



Asymptomatic patent processus vaginalis is a risk for developing external inguinal hernia in adults: A prospective cohort study

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ARTICLE INFO

Keywords:

Processus vaginalis
Inguinal hernia

ABSTRACT

Background: Inguinal hernia repair is common for children and adults across the world, but the mechanism behind hernia onset still requires elucidation. This prospective study aims to determine whether patent processus vaginalis (PPV) is a factor in the development of external inguinal hernias.

Method: We enrolled 1008 patients who underwent laparoscopic surgery and in whom the inguinal region was observed. If processus vaginalis existed, we measured the diameter and length. Patients were followed for three years after surgery to investigate the incidence of external inguinal hernias.

Result: No significant differences were found between age groups. Furthermore, no difference could be recognized in length or opening diameter of the PPVs between age groups. Three-year follow up was possible for 765 of 1008 patients enrolled in this study (76%), eight of whom, all male, developed external inguinal hernia during this period. Multivariate analysis for onset of inguinal hernia onset in male patients showed that PPV and length of the right PPV were independent risk factors for development of external inguinal hernia.

Conclusion: The patency rate, length, and diameter of the processus vaginalis do not differ according to age. The patency of the processus vaginalis in male patients is an independent risk factor for development of external inguinal hernia in adults.

1. Introduction

Every year, about 20 million repairs are performed worldwide for inguinal hernias. The lifetime incidence of inguinal hernias is reported to be 27% for men and 3% for women [1]. The predominant age of inguinal hernia is bimodal, it is most commonly seen in childhood and then again in middle-aged individuals, and clinical onset is rare in people in their 20s and 30s [2]. Meanwhile, patent processus vaginalis (PPV) is reported in about 20% of children [3]. Whether this PPV disappears as the child grows, or whether it continues to patency after adulthood and causes the development of external inguinal hernia are matters of interest. If PPV is the cause of external inguinal hernia in adults, the length and diameter of PPV may change with age. It has been

reported that about 12% of the PPV are found during laparoscopic surgery, regardless of age [4], but there have been no descriptions of morphological changes in processus vaginalis.

The aim of this study is to investigate whether the patency rate, length, and opening diameter of the processus vaginalis change with age, and to address the association between presence, length, and diameter of PPV and developing external inguinal hernia by a prospective cohort study.

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<https://doi.org/10.1016/j.amsu.2021.102258>

Received 23 February 2021; Received in revised form 23 March 2021; Accepted 23 March 2021

Available online 27 March 2021

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2. Methods

2.1. Patients

Enrolled in this study were 1008 patients that underwent laparoscopic surgery in our hospital and six affiliated teaching hospitals between April 2013 and March 2015. Mean age of the 1008 patients (577 males: 57%, 431 females: 43%) was 63 years (range 0–94 years). The main indications for laparoscopy were colorectal cancer (47%), cholecystectomy (31%), and gastric cancer (10%). We excluded patients who previously underwent inguinal hernia surgery, or were unobservable due to adhesions. All research was performed in accordance with relevant guidelines/regulations. This study was approved by the ethics committee of our hospital and informed consent was obtained from all included patients. This trial is registered at UMIN Clinical Trials Registry (UMIN-CTR number UMIN000010131). The works has been reported in line with the STROCSS criteria [5].

2.2. Measurement of processus vaginalis

During laparoscopic surgery, under intra-abdominal pressure of 8–12 mmHg, PPV was defined as a protrusion of the peritoneum lateral to the inferior epigastric vessels. When PPV was found, the opening diameter and the length of the processus vaginalis were measured using special forceps with a scale (Fig. 1). Follow-up was performed 3 years after laparoscopic surgery.

2.3. Follow-up

Three-year follow-up could be completed for 375 patients (76%); there were 67 deaths by malignant tumor, and 176 patients were lost to follow-up. Onset of external inguinal hernia was picked up by interview, and final diagnosis of inguinal hernia was achieved from echography, computerized tomography and surgical findings.

