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MEDECINS SANS FRONTIERES

Open Abdomen

Jaco Botes

21 March 2023



Topics

- Peritoneal Physiology
- Abdominal Compartment Syndrome
- Open Abdomen and DCS
- Indications for Open Abdomen
- Problems & Complications
- Temporary Closure
- Definitive Closure
- Pitfalls, Adjuncts and Failures

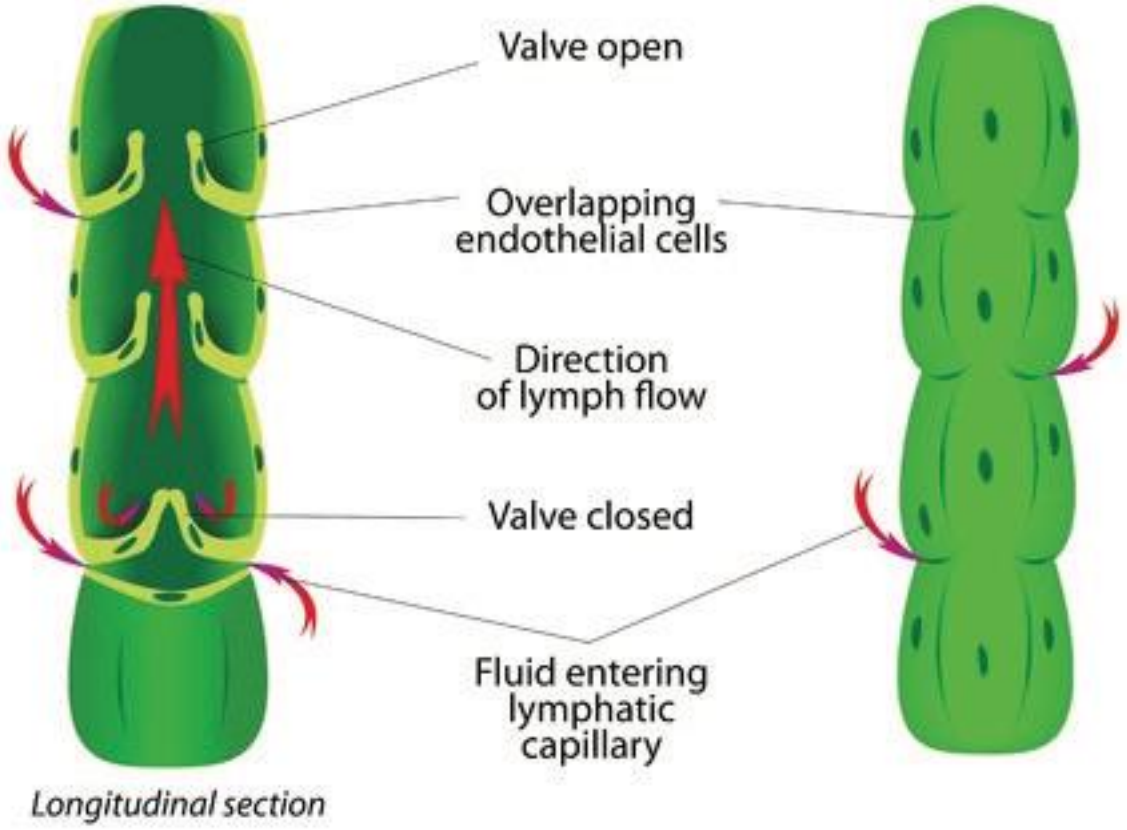
Anatomy: Peritoneum

- Total Area is approximately equal to the body surface area in adults: approx. 1.8 m^2
- 50-100ml of clear, sterile serous fluid
- Plasma ultrafiltrate: Electrolytes & Protein similar to interstitial space

- <u>Migrating immune cells:</u>
  - Macrophages >50%
  - Lymphocytes 44%
  - Dendritic cells 2%
  - Eosinophils <1%
  - Complement Factors

Peritoneal Flow

- Peritoneal fluid secreted by visceral and parietal surface
- Resorbed through terminal lymphatic lacunae lying below the fissures
- **>3l of fluid is transported daily through the left and right thoracic ducts**

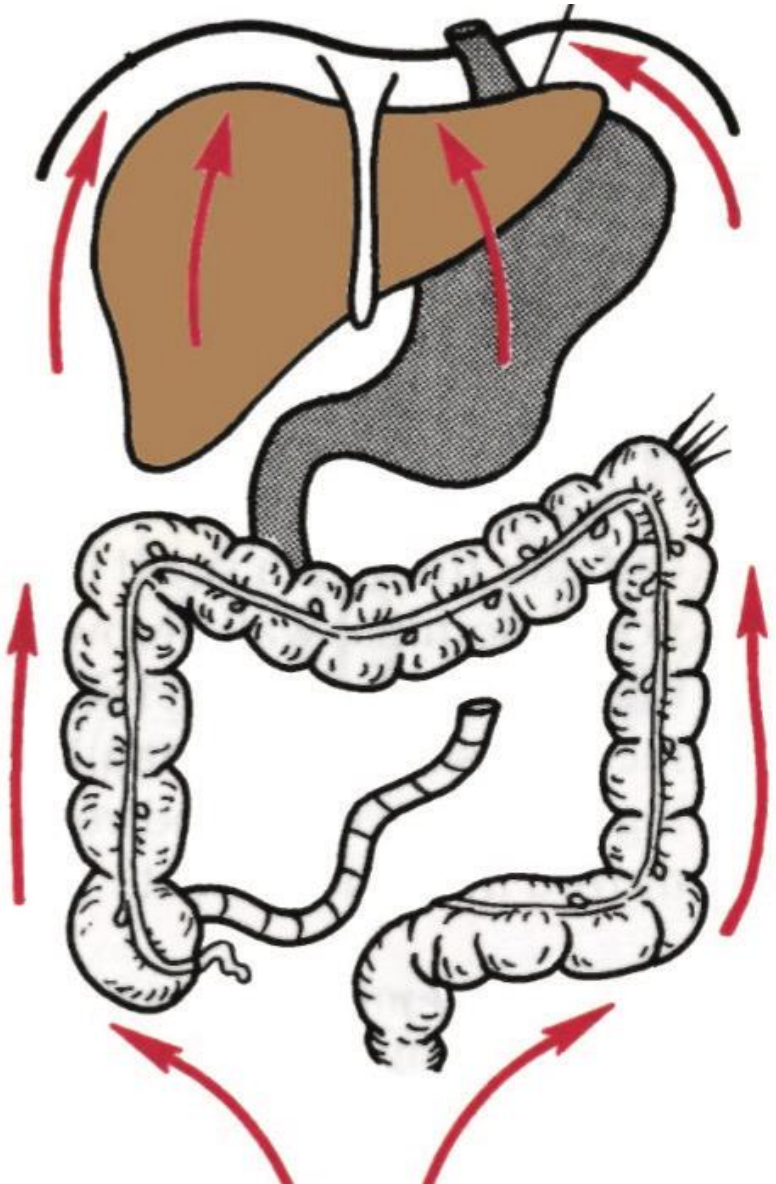


Peritoneal Pump

- Diaphragm Movement,
- Negative intrathoracic pressure
- Positive intra-abdominal pressure

  Move the peritoneal fluid and particles upward

Intraperitoneal blood is absorbed at a slower rate, but approximately 70% re-enters the blood-stream.



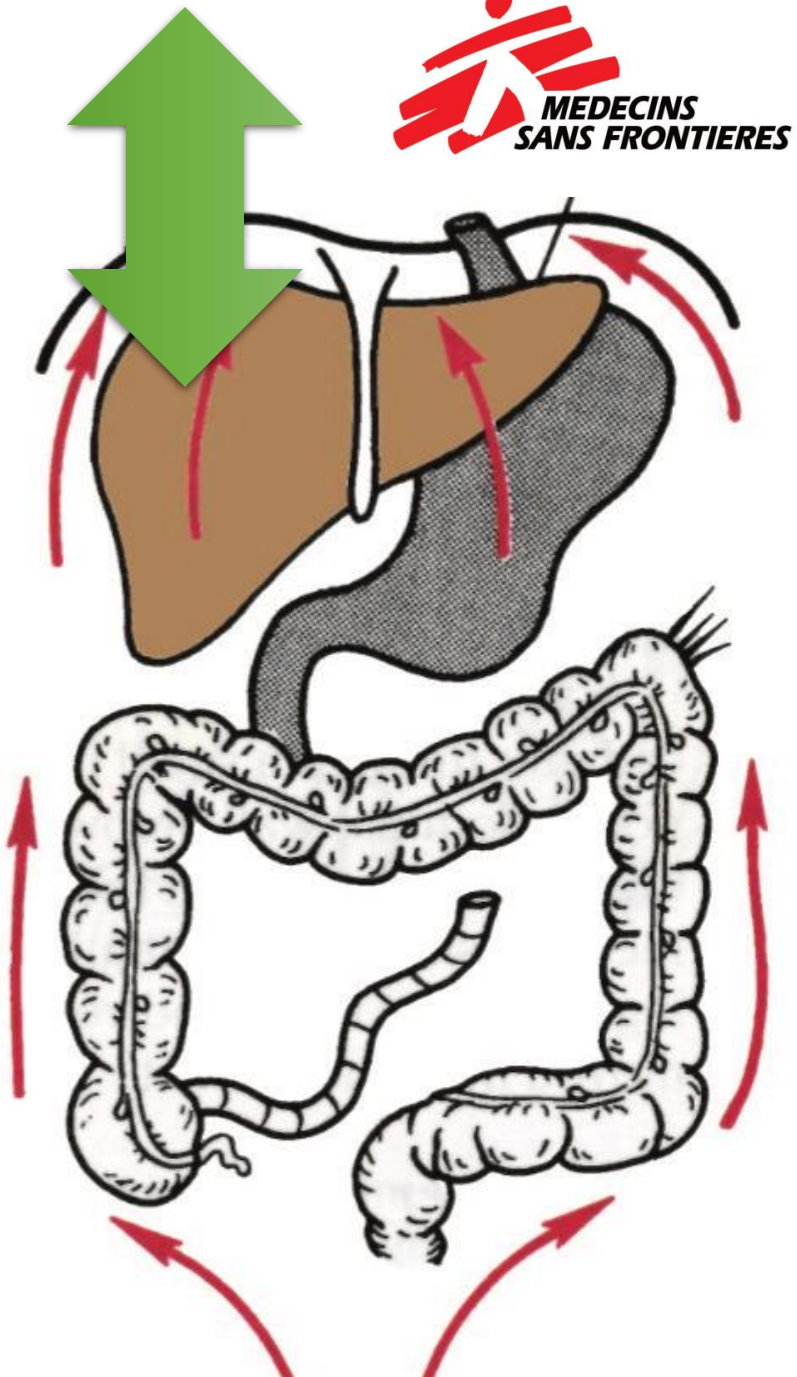
Peritoneal Pump

Inhibitors of clearance:

- Reducing breath intake
- Using general anaesthesia
- Positive intrathoracic pressure: incl. PEEP

