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ORIGINAL ARTICLE

A modified open intraperitoneal mesh (Garestin) technique for incisional ventral hernia repair

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Summary *Background/objective:* Incisional hernias (IHs) are a major problem following abdominal surgery. In an effort to resolve large IHs adequately, we herein present our own modified "open intraperitoneal mesh" technique, termed the *Garestin technique*.
Methods: We analyzed early postoperative complications (EPCs; wound infection, hematoma, and seroma) and late postoperative complications (recurrence) in 124 patients operated for IHs and recurrent IHs (RIHs) using our new technique. Our technique involved repairing hernias by preserving the hernia sac, which was later used to conceal the mesh that replaced the abdominal wall defect, thus dividing the mesh from subcutaneous tissue.
Results: We operated 66 patients with IH and 58 patients with RIH. In the 4-week postoperative follow-up, 29 patients had EPC; 9 of them had wound infections that healed upon antibiotic therapy, without the need for any surgical procedure. Of the 10 patients with recurrent herniation in the long-term follow-up, 6 previously had EPC. Recurrences occurred 4—25 months after the operation.
Conclusion: Our method is reliable and safe for large ventral hernia disposal, but the final conclusion requires a larger number of patients and a longer follow-up period.
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1. Introduction

Incisional hernias (IHs) are a major problem following abdominal surgery. Besides preoperative factors such as anemia, body mass index (BMI) over 25 kg/m^{2}, and smoking, which are the leading causes contributing to the development of IH,[1,2] laparotomy performed through a previous abdominal incision doubles the risk of IH.[3] In addition, wound infection increases the risk of IH formation 1.9 times.[4]

Evidence-based review of the literature carried out by Ceydeli et al[5] clearly showed that laparotomy wound closure also significantly contributes to hernia formation as a late complication. Grace and Cox[6] reported that at least half of the patients undergoing laparotomy wound dehiscence would develop IH. They also noted that tension sutures did not prevent hernia development.

Dietz et al[7] found that the "length of the hernia gap" was an independent prognostic factor for recurrence, whereas the "morphology" of hernia had no impact on early postoperative complications (EPCs) or recurrences.

Compared with mesh hernioplasty, herniorrhaphy by suturing showed poorer results.[8,9] Therefore, mesh application is considered to be a standard procedure in the treatment of IH, either through laparoscopic or open technique. Dumainian and Denham[10] emphasized that hernia size of 10 cm is the upper limit for the laparoscopic approach.[10] In addition, a high relapse rate is reported for laparoscopic management of recurrent IH.[11] Considering these facts, large and recurrent hernias, like the ones discussed in this study, should be operated by open technique. Proper positioning of the mesh (onlay, inlay, retromuscular, preperitoneal, or intraperitoneal)[12] in the treatment of IH is still an issue of major debate, which resulted in many publications with contradictory results.

Thus, in an effort to resolve the large IHs adequately, we herein present our own modified "open intraperitoneal mesh" technique, termed the "Garestin technique."

2. Methods

This paper is organized according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cohort studies.[13]

2.1. Study design

In this study, we included all patients operated for IHs and recurrent IHs (RIHs) by the modified "open intraperitoneal mesh" (Garestin) technique. We collected data on patients' demographics as well as EPCs and late postoperative complications (LPCs).

Upon the diagnosis of IH, all patients received the same preoperative preparation and treatment, which included administration of low-molecular-weight heparin (5000 IU Fragmin, administered subcutaneously) and prophylactic dose of antibiotics (1.5 g cefuroxime, administered intravenously) 60 minutes before the surgery.

After the operation, all patients received uniform postoperative care on the ward: rest, analgesics, and crystalloid solutions. Antibiotic therapy was continued for the first 24 hours after the operation. In the event of an infection, antibiotic therapy was continued until remediation, with the possible change of the antibiotic agent according to wound swab analysis.

Patients were discharged following drainage removal. Further follow-up was conducted on the outpatient basis.

2.2. Setting and participants

The study was conducted at the Department of Surgery of Varazdin General Hospital, Varazdin, Croatia. The patients were recruited in the abdominal outpatient clinic and operated between May 2010 and May 2014 by skilled abdominal surgeons. EPCs were noted between May 2010 and May 2014, and LPCs were noted between June 2010 and December 2014. We included patients of both sexes, adults aged 18 years and older, and patients with American Society of Anesthesiologists Physical Status I, II, or III. The exclusion criterion was the refusal of the patient to give informed consent.

