Muscle Point of Break to Tensile Forces Affect Ventral Hernia Repair

*Eldo E Frezza, Edoardo G Frezza, Cory Cogdill
1Eastern New Mexico University, Health Science Center, Roswell NM, USA
2University of Delaware, Newark DE, USA
3Mathematics, Physics and Science Department, USA

Abstract

Ventral hernia repair has been a challenging surgery during years. The most common initial repair was to repair the opening of the hernia. After the repair of the hernia with mesh our clinical observation showed that the pressure goes where the stitches are placed, therefore the line of suture is the "weakest link". This observation brought us to study the effect of the pressure applied to muscle tissue in the lab after sutured to a mesh. The experiment is to test the resistant of muscle after suturing to a non-absorbable mesh. This was done applying forces to different muscle type and thickness.

Method

Two types of muscle were used: a) top round with less fibers and b) flank steak with more fibers. Thickness of 0.4 mm up to 14 mm was used. Rectangular mesh and muscle were used. The pieces of meat cut at about 15 cm x 17 cm were suture at both sides longitudinally to Ventralyte. The weight was added to both sides via a pulley system that directed the force in a horizontal direction. The weight was added in 50 gram increments. Some of the weights were in pounds and converted to grams for convenience of reporting in the metric system.

Results

We then applied tension on both side of the mesh to find the point of rupture. We performed 3 experiments in each group. The top round with less fibers held an average of 2500 grams of weight while the flank streak with more fiber and average of 4600 grams, showing that fibers are the most important part for holding the stitches.

Conclusion

The muscle fibers break mostly at the level of the suture where the forces are applied and in thin muscle can break the fibers also in the center of the muscle itself. The point of break is directly correlated with thickness and fiber content of the muscle.

Keywords

Adominal wall physiology; Tensile force; Elastic force; Component separation; Ventral hernia repair; Ventral hernia; Phasix mesh; Biological mesh; Polypropelene mesh; Tensile stress; Newtons/cm²; Elastic bands; Muscle tissues; Cross sectional area; Tensile forces

Introduction

Ventral hernia repair has been a challenging surgery during years. The most common initial repair was to repair the opening of the hernia. In the last few years, we went from repairing the hole to the mobilization of muscle and closing of the whole abdominal wall. The component separation has been applying by requiring mobilization of fresh muscle [1] towards the midline to reinforce the area

*Corresponding author: Eldo E Frezza, Eastern New Mexico University, Health Science Center, Roswell NM, USA. E-mail: eefrezza@msn.com

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where the hernia is. This requires dissection of the fascia of the rectus muscle and closure of the midline linea alba [2,3].

It has been reported many times that the goals of the ventral hernia is to restore the strength of the abdominal muscle and restore the abdominal wall function by improving therefore the abdominal wall. This has been reported by different groups [4,5].

**Hypotesis**

The problem of the ventral hernia is not the hole itself because patient fails after repair of the hole with a simple mesh. Our hypothesis is that age, obesity, pregnancy, and any force applied to the abdominal wall creates stress on the muscle tissue by “stretching it out”, this is a stress already introduced to the tissue particularly if the abdomen is obese.

There is a recurrent theme in ventral hernia repair which is the recurrences, this is mostly due to break down of the repair. After the repair of the hernia with mesh our clinical observation showed that the pressure goes where the stitches are placed, therefore the line of suture is the “weakest link”. This observation brought us to study the effect of the pressure applied to muscle tissue in the lab after sutured to a mesh.

**Aims**

The experiment is to test the resistant of muscle after suturing to a non-absorbable mesh. This was done applying forces to different muscle types and thickness.

**Material and Method**

Two types of muscle were used: a) top round with less fibers and b) flank steak with more fibers. Thickness of 0.4 mm up to 14 mm were used. Rectangular mesh and muscle were used. The pieces of meat cut at about 15 cm x 17 cm were suture at bot side longitudinally to Ventralyte (C. R. Bard/Davol, Inc., Warwick, RI, USA) a synthetic mesh, is a propylene polypropelene mesh with one side hydrogel seprafilm,. This was suture to the meat with 8 sutures on each side to mesh. Sutures were roughly 1.0 cm from edge of mesh and meat. The distance between sutures was roughly 0.5 cm. The meat was cut in a 2 inch by 3-inch rectangle and the mesh was attached to both ends. The mesh was also attached to a string that held the weights by which to pull the meat apart (Fig 1). We then applied tension on both side of the mesh to find the point of rupture. The weight was added to both sides via a pulley system that directed the force in a horizontal direction.

