Ventral Incisional Hernias – Etiology and Repair Options

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OBJECTIVES

• Epidemiology
• Etiology
• Anatomy
• Preoperative evaluation
• Operative Strategies
Ventral Incisional Hernia

Defect formed at a prior abdominal incision site
Ventral Incisional Hernia

- 4-5 million laparotomies/year\textsuperscript{1,2}
- 400-500,000 incisional hernias develop\textsuperscript{3}
- 200,000 incisional hernia repairs/yr\textsuperscript{1-3}
- Common occurrence after abdominal surgery (up to 13\% of laparotomy incisions)\textsuperscript{4,5}

Why fix them?

- Increase in size over time
- Can lead to:
  - obstruction
  - incarceration
  - strangulation
  - enterocutaneous fistula
  - chronic back/abd pain
  - loss of abdominal domain
  - poor pulmonary function
Why do they form?

- Multi-factorial process
- Technique is not the sole cause
- Primary fascial pathology due to $^{1-2}$:
  - Abnormal collagen metabolism and production (found even in sites remote from hernia)
  - Increased matrix metalloproteinase (MMP) activity
- Secondary fascial pathology due to:
  - loss of normal tissue architecture
  - replacement of fascial planes with scar
- Mechanotransduction
  - mechanical forces (coughing, straining, stretching) induce changes in fibroblast function $^{3-4}$
  - loss of this during primary healing leads to weaker tissue
  - early laparotomy failure has significant incidence of recurrent hernia

Collagen I and III

- Collagen Type I – mature collagen, greatest strength component of ECM
- Collagen Type III – immature isoform, weaker, less crosslinking
- Low ratios of CI:CIII have been demonstrated in scar plates of recurrent hernias

MMP-2

- Encoded by *MMP2* gene
- Involved with tissue remodeling
- Breakdown collagen and other extracellular matrix proteins
- Found to be elevated in patients with recurrent hernias
- Mesh prosthesis interfere with MMP-2 regulation due to soluble factors, ECM modification or cell cross-talk

Collagen and MMP2s

CI/III - 14
CI/III - 3.6

MMP2
Wound Healing Biology

• Healthy tissue replaced by fibrotic tissue (fibrinogens and collagens)
• Relies on formation of sufficient scar tissue
Wound Healing Biology

• Greater collagen III deposition in scar between tissue or tissue/mesh, it can separate easier from itself and/or mesh edge (hence the greater overlap suggested in underlay repairs)
• Low quantity of collagen I helps explain the slow linear increase in recurrence over time
• Correlates with high frequency of VIH in those with AAA
• Correlates with sooner to recur hernias in multiply repaired hernias
• MMP-2, degrade collagen, higher in recurrent hernia patients¹
• With large VIH, have loss of mechanotransduction => loss of fibroblast signaling leading to disuse atrophy, fibrosis and muscle fiber changes ²⁻³

Fig. 1. A normal wound-healing cascade. In otherwise normal tissue, without impediments wound healing, sequential cellular and molecular elements of tissue repair are activated.

Fig. 2. During the initial “lag phase” of healing, the laparotomy wound is mechanically weakest. As surgical patients recover, increasing abdominal wall loads can cause acute wound failure.
VIH formation

- Cascade begins with early laparotomy wound failure (~11%)
- During lag phase of healing (weakest)
- 94% develop VIH w/in 3 years
- These represent occult dehiscences
- Most occult dehiscences occur w/in 30 days of wound closure

If purely technical...

The burst abdominal wound: a mechanical approach

T. P. N. Jenkins*
Failure that is multifactorial...

Graphical data from the general automobile club of Germany ADAC, representing a multi-causal failure. The black curve is representing the number of nondefective cars regard to years of use. The cross-lined curve is illustrating the yearly failure of cars caused by various defects (with courtesy of H. Schmaler, ADAC Germany).

J Min Access Surg 2006;2:151-4
Hernia recurrence data...