2.4. Statistics

Statistical analysis was performed using JMP ver. 14.1.0 (SAS Institute). Differences between groups were determined using Pearson's chi-squared test or T-test to compare categorical variables as appropriate. Factors were analyzed by multivariate logistic regression, and an odds ratio with a 95% confidence interval was calculated for each factor. Statistical results were considered significant at $P < 0.05$.

3. Results

3.1. Asymptomatic patent processus vaginalis

Patients (16.8%) had PPV without clinical symptoms. 20.6% of the male and 11.6% of the female had a PPV ($P < 0.01$). PPV was present on the right side in 55% of PPV-positive patients, on the left side in 24%, and bilateral in 21% ($P < 0.01$). (Male: right 53%, left 26%, bilateral 22%, Female: right 58%, left 28%, bilateral 14% $P = 0.32$).

3.2. The change of the patency rate among age groups

To investigate the change with age of the patency rate of processus vaginalis, patients were stratified into five age groups: <20 years, 20–39 years, 40–59 years, 60–74 years, and ≥ 75 years groups. In the <20 years age group, 9.1% had PPV, it was 15.2% in the 20–39 group, 14.7% in the 40–59 group 17.0% in the 60–74 group and 19.3% in the ≥ 75 group. There was no significant difference between the age groups and difference could not be recognized in length or opening diameter of the PPV in each age group (Figs. 2 and 3).

3.3. Developing external inguinal hernia in 765 patients

We examined the association between development of external inguinal hernia and clinical characteristics including age, gender, body mass index (BMI), PPV, and diameter and length of PPV of the eight

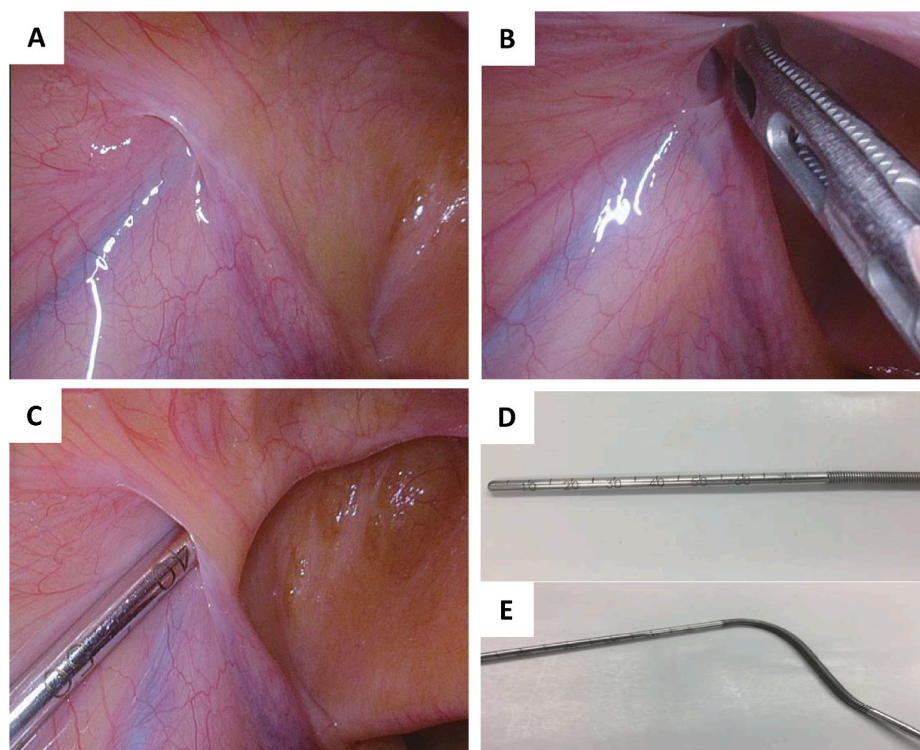


Fig. 1. Patent processus vaginalis and measurement. **A:** Small slit in the deep inguinal ring, **B:** Patent processus vaginalis (PPV) confirmed with laparoscopic forceps, **C:** Laparoscopic forceps with scale inserted into the PPV for measurement, **D:** laparoscopic forceps with scale. **E:** the base of the measuring rod bends with a spring.

