The Comparison of Inflammatory Responses and Clinical Results After Groin Hernia Repair Using Polypropylene or Polyester Meshes

N. Bulbulla · C. Kirkil · A. Godekmerdan · E. Aygen ·
Y. S. Ilhan

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Abstract The aim of this study was to compare the clinical results and the inflammatory responses against polypropylene and polyester meshes after groin hernia repair. Ninety patients with unilateral inguinal hernia randomly underwent Shouldice herniorrhaphy or Lichtenstein hernioplasty using polypropylene or polyester meshes. Venous blood samples were collected to evaluate serum interleukin-6 (IL-6) and C-reactive protein (CRP) levels. Postoperative acute and chronic pain and time to attain to normal activities were evaluated. IL-6 levels decreased to preoperative levels in all groups at 48th hour. CRP levels of mesh-implanted groups are significantly higher than preoperative level at 48th hour, while it reduced to preoperative level in Shouldice herniorrhaphy group. Patients treated with mesh repair had less postoperative acute pain and recovered more rapidly than those who underwent Shouldice herniorrhaphy. It was concluded that polypropylene and polyester meshes used in hernia repair caused similar inflammatory responses and that clinical results after groin hernia repair with these prostheses were not significantly different.

Keywords Groin hernia · Polypropylene mesh · Polyester mesh · Inflammatory response

Introduction

The tension-free hernioplasty with various prosthetic materials is a common method for the treatment of inguinal hernias. The prosthetic materials could induce an acute inflammatory response, followed by chronic foreign body reaction [1]. This inflammatory response appears to be characterized by increased levels of interleukin-6 (IL-6) and C-reactive protein (CRP) [2–4]. IL-6 modulates the acute-phase response (APR) and induces hepatocytes to synthesize various plasma proteins involved in the APR. IL-6 is one of the major cytokines inducing transcriptions of human CRP during the APR [5]. It rises 2 to 4 h after skin incision and reaches peak level about 4 to 24 h after major noncardiac surgery [6, 7]. CRP is crucial at the nonspecific host defense against inflammation and is one of the most sensitive markers of the APR after inflammation or surgery. Increasing levels due to inflammation occur within 6 to 12 h and peaks at about 48 h [8].

Severe chronic pain is a serious problem that may occur after groin hernia repair. Population-based studies and randomized clinical trials indicate that approximately 30 % of patients have some forms of pain, and 3 % of them report severe pain after the surgery [9, 10]. Nerve injury, tissue injury, and usage of biomaterials have been implicated as the reasons of chronic pain. Because the biomaterials used in humans may cause inflammatory reactions, there is further need to develop meshes that produce less foreign body reaction and more compatible with the human organism. In this prospective, randomized, and controlled clinical study, we aimed to compare the clinical results as well as inflammatory

N. Bulbulla
Department of Surgery, Ataturk Education and Research Hospital,
Antalya, Turkey

C. Kirkil · E. Aygen · Y. S. Ilhan
Department of Surgery, Medical Faculty, Firat University, Elazig,
Turkey

A. Godekmerdan
Department of Immunology, Medical Faculty, Firat University,
Elazig, Turkey

C. Kirkil (✉)
Firat Universitesi Hastanesi, Genel Cerrahi A.D.,
23169, Elazig, Turkey
e-mail: ckirkil@yahoo.com

responses against polypropylene and polyester meshes used in groin hernia repair.

Methods

After the approval of local ethics committee, 90 patients with unilateral inguinal hernia who did not experience any complications or recurrence were prospectively included. Patients with metabolic, endocrine, hepatic, pulmonary, or renal disease and receiving steroid or nonsteroid anti-inflammatory drugs or any transfusions were excluded. The procedures were explained to all patients and their written informed consents were obtained. They were randomized into three groups containing 30 patients each. Randomization was achieved by use of random number tables. The patients were completely unaware of which group they were in. Group I underwent Shouldice herniorrhaphy using 00 polypropylene sutures. The patients in groups II and III underwent Lichtenstein hernioplasty using the same size (13×9 cm) of polypropylene (PMII Prolene Mesh, Ethicon Inc., Johnson & Johnson Co., Somerville, NJ, USA) and polyester (Parietex, Sofradim, Villefranche sur Saone, France) meshes, respectively. All of the surgical procedures were done under local or spinal anesthesia. The hernias were classified according to the modified Gilbert's classification by Rutkow and Robbins [11]. Indirect hernia sacs were resected and peritoneal defects were closed with 00 silk in the manner of purse ring in all groups. The meshes were secured in position by 00 polypropylene sutures in tension-free hernioplasty groups.

