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Learning Curve of Resident Surgeons for Open Mesh Repair of Inguinal Hernia

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Objective: We evaluated the effect of postgraduate surgical education on inguinal hernia repair for resident surgeons.

Methods: A total of 93 adult patients underwent open mesh repairs for inguinal hernias. These patients were randomly assigned to junior or senior resident surgeon groups for inguinal hernia repairs. The surgical training program for inguinal hernia repair was subdivided into 3 consecutive steps: sections A, B, and C. The sections were defined as follows: (A) the starting point of the surgery to hanging the spermatic cord, (B) dissection of the hernia sac, and (C) placement of the hernia mesh. The time to complete each procedure was recorded. We then evaluated the learning curve of the junior resident surgeons for open mesh repair of inguinal hernia.

Results: The mean operative time of the junior resident group was significantly longer than that of the senior resident group. Particularly, the mean times of the junior residents for sections B and C were significantly longer than those of the senior resident group. However, the volume of intraoperative blood loss and the short-term outcomes were not significantly different between the groups. For section C of the procedure, the learning curve seemed shorter for junior resident surgeons who had completed the training program for inguinal hernia repair than that for junior resident surgeons who were just beginning this program.

Conclusion: This study demonstrates that a junior resident surgeon's initial experience with hernia repair is associated with an identifiable learning curve when participating in a suitable training program.

Key words: Inguinal hernia – Open mesh repair – Learning curve – Resident

Inguinal hernia repair is the most common procedure in general and visceral surgery worldwide. Globally, approximately 20 million hernia repairs are done every year.[1] Junior resident surgeons can have extensive exposure to inguinal hernia repair early in their surgical education and should learn

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how to perform hernia repairs under the supervision of an attending surgeon.[2] There are a number of studies that compare outcomes of procedures done at teaching hospitals by residents and procedures performed by attending surgeons. Almost without exception, the rate of recurrence of a hernia and occurrence of complications should be low. However, several clinical studies have shown significant differences in operation time, recurrence rate, and short term outcome following hernia repair between procedures performed by junior residents and those of others.[2–10] Moreover, the reported factors associated with recurrence were the surgeon's age, postgraduate year (PGY) level of the participating resident, and operation time.[9] These results have emphasized the need for a preclinical surgical training program for junior resident surgeons. Inguinal hernia repair has a steep learning curve, and preclinical surgical training programs remain a challenge in our hospital. Therefore, we chose to evaluate the effect of postgraduate surgical education on inguinal hernia repair for resident surgeons. Our surgical training program for inguinal hernia repair consists of three consecutive sections. In this report, we examined the effect on operation time for each section, intraoperative bleeding, and amount of experience in hernia repair to evaluate the surgical training program following inguinal hernia repair.

Patients and Methods

Patients

A total of 93 adult patients underwent open inguinal hernia repairs performed by surgical residents in Nippon Medical School Hospital between May 2011 and June 2012. A total of 11 residents were divided into 2 groups: junior residents (in their first year of the surgical training program, n = 5) and senior residents (in their second year, n = 6). The patients were divided into 2 groups as well: the junior resident group (n = 79) and senior resident group (n = 14). The patients were classified as I, II, III, or IV using the Japanese Hernia Society Classification system.

Surgical training program for inguinal hernia repair

We use a virtual training system for inguinal hernia which is readily available at low cost and is ideal for training in basic psychomotor skills, suturing, and knot tying. Our training program also includes a visual component in which the standard operation methods for inguinal hernia repair are learned using video or DVD.