Loss of Abdominal Pressure Gradient

- Loss of peritoneal cavity
- Open Abdomen



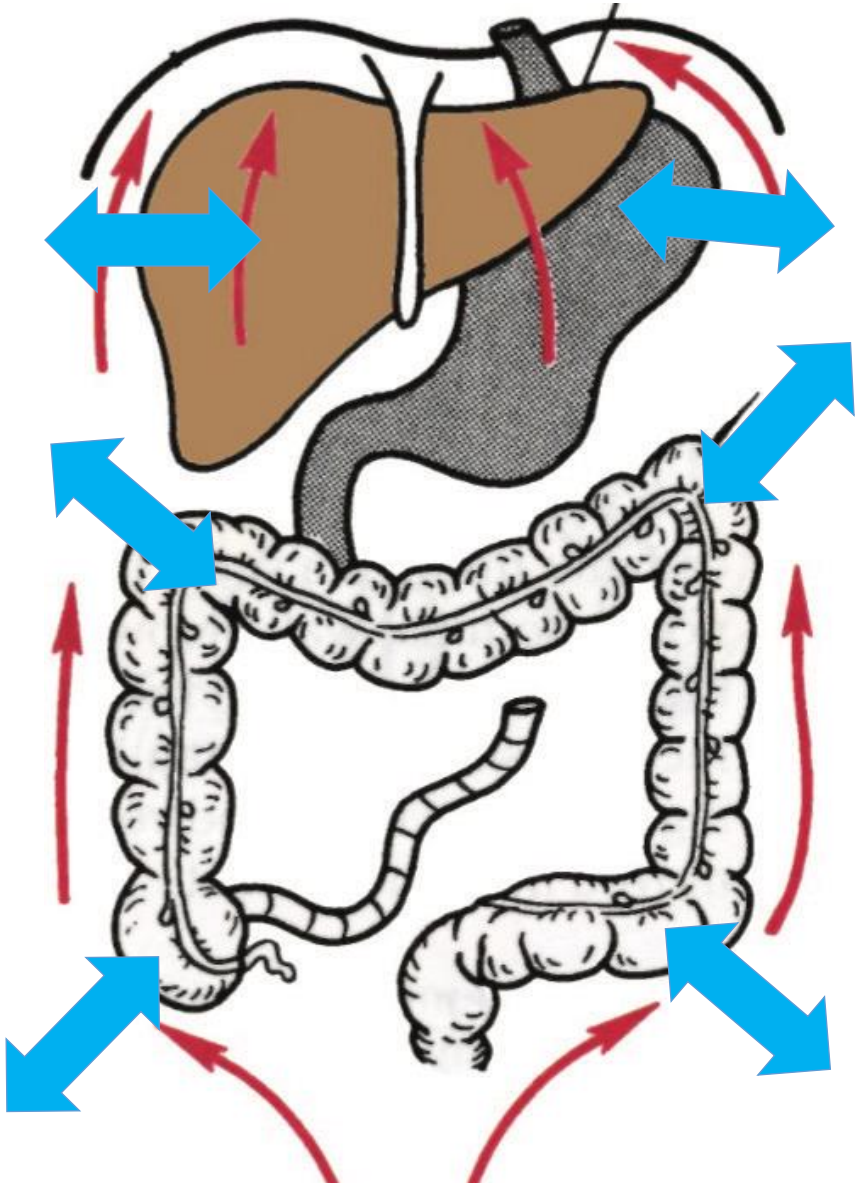
Peritoneal Surface

Two way fluid and electrolyte movement

- Water - Aquaporins
- Electrolytes - Diffusion AND Channels

- Macromolecules - ?Fissures ?Vesicles
  ?Capillary leak
- 50% Functionally absorbable area

Hypertonic saline solution infused can cause a large displacement of water (300-500 ml per hour) from the intravascular space into the peritoneal cavity



Loss of Peritoneal Space

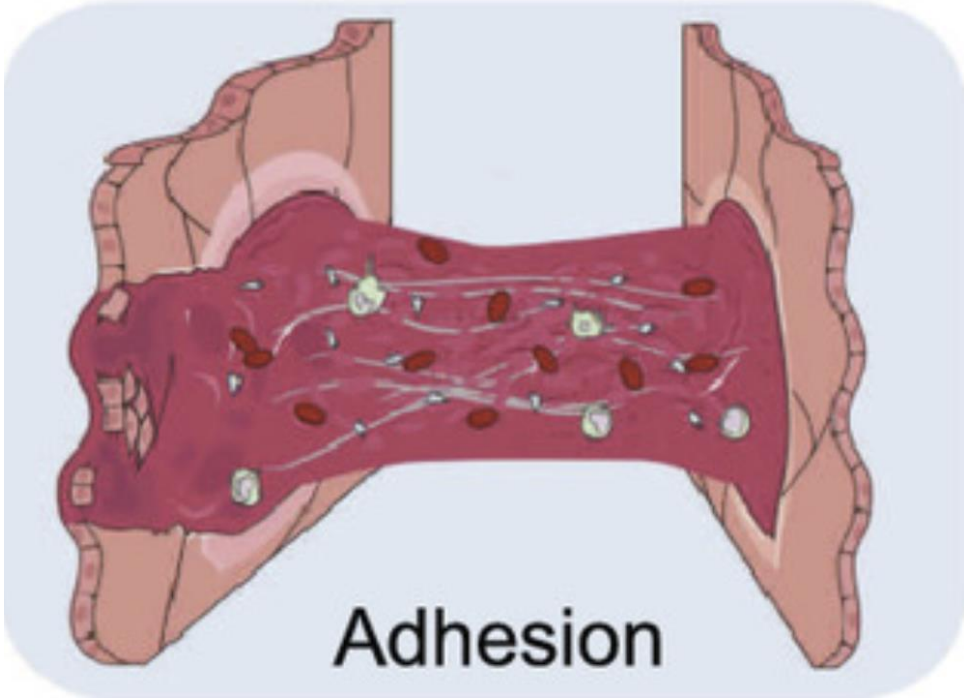
Expression of tissue factor on the surface of peritoneal macrophages

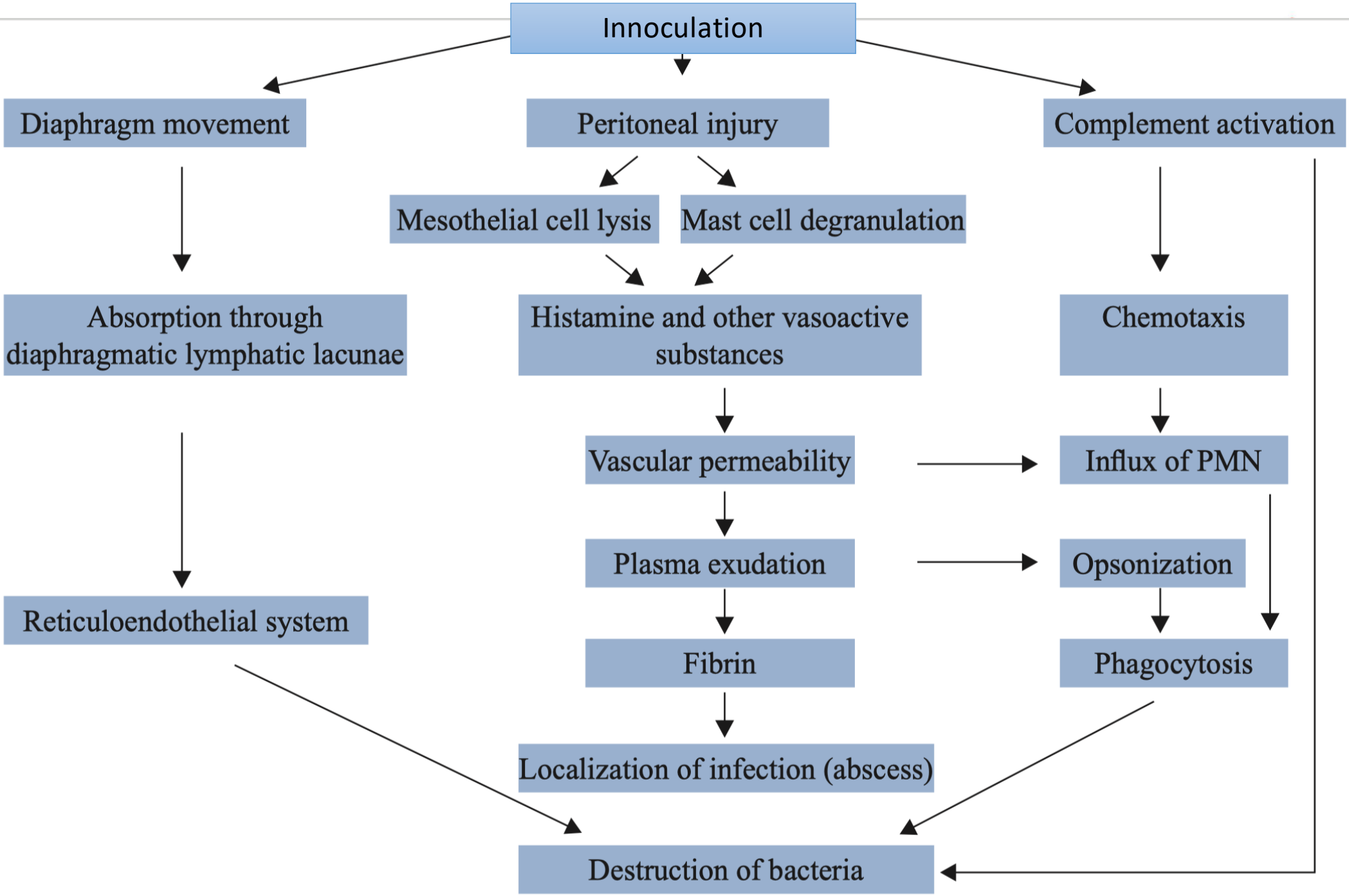
Capillary leak allows plasma to enter peritoneal space

Initiates local activation of the coagulation cascade

Results in fibrin deposits around the inflammatory focus

5 – 10 days = Complete Loss of Peritoneal Space




Innoculation
Diaphragm movement
Peritoneal injury
Complement activation
Mesothelial cell lysis
Mast cell degranulation
Absorption through diaphragmatic lymphatic lacunae
Histamine and other vasoactive substances
Chemotaxis
Vascular permeability
Influx of PMN
Plasma exudation
Opsonization
Reticuloendothelial system
Fibrin
Phagocytosis
Localization of infection (abscess)
Destruction of bacteria

Abdominal Compartment



Abdominal Compartment Syndrome

1st consensus paper WSACS 2006:

TABLE 2. **Consensus definitions regarding IAH and ACS**

Definition 1	IAP is the steady-state pressure concealed within the abdominal cavity.
Definition 2	APP = MAP – IAP
Definition 3	FG = GFP – PTP = MAP – 2 * IAP

IAH is graded as follows:

- **Grade I: IAP 12-15 mmHg**
- **Grade II: IAP 16-20 mmHg**
- **Grade III: IAP 21-25 mmHg**
- **Grade IV: IAP > 25 mmHg**

ACS is defined as a sustained IAP > 20 mmHg (with or without an APP < 60 mmHg) that is associated with new organ dysfunction / failure.

Primary ACS is a condition associated with injury or disease in the abdomino-pelvic region that frequently requires

Definition 9	ACS is defined as a sustained IAP > 20 mmHg (with or without an APP < 60 mmHg) that is associated with new organ dysfunction / failure.
Definition 10	Primary ACS is a condition associated with injury or disease in the abdomino-pelvic region that frequently requires early surgical or interventional radiological intervention.
Definition 11	Secondary ACS refers to conditions that do not originate from the abdomino-pelvic region.
Definition 12	Recurrent ACS refers to the condition in which ACS redevelops following previous surgical or medical treatment of primary or secondary ACS.

ACS: abdominal compartment syndrome; APP: abdominal perfusion pressure; FG: filtration gradient; GFP: glomerular filtration pressure; IAH: intra-abdominal hypertension; IAP: intra-abdominal pressure; MAP: mean arterial pressure; PTP: proximal tubular pressure.
Adapted from Malbrain et al[4].

