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ORIGINAL ARTICLE

Long-term results of a prospective randomized trial of midline laparotomy closure with onlay mesh

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Abstract

Purpose Incisional hernia (IH) continues to be one of the most common complications of laparotomy. The short-term protective effect of the use of mesh has been demonstrated in several studies. At present, there is little evidence on the long-term results of the prophylactic use of mesh. The aim of the present study is to analyze the long-term prevention of IH 5 years after a midline laparotomy during elective surgery.

Methods A prospective study was performed including all of the 160 patients that had been previously included in the prospective, randomized, controlled trial performed between May 2009 and November 2012. The protocol and results at 1 year have been previously published in 2014. The patients in group A (mesh) were fitted with a polypropylene mesh to reinforce the standard abdominal wall closure. The patients in group B (non-mesh) underwent a standard abdominal wall closure and were not fitted with the mesh. All patients were followed for 5 years or until the diagnosis of incisional hernia was made, further surgery was performed, or the patient died. Cases lost to follow-up were also registered.

Results Five years after surgery, in group A (mesh) we have found 4/80 (5.1%) incisional hernias, while in group B (no mesh) 37/80 patients were diagnosed with an incisional hernia (46.8%). The Kaplan–Meier survival curves for these results show statistically significant differences ($p > 0.001$).

Conclusion The protective effect of the use of an onlay mesh in abdominal wall closure is significantly maintained in the long-term, up to 5 years after surgery.

International Standard Randomized Controlled Trial number: ISRCTN98336745.

Keywords Incisional hernia · Polypropylene mesh · Prevention

Introduction

Incisional hernia (IH) continues to be one of the most common complications of laparotomy with an incidence of approximately 45% [1] in the general population, and up to 70% in high-risk patients [2]. These hernias cause a significant negative impact on the physiology of the abdominal wall and quality of life of these patients. They can also be the cause of severe complications [3], representing considerable direct and indirect costs estimated in 10,107 € per patient [4].

In recent years there has been increasing interest in IH prevention using mesh in abdominal wall closure [5–8], that has included symposiums on the topic [9] and a section in the Clinical practice Guidelines published by the European Hernia Society [10].

The short-term protective effect of the use of mesh has been demonstrated in several studies, but there is not enough evidence to recommend the type of mesh to be used, its placement (onlay, sublay) or if mesh should be used in all patients or only in high-risk ones. At present, there is little evidence on the long-term results of the prophylactic use of mesh [11].

Our group published a randomized clinical trial in 2014 [12] that showed a significant reduction of IH with the use of onlay mesh in the first 12 months after surgery.

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The aim of the present study is to analyze the long-term incidence of IH and other complications in patients included in the previous trial, 5 years after surgery.

Materials and methods

A prospective study was performed including all of the 160 patients that had been previously included in the prospective, randomized, controlled trial performed between May 2009 and November 2012, registered in International Standard Randomized controlled Trial code ISRCTN98336745. The results at 1-year follow-up were published in 2014 [12]. Results at 5 years of follow-up are evaluated in the present study.

The study was approved by the Ethics Committee of Joan XXIII University Hospital and each patient included signed an informed consent at the time of inclusion in the first study. They were also informed of their entrance in the follow-up study.

Inclusion criteria were the same as in the prior study: patients with midline laparotomy in elective surgery with an ASA (American Society of Anesthesiologists) score of less than 4. Exclusion criteria were: ASA > 4, life-expectancy < 12 months, allergy or intolerance to polypropylene, prior history of incisional hernia repair, need for stoma or treatment with steroids.

The protocol has been previously published [12]; patients were randomly divided into two groups following a table obtained by a computer program. Patients assigned to group A (mesh) had a standard laparotomy closure using a continuous polydioxanone 1 loop (PDS, Ethicon US), following the 4:1 [13] ratio and a light polypropylene mesh (Biomesh Light P8 polypropylene mesh, Cousin Biotech, Wervicq-Sud, France) was fitted onlay, using interrupted polyglactin 2/0 (Vicryl, Ethicon US), covering a margin of 3 cm on each side of the suture area. An aspiration drain was placed in the subcutaneous level. Patients assigned to group B (no mesh) had a laparotomy closure using a continuous polydioxanone 1 loop (PDS, Ethicon US), following the 4:1 ratio. No drains were used in this group.