General or spinal anesthesia was administered to the patients in the operating room, and anesthesia was maintained using standard techniques. Antibiotics were administered intravenously, usually as a single dose of piperacillin sodium. Subsequently, an inguinal incision was performed, and the external oblique aponeurosis was incised. The inferior epigastric vessels, which are the main anatomic landmarks, were identified; and the type of hernia was determined. Then, the attending surgeons decided whether to perform mesh repair by the Lichtenstein method[11] using lightweight mesh, the Ultrapro plug method,[12] or the Direct Kugel method.[13] The surgical training program for inguinal hernia repair was subdivided into 3 consecutive steps: sections A, B, and C. Sections were defined as follows: (A) from the starting point of the surgery to hanging the spermatic cord, (B) dissection of the hernia sac, and (C) placement of the hernia mesh. The operation time was recorded for each procedure. Surgical residents performed most of the repairs with the assistance of an attending surgeon. The experience of the attending surgeons in the technique to which the patient was randomized was recorded at the beginning of each operation, as was the postgraduate surgical education level of the resident who performed the procedure.

The learning curve for inguinal hernia repair can be evaluated by operation times. The 79 patients from the junior resident group were further subdivided into 2 groups: the first term group (whose procedures were performed by residents at the beginning of the surgical training program, within 6 months, n = 28) and the later term group (whose procedures were performed by residents experienced in hernia repair under the surgical training program, n = 51). The operation time was also recorded for each group.

Evaluation

In 93 patients, postoperative evaluation of pain was assessed by telephone at 2 weeks, 3 months, 6 months, and 1 year after the surgery. We instructed the patients to visit the hospital if recurrence occurred.

Statistics

Data are expressed as the mean ± SE. Statistical analysis was performed using Student t test, χ^2 test, and Mann-Whitney U test. Statistical significance was assumed if the P value was less than 0.05.

Table 1 Summary of all patients

	Value
Age, y	68.13
Sex, n	
Male	90
Female	3
Side, n	
Right	50
Left	35
Bilateral	8
Type, n	
I	73
II	18
III	0
IV	10
Operative time, min	96.23
Bleeding, mL	8.3
Repair, n	
Lichtenstein	18
UPP	67
Direct Kugel	8
Doctor, n	
Resident	79
Senior resident	14
Section, min	
A	11.0
B	37.1
C	68.8

UPP, Ultraplug pro.

Results

Between May 2011 and June 2012, there were 101 open inguinal hernia repairs performed on 93 patients: 90 men (96.8%) and 3 women (3.2%). These patients and their operative summaries are shown in Table 1. The average age of the patients was 68.13 years. There were 101 primary hernias, and no repairs were performed for recurrent hernias. A total of 85 patients (91.3%) had unilateral hernia repair, and 8 patients (8.6%) had simultaneous bilateral repair. Intraoperatively, among a total of 103 hernia defects, 73 indirect hernias (70.9%), 18 direct hernias (17.4%), and 10 pantaloon hernias (9.7%) were treated. Mean operation time was 96.23 minutes, and mean operation blood loss was 8.3 mL. Among a total of 93 hernia defects, 18 were repaired using the Lichtenstein repair method with light-weight mesh, 67 (%) were repaired using the Ultrapro plug method, and 8 (%) were repaired with the Direct Kugel method. For all patients, the mean operation times for sections A, B, and C of the surgical training program were 11.0, 37.1, and 68.8 minutes, respectively (Table 1).

Table 2 The patients divided into 2 groups, resident group and senior resident group

	Junior resident (n = 79)	Senior resident (n = 14)	*P* value
Age, y	67.5	71.7	n.s.
Sex, n			
Male	76	14	n.s.
Female	3	0	
Side, n			
Right	42	8	n.s.
Left	30	5	
Bilateral	7	1	
Type, n			
I	62	11	n.s.
II	16	2	
III	0	0	
IV	8	2	
Operative time, min	99.7	76.6	0.019
Bleeding, mL	8.8	5.1	n.s.
Repair, n			
Lichtenstein	18	0	n.s.
UPP	54	13	
Direct Kugel	7	1	
Section, min			
A	11.3	9.5	
B	38.7	26.3	
C	71.6	52.9	

UPP, Ultraplug pro.

