The Biology of Hernia Formation
and
How Should We Use This Information in Clinical Practice

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Biology of Hernia Formation
Questions to Think About

Why do some people (but not others) form

- Direct inguinal hernias
- Incisional hernias
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Questions

Would anyone in the audience not use a prosthetic material for repairing a

- Direct inguinal hernia
- How about an incisional hernia?

Questions to Think About

- What is the best alloplastic prosthetic material?
  - Polypropylene – which type
    - which weight? which pore size?
  - ePTFE
  - Dacron
  - Composite type – polypropylene and ePTFE
- What about bioprostheses (human, pig, cow tissue?)
- Or synthetic absorbables?
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Overall Aim of Talk

- Healing of wounds*
- Abnormalities in acquired hernias*
  - Molecular/genomic causes**
- Principles of repair
- Review techniques we all know within the above concepts

*Briefly
**Really, really briefly

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Global Classification

- Congenital
- Acquired
  - Tissue loss
  - Technical mishap
  - Dysmetabolism*

Shouldn’t our operative approach VARY with type of hernia?

*Probably the most important
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**Congenital Hernias**
- Developmental mishaps
- Global types – any potential abdominal wall "foramen"*
  - Umbilical (universal)
  - Indirect inguinal
  - Epigastric
  - Diaphragmatic (neonates)
  - Femoral? Obturator?**

*Any orifice of the coelomic cavity
**Developmental in older patients?

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**“Acquired” Type Hernias* - 1st Type**
- Tissue loss
  - Blast injury
  - Necrotizing soft tissue infection
  - Closure by second intention
- Technical mishap
  - Suture(s) broke
  - Poor placement**

*There is a reason(s) for these to develop
**Probably unusual
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**“Acquired” Type Hernias – 2nd TYPE**

- Degenerative
  - Direct inguinal *
  - Diastasis rectus

- Metabolic
  - Collagen disorders
  - Most incisional hernias?

*Why not women?*

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**Hernias - Incidence**

- Indirect inguinal hernias: 1-2%
- Direct inguinal hernias: 12-20% men
- Incisional hernias: 2-8% celiotomies*

*Varies with risk factors*
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Hernias - Incidence

- Indirect inguinal hernias: 1-2%
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BUT WHY?

*Varies with risk factors

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Incidence of Incisional Hernia*

- Overall 2-8%
- Obesity 8-15%
- AAA repair 10-35%
- Open Bariatric surgery 15-20%
- Recurrence after 1º repair 60-80%†

But why such differences?

*After midline celiotomy
†Flum, Burger, VanderLinden, others
What Causes Acquired Hernias?

Risk Factors

- Obesity
- COPD
- Malnutrition
- Increased intraabdominal pressure
- Age
- Steroids
- Cancer

BUT WHY?

What Causes Acquired Hernias?

Basic Thesis

Non-technical acquired hernias are related to:

- **Dysmetabolism**
  - Abnormal inflammatory response
  - Abnormal wound healing
  - Decreased anabolism
  - Increased catabolism
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Physiology of Wound Healing - Phases

- Inflammation
- Proliferation
- Collagen formation
- Protein breakdown
- Remodeling
- Change in Collagen

*3 mo to 2 yr

Prototype Model -- Incisional Hernias

Shouldn’t the Etiology of formation influence our method of repair?
What Causes Acquired Hernias?

**Measurable Abnormalities—Early**

- Decreased ratio of Type I/Type III collagens
- Irregularly arranged collagen fibers
- Abnormal matrix metalloproteinase (MMP) expression/activity* 

*Zinc-dependent proteases, substrate specific

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**Inguinal Hernia—Maturation Phase**

- Remodeling of extracellular matrix
  - Dynamic ongoing process
  - Upregulation of MMPs (matrix metalloproteinases)
- Pathogenesis of incisional hernias
  - ↓ MMPs in wound - EARLY
  - ↑ MMPs in wound – LATE
  - Abnormal collagen synthesis
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Etiologies of Dysmetabolism

- Gene mutations (deletions, insertions)
  - Ehlers Danlos syndrome (collagen Type II),
  - Williams syndrome (elastin)
  - Familial arterial aneurysm syndrome

- Polymorphisms (minor, common differences in gene)
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Etiologies of Dysmetabolism

- Gene mutations (deletions, insertions)
  - Ehlers Danlos syndrome (collagen Type II), Williams syndrome (elastin)
  - Familial arterial aneurysm syndrome
- Polymorphisms (minor, common differences in gene)
- **Epigenetic causes**

**Epigenetic causes---?most frequent?**
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Genomic Control

<table>
<thead>
<tr>
<th>Promoter region</th>
<th>Coding region</th>
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<tbody>
<tr>
<td>Mutations</td>
<td></td>
</tr>
<tr>
<td>Polymorphisms</td>
<td></td>
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</tbody>
</table>

Epigenetic causes
- Methylation
- Silencing
- Processing message/protein
  - Post-transcriptional
  - Post-translational

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Epigenomic Phenomena

- Obesity?
- Smoking?
- Cancer?
- Others?

