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Review of the Effectiveness of Composite Barrier Mesh Used for Laparoscopic Ventral Hernia Repair

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ABSTRACT

Background: The objective of this research is to provide an overview of the physical and biomechanical properties of composite barrier meshes frequently used in Laparoscopic Ventral Hernia Repair as well as reviewing the existing relevant literature assessing the characteristics and effectiveness of both procedures.

Methods: A secondary research is used using existing literature review of the preclinical and clinical literature designed to compare the Composite prostheses with permanent barriers (COMPOSIX, VENTRIO, DUALMESH, DYNAMESH and TiMESH) to composite prostheses with absorbable barriers (PROCEED, C-QUR, PHYSIOMESH, PARIETEX and SEPRAMESH).

Results: Significant differences were observed between Composite prostheses with regard to its physical and biomechanical properties. Amongst the permanent barrier meshes, Dualmesh showed the highest suture retention strength. On the other hand, between the absorbable barrier meshes, Sepramesh proved to have the most significant suture retention and tears strength. Overall, all meshes established tensile strengths greater than 16-32 N/cm.
Moreover, that composite meshes with absorbable barriers had less complications of adhesions, recurrences and wound infection compared with meshes with permanent barriers.

Conclusion: Composite meshes with absorbable barriers proved to be superior to permanent ones. Other findings demonstrated there was no significant difference of effectiveness among absorbable barriers.

Keywords: Absorbable barrier,Laparoscopy, Ventral Hernia, Mesh, Adhesions, Recurrence,Permanent barrier.

INTRODUCTION

Ventral hernia repair must be a real challenge for surgeons. Throughout the past 50 years, hernia repair techniques have manifested a substantial evolvement starting from primary suture repair, to the use of synthetic mesh products in order to form a "tension free" repair, and eventually minimally invasive laparoscopy techniques[(1)]. Since 1993, when Le Blanc reported the first case of laparoscopic incisional hernia repair with the use of synthetic mesh [(2)], the surgery of laparoscopic ventral hernia repair (LVHR) has attained many improvements. The use of laparoscopic techniques and meshes improved recurrences, postoperative pain, adhesion formation, length of hospital stay, and wound infection compared with open techniques.

Many types of mesh are being used for LVHR. These materials are in direct contact with the abdominal viscera and might lead to adhesions resulting in pain, bowel obstruction, fistula formation, or adhesiolysis-related complications like enterotomy and unplanned bowel resection during consequent surgical procedures [(1)]. Common methods to reduce adhesion include refining surgical techniques to reduce trauma, interference with fibrinolysis pathway through fibrinolysis stimulators, or physical barriers such as anti-adhesives liquids, films, or barrier materials[(3)].

In 1950s, Usher has introduced the uncoated polypropylene meshes which has led to an evolution in the Prosthetic mesh materials field[(1)]. Composite barrier mesh materials have become increasingly popular for LVHR. These materials have been designated to prevent adhesions between the mesh and the viscera by mechanically separating the viscera from injured area of the peritoneum until reperitonealization occurs[(3)]. There are two main types of barriers with different compositions: absorbable and non-absorbable (permanent). Absorbable barrier layers can be found as the oxidized regenerated cellulose in PROCEED Surgical Mesh (Ethicon, Somerville, NJ), the omega-3 fatty acid layer in C-QUR Mesh (Atrium Medical, Hudson, NJ), the polyglicaprone-25 (Monocryl) in PHYSIOMESH (Ethicom), the collagen layer in PARIETEX COMPOSITE (Covidien, Mansfield, MA), sodium hyaluronate (HA), carboxymethylcellulose (CMC) and polyethylene glycol (PEG) in SEPRAMESH IP COMPOSITE (Bard, Davol, Warwik, RI)[(3)]. Permanent barriers layers can be found as expanded polytetrafluoroethylene (ePTFE) in COMPOSIX and VENTRIO meshes (Davol), DUALMESH (Gore Medical, USA) and as

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polypropylene in DYNAMESH IPOM (FEG Textiltechnik mBH, Aachen, Germany) and TiMESH (ppm medical titanium gmbh, Nurnberg, Germany)[3].

The objective of this review was to provide an overview of biophysical properties of composite barrier meshes commonly used for Laparoscopic Ventral Hernia Repair and review the current literature related to its characteristics and effectiveness.

MATERIALS AND METHODS

The present review article summarized twenty-two studies published during the years 2003-2017 available at PUBMED, an archive of biomedical and life sciences journal literature at the U.S. National Institutes of Health's National Library of Medicine (NIH/NLM). In addition, public medical materials related to composite barrier meshes used in laparoscopic ventral hernia repair were utilized. These studies mainly discussed physical and biomechanical properties of different meshes in addition to information about adhesions, recurrence rates and wound infections. The criteria of inclusion were studies which had discussion of physical and biomechanical properties as well as information about adhesions, recurrence and wound infections of composite meshes. The criteria of exclusion were studies about other kinds of meshes except composite meshes**.**

Materials evaluated:

Five permanent barrier mesh; COMPOSIX, VENTRIO, DUALMESH, DYNAMESH and TiMESH and five absorbable barrier mesh; PROCEED, C-QUR, PHYSIOMESH, PARIETAL and SEPRAMESH.