Postoperative acute pain was evaluated at 2nd and 12th hours by a visual analogue scale (VAS) whose score was 0 to 10 in all patients. In the case of pain that was tolerated or not expressed by the patient, analgesic medication was not given up until 2 h after the operation. Otherwise, postoperative pain was evaluated immediately, and then, pethidine HCl 100 mg was injected intramuscularly. After the first VAS was obtained, pethidine HCl 100 mg was administered to all patients with 8 h intervals during postoperative day 1. During 2 to 5 days after the operation, paracetamol 500 mg was given per os routinely three times a day. In the following days, the patients were told to take paracetamol if they needed. Any anti-inflammatory drug was given till 14th postoperative day. Times to attain normal activities and to work back were recorded for all patients except for the retired and unemployed. Time to attain normal daily activities, described as walking, wearing, and sitting onto the toilet without any assistance, was noted.

Five milliliters of venous blood samples was obtained just prior to beginning the operation and at 12th and 48th hours postoperatively and at 14th day for the detection of serum IL-6 and CRP levels. Samples were centrifuged at 3,000 rpm for 5 min within 30 min of venipuncture. Then, they were frozen at −80 °C until measurement. Serum IL-6

level was studied by enzyme-linked immunosorbent assay using human IL-6 kit (Biosource, Camarillo, CA, USA) with <2 pg/mL minimum detectable dose (range 0–500 pg/mL). Serum high sensitivity CRP was measured by N high sensitivity CRP kits (Dade Behring GmbH, Marburg, Germany) and a Behring Nephelometer 100 Analyzer (Dade Behring GmbH), using the immunonephelometric method. The lowest limit of detection was 0.175 mg/dL.

Patients underwent clinical review and examination at 12 months. Chronic pain was asked with a questionnaire as described by Bay-Nielsen et al. [9].

Statistical Analysis

Parametric data were presented as mean±standard deviation (SD) and were compared with one-way analysis of variance. If there was a statistical difference, multiple comparisons of Tukey's and Dunnett's were applied as post hoc tests. Non-parametric data were analyzed with Kruskal–Wallis test. The paired sample *t* test was used to evaluate paired parametric data. A *p* value<0.05 was considered statistically significant.

Results

Three patients in group I, one patient in group II, and three patients in group III were excluded because of inconsistency with study protocol or complications as seroma and hematoma. Because it was known that these complications induce the circulating levels of soluble cytokines as IL-6 [12, 13], age, gender, working condition, types of hernia and anesthesia, and

Table 1 Patient characteristics

	Group I (n=27)	Group II (n=29)	Group III (n=27)
Age	48.3±10.5	50.6±7.7	56.5±15.6
Gender (male/female)	26/1	27/2	27/0
Working conditions			
Retired or unemployed	6	4	4
Official or student	16	20	19
Worker	5	5	4
Right/left	20/7	19/10	18/9
Hernia (type modified Gilbert)			
2	14	6	10
3	1	2	3
4	12	12	10
5	0	1	1
6	0	8	3
Anesthesia (local/spinal)	24/3	25/4	25/2
Duration of operation (min)	41.4±7.6	45.1±8.3	40.8±6.7