Abdominal wall closure was performed by all of the members of the surgical department, without the assistance of an abdominal wall specialist.

A follow-up visit was performed in all cases at 5 years after surgery by an independent observer; a member of the Department without access to the randomization, to determine the presence or absence of incisional hernia. IH was defined as a new defect in the abdominal wall or if there was a palpable hernial protrusion under the laparotomy scar when Valsalva maneuvres were carried out in the supine decubitus position and/or in the bipedestation posture. When an IH was clinically diagnosed, a computed tomography (CT) scan was carried out to confirm the diagnosis. In cases where the patients had abdominal CT scans as follow-up for their underlying disease, these were evaluated by two independent radiologists and the results were registered. IH was defined radiologically as a defect in abdominal wall in the CT scan located at the level of the laparotomy closure.

All patients were followed for 5 years or until the diagnosis of incisional hernia was made, further surgery was performed, or the patient died. Cases lost to follow-up were also registered.

All incisional hernias were registered, with the date of diagnosis, date of CT diagnosis, follow-up loses and causes and associated complications. We also analyzed the need for surgery in patients who presented an IH, results of surgery and follow-up, as well as patients that did not undergo surgery and the reasons.

Continuous variables are described with mean ± standard deviation (SD), and absolute and relative frequencies (%) are used to describe categorical variables.

A Kaplan–Meier survival analysis with Breslow's hypothesis contrast test was used to compare the principal variable and prognostic factors between the groups. The dependent variable was the presence of IH and the follow-up period from the date of surgery to the date of diagnosis of IH, the date of the last control or the date of the end of the study. The likelihood of IH and the Kaplan–Meier curves are presented at 60 months for both groups.

Finally, to adjust for confusion factors we performed a multivariate Cox proportional hazards regression. The variables included in the model were: intervention group, age (> 75 years, ≤ 75 years), sex (male/female), neoplasia, location of the tumor in the colon and BMI (> 30 vs ≤ 30).

The accepted level of statistical significance was $p \leq 0.05$. Data were analyzed using the SPSS Statistic program version 15.

Results

From 2014 until June 2017, a prospective follow-up was performed of all patients included in the randomized trial that had been operated on in elective surgery between 2009 and 2011.

The demographic characteristics of the groups have been previously analyzed and published, and no statistically significant differences were observed between the groups with regards to sex, age, ASA score, BMI, and comorbidities grouped as diabetes mellitus, respiratory disease and cardiac disease. There were no significant differences in the surgical variables such as blood loss or contamination between the groups.

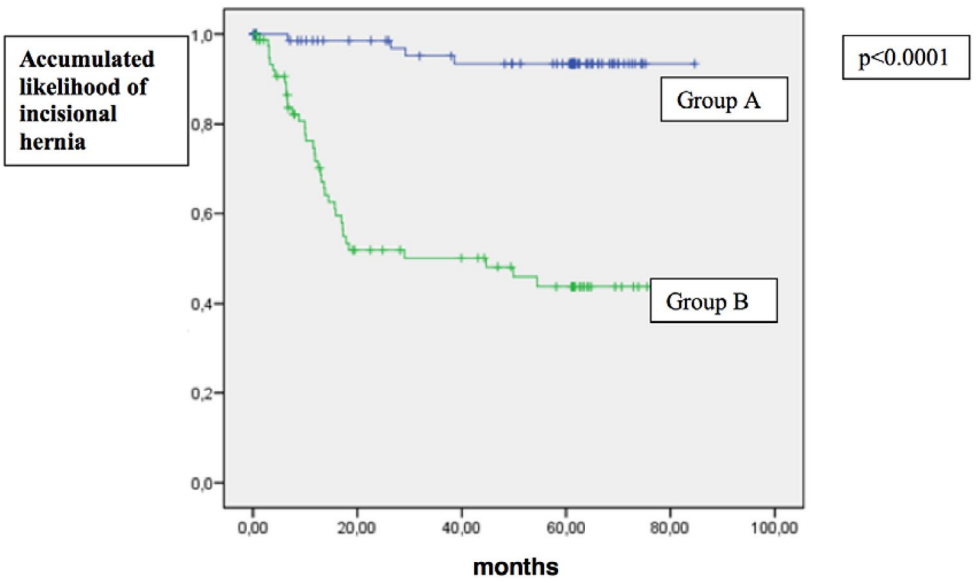

Fig. 1 Accumulated likelihood of incisional hernia at 5 years of follow-up: Kaplan–Meier survival analysis. Group A mesh; group B non-mesh

Five years after surgery, in group A (mesh) we have found 4/80 (5.1%) incisional hernias, while in group B (no mesh) 37/80 patients were diagnosed with an incisional hernia (46.8%). Figure 1 compares the Kaplan–Meier survival curves for these results with statistically significant differences ($p < 0.001$).