WSACS The Abdominal Compartment Society

Incidence ACS

Medical & surgical ICU	**0.5 – 8%**
Trauma:	**14%**
IAH:	**30 – 70%**

	Expected IAP
Normal adult	0 – 5 mmHg
ICU patient	5 – 7 mmHg
Post laparotomy	10 – 15 mmHg
Patient in septic shock	15 – 25 mmHg
Acute abdomen	25 – 40 mmHg

Obesity :

- currently no guidelines to quantify obesity associated IAH
- *anaesthetized bariatric surgical patients:*
  1. *Baseline IAP increased by 0.14mmHg for every unit of BMI (non pathological IAP)*
  2. *Mean baseline IAP = 6-9mmHg with an average BMI 48kg/m2*

Risk factors for IAH

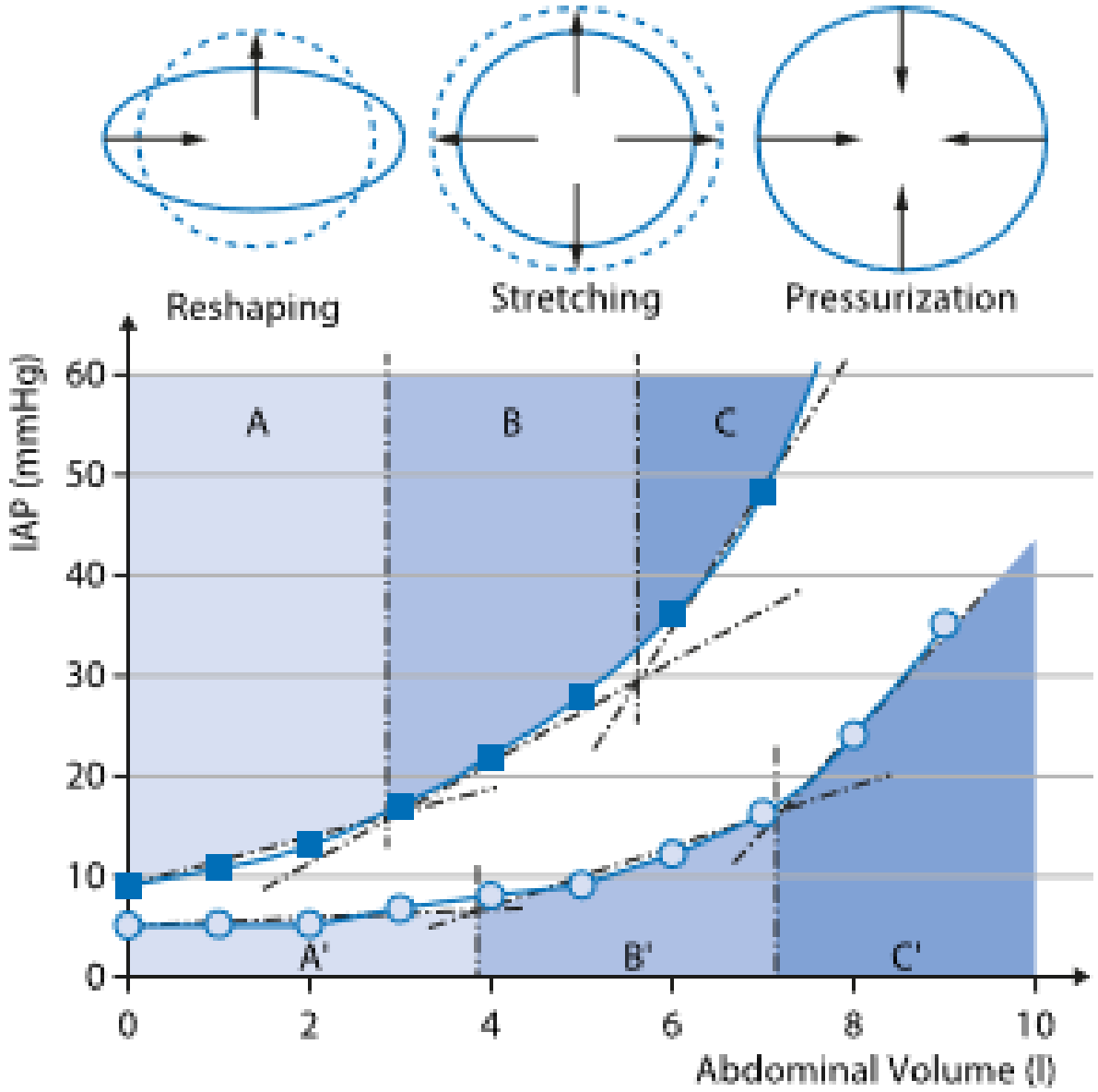
TABLE 1. **Risk factors for the development of IAH and ACS**

Related to diminished abdominal wall compliance
Mechanical ventilation, especially fighting with the ventilator and the use of accessory muscles
Use of positive end expiratory pressure (PEEP) or the presence of auto-PEEP
Basal pleuroneumonia
High body mass index
Pneumoperitoneum
Abdominal (vascular) surgery, especially with tight abdominal closures
Pneumatic anti-shock garments
Prone and other body positioning
Abdominal wall bleeding or rectus sheath hematomas
Correction of large hernias, gastroschisis or omphalocoele
Burns with abdominal eschars
Related to increased intra-abdominal contents
Gastroparesis / gastric distention / Ileus / Colonic pseudo-obstruction
Abdominal tumour
Retroperitoneal/ abdominal wall hematoma
Enteral feeding
Related to abdominal collections of fluid, air or blood
Liver dysfunction with ascites
Abdominal infection (pancreatitis, peritonitis, abscess,…)
Haemoperitoneum
Pneumoperitoneum
Related to capillary leak and fluid resuscitation
Acidosis* (pH below 7.2)
Hypothermia* (core temperature below 33 °C)
Coagulopathy* (platelet count below 50000/mm^3 OR an activated partial thromboplastin time (APTT) more than 2 times normal OR a prothrombin time (PTT) below 50% OR an international standardised ratio (INR) more than 1.5)
Polytransfusion / trauma (> 10 units of packed red cells / 24 hours)
Sepsis (as defined by the American – European Consensus Conference definitions)
Severe sepsis or bacteraemia
Septic shock
Massive fluid resuscitation (> 5 liters of colloid or > 10 litres of crystalloid / 24 hours with capillary leak and positive fluid balance)
Major burns

*The combination of acidosis, hypothermia and coagulopathy has been forwarded in the literature as the deadly triad[84,85].
Adapted from Malbrain et al[4].

4x main causes:
Ruptured Aortic Aneurysm
Acute pancreatitis
Severe Sepsis
Major Trauma

Accommodation of abdominal cavity



1. Linear reshaping phase: spherical to circular
2. Stretching phase of rectus abdominis: curvilinear phase
3. **Small increase in IAV results in dramatic increase in IAP**

Abdominal Perfusion Pressure

APP = MAP – IAP

- Better predictor of MR vs Lactate & Urine Output

  (*Cheatham & colleagues: retrospective review - 144patients Rx for IAH)*

- APP <60mmHg reliably predicted : need for urgent intervention

- WSACS: no recommendation regarding the use of APP as resuscitative end point

What Happens to the Body's Organs?

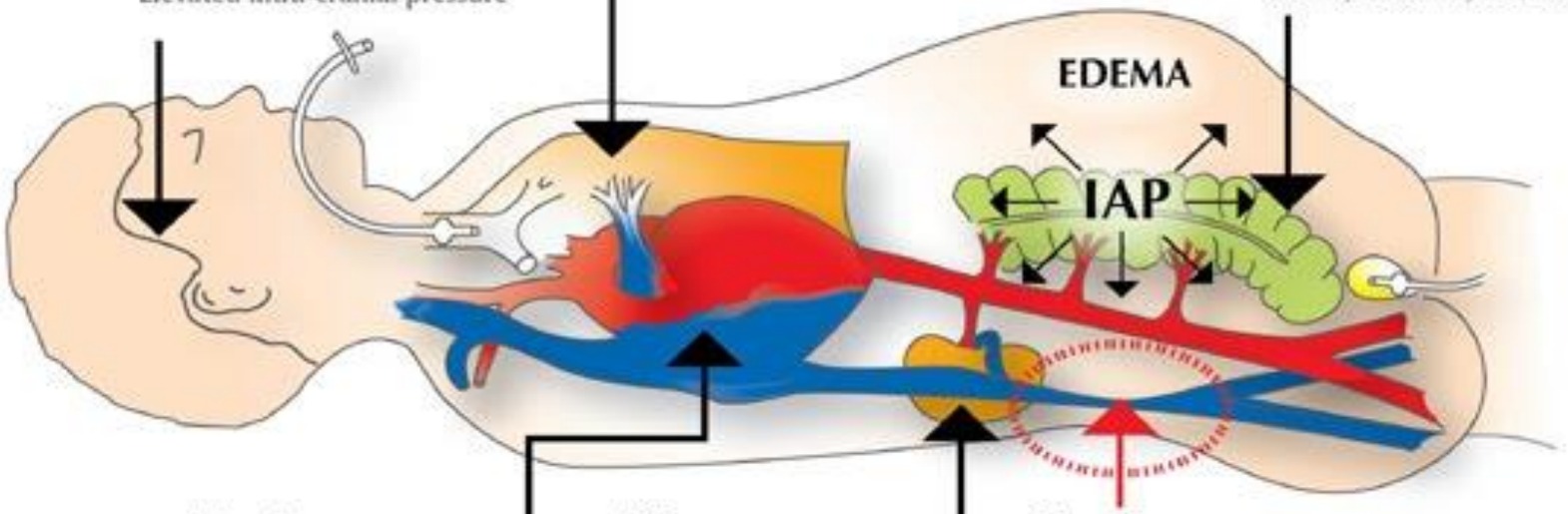
A Vicious Cycle

Fluid resuscitation for critical illness

Total body fluid third spacing/edema

Elevated intra-abdominal pressure due to bowel edema

Vena cava compression



Reduced blood return to heart (preload)

Reduced cardiac output

Reduced blood flow to organs

Multi-system organ dysfunction/failure

Consequences of ACS

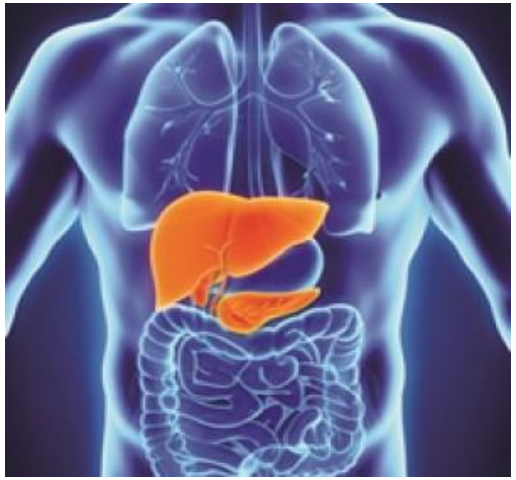


- ***Early recognition****:WSACS recommendation – q4-6hrly in critically ill >1 R/F*
- <u>Mechanical ventilation</u>: (multifactorial)
  - Decreased FRC & TV
  - Increased peak inspiration pressure, plateau pressure & mean airway pressure
  - Decreased pulmonary compliance

- <u>Haemodynamic sequelae</u>:
  - Increased systemic vascular resistance by compressing aorta & splanchnic circulation resulting in increased afterload + decreased SV
  - Compressed IVC: secondary venous pooling in limbs, and decreased VR
    (CVP raised: IAP = 30mmHg leads to 4x increase CVP)
  - Increased ITP decreases cardiac filling by decreasing right ventricular compliance. Right ventricular end diastolic volume index = guide during volume therapy.
  - Net decreased CO & hypotension

4. Renal dysfunction:

- Prerenal (decreased CO) + tubular process(reduced renal plasma flow; +RAAS)
- If IAP >20mmHg: vascular resistance of renal vessels increases to 500%