Data are expressed as mean±SD

Table 2 Mean serum IL-6 and CRP levels

	Mean serum level ($\pm$ SD)	Group I ($n=27$)	Group II ($n=29$)	Group III ($n=27$)
IL-6 (pg/mL)	Preoperative	66.6 $\pm$ 67.2	62.7 $\pm$ 68.4	53.3 $\pm$ 79.1
	At 12th hour	98.2 $\pm$ 65.1*	105.3 $\pm$ 81.8*	80.9 $\pm$ 52.6*
	At 48th hour	56.8 $\pm$ 48.3	73.0 $\pm$ 75.4	61.9 $\pm$ 57.4
	On 14th day	29.6 $\pm$ 15.5	47.4 $\pm$ 46.8	37.4 $\pm$ 43.3
CRP (mg/dL)	Preoperative	19.1 $\pm$ 16.8	18.6 $\pm$ 34.1	13.8 $\pm$ 12.3
	At 12th hour	36.2 $\pm$ 34.8*	46.4 $\pm$ 31.5*	35.5 $\pm$ 30.4*
	At 48th hour	26.1 $\pm$ 29.9	31.7 $\pm$ 29.2*	30.8 $\pm$ 18.7*
	On 14th day	15.4 $\pm$ 9.2	26.3 $\pm$ 14.6	22.6 $\pm$ 19.6

There was no significant difference between groups at any sampling time

* $p<0.05$, significantly elevated value from the preoperative value

duration of operation were summarized in Table 1. There was no difference between groups, except the type of hernia. However, numbers of the resected indirect sacs were similar.

Table 2 shows mean serum IL-6 and CRP levels. IL-6 levels significantly increased 12 h after operation in all groups compared with their baseline levels. However, there was no significant difference between preoperative levels and the levels on 2nd or 14th days after operation in all groups. There was also no difference between groups at any sampling time. Serum CRP levels indicated that it was significantly increased 12 h after operation in all groups compared with their baseline levels. Its level remained significantly high ($p<0.05$) 48 h after surgery in groups II and III, whereas it reduced to preoperative level in group I (Table 2). Mean CRP levels declined to the preoperative levels 14 days afterwards in these groups. However, there was no difference between groups at any sampling time.

Mean VAS pain scores at 2nd and 12th hours after operation were significantly high in group I ($p<0.05$ and $p=0.001$, respectively) compared with groups II and III (Table 3). There was no statistically significant difference between groups II and III. Patients in group I attained normal activities later than patients in groups II and III ($p=0.01$ and $p<0.001$, respectively), but there was no significant difference between these two groups regarding time to work back. There was also no significant difference between groups when chronic pain ratios were compared

1 year after operation (Table 3). There was no recurrence in any groups during follow-up.

Discussion

In this study, we determined that the inflammatory response to polypropylene and polyester meshes after tension-free hernioplasty with similar characteristics and this response (at least CRP at 48th hours) was prolonged compared to Shouldice herniorrhaphy. However, there was no difference between chronic pain indices after Lichtenstein hernia repair using polypropylene and polyester meshes and Shouldice repair.

The material used for hernia repair has a direct influence on the patients' quality of life [14]. The polypropylene prostheses, which are more frequently used, induce a rapid and useful acute inflammatory response as well as a strong scar tissue [15]. However, in recent studies, it was shown that rigid and nonabsorbable heavyweight meshes may be a reason of chronic pain after hernia repair [14, 16]. Therefore, new studies have been focused to develop meshes that produce less foreign body reaction, with high compatibility with the human organism. Compared to the conventional polypropylene meshes, polyester implants provide larger porosities and an increased softness. It has lower surface density (75 versus 95.9 g/m²) and higher porosity (97 versus 49.8 %) than polypropylene mesh [17].

Table 3 Mean VAS, time to return to normal activities and to work, and chronic pain incidence

	Group I	Group II	Group III
VAS at 2nd hour (mean $\pm$ SD)	5.5 $\pm$ 1.2	4.1 $\pm$ 1.1*	4.0 $\pm$ 1.0*
VAS at 12th hour (mean $\pm$ SD)	3.4 $\pm$ 1.2	1.9 $\pm$ 0.8**	1.9 $\pm$ 0.7**
Time to attain normal activities (day, mean $\pm$ SD)	4.1 $\pm$ 1.2	3.3 $\pm$ 0.9***	2.6 $\pm$ 0.5§
Time to work back (day, mean $\pm$ SD)	26.0 $\pm$ 8.4	20.1 $\pm$ 7.8	20.0 $\pm$ 6.5
Chronic pain incidence, n (%)	22.2	24.1	18.5