In comparison to the results obtained at 12 months of follow-up, there were 2 new IH in group A (mesh) and 7 new IH in group B (no mesh). No patients had complications at the 5-year follow-up (there were no cases of chronic pain, seroma, infection or hematoma…).

Figure 2 shows the distribution by groups of patients that needed surgery, died or were lost to follow-up. There were no differences between the groups with respect to loss of follow-up, deaths or further surgery, and the only differences that were found was the incidence of incisional hernia.

Four patients presented IH in group A (mesh). One (25%) had a successful open retromuscular hernia repair without complications and 3 patients (75%) have not undergone surgery (no complaint of symptoms).

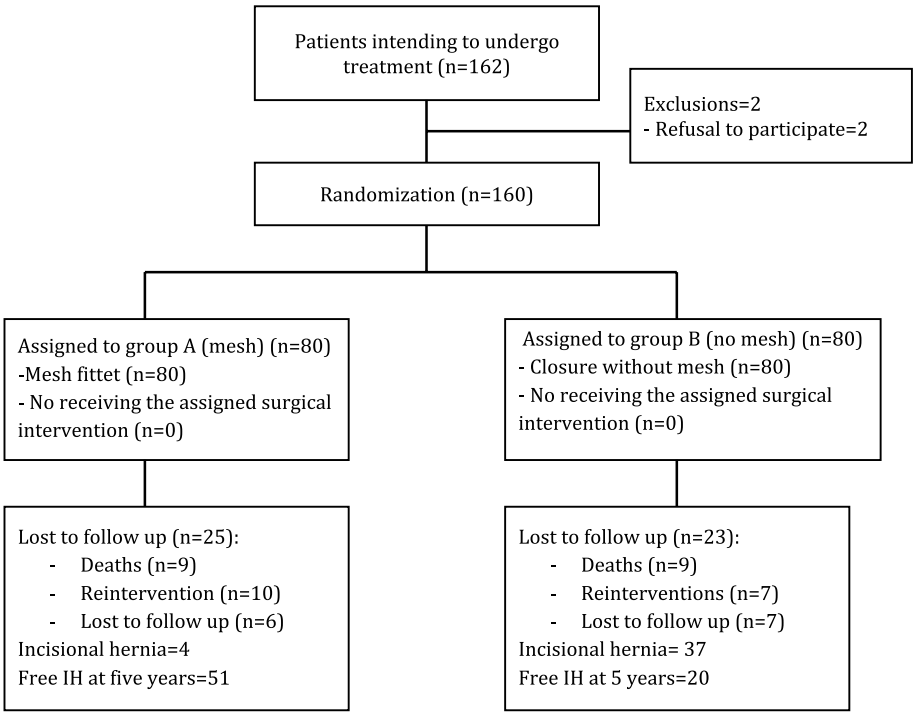

Fig. 2 CONSORT (consolidated standards of reporting trials) flow diagram showing the withdrawal and exclusion of patients at 5 years of follow-up

Thirty-seven patients presented IH in group B (no mesh) during follow-up. Twelve (32%) had hernia repair surgery, all using the Chevrel technique [14]; three presented seromas as a postoperative complication, one patient presented a superficial wound infection, one hematoma, and three had late hernia recurrence. Ten (31%) patients did not undergo further surgery because they died during follow-up due to causes unrelated to the IH, 12 (32%) did not present symptoms, and 3 (9%) are on the waiting list for IH repair surgery.

A univariate analysis was performed on factors related to the long-term occurence of IH that did not show any statistically significant differences except for the use of mesh and age > 75. In the multivariate analysis female sex and age > 75 were found as risk factors for the occurence of IH, and the use of mesh was found as a protective factor for IH with significant differences (Table 1).

Obesity was studied independently as a possible risk factor for IH, dividing the patients into two groups according to a BMI above or below 30, and no statistically significant differences were found at 5 years of follow-up.