5. Hepatobiliary system:

- Significantly decreased venous, arterial and microcirculatory blood flow
- IAP = 20 mmHg decreases portal vein flow by 35%
- Hepatic impairment (present in 80.3%) manifests:

  decreased clearance plasma lactate

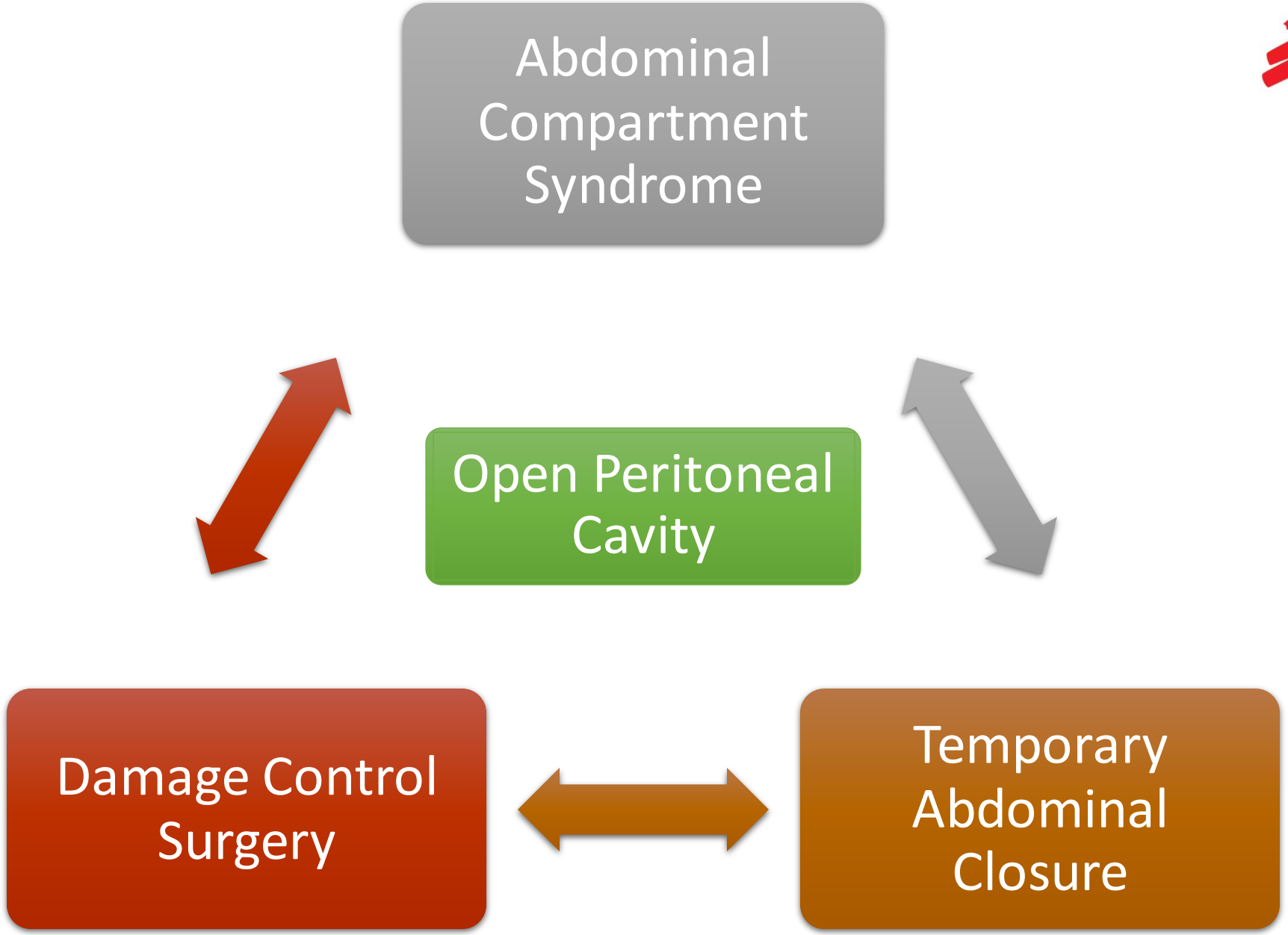
  (not solely attributable to increased lactate production)

  Deficient clearance of lactate confuses clinical interpretation of lactate as end point of resuscitation
- Increased lactate, depress serum pH, decreased myocardial contractility



6. Bowel ischemia:
   - Impair mesenteric circulation; decrease mucosal blood flow with inadequate intestinal mucosal oxygen levels
   - Manifest as intestinal oedema/ileus further increasing IAP
7. Sepsis/septic shock
   - IAP >25mmHg >60min: impair mucosal blood flow in well resuscitated pt
   - Bacterial translocation across injured mucosal barrier.
8. Cerebral:

   Decompressive laparotomy: decreases IAP + 10mmHg decrease in ICP (trauma pt)


Abdominal Compartment Syndrome
Open Peritoneal Cavity
Damage Control Surgery
Temporary Abdominal Closure

History of Damage Control Approach

"The process of limiting the damaging effects of an action or mistake"

- Named after the emergency **control** of situations that may cause the sinking of a watercraft.



- **Goals are not definitive repair**

- <u>Examples</u>:
  - Locking off the damaged area from other ship's compartments to save the ship

History of Damage Control Approach

- First considered to control **Massive Liver Haemorrhage**

  - **1980s** Staged laparotomy had a survival benefit in exsanguinating trauma patients (Stone et al)

- **Early 1980s -** first reports describing the Abdominal Compartment Syndrome after major abdominal surgery

History of Damage Control Approach

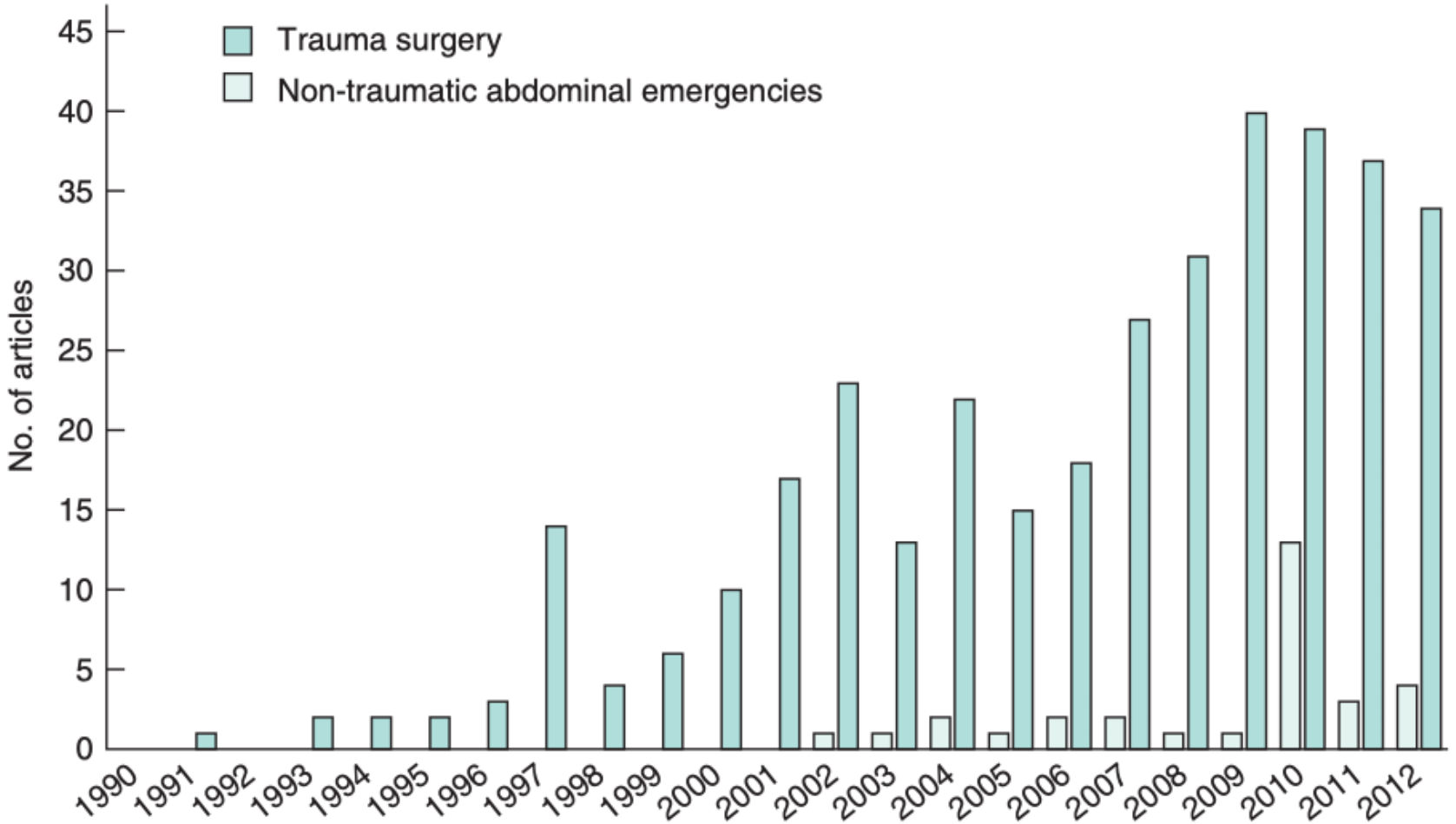
- **1988 -** Feliciano hypothesized that use of "**rapid conservative operative techniques**" may have contributed to survival

- **1993 -** Rotondo & Schwab proposed that abbreviated laparotomy be called "**damage control**" and **defined the stages** of abbreviated laparotomy

  " 7 fold improvement in survival *if major vascular injury and >2 visceral injuries "*

- **1998 -** Over1000 critically injured patients had been reported to have been managed with DC laparotomy

Articles with 'Damage Control' in the title by year of publication



Part of Damage Control Surgery

Damage Control Surgery can be divided into 5 distinct stages:

1. Patient Selection
2. Operative Haemorrhage and Contamination Control
3. Physiological Restoration in the ICU
4. Definitive Surgery
5. Abdominal Wall Closure

DCS & Open Abdomen: Patient Selection

Preoperative

- Hemodynamic instability: SBP < 90 mmHg
- Hypothermia: Temp < 34 C
- Acidosis: pH < 7.2
- Coagulopathy
- High Injury Severity Scale Score

Intra-operative

- Surgical Anatomy or injury pattern
- Massive Transfusion
- Resource Limitation: skill, personnel, medical equipment
- Need for staged abdominal closure

Indications for Use of Damage Control Surgery in Civilian Trauma Patients - Ann Surg 2016;263:1018–1027

Damage Control Resuscitation: Stages/Areas

ICU Physiological Resuscitation

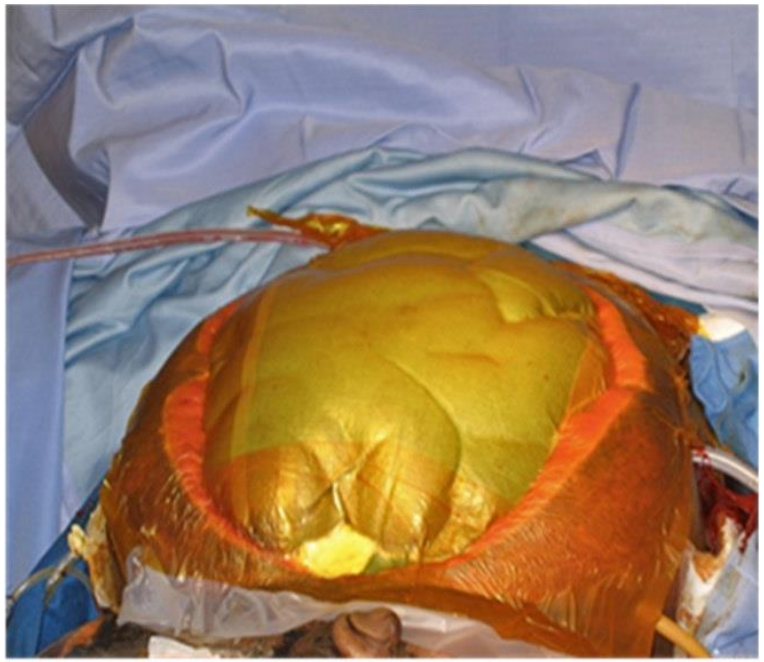
- Restore Body Temperature
- Optimise Oxygen Delivery
- Correct Clotting Profiles
  - TEG and ROTEM
- Target Physiological endpoints
  - Lactate, SvO2, Urine Output, pH
- Monitor for Abdominal Compartment Syndrome
- Beware Fluid Shifts
- Recognition of Additional Injuries

The Open Abdomen

Benefits

- Access to Abdomen
- Decreased Abdominal Pressure
- Abbreviated Surgery





Indications for Open Abdomen

1. Damage Control Laparotomy
2. Suspected or Established ACS
3. Mesenteric ischaemic
4. Abdominal Wall Loss
5. High Dose Inotropes
6. Planned Relook for Source Control