* $p<0.05$ significance versus group I, ** $p=0.001$ significance versus group I, *** $p=0.01$ significance versus group I, § $p<0.001$ significance versus group I

In the literature, there are contradictory results with inflammatory responses to conventional and tension-free hernia repairs. Gurleyik et al. [3] reported that a similar inflammatory response was noted in patients with either prosthetic mesh repair or with conventional repairs of indirect inguinal hernias. On the contrary, Di Vita et al. [4] showed that Lichtenstein hernioplasty with polypropylene mesh was associated with a higher inflammatory response compared with Bassini herniorrhaphy. In this study, Di Vita et al. reported that inflammatory response in patients who used polypropylene meshes remained high for 48 h after the surgery and decreased to the preoperative level 7 days afterwards. However, in the present study, 14th postoperative day was preferred to determine the APR to surgery and meshes. Therefore, a more reliable interval between surgical inflammation and foreign body reaction was achieved.

In a recent study, Asarias et al. [18] evaluating gene expression profiles and histologic specimens reported that polypropylene and polyester induced a greater and more persistent inflammatory response than PTFE, which elicited a response most similar to that induced by suture repair. In the present study, it was shown that inflammatory response declined to baseline level at 48 h in Shouldice repair. CRP levels remained significantly high in patients treated with meshes, regardless of polypropylene and polyester, although there were no statistical differences between groups. This difference could be associated with the presence of the mesh that causes foreign body reaction. Even if there was a foreign body reaction in the mesh-implanted groups, the decreasing of CRP to baseline level on 14th day could indicate that both polypropylene and polyester meshes provide precocious tissue integration.

It was interesting that in all groups, serum IL-6 levels on 14th day diminished markedly, although it did not reach statistical significance compared to preoperative values. The relatively high preoperative IL-6 levels may cause this situation. In these patients, psychological stress which occurred in operating room can also induce the production of IL-6 because there were clinical and experimental evidences that psychological stressor elevates plasma IL-6 [19–21]. However, it was impossible to decide about the effect of preoperative anxiety on IL-6 levels in this study because the emotional statuses of patients were not evaluated.

Contradictory results were reported in the studies comparing Lichtenstein and conventional hernia repairs according to early postoperative pain and time to attain normal activity or time to work back. Several researchers [22, 23] emphasized that there was no difference between two techniques, whereas others [24–27] advocated that Lichtenstein hernioplasty was superior to conventional repair. We also showed that early postoperative pain and time to attain normal activities were less in Lichtenstein groups regardless of the kind of mesh.

Chronic pain after groin hernia repair is a serious problem and it occurs in 5 to 30 % of patients [28, 29]. In a population-based study within the Swedish and Danish Hernia Database Collaboration, Bay-Nielsen et al. [30] reported similar chronic pain rates after Lichtenstein and conventional hernia repairs. Recently, it was suggested that peculiarities of implants used for tension-free hernia repair might affect the clinical results. Langenbach et al. [14] reported that a multifilament, slight, and smooth polypropylene mesh causes less postoperative pain and inability to work compared with conventional polypropylene mesh. Furthermore, O'Dwyer et al. [16] showed that the lightweight mesh that was constructed of multifilaments of polypropylene with additional absorbable polyglactin and had larger porosities caused less chronic pain compared with heavyweight mesh. Although polyester mesh had larger porosities and softness, we determined no significant difference between polypropylene and polyester meshes regarding chronic pain. In addition, chronic pain incidence after Shouldice herniorrhaphy also was not different than those after Lichtenstein hernia repair regardless of using prosthesis. Similarly, Sadowski et al. [31] reported that polyester mesh did not cause a decrease in the chronic pain when it compared with polypropylene mesh for Lichtenstein inguinal hernia repair.

Although Shouldice herniorrhaphy was used as a control group in this study, this may not represent the actual control group. However, no other control group can be categorized during such studies. In addition, Schwab et al. [32] reported that immune activity in response to the Shouldice operation was slightly lower (not significant) when the procedure was carried out under local anesthesia in a recent study.

Conclusions

It was concluded that polypropylene and polyester meshes used in hernia repair caused similar inflammatory responses. It was also shown that chronic pain ratios 1 year after the operations were not different regardless of the kind of mesh.

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