The patients and operative summaries for the junior resident group and the senior resident group are shown in Table 2. Next, we evaluated the learning curve of hernia repair in young surgeons. The mean operation time in the junior resident group was significantly longer than that of the senior resident group ($P = 0.019$; Fig. 1). Furthermore, the mean operation times of sections B and C for the junior resident group were significantly longer than those

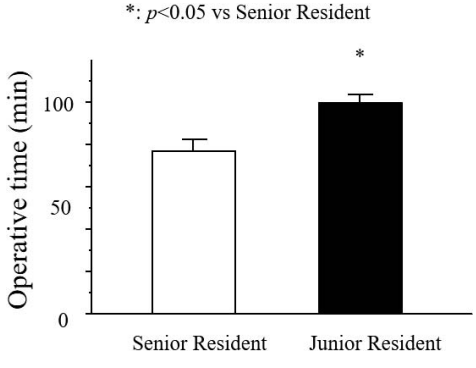

Fig. 1 The mean operative time for the junior resident group was significantly longer than that for the senior resident group ($P = 0.019$).

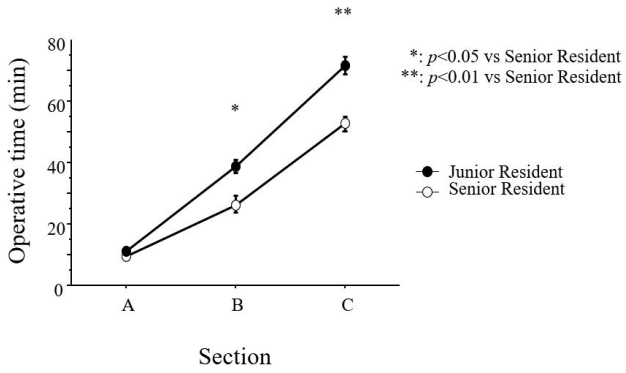

Fig. 2 The mean times of sections B and C of the resident group were significantly longer than those for the senior resident group (sections B and C, $P = 0.023$ and 0.0068, respectively).

for the senior resident group (sections B and C, $P = 0.023$ and 0.0068, respectively; Fig. 2).

To examine the learning curve of inguinal hernia repair, we evaluated our surgical training program. The first term group of the junior residents performed repairs on 28 patients at the beginning of the program, and the later term group of the junior residents repaired 51 patients. The patients and operative summaries for the first and later term groups are shown in Table 3. Figure 3 shows that the mean operation time of section C for the first term group was significantly longer than that for the later term group ($P = 0.0474$). These results indicate that the junior residents can acquire the surgical technique for inguinal hernia through our surgical training program.

Discussion

We evaluated the learning curve of resident surgeons for open mesh repair of inguinal hernia by measuring the operative time it took to complete each section of the procedure. The learning curve for the Lichtenstein hernioplasty method is relatively short, and the procedure is simple enough to be included in the surgical training program.[14–16] Some reports have revealed that the operative time for inguinal hernia repair performed by residents is longer than that of senior surgeons.[2,9,10] Our results confirm this difference between our junior resident group and senior resident group (Fig. 1). However, a few reports on the learning curve of open inguinal hernia repair indicate that younger surgeons can shorten their operative time more quickly than experienced surgeons can.[17] This suggests that the operative time for this procedure will improve for younger surgeons as they increase their experience. However, the study does not demonstrate how residents shorten operative time or the number of cases needed to gain the necessary experience to do so. To investigate this problem, we subdivided the inguinal hernia repair procedure into 3 consecutive steps. The reason for this division was to separate steps that require different manipulations. In section A, residents must dissect the skin using a scalpel and then separate the spermatic cord from the

Table 3 The patients of the resident group divided into 2 groups, first term group and later term group[a]

	First term (n = 28)	Later term (n = 51)	*P* value
Age, y	66.2	68.2	n.s.
Sex, n			
Male	27	49	n.s.
Female	1	2	
Side, n			
Right	16	26	n.s.
Left	11	19	
Bilateral	1	6	
Type, n			
I	22	40	n.s.
II	4	12	
III	0	0	
IV	3	5	
Operative time, min	103.6	97.6	n.s.
Bleeding, mL	10.5	7.9	n.s.
Repair, n			
Lichtenstein	6	12	n.s.
UPP	22	32	
Direct Kugel	0	7	
Section, min			
A	12.3	10.7	
B	41.3	37.4	
C	79.3	67.6	

n.s., Not statistically significant; UPP, Ultraplug pro.