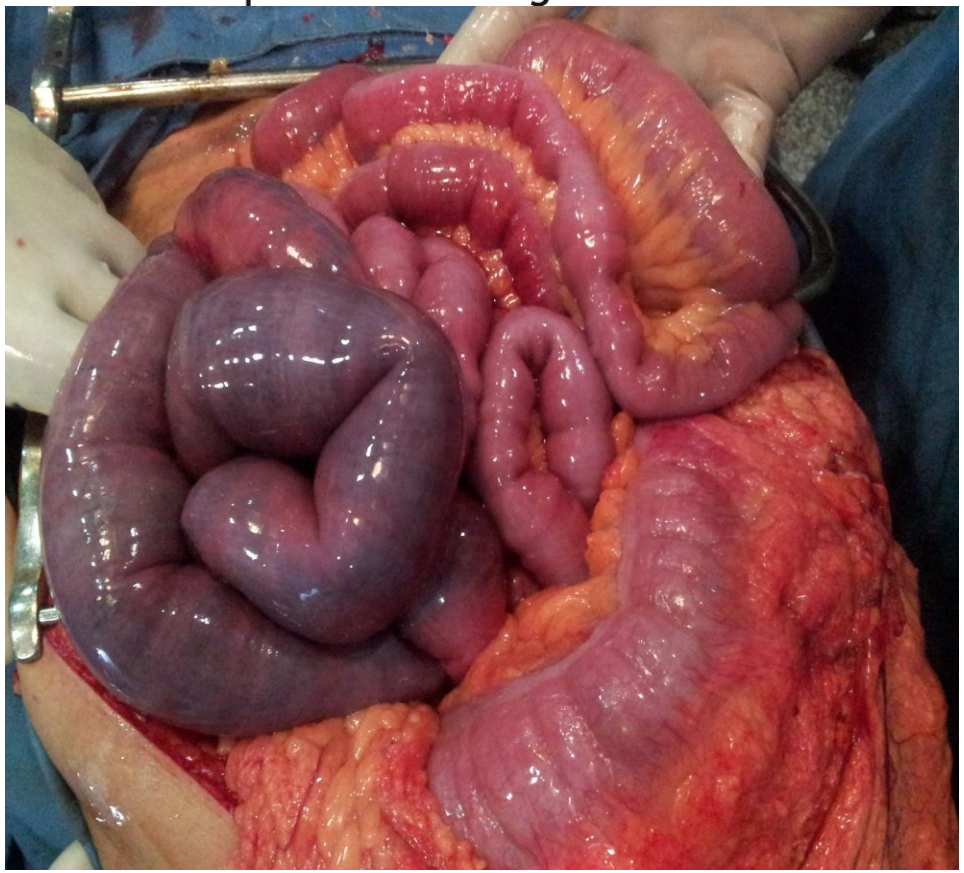
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Coccolini et al. World Journal of Emergency Surgery (2018) 13:7
DOI 10.1186/s13017-018-0167-4

World Journal of Emergency Surgery

REVIEW Open Access

The open abdomen in trauma and non-trauma patients: WSES guidelines



The Problems with an Open Abdomen

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Local:

- Exposed Bowel
- Adhesion Formation
- Fascial Retraction

Systemic

- Compromised Respiration
- Fluid, Protein and Immunoglobulin leak
- Catabolic State

Complications of Open Abdomen

1. **Dressing failure**: ongoing haemorrhage, poor sedation, inadequate placement
2. Enteroatmospheric **Fistula**
3. SSI & IA **Infections**:
   - Trauma + open abdo: 20% IAI & 5% GIT fistula
4. **Fascial retraction + ventral hernia** (most common late complication)
   - 10% open abdomen progressed to definitive closure develop VH by 21 months
5. Frozen abdomen
6. Permanent protein loss

The Perfect Abdominal Closure

- Easy
- Fast in, Fast out
- Reduce Abdominal Compartment Pressure
- Protect the Bowel
- Prevent Adhesion of Bowel to Abdominal Wall
- Prevent Facial Retraction
- Prevent Skin Retraction
- Controls Fluids
- Cheap
- Available

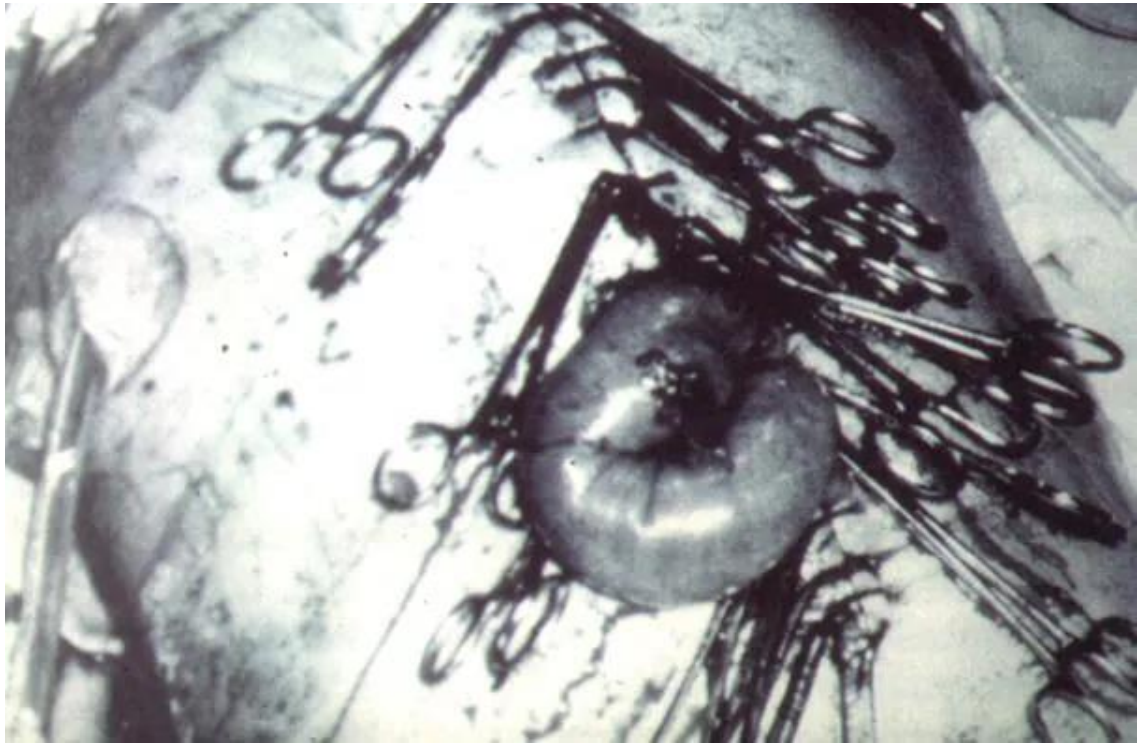


Towel clamps

Towel Clamps

- Probably Fastest Closure technique
- Risk of Evisceration

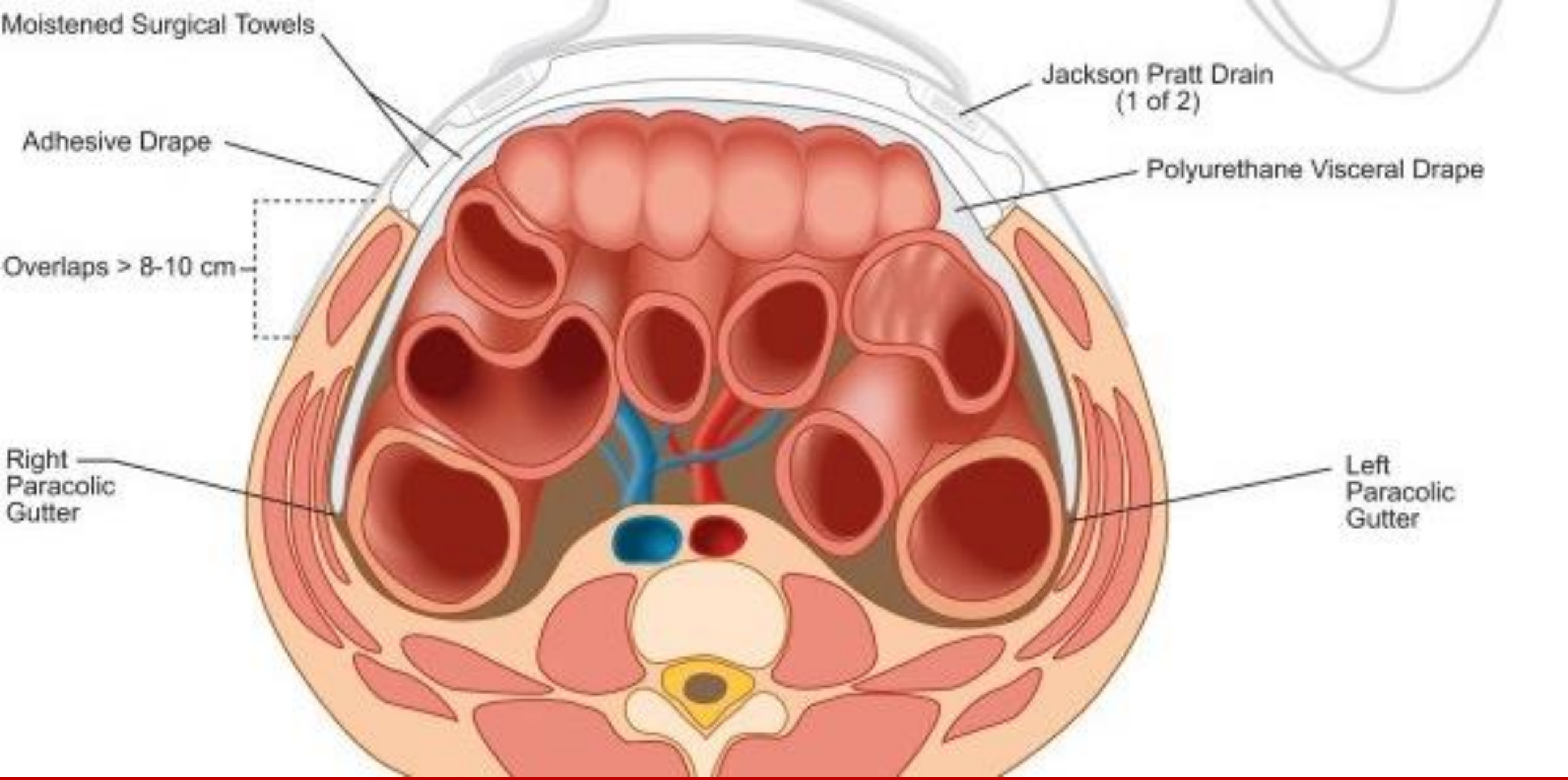
    13 – 36% Abdominal Compartment Syndrome