Anatomy of the Abdominal Wall
Anatomy of the Abdominal Wall
Function of Musculofascial Layers

• 5 paired muscles (3 flat, 2 vertical)
• 3 flat – int/ext oblique and transversalis
• Increase abdominal pressure to facilitate defecation, micturition, and parturition
• Stabilizes trunk
• 2 vertical – rectus abdominus and pyramidalis
• Rectus - tensor of the abdominal wall, flexor of the vertebrae, stabilize the pelvis during walking, protects the abdominal viscera, aids in forced expiration
Innervation of Abdominal Wall

- T7-L2
- Nerves lie in space b/w internal oblique and transversalis
- At risk for injury during component separation
Predictors of VIH

- Obesity
- Pulmonary disease
- Wound infection
- Intra-abdominal sepsis
- Malnutrition
- Anemia
- Corticosteroid dependency
- Prior VIH repair
- Collagen vascular diseases
- AAA
- Low Cl:ClIII ratios and elevated MMPs
Goals of VIHR

- Restore abdominal wall continuity
- Restore function to abdominal wall via
  - Recreate linea alba with primary fascial closure
  - Preservation of blood supply and nerve innervation
  - Durable repair
- No tension
- Close abdominal wound

Appeal of Restoration of Linea Alba
Functional Repair

• Patients with VIHR have lower peak torque generation by hip flexors vs controls
• Functional repair has greater torque vs nonfunctional repair¹
• Clinical utility of torque measured here is unclear

Preoperative Goals

- Optimize patient physiology
- Optimize nutrition
- Define anatomy
- Remove septic sources
- Identify fistulas
- Explant any involved prostheses
- Review all operative reports
- Review all imaging (i.e. CT)
- Weight loss
- Smoking cessation
Issues with repair

• No universal technique for repair
• Functional repair versus prosthetic covering
• High recurrence rate (RR) for repairs
  - Primary suture repair near ~50% RR $^{1-3}$
  - Mesh repair 2-36% RR

Techniques

• Primary Suture Repair
• Open vs Laparoscopic vs Endoscopic
• No separation + prosthetic (onlay, sublay, inlay)
• Component Separation Technique (CST) +/- prosthetic
• Endoscopic CST +/- prosthetic
• Rives-Stoppa/Retrorectus repair
• Autologous tissue repair
• Preoperative Pneumoperitoneum
Prosthetic Repair

- Polypropylene (PP) has greatest tissue in-growth of all meshes available, ideal in non-to-limited contaminated cases, minimal degradation
- PP lowers hernia recurrence in VIHR
- Polyester has hydrolytic breakdown overtime\(^1\)
- ePTFE has fewest bowel complications due to its nonadhesiveness to bowel (no ingrowth)
- Absorbable/biologic meshes only used in cases where mesh infection is a significant risk and cannot perform primary closure

1. Eur J Vasc Endovasc Surg 13, 540-548 (1997)
Primary Suture Repair

- Unless < 5cm transverse = >50% RR
Sublay or Bridge Repair

- Recommended repair w/mesh
- Lowest RR
- Lowest mesh infection

Onlay Repair

• Primary fascial closure
• Mesh is sutured to anterior rectus sheath
• Advantage - keeps mesh separated from abdominal contents
• Disadvantage – wound repair under tension, and mesh infection when surgical wound is infected
Inlay

• Hernia sac excised and fascial margin is identified around the hernia defect.
• Mesh is sutured circumferentially to fascial edge.
• Polypropylene would be used when omentum can be placed between intestine and mesh;
• ePTFE should be used when there is no omentum available
• Exceedingly high recurrence rate and should be an abandoned practice
Retrorectus Repair