[a]In each section time, refer to Fig. 3. there was no statistical significance any other factors.

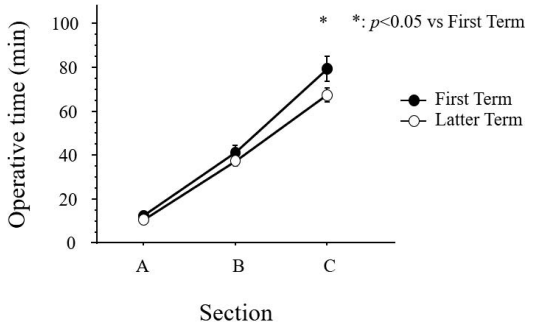

Fig. 3 The mean time of section C of the first term group was significantly longer than that of the later term group ($P = 0.0474$).

surrounding tissue using scissors. In section B, they are required to demonstrate the anatomic understanding needed to recognize the spermatic duct, testicular arteries, and veins that make up the spermatic cord and to separate these from the hernia sac. Moreover, the residents must diagnose the hernia as direct or indirect in this section. Finally, in section C they are required to place and suture the mesh in the appropriate space. The performance of the junior and senior resident groups was significantly different in sections B and C but not in section A (Fig. 2). This suggests that section A has less of an impact on the learning curve for inguinal hernia repair than do sections B and C. This may indicate that residents will shorten their operative time by improving their time from sections A to C. Moreover, to evaluate how the shortening of operative time occurs, we subdivided the patients operated on by the junior residents into 2 groups, the first term group and the later term group. We defined the first term group as the first 28 patients (35%) who received treatment from the residents when they were at the beginning of the training program. We had at first defined this group as the first 50% of patient cases; however, there was no statistical significance observed for any of the procedural sections, so we decreased the number of cases defining the first term group to the first 35%. When defined as 35% of cases, a statistical significance was seen for section C but not for sections A or B (Fig. 3). This indicated that residents begin to shorten their overall operative time by shortening their time from section B to C. The time for section B did not improve during the early stage of training, so the total operative time of the later term group was not statistically better than that for the first term group. Sections A and B may be the most difficult sections of the inguinal hernia repair procedure. We considered that the transition from section A to B has several complexities compared with section A alone or the transition from section B to C. In the transition from section A to B, residents were required to diagnose whether the hernia was direct or indirect. Moreover, they were required to recognize and understand important anatomic features; if they made a mistake, they would injure the spermatic cord and testicular vessels. Residents therefore spent a lot of time in this section and felt that it is the most difficult section. We find from this result that it is very important for residents to improve their operative time for sections A to B.

It is also important to consider the attending surgeon supervision when residents performed operations. Fallon *et al*[18] have reported that when surgical procedures were performed with low levels of supervision, complications and mortality rates increased. In our institution, several attending surgeons are present to teach the procedure for open hernia repair to the residents. The attending surgeons' term of experience is between 7 and 30 years. In this study, we did not discuss the experience of the attending doctors. Further investigation is needed to consider these factors.

We should also consider the outcome in this study. Several reports have demonstrated that having a resident perform open hernia repair is a strong independent predictor for hernia recurrence.[2,9] In our study, some complications were detected after surgery: 3 cases of seroma (3.2%), 3 cases of hematoma (3.2%), and 3 cases of surgical site infection (3.2%). However, there was no need for surgical treatment for these complications. Recurrence rate could not as yet be evaluated because of the short follow-up term. However, we plan to continue careful follow-up with the patients in this study.

Conclusion

This study demonstrates that a junior resident surgeon's initial experience with hernia repair is associated with an identifiable learning curve when participating in a suitable training program. We demonstrate that the transition of section A to B of open hernia repair procedures is the most difficult, and these are the important sections of the operation for residents to perform, and they are the ones that most affect the learning curve. Residents must gain the competence to shorten the operative time in these sections to perform at the level of senior surgeons in open hernia repair.

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