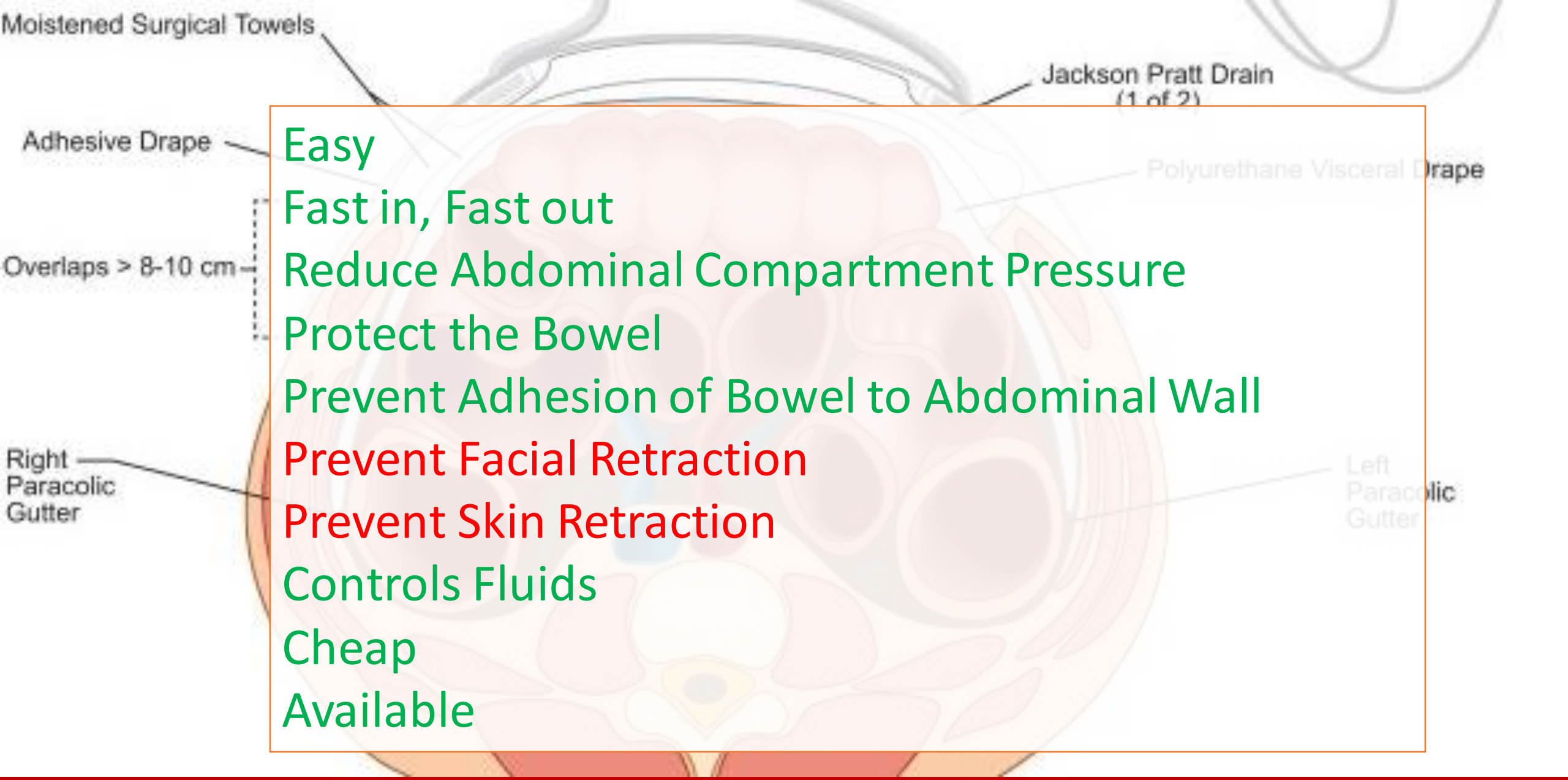




Temporary abdominal wall closure (TAC)



Barker Technique / Sandwich VAC Pack



Easy

Fast in, Fast out

Reduce Abdominal Compartment Pressure

Protect the Bowel

Prevent Adhesion of Bowel to Abdominal Wall

Prevent Facial Retraction

Prevent Skin Retraction

Controls Fluids

Cheap

Available

Barker Technique / Sandwich VAC Pack

Barker Technique / Sandwich VAC Pack

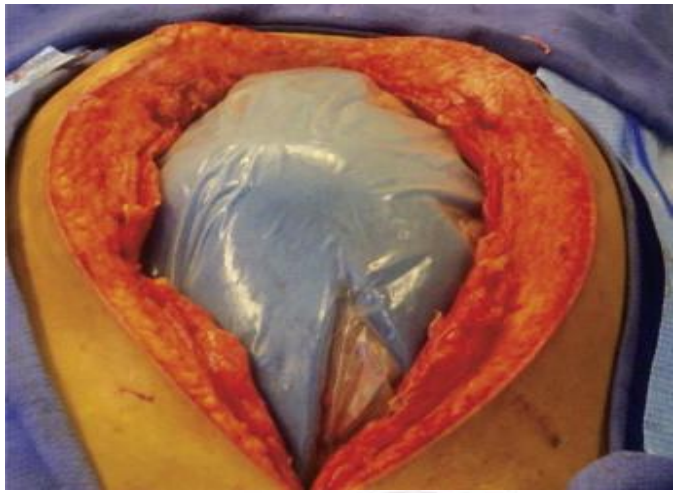




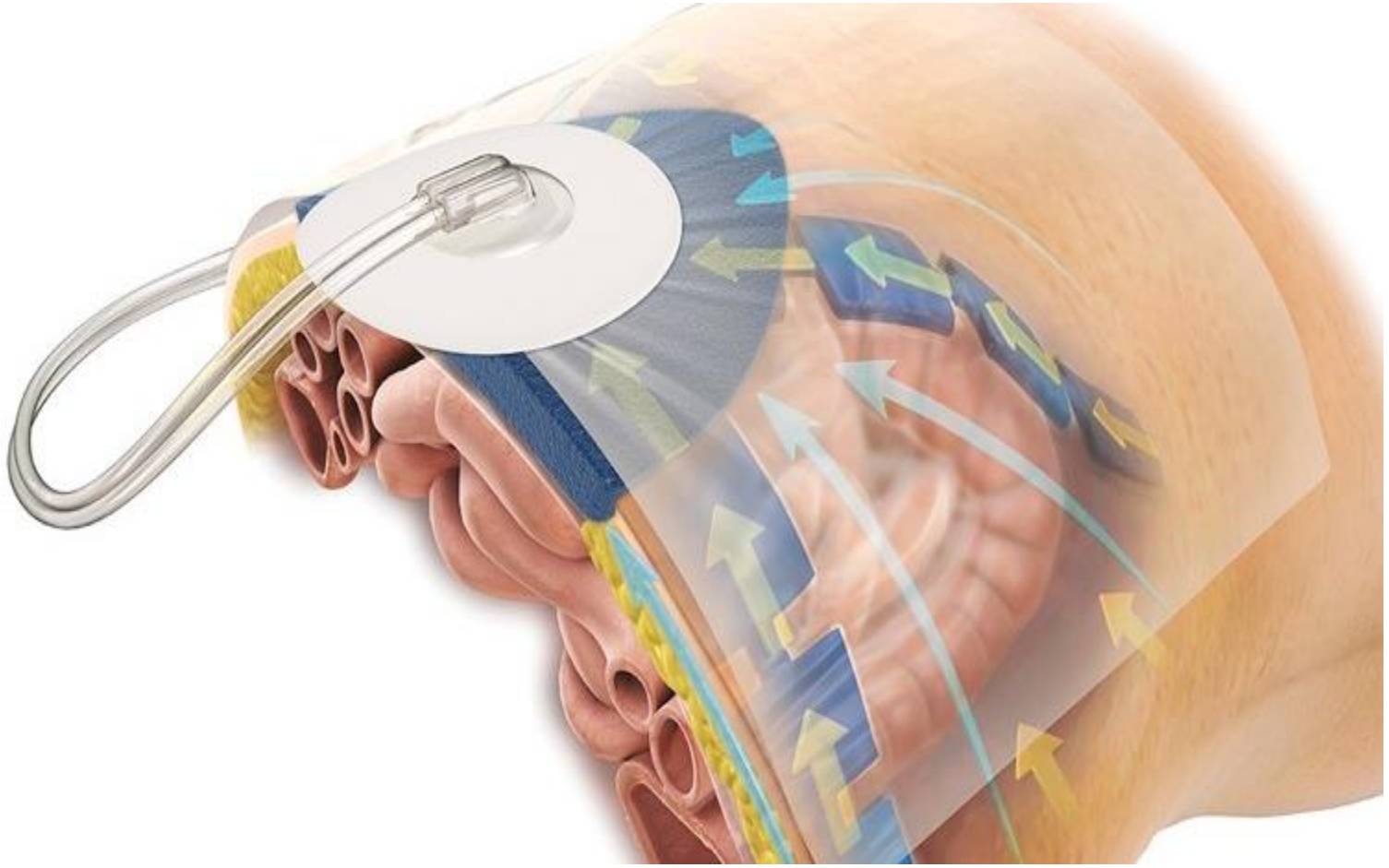


Fig. 1. Modified Vac dressing – adaptation of an Opsite sandwich.