Discussion

There is an increasing interest in the prevention of incisional hernia, a problem that is directly related to surgical technique and presents a high incidence of up to 40.9% in laparotomies and 37.1% of laparoscopies [1] when careful surveillance is performed. We found similar results in our prior analysis, where we found 37.5% IH at 12 month follow-up in patients without mesh [12].

In patients that present risk factors such as obesity, this incidence can increase to up to 70% [15]. Incisional hernias cause an important negative impact on the quality of life of these patients, resulting in incapacity, pain, and long-term abdominal wall dysfunction [16]. Although there have been recent advances in the treatment of IH, there is still a high rate of recurrence (12–54%), which increases morbidity [17]. A French study estimated that the average direct cost of each IH was 4731 €, which was elevated to 16,367 € in severe cases and in patients at an active work age [4].

Therefore, preventing the occurrence of IH has gained importance, as can be shown in the recent publication of the European Hernia Society Clinical Guidelines for abdominal wall closure [10]. The guidelines describe the use of the short stich technique as a possible method to reduce the incidence of IH, but due to the low amount of evidence, they recommend that more studies be performed comparing the short stich technique with the use of prophylactic mesh or a combination of both. The mesh stimulates fibrosis and angiogenesis of the surgical area and allows a higher tensile strength in the wound [18]. A meta-analysis published in 2016 considered that there are few high-quality studies that analyze the use of prophylactic mesh; these do suggest that they can prevent the occurrence of IH [6, 19–21] but there is little evidence on the type of mesh to use; where to place it, and the mechanisms for its fixation. This same meta-analysis highlights the fact that there are no long-term studies that analyze the results of the use of prophylactic mesh.

Our group has a special interest in IH prevention, and in 2009 we started a prospective, randomized, single-blinded trial to evaluate the protective effect of the use of an onlay polypropylene mesh. This study demonstrated a statistically significant reduction in the incidence of IH in the mesh group (1.5% vs 35.9%) at 12 months after surgery. In this prior publication [12], we analyzed the 12-month results because it is the postoperative period when most IH seem to appear, as it constitutes the time needed for maturation of wound healing, when the aponeurosis obtains 90% of its resistance [22]. Nevertheless, some authors state that longer follow-ups would find new cases of IH, as the effect of the mesh could be temporary [10]. O'Hare [11] described a clear long-term preventive effect of a pre-peritoneal mesh (47 months average follow-up) in patients who had undergone surgery for aortic aneurysm repair, although it was not a comparative study. For this reason, we decided to perform an analysis of the same patients at 5-year follow-up. Our results show, for the first time, that the protective effect of the mesh is maintained in the long-term. The differences between the groups are very similar to those found at 1-year follow-up and are statistically significant.

Furthermore, although a small percentage of IH appeared during the longer follow-up period, most of them were found during the first year of follow-up.

We observed that the occurence of IH stabilizes around the first 20 months of follow-up. This coincides with other studies that have reported the appearance of the majority of IH in the first 24 postoperative months [21]. The occurence of new IH after 24 months of follow-up is much lower and the significant differences are maintained between the groups.

Table 1 Multivariate analysis of possible risk factors for IH

	p	Rate ratio (RR)	95% CI RR*	
Group A/B	**< 0.0001**	**0.044**	**0.013**	**0.148**
Age > 75/≤ 75 years	**0.027**	**2.509**	**1.108**	**5.683**
BMI at the moment of surgery > = 30%/< 30%	0.486	1.302	0.620	2.733
Neoplasia (yes/no)	0.643	0.776	0.265	2.271
Location of surgery: colon (yes/no)	0.473	1.055	0.912	1.220
Sex (female/male)	**0.046**	**2.028**	**1.011**	**4.067**
Diabetes (yes/no)	0.182	0.512	0.191	1.370
Other	0.262	1.512	0.734	3.114

Bold value indicates statistically significant

The fact that our study was performed at 60 months of follow-up allows us to confirm that the highest rate of IH occurs in the first 2 years postoperatively and that the protective effect of the mesh continues to last at long-term follow-up.

The literature is not clear on where the best place to fit the mesh is, although it does seem than the onlay or retromuscular positions reduce the risk of IH most effectively, with no differences between the two techniques [8]. We believe that the onlay position is a good option as it is a simple technique that can be reproduced by all general surgeons, and does not require an abdominal wall specialist.