These may be the most common!
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So, what does all this mean for us as clinical surgeons?

How should we repair incisional hernias?

Incisional Herniorrhaphy

- What is the recurrence rate (at 10 years) after primary autogenous repair?
  - 5%
  - 10%
  - 25%
  - 50%
  - >50%*

Incisional Hernia Considerations - 1

- Etiopathogenesis of incisional hernia
  - Poor technique
  - Infection
  - Tissue loss
  - Presumed “metabolic” disorder
  - Risk factors

Incisional Hernia Considerations - 2

- Local contamination
  - Tissue infection
  - Gross contamination
  - “Clean-contaminated” wound
- Fascial “gap”
  - Exposed gut vs intact peritoneum
### Biology of Hernia Formation

#### Incisional Hernia – Concept of Repair

<table>
<thead>
<tr>
<th>Autogenous Tissue Repair</th>
<th>Prosthetic-Based Alloplastic Repair*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1º suture repair</td>
<td>Mesh prosthesis</td>
</tr>
<tr>
<td>Components separation*</td>
<td>Solid prosthesis</td>
</tr>
<tr>
<td>Tissue transfer*</td>
<td>Bioprosthesis (tissue matrix)</td>
</tr>
<tr>
<td>■ Free graft†</td>
<td></td>
</tr>
<tr>
<td>■ Pedicled graft†</td>
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*“Tension-free” concept.
†Fascial or myofascial.

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**this is an autogenous tissue repair**

†Fascial or myofascial.
## Biology of Hernia Formation

### Incisional Hernia – Concept of Repair

#### Autogenous Tissue Repair
- 1º suture repair
- Components separation*
- Tissue transfer*
  - Free graft†
  - Pedicled graft†

#### Prosthetic-Based Alloplastic Repair*
- Mesh prosthesis
- Solid prosthesis
- Bioprosthesis (tissue matrix)

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*"Tension-free" concept.
†Fascial or myofascial.  **Note these have never worked**

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## Autogenous Tissue Repairs

### When to consider?

- Technical errors
  - Suture breaks
  - Fascial infection
  - Open abdomen (not dehiscence!)
- Contamination
- No abnormal tension, as with
  - Tissue loss
  - COPD
  - Obesity
- Dysmetabolism? No!
Hernia defect

Skin

Anterior rectus fascia

Posterior rectus fascia

Peritoneum

Rectus muscle

Rectus muscle

Autogenous Repair
Components Separation

Rollover

Or

Lateral Relaxation

This is an autogenous tissue repair note NO MESH

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PROSTHETIC-BASED REPAIRS – Considerations 1

A) Type of prostheses

Mesh vs Solid
type of material ePTFE
Size of pores
Weight of mesh

*Water-tight, tissue ingrowth
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Prosthetic-Based Repairs – Considerations 2

B) Placement of prostheses
- Reinforcement of 1º fascial closure
- Patch of persistent defect
  - Onlay
  - Inlay
  - Sandwich—onlay and sublay
  - Sublay
    - Intramural (Rives/Stoppa)
    - Intraperitoneal (laparoscopic, open)
    - Extent of overlap on fascial edges
    - Ingrowth (mesh) vs suture fixation (ePTFE)
    - Contact with intraperitoneal content?

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Prosthetic-Based Repairs – Considerations 3

- Contamination- Permanent vs absorbable prostheses----cost
- Absorbable (Vicryl®, Dexon®)
- Bioprosthesis (AlloDerm®, Pigaderm(Strattus®)
- Surgisis®, Permacol®, etc, etc, etc)
- Synthetic (BIO-A®, Phasix®, TIGR®)
- Large pore polypropylene
Autogenous Repair - Mesh Reinforcement

Prosthetic Patch Inlay
Prosthetic Patch Onlay

Wide Prosthetic Patch Onlay
Prosthetic Patch Onlay - Sandwich

Intramural (Rives-Stoppa)
Intraperitoneal Prosthetic Patch Repair

Intraperitoneal (Rives-Stoppa)
Incisional Herniorrhaphy

Reported Results*

- 1º autogenous repair >50%
- Components separation 15-30%
- Prosthesis-based repairs
  - Onlay/inlay repairs 20-40%
  - Sublay repairs
    - Intramural 5%
    - Intraperitoneal** 5-10%