The study protocol was approved by the Ethics Committee of the Varazdin General Hospital and the trial was registered at ClinicalTrials.gov (NCT01953302). All included patients gave their informed consent at the time of hospital admission, prior to the surgery.

2.3. Modified "open intraperitoneal mesh" (Garestin) technique

In the first part of the operation, the hernia sac was prepared and, in all cases, fully preserved during the operation. The hernia neck length (i.e., the craniocaudal length of fascial diastasis) was also measured. In the cases of recurrent hernia with previously placed synthetic material, the material was removed completely. The appropriate mesh size was then determined; for this purpose, the mesh dimensions should exceed hernia neck borders by a minimum of 5 cm in all parts of the hernia. If the hernia neck was larger than the longitudinal dimension of the available mesh, we used two meshes, which overlapped by at least 2 cm and connected with resorbable sutures in the center line (VICRYL 2-0 USP). In all patients, we used the PROCEED surgical mesh.

In the next step, the decision to reduce or preserve muscle fascia diastasis (whether or not to close fascia primarily) was made. Diastasis was preserved if it was suspected that, due to the size of fascia diastasis, reduction by suturing fascia over the mesh would increase intra-abdominal pressure and potentially abdominal compartment.

The mesh was placed intraperitoneally, which was followed by transfascial fixation of the mesh. It should be noted here that in patients with liver cirrhosis and greater amount of ascites, a Robinson drain was placed before the mesh fixation. Fixation was done through several small lateral skin incisions (Figure 1).

Polysorb (2-0 USP, undyed) was used to fixate the mesh edges. First, we performed transfascial mesh fixation in the cranial and caudal parts of the mesh, and sutures were immediately tied to provide mesh stability for further surgery. We then placed transfascial sutures circularly on both
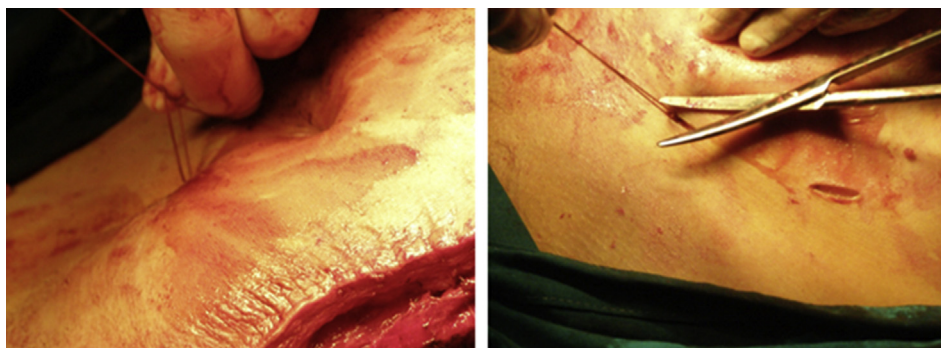
Figure 1   Tightening of the transfascial suture.

sides of the mesh, one side after the other. The maximum distance between transfascial sutures was 7–8 cm. If the patient had abdominal preternatural openings, transfascial sutures were first placed on the side of the preternatural opening, so as not to hurt and discredit the openings.

We then placed intraperitoneal drains (negative pressure drains) on the mesh. One or more drains were applied, depending on the "blind space" size. Intraperitoneal drainage was performed through the skin in the right hemiabdomen region, via the skin incision of transfascial sutures, if possible.

In the next step, the peritoneal space closure was accomplished. If, in early intraoperative planning, fascial diastasis reduction was planned, fascia was sutured over the mesh with resorbable elongated suture (Maxon 2-0 USP; Figure 2).

By contrast, if preservation of diastasis was planned, due to concerns of abdominal compartment syndrome (ACS) development, the mesh was fixated to the fascial edge imitating the *double-crown* method (Figure 3). The rest of the hernia sac, reduced to the appropriate dimensions, was placed over the mesh and sutured to the contralateral edge of fascia using resorbable interrupted sutures (VICRYL 2-0 USP), thus ensuring the intraperitoneal position of the mesh (Figure 4).