There are also few complications associated with this method. Seromas have been described with the onlay position, but most of these can be treated conservatively without needing drainage. In the 5-year follow-up we did not detect any late complication related to postoperative seromas. The meta-analysis published by Borab [8] describes a similar incidence of seromas as found in our study; most were treated conservatively without surgery. Although there is no clear evidence for their use [23], in our group we use aspiration drains to decrease the incidence and repercussion of seromas. A cost-effective analysis published by Fischer et al. stated that postoperative seromas are one of the health problems that patients least worry about after abdominal surgery when compared to other complications [24].

Since the publication of the first results of our study [12], the Clinical Guidelines of the European Hernia Society have been published [10], which describe the techniques considered to be the correct methods of abdominal closure with scientific evidence. The technique used by our group follows the recommendations of this Guideline in both groups, except the use of small bites, since this was considered effective after our study was completed [25, 26]. An incidence of 5–15% of IH has been described with this technique, but only in centers with specialized abdominal wall surgeons. If the analysis is generalized to groups that are not specialized in abdominal wall or other surgical specialties, these rates can increase up to 40%, coinciding with the findings of our prior study and other recent publications [1, 12]. For this reason, we believe that even if the short stich technique is used, the association of mesh in abdominal wall closure will achieve better results in IH prevention.

As there were no technical differences in the two groups of our study, we consider that the effect of the onlay mesh is demonstrated. It is possible that the differences could be smaller if the aponeurosis closure is performed using small bites, but further studies will be needed to evaluate the effect of the combination of the small bites technique associated with the use of prophylactic mesh.

Although it was not the main objective of this study, we performed a uni- and multivariate analysis in order to detect possible risk factors for IH at long term. These analyses have allowed us to confirm that an onlay mesh is a protective factor. In the univariate analysis, we did not observe a significant relation of IH with any of the other prognostic variables. The multivariable analysis showed female sex and age > 75 as risk factors for IH (Table 1).

Obesity has been described as a risk factor for the occurence of IH [15], so we performed a specific analysis dividing the patients into two groups according to their BMI (over or under 30), but no statistically significant differences were found between the groups. Furthermore, no significant association was found in the multivariate analysis.

Even though we attempted to identify specific risk factors to limit the indication of the use of a prophylactic mesh, we believe that the absence of clear risk factors and the evident protective effect of the mesh allow us to recommend its placement in all midline laparotomies.

The costs of IH have been extensively studied taking into account the differences between the health care systems in different countries [4, 27] and its magnitude justifies the need for new techniques to prevent IH. Although there are more and more studies on the protective effect of the use of mesh on IH, there are few studies that analyze the economic impact. This is partially due to the complexity of the analysis, as Fisher describes [28]; the costs that are directly related with the surgery needed to repair the hernia should be added to indirect costs for the patient, such as travel expenses and recovery, and indirect costs to society such as loss of productivity and health care costs. These variables were not evaluated initially in our study and have therefore not allowed us to perform a cost analysis of the use of prophylactic mesh. Although the calculation is difficult, Fisher concludes [28] that the use of a prophylactic mesh is more effective, less expensive and more cost-effective than simple primary closure of a laparotomy in high-risk patients.

The main limitation of the present study is that the original trial was designed to perform an analysis at 12–24 months after surgery, and not for long-term follow-up. However, the patients lost to follow-up are similar in both groups, and therefore we consider that the important statistically significant difference in IH rates between the groups and the importance of the results justify this long-term analysis. Another limitation of the study is the long inclusion period that was caused by the increasing use of laparoscopy in our center. The limitations inherent to the original study were discussed previously in the prior publication [12].

Conclusion

The present study shows that after a strict follow-up of patients who underwent a midline laparotomy, the incidence of IH is higher (40%) than the rates published in the literature. Long-term follow-up allows us to confirm that most of these IH occur in the first 2 years after surgery.

The protective effect of the use of an onlay mesh in abdominal wall closure is significantly maintained in the long term, up to 5 years after surgery.

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Compliance with ethical standards

Conflict of interest AC declares no conflict of interest. CO declares no conflict of interest. MM declares no conflict of interest. MO declares no conflict of interest. BE declares no conflict of interest. RJ declares no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Human and animal rights This project does not contain any studies with animals performed by any of the authors.

Informed consent All patients signed informed consents when recruited.

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