RESULTS

After a review of the selected articles, physical properties were separated into four aspects: areas of interstices, diameter of mesh filaments, thickness and density. Likewise, biomechanical properties were separated into four aspects: suture retention, tear resistance, uniaxial tensile (strain) and ball burst [1].

One study compared seven composite meshes: four with absorbable barriers: PARIETEX, PROCEED, SEPRAMESH and C-QUR and three with permanent barriers: COMPOSIX E/X, COMPOSIX L/P and DUALMESH [5]. Composite meshes with permanent barrier having macroporous demonstrated better area of interstices than those having microporous. Diameter of mesh filaments is relative and depends on how filaments are organized in each prosthesis. No differences were observed in relation of thickness and density between permanent and absorbable meshes [5]. All meshes displayed tensile strength more than 50 N except PARIETEX. For Uniaxial tensile at 16 N/cm stress, only COMPOSIX displayed near physiologically values and it was relevant. There was no significant differences regarding ball burst between composite meshes with permanent barrier and absorbable[5].

Courcoulas *et al.* demonstrated the case of twenty-seven obese patients with BMI more than 35 kg/m2 and a mean mesh defect ratio of 2.4:1. All patients went through laparoscopic ventral hernia repair using three different types of mesh with a follow up period of 14.9 month (mean follow up). Recurrence rate was 18.5%, the highest was using DUALMESH (23%) followed by COMPOSIX (1%)[9] . **Jenkins *et al.*** demonstrated a study of sixty nine patients with hernia defect using different types of mesh applied through laparoscopic ventral hernia repair. The highest small bowel/colon adherent to the mesh was by uncoated macroporous mesh (100%), followed by Biologic mesh (87.5 %), COMPOSIX (76.5%), absorbable barrier coated mesh (66.7%) and lastly DUALMESH (64.3%). As to recurrence rate, the highest was with COMPOSIX (94.1%), followed by uncoated macroporous mesh (91.7%), absorbable barrier coated mesh (72.2%) and lastly DUALMESH (71.4%)[10]. A further study including eighty-eight patients with hernia defect more than 4 cm using PARIETEX composite meshes to repair the defect, by laparoscopy, and with a mean follow up of 134 days, found no recurrence rate, with only two infected meshes were reported[6].

A study done on the cases of 101 hernia repair patients, with defect less than 3 cm, investigated the effectiveness of PROCEED mesh. A postoperative clinical follow up for 12 months was performed. Recurrence rate was 5.1% and early wound infection was 17.8% [7]. Furthermore, **Bontinck *et al.*** demonstrated twenty-two pilot studies with defect hernia more than 4 cm ventral hernia repairing using PROCEED mesh. The cases were clinically followed for 18 months and recurrence rate was only found in two cases (9%)[12,13]. Martinez et al. demonstrated another case of 120 patients, with hernia defect more than 10 cm, using two different types of meshes, COMPOSIX (permanent barrier) and VENTRIO (absorbable barrier). Clinical follow up for 12 months was performed. The mean defect size was 14.7 cm and the mean age was 63.6 years. COMPOSIX mesh had higher rate in recurrence and infections in comparison to VENTRIO mesh[14].

Furthermore, four types of meshes in mature rats were investigated in a total adhesion study and after seven days it was found that the lowest rate was using C-QUR (p=0054), followed by TiMESH (P=0.016). Regarding the adhesion grade score, the highest rate

was TiMESH (2.6) and the C-QUR was the lowest (1.0). The final result in this study reported there was no significant difference relating adhesions between TiMesh and C-QUR[15]. A farther examination was performed for 96 patients with ventral hernia using PROCEED mesh for LVHR and fifty months of follow-up. The data collected relating to the complications were divided in two groups: early and late. Two cases with chronic pain and one with urinary retention were found at the early stage and regarding late complications, there were no recurrent hernia or infections[16].