*With long-term (>2 years)
**Includes laparoscopic
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My Approach – Congenital Hernias*

- 1º autogenous repair
- > teenager indirect inguinal hernia – ? add bioprosthesis onlay)**
- Add sublay permanent prosthesis if risk factor
  - Obesity
  - Smoker
  - H/O direct inguinal hernia
  - Diastasis rectus
  - Malnutrition
  - Tension, i.e. large defect

*Small umbilical, epigastric, indirect inguinal

**I have no data on this

My Read of This Topic – Incisional Hernias

- Recurrence with primary repair too high
- Dependence on suturing of prosthetics to fascia – high recurrence*
- Best approach
  - Synthetic mesh incorporation/transgrowth
  - Wide overlap
  - Sublay (mechanical argument)
- Fascial reapproximation vs patch of defect

*One drawback of lap repair
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My Approach – Incisional Hernias

- Technical error – 1º autogenous repair (rare)
- Local infection/contamination
  - Bioprosthesis
  - Absorbable mesh
  - 1º autogenous repair (rare)
- Risk factors or no known risk factors
  - Prosthetic repair
    - Intramural Rives/Stoppa – mesh
    - Intraperitoneal sublay - ePTFE ± mesh
- Previous prosthetic infection*

*I wish I knew how, esp. if MRSA!

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Previous Prosthetic Infection

- Non-MRSA infection
  - Closed wound (≥3 months)
  - No active distant infection
  - Re-repair with mesh
- MRSA infection
  - NO IDEA
  - 50% recurrent MRSA infection?
  - Laparoscopic?
  - ePTFE vs mesh?
  - Bioprosthesis?
- Hypothesis – MRSA “lives” dormant in tissues—reactivated on local trauma”; concept of “slime” and “biofilms”
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Giant Incisional Hernias

Many Considerations!!!!

- Skin/subcutaneous closure/coverage of prosthesis
- Surface area of exposed prosthesis
- Patient weight!

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Experience with 280 Rives/Stoppa Repairs*

- Complicated incisional hernias**
- Large primary hernias with risk
- Flank hernias (n=15)
- Complex hernias – multiple lesions (10%)
- 40% previous mesh-based repairs

**Selected patients, usually prior failed repairs
Stoppa Repair
Concept

- Tension free
- Patch from "inside" rather than "external" onlay patch
- Very large surface area of mesh for tissue growth

Hernia defect
Prolene mesh

Modified Stoppa Repair
(Intraparietal Mesh)

Rectus muscle
Peritoneal sac
Peritoneum
Mesh
Incisional Hernia

Major Principles of Rives/Stoppa Repair

- Preserve excised hernia sac
- If possible, stay extraperitoneal
- Wide lateral mobilization (10 cm)
  - Past lateral border of rectus if necessary
  - Using a posterior component separation
  - Over costal margin rostrally
  - Under xiphoid and distal sternum
- Try to cover anterior surface of mesh (even if under tension) with anterior rectus fascia
- Overnight closed suction drainage only
Rives-Stoppa Herniorrhaphies
Results (290 patients)

- Mortality 0%
- Morbidity
  - Wound infection 2%
  - Early mesh explantation 2%*
  - Late mesh infection 3%
- Recurrent hernia (any cause) 5%

*One technical, one my very poor judgment

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Summary

- Understanding the biology should affect our type of repair
- Incisional hernias repaired by 1° suture repair have a >50% recurrence rate
- Inlay and limited onlay repairs – recurrence rate 30-40%
- Sublay repairs are best-proven method
- New interest in extensive overlap onlay repairs with mesh await long-term follow-up*

*Concerns regarding subcu infection
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Future Questions

1) Which mesh is best?
   ■ Big pore vs Medium pore
   ■ Lightweight

2) Will newer bioprostheses replace alloplastic prostheses?

3) Should we try to “prevent” incisional hernias with a prosthesis?* (I think yes) If so biologic or synthetic?

4) Mechanics of abdominal wall

*High risk patients- AAA, prior incisional hernia, obesity

Ventral Hernias

Concepts From an Engineering Standpoint

- Linea alba is a “tendon”
- With defects, rectus muscle atrophies
POSTERIOR
COMPONENTMENT SEPARATION
Posterior Component Separation - 3