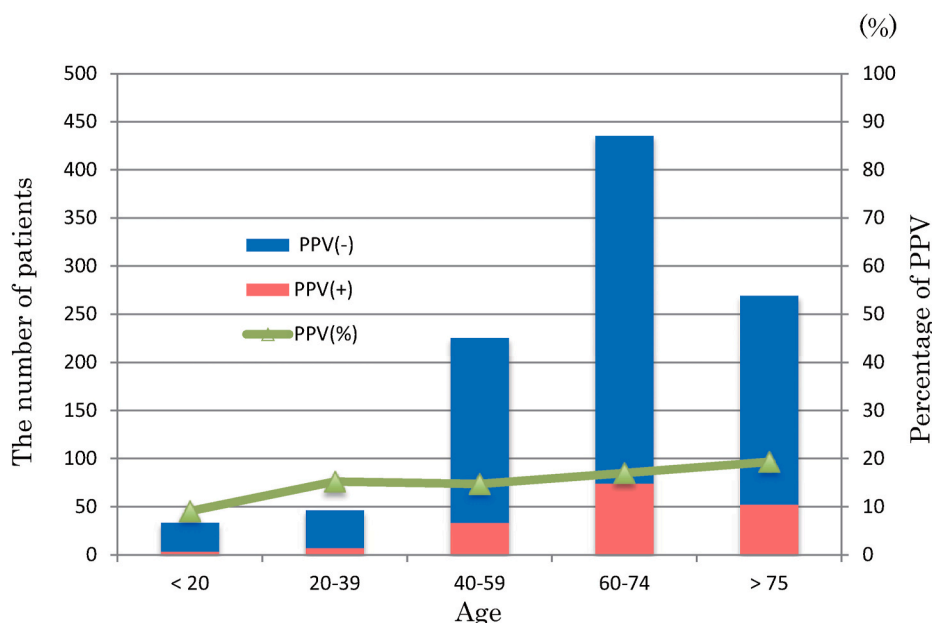


Fig. 2. The number and patency rate of the processus vaginalis among age groups. Red: number of patients with patent processus vaginalis (PPV), Blue: number of patients without PPV, Green: the percentage of patients with PPV. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

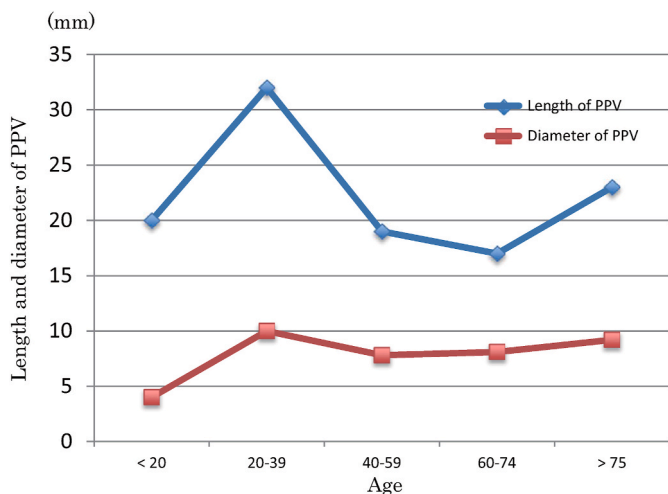


Fig. 3. The change of the length and diameter of processus vaginalis relate to age groups. Red: mean diameter of patent processus vaginalis (PPV), Blue: mean PPV length. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

patients that developed external inguinal hernia during this period, all of whom were male. The incidence of external hernia from the group with PPV was 4.8% (5/105), and the incidence from the group without PPV was 0.9% (3/332). The associations between patient demographic data and development of external inguinal hernia are shown in Table 1. Factors including male sex, PPV positivity, and the length and diameter of right-side PPV were significantly associated with development of external inguinal hernia (Table 1).