Vacuum assisted closure: Abthera KCI







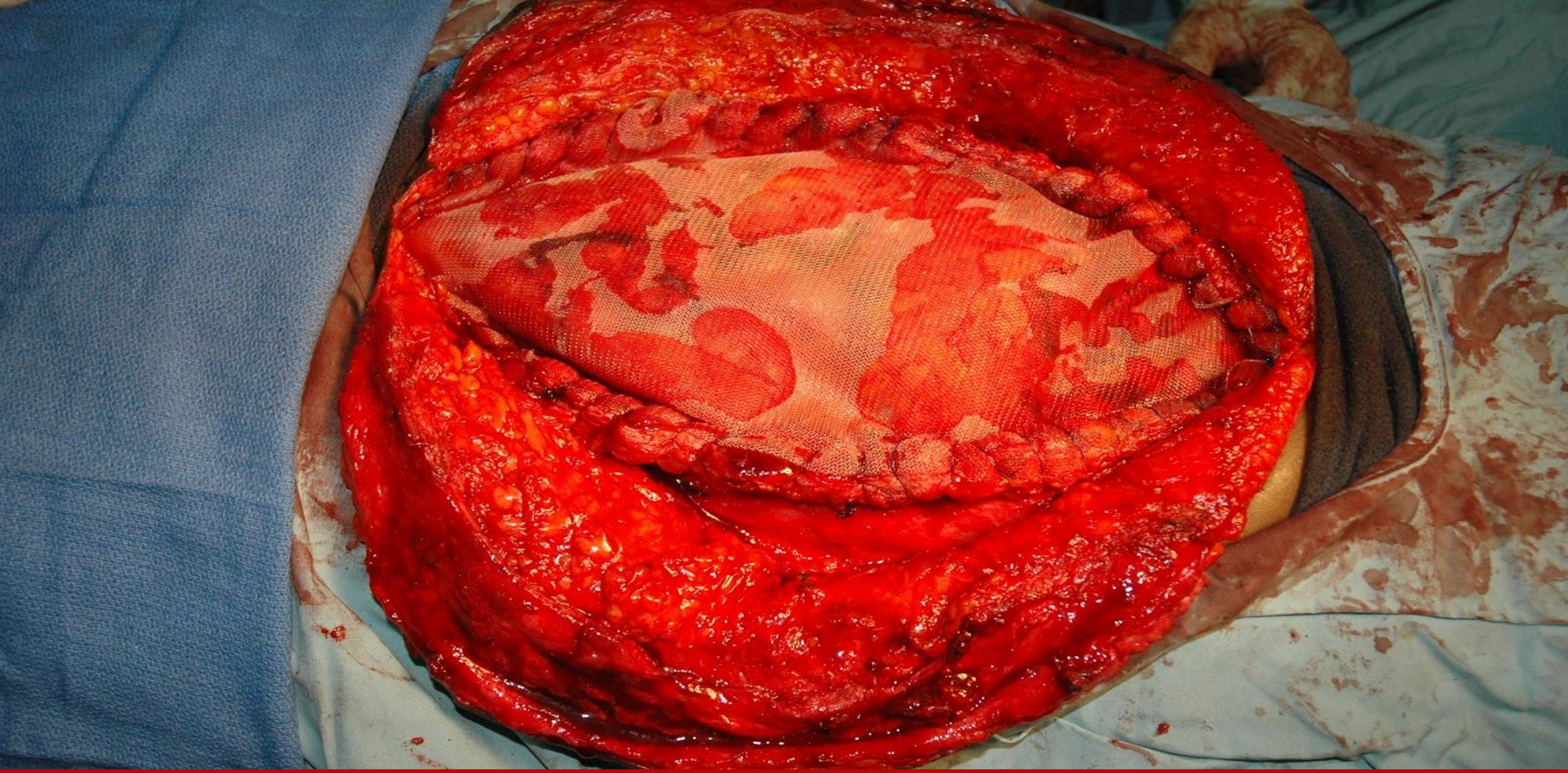
Vacuum assisted closure: Abthera KCl





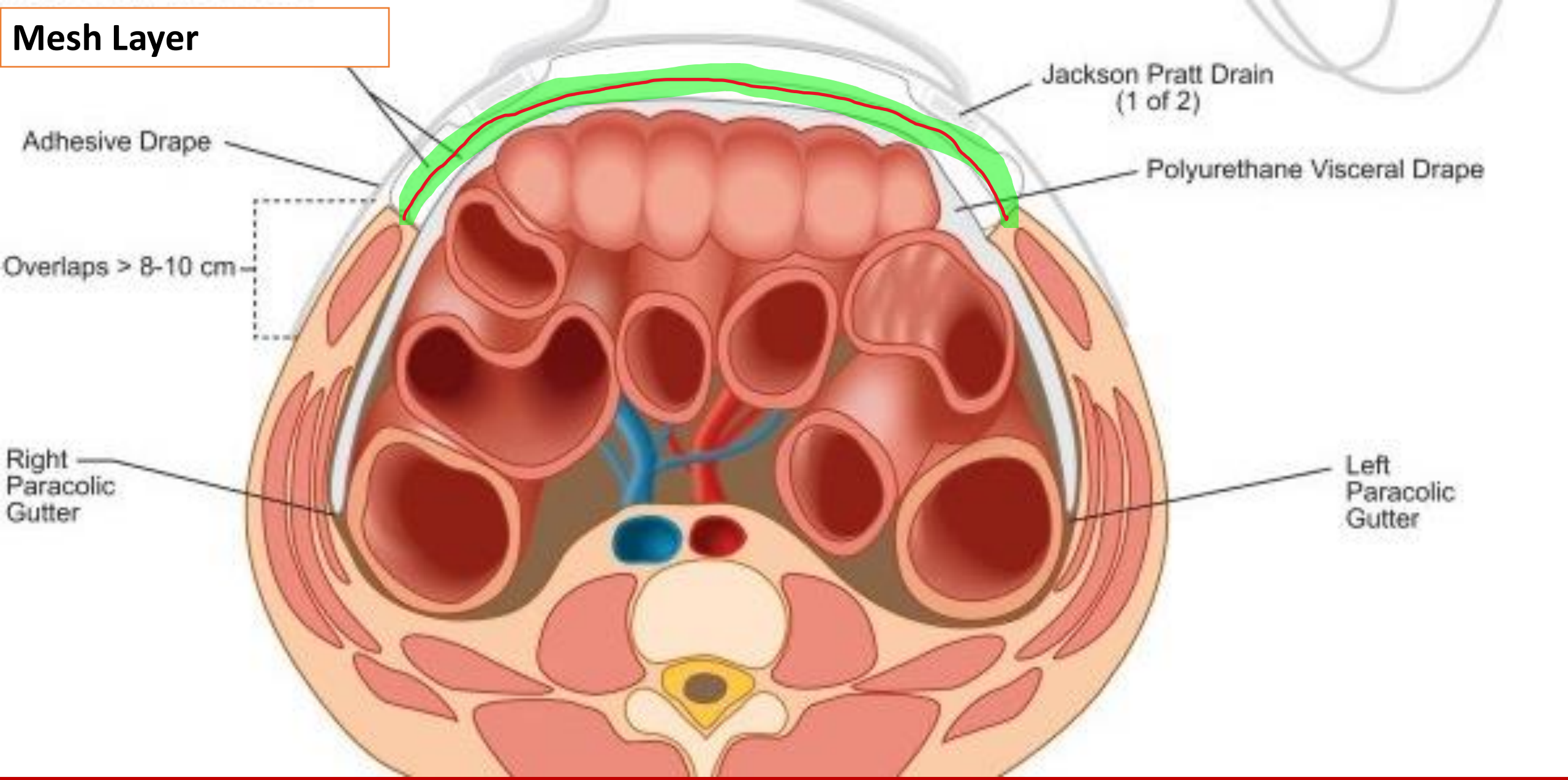
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Absorbable mesh: Vicryl

Mesh Layer



Absorbable mesh: Vicryl

Mesh Mediated Fascial Traction

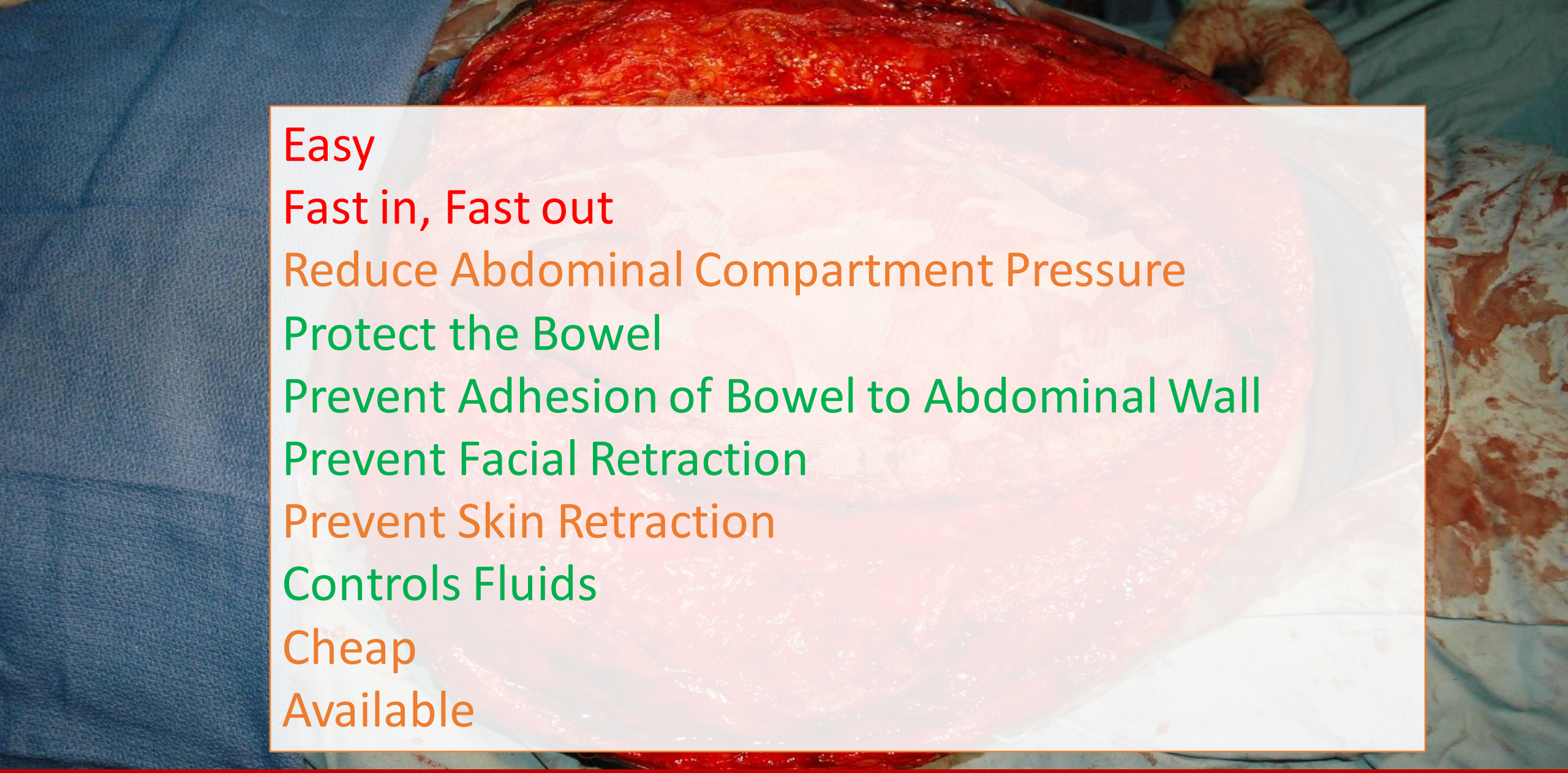
- Increases the time frame for closure from 7 days up to 32 days
- Primary closure rates of 60-100%

- Resource intensive…
  - GA every 48-72 hours until closed

Good Option for 2nd or 3rd relook after VAC pack placement, if not able to close abdomen