After the mesh was placed intraperitoneally, hemostasis and drainage of the subcutaneous space were performed.
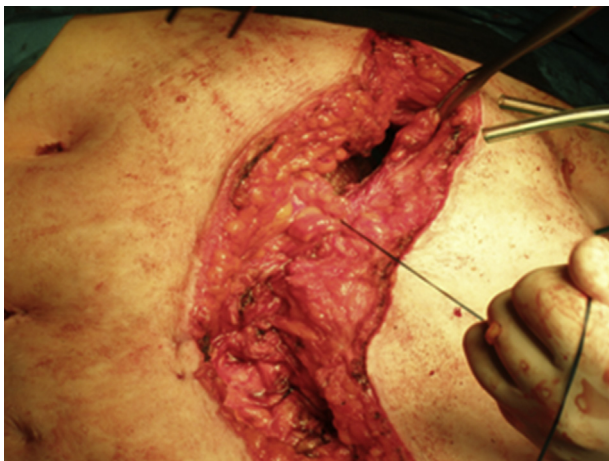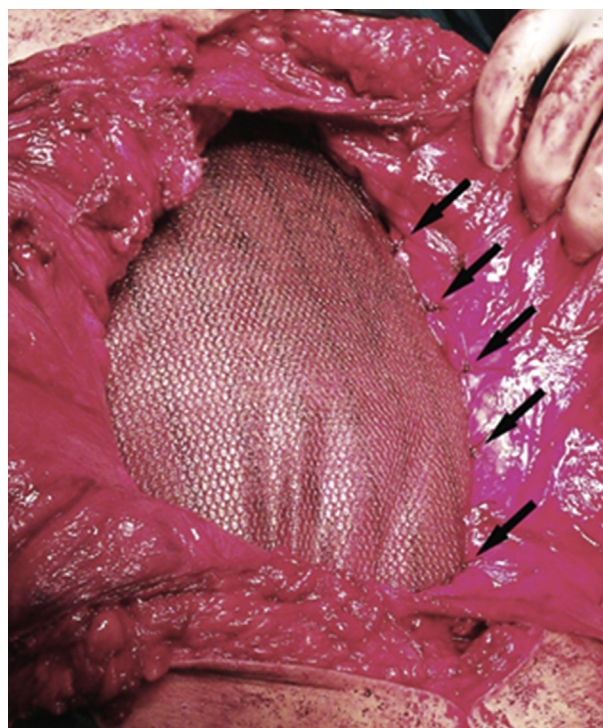

Figure 3   Double-crown imitating method for mesh fixation. The arrows show mesh to fascia edge sutures.

Subcutaneous drainage was performed through the skin in the left hemiabdomen region, via the skin incision of transfascial sutures, if possible. In the next step, subcutaneous sutures and skin sutures were placed (Figure 5).

The removal of drains began on the 5th postoperative day, first by removing the intraperitoneal drains, then the subcutaneous drain, in the counterclockwise direction. The Robinson drain was retained for 10–14 days.[14]

2.4. Variables

The primary outcome measure was number/frequency of the EPCs and LPCs (wound infections, seroma, and hematoma). Complications within the first 4 weeks after the surgery were considered as EPCs, and complications first noted 4 weeks after the surgery were considered as LPCs. The criteria for infection were redness or purulent wound
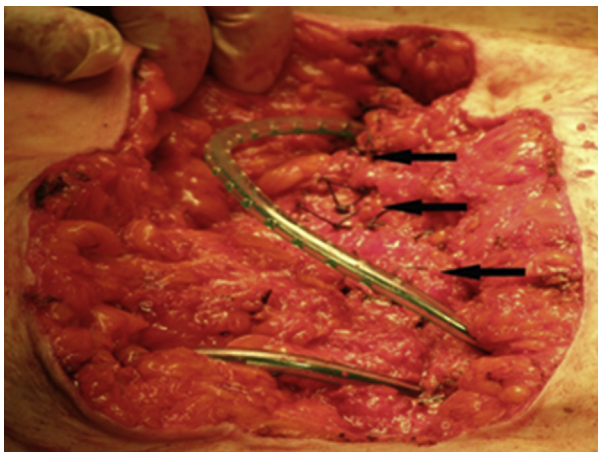

Figure 2   Fascia sutured over the mesh.

Figure 4 The hernia sac over the mesh and subcutaneous drainage. The arrows show the region from the hernia sac to contralateral fascia edge sutures.

secretion; seroma and hematoma were verified clinically or by ultrasonography.

The secondary outcome measure was the number of hernia recurrences in the late postoperative period, from 4 weeks up to the end of the study. We noted the time of hernia recurrence, while the recurrent hernia itself was verified by ultrasonography.

2.5. Study size

We decided not to restrict the final number of patients to be included in this study, but rather restricted the time frame to 4 years, and therefore, this study included all patients operated for IH ($n = 66$) and RIH ($n = 58$) in Varazdin General Hospital from May 2010 to May 2014.