3.4. Development of external inguinal hernia in male patients

Only male patients had the onset of external hernia, so we focused on male patients. The correlation between male patient characteristic data and development of external inguinal hernia is shown in Table 2. Factors including PPV positivity, and right-side PPV length and diameter of

Table 1
Clinical characteristics and developing external inguinal hernia in 765 patients.

	DEIH (N = 8)	Non-DEIH (N = 757)	P value
Age	68.0 ± 12.1	64.4 ± 15.7	0.5189
Gender			
Male	8	429	0.0164
Female	0	328	
BMI (mean ± SD)	25.3 ± 3.6	22.8 ± 3.7	0.0589
PPV			
Present	5	140	0.0028
Absent	3	617	
Length of right PPV (mm, mean ± SD)	18.1 ± 25.3	2.86 ± 9.7	0.0081
Length of left PPV (mm, mean ± SD)	2.5 ± 4.6	1.42 ± 5.7	0.6055
Diameter of right PPV (mm, mean ± SD)	5.37 ± 5.0	1.33 ± 4.2	0.0204
Diameter of left PPV (mm, mean ± SD)	2.5 ± 4.6	0.77 ± 2.8	0.2036

Abbreviations: DEIH, developing external inguinal hernia; PPV, patent processus vaginalis; BMI, body mass index; SD, standard deviation.

Table 2
Clinical characteristics and developing external inguinal hernia in male patients.

	DEIH (N = 8)	Non-DEIH (N = 429)	P value
Age	68.0 ± 12.1	65.2 ± 14.7	0.5923
BMI (mean ± SD)	25.3 ± 3.6	22.9 ± 3.4	0.0651
PPV			
Present	5	100	0.0107
Absent	3	329	
Length of right PPV (mm, mean ± SD)	18.1 ± 25.3	3.6 ± 10.7	0.0028
Length of left PPV (mm, mean ± SD)	2.5 ± 4.6	1.8 ± 6.7	0.7729
Diameter of right PPV (mm, mean ± SD)	5.37 ± 5.0	1.53 ± 4.4	0.0359
Diameter of left PPV (mm, mean ± SD)	2.5 ± 4.6	0.97 ± 3.2	0.2181

Abbreviations: DEIH, developing external inguinal hernia; PPV, patent processus vaginalis; BMI, body mass index.

PPVs were significantly associated with development of external inguinal hernia (Table 2).

3.5. Multivariate analysis for development of external inguinal hernia in male patients

PPV and length of PPV are correlated with each other, so analysis was divided into two parts (Tables 3 and 4). Multivariate analyses for the onset of external inguinal hernia in male patients showed that the existence of PPV and the length of right-side PPVs showed significance.

4. Discussion

Processus vaginalis develops in the third month of gestation when part of the peritoneum protrudes into the internal inguinal ring. In males, it is involved in the descent of the testes at 7 months of gestation. At 36–40 weeks of gestation, the distal end becomes tunica vaginalis, and the proximal end closes. In females, this is the canal of Nuck, as the ligamentum teres uteri descends toward the labia majora. The time of closure of the processus vaginalis has not been determined; patency is present in about 60% of patients at 7 months of age and in about 20% of adult autopsy cases without a history of hernia [6,7]. An external inguinal hernia in childhood is thought to be caused by protrusion of the intestine into the unclosed processus vaginalis. Incidence of inguinal hernia is high in childhood, it then decreases in adolescence but then increases again with age [8]. In this study, the patency rate of processus vaginalis was constant at about 20% across generations, and the length and diameter did not change. This suggests that the processus vaginalis that did not close in childhood remains unchanged in adulthood and remains patent.

In this study, five patients from the group with PPV developed external inguinal hernia. The odds ratio was 5.48 when compared with the incidence from the group without PPV. PPV therefore appears to be an independent risk factor for the development of external inguinal hernia. Inguinal hernia are more common on the right side than on the left side [9]. In this study, the patency rate of right-side processus vaginalis was as high as 55%, which suggests that the patency of the processus vaginalis plays a major role in the development of inguinal hernias. The lifetime incidence of inguinal hernia for men is reported to be 27%, which is close to the patency rate of the processus vaginalis in men. Old age [10], family history [11], chronic cough [12], constipation [13], and a history of prostate surgery [14] are considered to be risk factors for inguinal hernias.