Barzana et al. reported a study of a 54 years old female patient with a ventral hernia using COMPOSIX mesh for LVHR. After four years, she developed recurrent hernia then laparoscopic ventral hernia repair with DUALMESH was done with no report of recurrence up to 10 months[17]. **Tandon *et al*.** demonstrated the case of 88 patients with hernia defect undergone LVHR with two types of composite meshes: Parietal and DYNAMESH-IPOM. The median follow up was 53 months. High recurrence rate in Parietex mesh (12.9%) was documented and for DYNAMESH-IPOM (3.8%). High incidence of intestinal obstruction secondary to adhesions in DYNAMESH-IPOM (11.5%) compared to PARIETAL mesh (6.4%) was found[18]. An additional study performed on pigs to investigate two different types of meshes, found that abdominal continent adherent to the mesh was higher in DUALMESH (0.25%) comparing with TiMesh(0.085%)[19]. Study performed in rats to investigate different types of meshes was found there was no difference of adhesions and recurrences rates between C-QUR mesh and PARIETEX mesh[20].

DISCUSSION

Several clinical studies have assessed the physical and biomechanical properties of several prostheses used for LVHR [5,6),7]. Effectiveness of these meshes preventing adhesions and its complications like adhesiolysis, unplanned enterotomy, bowel resection, wound infection and recurrences trying to help in choosing the best mesh was also demonstrated [5,6,7].

Both physical and biomechanical properties of prostheses have been attributed a main role in adhesion prevention. There are many different chemical compositions of the coating of meshes but these differences did not result in any significant changes in adhesions formation. This interesting finding identify the mere presence of a layered coating as the most important factor in reducing intraperitoneal adhesions[5,6,7]. In one study, **Scott *et al.*[8]**demonstrated by analyzing histological differences of reactions of three composite meshes with absorbable barriers that fully absorbable mesh devices may provide more optimal mechanical and histological properties to support gradual load transfer to the abdominal wall than biologically derived scaffolds.

It is probable that the components of these barriers provoke a wide range of inflammatory responses, resulting in the range of adhesions coverage and tenacity observed[1]. Numerous preclinical animal models have attempted to determine the adhesions characteristics and effectiveness of barrier mesh prostheses available for ventral hernia repair applications[19].

Prosthetic mesh materials have evolved since Usher first introduced uncoated polypropylene mesh in the late 1950s(1). Clinical studies identified recurrence rates without mesh up to 63% and using mesh up to 32%[10]. Other study demonstrated recurrence rates using mesh up to 1% and repairing without mesh up to 11%[11].

Since 1993, when Le Blanc reported the first case of laparoscopic incisional hernia repair with the use of synthetic mesh[2], the surgery of laparoscopic ventral hernia repair had obtained many improvements. The use of laparoscopic techniques and meshes improved recurrences, postoperative pain, length of hospital stay, adhesion formation and wound infection compared with open techniques. Jenkins *et al*. demonstrated recurrence rate in laparoscopic ventral hernia repair up to 4,7% with a mean follow up of 20 months in 799 patients. One study[11]demonstrated that the complications, between laparoscopy and open approach using mesh, are the same and depending of others factors like cost and shorter time.

A published guideline by an Italian Consensus Conference recommended caution for defects greater than 10 cm, however did not consider such defects as absolute contraindication. On the other hand, the same group recommended that hernias with a defect size less than 3cm should not be approached laparoscopically[22]. There are few articles performed research in obese patients or in a big hernia defect repair. For this reason, many surgeons prefer conservative treatment owing to the technical challenges as well as the high morbidity, and the rather high recurrence rate[21].

Largely, several coated meshes are commercially available for laparoscopic intraperitoneal hernia repair. Worth mentioning that Adhesion prevention and mesh incorporation are considered some of the key factors in selecting the optimal mesh. Both the chemical composition and the morphology of meshes have been attributed a main role in adhesions prevention. Many articles confirm restraining the use of uncoated

macroporous mesh in LVHR. The reason for that is the high recurrence rate and bowel adhesions observed.

One of the favored sites for adhesion formation with composite meshes is the mesh border. Close observation of mesh borders showed that the inflammatory infiltrate originating from the abdominal wall ranged beyond the mesh border and thus the coating[8]. Other articles demonstrated the main reason for adhesions is surgical technique[10]. Current mesh fixation techniques are associated with chronic pain and intestinal adhesions, with rare reports of erosion, fistulization, or both[5]. Research involving alternative fixation techniques in LVHR is ongoing to minimize or avoid these complications.

Wound infection was less likely manifested in Laparoscopic ventral hernia repair than open repair. Nevertheless, recurrence rates and post-operative pain were similar between both techniques during mid-term follow up[22].

CONCLUSION

The effectiveness and overall adhesion characteristics of barrier mesh prosthesesfor LVHR has been the focus of many several preclinical animal models as well as clinical studies.

Nevertheless, the fact that not all types of meshes were included in such studies nor had them compared the meshes under the same condition hindered the precision of the decision on adhesion characteristics and effectiveness of these materials.

It is important to mention that most of the existing commercial meshes with a layered coating usually prevent adhesion formation equally. Thus, other parameters like costs and mesh handling should be greatly considered in the decision of selecting a mesh for laparoscopic ventral hernia repair.

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