2.6. Quantitative variables

Prior to the surgery, patients' had their BMI measured as an independent prognostic factor.[15] The hernia neck length was measured intraoperatively.

2.7. Statistical analysis

Patients' age, sex, and BMI data were summarized using descriptive statistics. Categorical variables were compared using Fisher exact test, and continuous variables were compared using the t test for independent samples or Mann—Whitney test, depending on the data distribution. The association between the variables was calculated using rank correlation. All statistical analyses were performed by A.L. using MedCalc version 9.5.1.0 (MedCalc Software, Mariakerke, Belgium).

3. Results

3.1. Participants and descriptive data

We operated 66 patients with IH and 58 patients with RIH. There were 46 male and 78 female patients, aged between 34 years and 87 years [mean ± standard deviation (SD): 64 ± 12 years]. Their BMI ranged from 15 kg/m^2 to 36 kg/m^2 (mean ± SD: 23 ± 5 kg/m^2). Hernia neck lengths (measured intraoperatively) ranged from 5 cm to 49 cm (mean ± SD: 19 ± 9 cm). The mean ± SD for the IH neck length was 16 ± 7 cm, whereas it was 23 ± 10 cm for RIH; thus, the RIH

Figure 5 Early and late postoperative views.

neck length was greater than the IH neck length ($p < 0.001$; Table 1). Patients with higher BMI had greater hernias ($p < 0.001$). We noted a significant difference in BMI between patients with IH and RIH (mean $\pm$ SD: 21 ± 4 kg/m^2 vs. 24 ± 5 kg/m^2, $p = 0.0016$). There was no age difference between patients with IH and RIH (mean $\pm$ SD: 62 ± 13 years vs. 65 ± 10 years, $p = 0.136$).

3.2. Outcome data

There were nine (7.3%) wound infections: three (2.4%) in IH and six (4.9%) in RIH. Wound infections correlated with hernia size ($p = 0.004$), but there was no association between BMI and wound infections ($p = 0.195$). All wounds healed following antibiotic therapy, without the need for any surgical procedure.

We noted 21 (17%) wound seromas: 13 (10.5%) in IH and 8 (6.5%) in RIH cases. There was no association between seroma and hernia size ($p = 0.716$) or BMI ($p = 0.400$).

There was one (0.8%) hematoma that developed in a patient with newly detected coagulopathy.

3.3. Main findings

In the long-term follow-up (mean $\pm$ SD: 20 ± 10 months), we detected 10 (8.1%) hernia recurrences, with 6 (4.8%) of them being detected in patients operated for RIH ($p = 0.512$). Of the 10 patients with hernia recurrence, 6 had some of the EPCs: 4 had wound infection and 3 had wound seroma. The recurrences were associated with previous wound infections ($p = 0.002$), but not with wound seroma ($p = 0.371$). Recurrences were more common in patients with bigger hernias ($p < 0.001$) and in patients with a higher BMI ($p < 0.001$).

Recurrences occurred between 4 months and 25 months postoperatively (mean: 12 ± 6 months). The time of recurrence was not associated with hernia size ($p = 0.436$), seroma ($p = 0.494$), or infection ($p = 0.337$), but it was strongly and inversely associated with patients' BMI ($p = 0.011$).

3.4. Other analyses

Hospital stay duration varied between 3 days and 21 days (mean: 8 ± 3 days). The longest in-hospital stay was noted for the patient with newly diagnosed coagulopathy and postoperative hematoma. Patients with RIH stayed in hospital longer than those with IH ($p = 0.023$). The duration of hospital stay was not associated with the size of the hernia ($p = 0.684$) or BMI ($p = 0.836$; Table 2).

4. Discussion

4.1. Primary findings

We operated 66 patients with IH and 58 patients with RIH. In the 4 weeks of postoperative follow-up, 29 patients had EPC: nine of them had wound infections that healed upon

Table 1. Demographic data of the study patients who received the modified "open intraperitoneal mesh" (Garestin) technique.

Patients' data	n (%) or mean $\pm$ SD
Sex	
Male	46 (37)
Female	78 (63)
Hernia	
Incisional	66 (53)
Recurrent incisional	58 (49)
Age at the time of surgery (y)	
< 39	3 (2)
40−49	15 (12)
50−59	26 (21)
60−69	35 (28)
70−79	38 (31)
80−89	7 (6)
Mean $\pm$ SD	64 $\pm$ 12
Body mass index (kg/m^2)	
< 25	89 (72)
25−30	17 (14)
> 30	18 (14)
Mean $\pm$ SD	23 $\pm$ 5

SD = standard deviation.