PPV is reported to be an important factor in the development of hernias [15]. However, since the length and diameter of PPV do not change with age, additional factors are added, and hernias may develop at a high rate.

External inguinal hernias are more common than direct hernias after radical retro-pubic prostatectomy. The incidence of inguinal hernias after radical retro pubic prostatectomy has been reported to occur in the range 12%–21% [16]. Fujii et al. reported that ligation of potential PPV close to the peritoneal cavity reduced the incidence of inguinal hernia after prostate surgery to 1% [17]. This report not only indicates that patency of the processus vaginalis is an important factor in the development of inguinal hernias, it also suggests that if the processus vaginalis has not developed hernia, ligation of the processus vaginalis alone may prevent future development of hernias.

This study has several limitations; only a small number of patients developed external inguinal hernia, and further investigations including longer follow-up time are thus required.

Laparoscopy has been used in a variety of surgeries, and as a result, it has become common to incidentally find PPV. Multivariate analysis of the factors contributing to the development of inguinal hernias in the current study suggests that the length of the right peritoneal sheath may be a factor in the development of inguinal hernias in males. Ligation of the PPV with these factors may have a preventive effect on future

Table 3

Multivariate analysis of development of external inguinal hernia in male patients.

Variable	Development of external inguinal hernia		
	OR	95% CI	P value
Age	1.02	0.95–1.08	0.6004
BMI	1.24	1.00–1.53	0.0516
PPV (present)	5.48	1.24–24.21	0.0222

Abbreviations: OR, Odds ratio; CI, confidence interval; BMI, body mass index; PPV, patent processus vaginalis.

Table 4

Multivariate analysis of development of external inguinal hernia in male patients.

Variable	Development of external inguinal hernia		
	OR	95% CI	P value
Age	1.0138	0.95–1.08	0.6604
BMI	1.2072	0.98–1.08	0.0817
Length of right PPV	1.0366	1.01–1.07	0.0293
Length of left PPV	1.0061	0.92–1.10	0.9004

Abbreviations: OR, Odds ratio; CI, confidence interval; BMI, body mass index; PPV, patent processus vaginalis.

development of inguinal hernias.

5. Conclusion

The patency rate, length, and diameter of the processus vaginalis are no difference of age. The patency of the processus vaginalis in male patient is an independent risk factor for developing external inguinal hernia in adults.

Declaration of competing interest

The authors declare no conflict of interest in this study.

Acknowledgements

We acknowledge proofreading and editing by Benjamin Phillis at the Clinical Study Support Center, Wakayama Medical University.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2021.102258>.

Ethical approval

This study was approved by the Wakayama Medical University Human Ethics Review Committee (approval number 1130) and informed consent was obtained from all included patients.

Sources of funding

There is no funding in this study.

Author contribution

Takashi Watanabe: Formal analysis, Investigation, Data curation, Conceptualization, Writing-original draft.

Shozo Yokoyama: Investigation. **Makoto Iwahashi:** Investigation.

Kazunari Mori: Investigation. **Naohisa Yamade:** Investigation.

Kazuya Yamaguchi: Investigation. **Katsunari Takifuji:** Investigation.

Yasuyuki Mitani: Investigation. **Kenji Matsuda:** Investigation.
Hiroki Yamaue: Conceptualization, Methodology, Supervision,
 Writing-review and editing.

Registration of research studies

Name of the registry:
 This trial is registered at UMIN Clinical Trials Registry.
 Unique Identifying number or registration ID:
 UMIN-CTR number UMIN000010131.
 Hyperlink to your specific registration (must be publicly accessible
 and will be checked): https://upload.umin.ac.jp/cgi-open-bin/ctr_e/ctr_view.cgi?recptno=R000010740.

Guarantor

Hiroki Yamaue, M.D., Ph.D., Professor of Second Department of Surgery, Wakayama Medical University.

Consent

This study was approved by the ethics committee of our hospital and informed consent was obtained from all included patients for publication of this report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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