The weight was added in 50 gram increments. Some of the weights were in pounds and converted to grams for convenience of reporting in the metric system.

![Figure 1: The Experiment](image)

**Results**

We performed 3 experiments in each group. The top round with less fibers held an average of 2500 grams of weight while the flank streak with more fiber and average of 4600 grams, showing that fibers are the most important part for holding the stitches.

<table>
<thead>
<tr>
<th>Meat Thickness</th>
<th>Top round steak</th>
<th>Flank Steak</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-4 mm</td>
<td>2600+800</td>
<td>4650+900</td>
</tr>
</tbody>
</table>

**Discussion**

Abdominal wall defect represents a difficult surgical problem require appropriate management for acceptable results [5,6]. CSR and VHR have been employed satisfactorily when mesh has been used, with CSR being recommended when fistula is present, when infection is likely, and after ileostomy or colostomy closure [6,7,8]. This paper shows, in terms of reoperative rates, a marked preference for CSR as a first-choice procedure, a recommendation that concurs with the findings of others [9]. What the physical experiments demonstrated was that differences in reoperative rate might relate to the body habitus and local factors with respect to the abdominal...
wall strength [10].

In our experience [11] the redo surgery in the Ventral Hernia Repair (VHR) group were those with the highest BMI 54 compared with 39 average when they have their hernia repairing the first place. An increase in BMI instead was the higher indication for hernia repair for the group with Component Separation Repair (CSR). The latter in fact had higher BMI than the VHR group showing that obesity and gain weight can play a role in the hernia formation and loss of abdominal physiology. The CSR group though despite the higher BMI had less recurrences, showing an improvement by repair the whole abdominal wall.

Therefore, given the fact that there is a high incidence of recurrence of the ventral hernia in these patients, the issue was how to do to repair ventral hernia.

Initially we tried to fix this issue by bringing fresh tissue in the midline with the component separation technique, but that was not enough because we need to reinforce the all abdominal wall and that is why we have been placing a large mesh to do that (Phasix, C. R. Bard/Davol, Inc., Warwick, RI, USA).

This did not address the real issue of forces applied to the abdominal wall.

As showed in our muscle experiments the tensile force work strongly around the suture repair on the muscle side when stitches are placed. In the thin muscle experiment the rupture occurred right at the suture line in the thicker muscle with more fascia littler bit more far from the stitches. The thicker is the muscle the better the stitches hold. The stitches hold better in the mesh area but in the muscle side due to the forces applied the muscle fibers breaks mostly at the level of the suture where the forces are applied and in thin muscle can break the fibers also in the center of the muscle itself. Therefore, the point of break is directly correlated with thickness and fiber content of the muscle. Young healthy muscle will work better than non-functioned muscle.

Unfortunately, obesity, age, malnutrition etc. make the muscle becoming thinner and therefore we have more situation like our first observation.

There are many other factors possibly as work, like strength of bonding between mesh and fleshy tissue for healthy individuals vs. obese and those with poor blood flow

1. The Diameter of the abdomen (possibly measured as BMI, but better measured girth or distance around the belly button)
2. Age- Might affect elasticity of the muscle tissue
3. Stress/Strain while lifting/bending/ obesity etc
4. The gravity forces to the abdomen particularly if large
5. These effects depend upon one another. Note that the wider the band is initially, the greater the effect of the change in length would be and vice versa; that’s where the explanation problems come in.

Conclusions
1. The point of break is a fact in the muscle and is seen around the stitches placed in the muscle
2. Older muscle becoming thinner and less elastic
3. Mesh by itself does not solve the problem of ventral hernia
4. Component separation bringing fresh muscle reinforced by mesh [12] is the only solution to repair the hole abdomen.

References