- Retrorectus repair: aka Rives-Stoppa technique.
- This technique utilizes the hernia sac to separate the mesh from the intra-abdominal contents.
- Superior to the umbilicus, dissection is performed above the posterior rectus fascia and under the rectus muscle.
- Below the umbilicus, dissection occurs in the preperitoneal space due to the lack of a posterior rectus sheath.
- A large piece of mesh is placed in the newly formed space, and fixated to the muscle layer above.
- This repair has low recurrences (<5%) and complications
Fig. 4. The prosthesis is secured in the retromuscular space as shown. *Inset* Final position of the mesh and sutures

Fig. 5. The anterior sheath is closed. If tension is present, relaxing incisions may be used (*inset*)
Component Separation Technique

- Described by Ramirez, Ruas and Dellon in 1990\(^1\)
- Involves incising aponeurosis of external oblique muscle and the posterior rectus sheath
- Must raise large lipocutaneous flaps
- Risk injuring perforating vessels and nerves

Fig. 4. The prosthesis is secured in the retromuscular space as shown. *Inset* Final position of the mesh and sutures

Fig. 5. The anterior sheath is closed. If tension is present, relaxing incisions may be used (*inset*)
Fig. 5. Schematic diagram of preoperative anatomy. The relaxing incision should be directed medially away from the Hesselbach’s triangle to avoid lower-quadrant hernia.

Fig. 7. Schematic diagram of postoperative anatomy of Figure 6.
Fig. 1. Maximum defect dimension that can be reconstructed in upper, middle, and lower abdominal area by using bilateral muscle complex mobilization with surgical separation of the external and internal oblique muscles performed to the posterior axillary line. Note that separation of the rectus muscle off of the posterior rectus fascia above the arcuate line yields an additional 2 cm of medial muscle advancement at each level.
**Fig. 4.** Full-thickness 12 × 25 cm abdominal wall defect from an accidental gunshot wound and multiple surgical explorations. 
*(Left)* Frontal view, *(center)* lateral view, *(right)* oblique view.

**Fig. 5.** *(Left)* After reconstruction by anatomic component separation, the 8-month postoperative view demonstrates a markedly improved abdominal appearance in frontal view. *(Center)* Profile view demonstrating excellent abdominal contour. *(Right)* Oblique view showing much improved contour and healing of abdominal tissue.
CST

- Major wound morbidity in 30-40% ¹⁻³
  - seromas
  - subcutaneous abscesses
  - flap necrosis
- Low recurrence rate, ~8.5%⁴

Endoscopic Component Separation

• Advantages$^{1,2}$
  - less wound surface area
  - less skin flap necrosis
  - fast
  - totally extraperitoneal
  - preserved epigastrics and perforators

• Disadvantages$^{1,2}$
  - increased cost
  - doesn’t provide as much advancement as open (86%)$^1$

• However Roth et al demonstrated equal advancement compared to open in cadaver model$^2$

Laparoscopic VIHR IPOM

• Prosthetic mesh placed over defect with 3-5-cm overlap from hernia orifice
• Circumferential transfascial suture fixation at 4 sites, tack rest
• Limits excessive tissue dissection
• Less wound complications and pain
• Shorter LOS
• Risk of bowel injury ~3.5% ¹
• Doesn’t restore function to abdominal wall

Just cover the hole

Mesh Repair

Hernia sac
Rectus
Mesh

1. Side strength unchanged
2. Adynamic central zone
3. Circumferential pull by abdominal wall tightens mesh
Laparoscopic Medialization of Rectus

- Carter-Thomason suture passer using monofilament suture
- Horizontal mattress sutures
- 2 cm bites
- 2-3 cm travel
- Lower insufflation pressure and tie sutures
- If unable to close, may need ECST
- Reinforce repair with prosthetic
Lap VIHR IPOM w/ECST

- Ideal for large defect <~15 cm in midline
- First eCST performed
- Transfascial horizontal mattress sutures place to close midline fascial defect
- IPOM mesh placement with 5 cm overlap
What to do with significant loss of domain?
Gradual Tension Methods

- Serial excision\(^1\)
- Requires many operations (~7) and 30 day LOS
- Whittman patch
- Velcro like reapprox tool
- Sewn to fascia, adjusted daily to bring fascia closer together
- 82% fascial closure rate \(^2\)