Table 2 Intraoperative data and postoperative course in the study on the modified "open intraperitoneal mesh" (Garestin) technique.

Intraoperative data and postoperative course	n or mean $\pm$ SD
Hernia neck length (cm)	19 $\pm$ 9[a]
Hospital stay duration (d)	8 $\pm$ 3[b,c]
Early complications[d]	20
Infections[c]	9[e]
Seroma[f]	21
Hematoma[f]	2
Recurrences	10[g]
With early complications	7
With infection	4
Time to recurrence (mo)	12 $\pm$ 6[h]

BMI = body mass index, SD = standard deviation.
[a] Recurrent incisional hernias versus incisional hernias, $p < 0.001$, Mann−Whitney test.
[b] Longer hospitalization was needed for patients with recurrent incisional versus patients with incisional hernias ($p = 0.002$, Mann−Whitney test), but duration of hospital stay was not associated with the size of the hernia ($p = 0.684$) or BMI ($p = 0.836$), rank correlation.
[c] *Criteria:* redness or purulent secretions on the wound.
[d] During the first 4 weeks after the operation.
[e] Correlated with the size of the hernia, $p = 0.004$, Mann−Whitney test.
[f] Verified clinically or by ultrasonography.
[g] Recurrences were more common in patients with larger hernias ($p < 0.001$, Mann−Whitney test), in patients with higher BMI ($p < 0.001$, Mann−Whitney test), and in patients with wound infection in the early postoperative period ($p = 0.002$, Fisher exact test).
[h] Time of recurrence was inversely proportional to patients' BMI ($p = 0.011$, rank correlation).

antibiotic therapy, without the need for any surgical procedure.

Of the 10 patients with recurrent herniation in the long-term follow-up, six had EPC previously. Recurrences occurred 4—25 months after the operation.

4.2. Limitations

The possible limitation of this study is its relatively small sample size. However, due to the sound primary outcome, we are confident that our result will be confirmed by future larger studies. In addition, we did not record the American Society of Anesthesiologists status of the patients and the coexisting diseases, as well as the postoperative pain, but these data could be added in the future studies.

4.3. Interpretation

For now, prophylactic use of mesh to prevent IH formation is not recommended in all patients. Mesh usage has become the gold standard in treating IH, despite the debate regarding mesh positioning.[16]

Surgical-site infections are serious complications of hernia repair. In surgical-site infection monitoring, a clear distinction between total superficial infection and mesh infection should be emphasized.[17] While total superficial infections underlay conservative treatment, mesh infections require more or less complete removal of the synthetic material.[17,18]

Intra-abdominal hypertension (IAH) has a prevalence of at least 50% among critical patients and was identified as an independent life-threatening risk factor.[19] IAH and ACS should be considered in every large hernia operation.

We believe that intraperitoneal position is an ideal mesh position that provides adequate mechanical support to the weakened abdominal wall. In our technique for hernia repair, we preserved the hernia sac to conceal the mesh that replaces the abdominal wall defect. Dividing the mesh from subcutaneous tissue and preventing potential mesh infection that would require reoperation and removal of the mesh are of great importance. Our results support our hypothesis that all wound infections in this study were total superficial infections and can be successfully resolved conservatively, as the mesh is completely laid intraperitoneally.

In addition, our *double-crown method mimicking* is a tension-free method. In contrast to other *nontension-free* methods such as herniorrhaphy or fascia suturing over the positioned mesh, our method prevents IAH and ACS, thus preventing life-threatening complications of elective surgery.

Positioning of the drains also plays an important role in our method. Placing drains between the peritoneum/hernia sac and the mesh assures adequate seroma removal, thus providing satisfactory mesh—tissue ingrowth. Mesh edges (especially around transfascial sutures) are places of antecedent ingrowth, and therefore, seroma in the center of the mesh prolongs mesh—tissue ingrowth. Drains provide quicker seroma removal and secure faster mesh—tissue ingrowth.

In our "open intraperitoneal mesh" (Garestin) technique, the preserved diastasis of rectus fascia, which prevented ACS, and the use of hernia sac to conceal the mesh, which replaced the abdominal wall defect, played key roles.

4.4. Conclusion

In conclusion, we believe that the method presented here is reliable and safe for large ventral hernia disposal, but the final conclusion requires a larger number of patients and a longer follow-up period.

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