to hernia recurrence, especially in large Type I hernias.

Declarations

Abbreviations

*TAPP*: transabdominal preperitoneal

*MPO*: myopectineal orifice

*LH*: laparoscopic hernioplasty

*JHS*: Japan Hernia Society

Ethics approval and consent to participate

This study was approved by the Hamamatsu University School of Medicine Independent Ethics Committee (Permission number: 18-060), and opt-out consent was obtained via our websites, where permission was requested for the use of the participants’ personal information in this study.
Consent for publication
Not applicable

Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests
The authors declare that they have no conflicts of interest or financial ties to disclose.

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Authors’ contributions
M. S. designed the study, analyzed the data, and wrote the manuscript. M. N. and T. W. reviewed the videos and critically revised the manuscript. T. O. and A. T. reviewed the videos. N. S. critically revised the manuscript. H. W. reviewed the videos and critically revised the manuscript with important conceptual and editorial input. All authors read and approved the final manuscript.

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Tables

Due to technical limitations, Tables 1 - 3 are only available for download from the Supplementary Files section.

Figures
Assessment items for the video review. Left panel, items regarding dissection (green zone): (A) dissection until exposure of Cooper’s ligament, (B) dissection until exposure of the rectus abdominis muscle, (C) dissection >2 cm lateral from the lateral triangle, (D) dissection >2 cm anterior from the hernia orifice, (E) dissection >2 cm posterior to the hernia orifice. Right panel, items regarding mesh size or placement (blue mesh): (F) sufficient prosthesis size, (G) prosthesis overlap >2 cm medial to the MPO, (H) prosthesis overlap >2 cm lateral to the MPO, (I) prosthesis overlap >2 cm anterior to the MPO, (J) prosthesis overlap >2 cm posterior to the MPO, (K) presence of mesh folding or crinkling posteriorly, and (L) prosthesis fixation (purple button). Red lines show the MPO.
Figure 2

Heatmap and hierarchical clustering of video review assessment scores. A cell
shows an average score of the video review assessment among the five reviewers with the colors (color bar), where satisfactory scores are shown in blue and unsatisfactory ones in red. The serial numbers of the cases are shown on the left-hand vertical axis, and the cases who suffered hernia recurrence are marked with asterisks. The clustering tree is shown on the right-hand vertical axis.

Figure 3

Time series of the mesh area of all 711 patients. The cases who suffered hernia recurrence are marked with asterisks. The vertical dotted line is the border between the two periods.
**Figure 4**

Colored score table of video review assessment in the later period. Colored cells show video review assessment scores for each case, sorted according to score value in each item. Univariate analysis of the items for future recurrence and control cases in the later period was done by Mann-Whitney U test, and p values were shown on the right. The color bar shows the score, with satisfactory scores shown in blue and unsatisfactory ones in red.

**Supplementary Files**

This is a list of supplementary files associated with the primary manuscript. Click to download.

Table3.pdf
Supp Tables.pdf
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Table2.pdf