Tissue Expanders

- Expansible prosthesis placed under tissue to be stretched through repeated instillations
- Advantages include innervated, vascularized, autologous tissue
- Provides dynamic, tension-free support without free tissue transfer.
- Disadvantages: 20% early exposure/infection rate ¹
- Requires many treatments
- Have been used to cover large defects ²

Preoperative Progressive Pneumoperitoneum (PPP)

- First described in 1940 by Dr. Ivan Goni-Moreno for giant ventral hernias
- Increases the capacity of the retracted abdominal cavity, performs a pneumatic lysis of intestinal adhesions, allows the reduction of the hernia contents, and improves diaphragmatic function1-3
- Contraindicated in cardiac and pulmonary insuff, infected abdominal wall and incarcerated hernias

Many catheters used (foley, dialysis catheter, central venous catheter, veress needle)

Gases used are, ambient air, NO and CO2. NO lasts longer.

After 4 days, no real increase in expansion

HSV – hernia sac volume
ACV – abdominal cavity volume
VR – volume ratio

$$VR = \frac{HSV}{ACV}$$

HSV >25% ACV -> PPP
500 ml initially of gas

Then 500 ml daily until volume reached

OR after HSV reached
Autologous Grafts and Flap Closure

- Use native tissue
- Tensor fascia lata graft (often a free fascial graft)
- Flap selection based on location and arc of rotation
Common flaps used

- Latissimus dorsi
- Rectus abdominis
- External oblique
- Tensor fascia lata
- Rectus femoris
Free tissue transfer

• Requires adequate recipient vessels
• Allows to transfer innervated muscle
• Technically more demanding
• Required for large abdominal wall defects (loss of abdominal wall from trauma, cancer resections, etc)
Autodermal Grafts

• Use of full thickness skin as bridge
• Skin graft over defect excised
• Several ways to prepare graft:
  - remove subq layer, implant upside down
  - perforate skin
  - boil in NS x 5 seconds, use scalpel to remove epidermis
  - soak in 96% ethanol x 3 min, rinse in saline, perf skin
• Used as onlay repairs
Hernia Prophylaxis

• Placement of mesh at the time of index laparotomy is safe and low hernia RR at 1 year 1-2 (particularly in obese)

• Animal models with growth factor and cytokine injection in abdominal wall or growth factor impregnated mesh after laparotomy decrease incisional hernias 3-5

Technical Keys to Success for Prevention

- For primary fascial closure at index laparotomy:
  - 4:1 suture:wound length
  - monofilament non/slowly absorbable suture
  - 1 cm bites with 1 cm travel

The burst abdominal wound: a mechanical approach
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**Algorithm**

Patient assessment for risk of SSO (Grade 1, 2, 3 or 4)

- Decide on best approach for repair (Open versus Laparoscopic)
  - Laparoscopic
    - Most often repaired w/synthetic mesh
  - Open
    - Defect small enough to close primarily (≤2 cm): Reinforce with prosthetic repair material
    - Defect too large for primary repair
      - Component separation w/complete rectus closure plus reinforcement w/prosthetic
      - Component separation w/incomplete rectus closure, some bridging w/prosthetic is unavoidable

**Grade 1:** Choice of repair material by surgeon preference and patient factors

**Grade 2:** Increased risk for surgical site occurrence suggests additive risk of permanent synthetic repair material, and potential advantage for appropriate biologic reinforcement

**Grade 3:** Permanent synthetic repair material generally not recommended; potential advantage to biologic repair material

**Grade 4:** Permanent synthetic repair material not recommended; biologic repair material should be considered
Conclusions

• Wound biology holds key to lessening recurrence
• Functional restoration should be standard approach
• All VIH should consider reinforcement with prosthetic (bridge/underlay)
• Suture repair and inlay repair of VIH should be abandoned
• VIHR should be customized to each patient
Questions?