Absorbable mesh: Vicryl



Easy

Fast in, Fast out

Reduce Abdominal Compartment Pressure

Protect the Bowel

Prevent Adhesion of Bowel to Abdominal Wall

Prevent Facial Retraction

Prevent Skin Retraction

Controls Fluids

Cheap

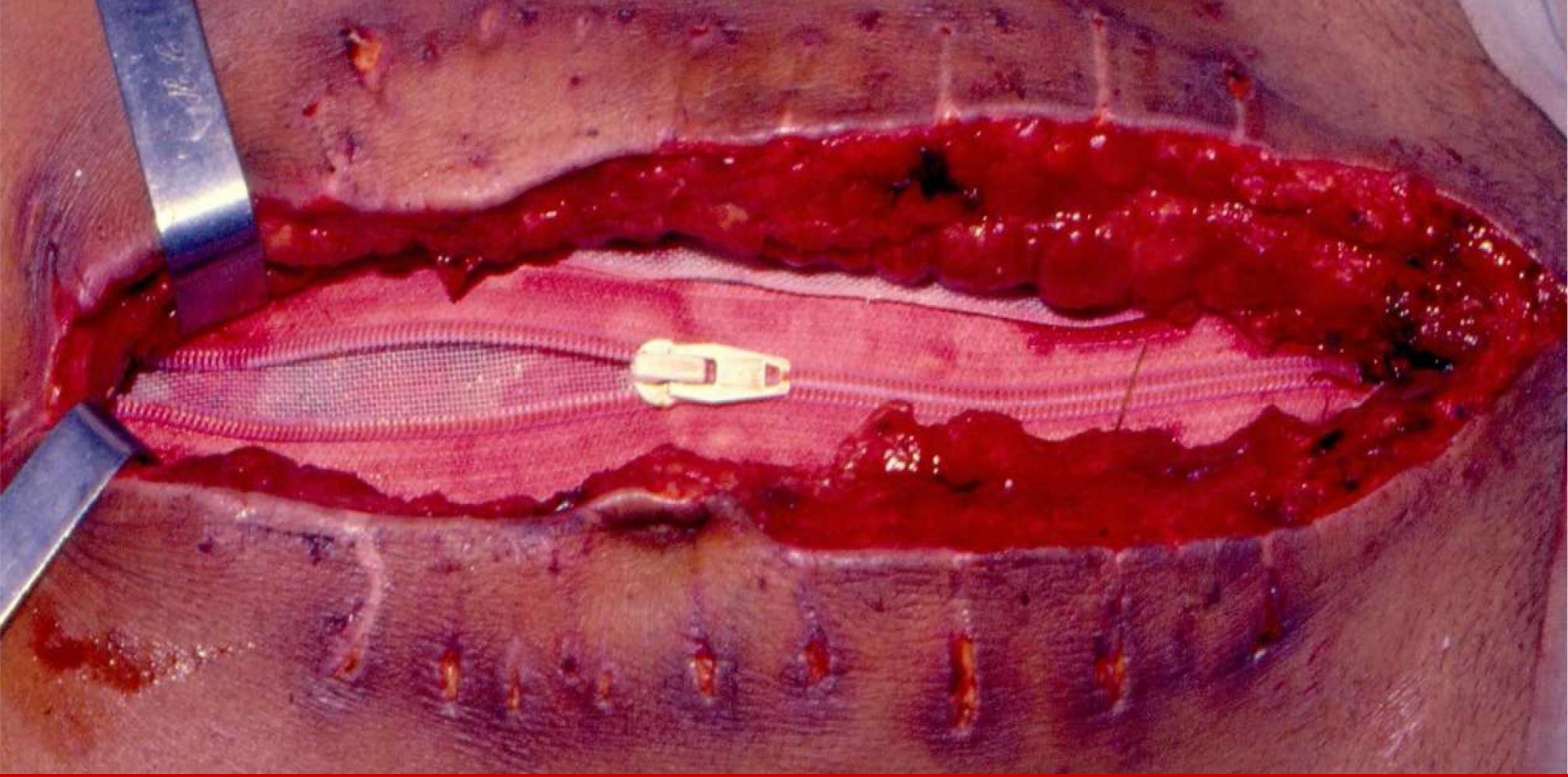
Available

Sandwich with Absorbable Mesh: Vicryl

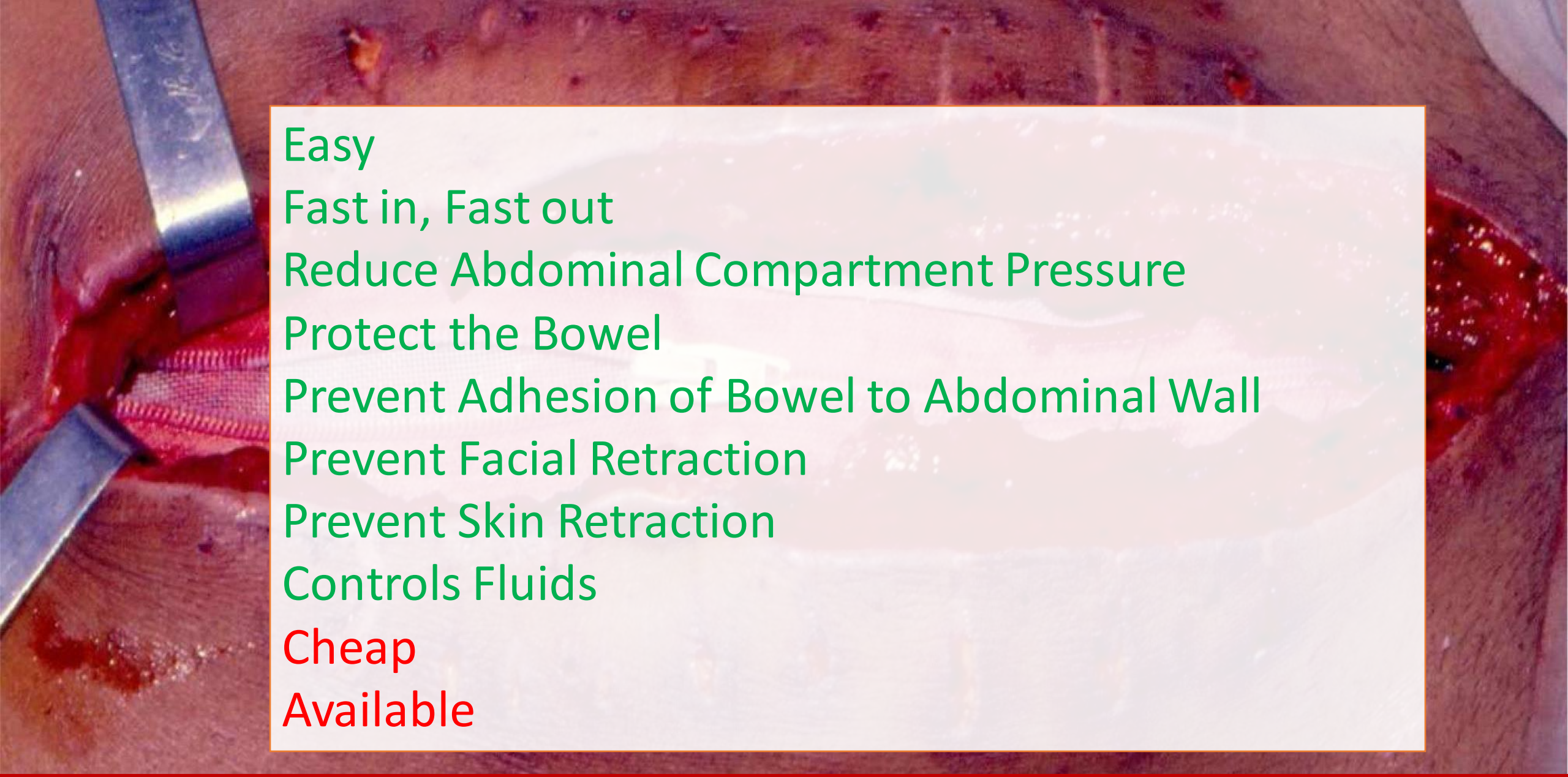
Mesh Mediated Fascial Traction

Box 2: Using mesh mediated abdominal closure together with the Barker VAC pack with *MSF standard equipment*

- Place a VAC pack or plastic separator on the bowel (see Box 1: *Creating the VAC Pack*)
- Suture a large absorbable Vicryl mesh to the free edge of the fascia using a continuous absorbable suture with a tapered needle, only put gentle tension on the fascia
- Fill the incision with additional packs and place the drains as described above
- On consecutive laparotomies, incise and close the mesh in the midline using a running vicryl suture
- On each consecutive laparotomy, slowly tighten the mesh by gathering up more material in the midline until the fascia comes together with minimal tension for fascial closure
- Before definitive closure, make sure to remove any packs and plastic barriers previously placed in the abdomen!



Commercial zipper devices

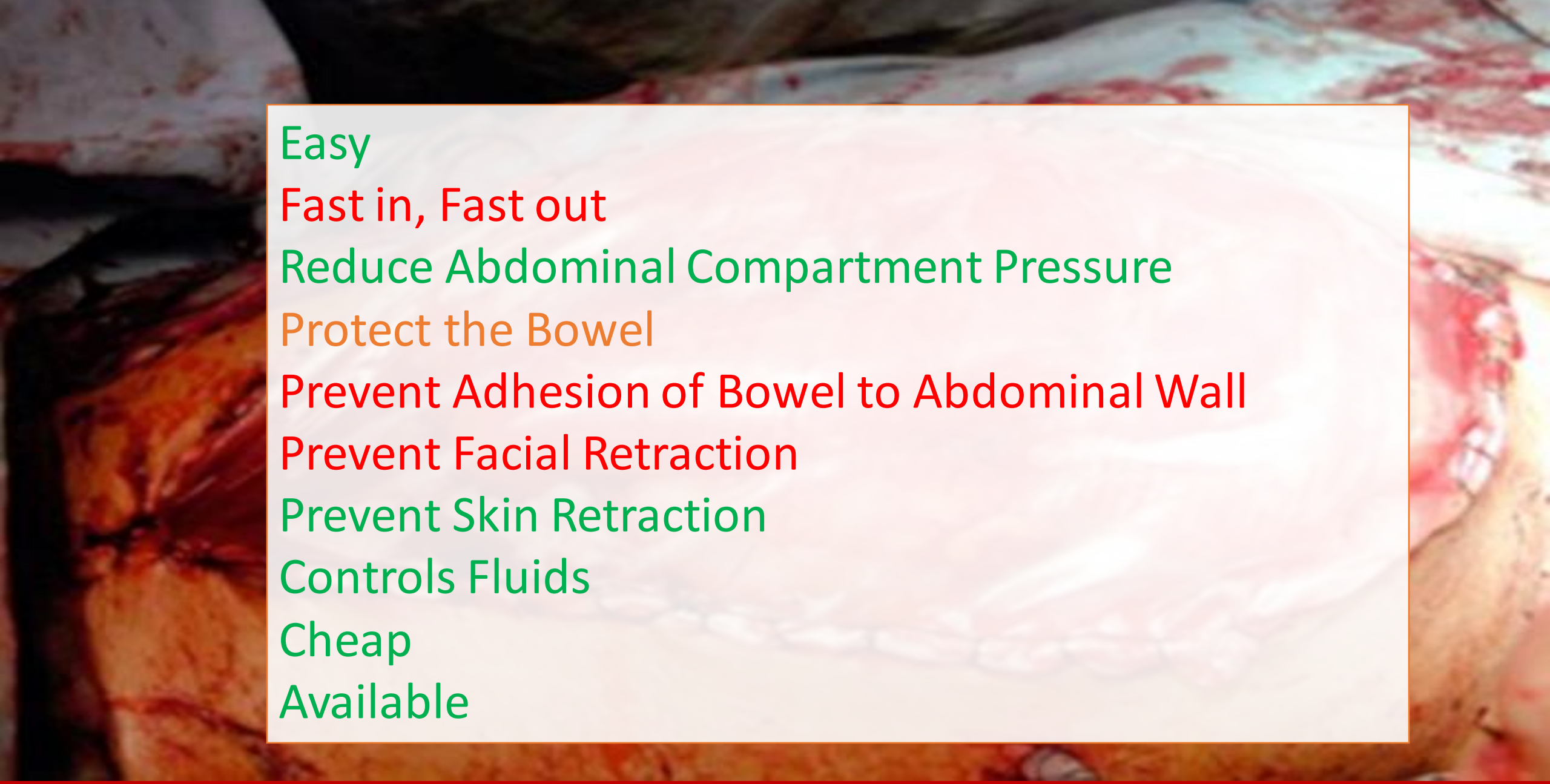


Easy
Fast in, Fast out
Reduce Abdominal Compartment Pressure
Protect the Bowel
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Controls Fluids
Cheap
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Commercial zipper devices



Bogota bag



Easy

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Controls Fluids

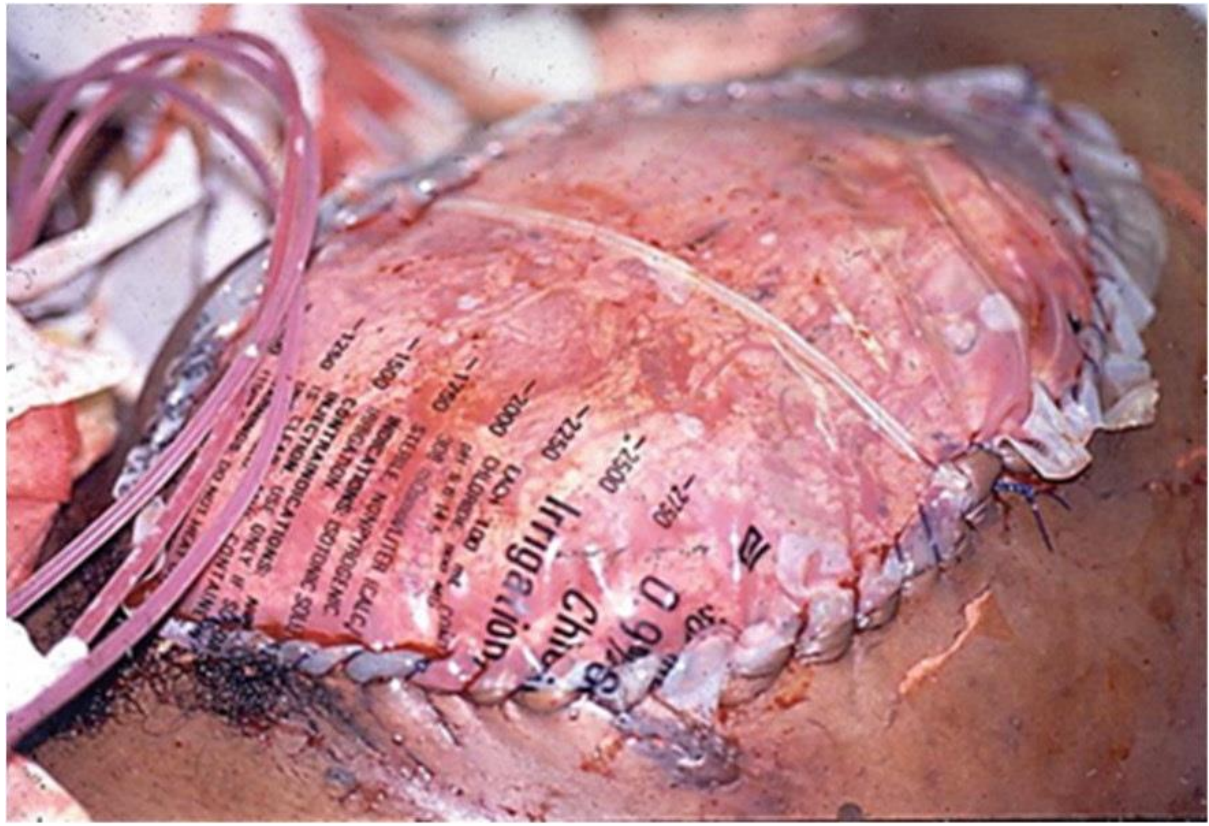
Cheap

Available

Bogota bag

Bogota Bag

- Converting Temporary to Definitive
- Prevents further Fascial/Skin Retraction
- Allows for dressing change in ward
- Granulation layer to prepare for SSG





DIFFICULT

When to close an open abdomen?

- Complication rate increases after 8 days of open abdomen vs closure under tension risk for recurrent ACS
- Delayed closure MR 24.8% vs early closure MR 12.3% ($p<0.0001$, n=3 125)
- 15% need re-exploration due to recurrent ACS or wound dehiscence
- Not closed by day 10… suggest additional cover with absorbable mesh

*Chen et al

EARLY!

Timeline

0 - 48hrs TAC

- Barker Sandwich VAC Pack

After 2nd Relook

- Sandwich with Absorbable Mesh: Vicryl

Failed Closure / Mesh Unavailable

- Bogota to Skin
- SSG when granulated

Pitfalls

- **Bowel:**

  Avoid High Pressure Suction
- **Sheath Retraction:**

  Avoid damaging sheath with recurrent suture lines

  Always attempt to bring sheath to midline
- **Skin:**

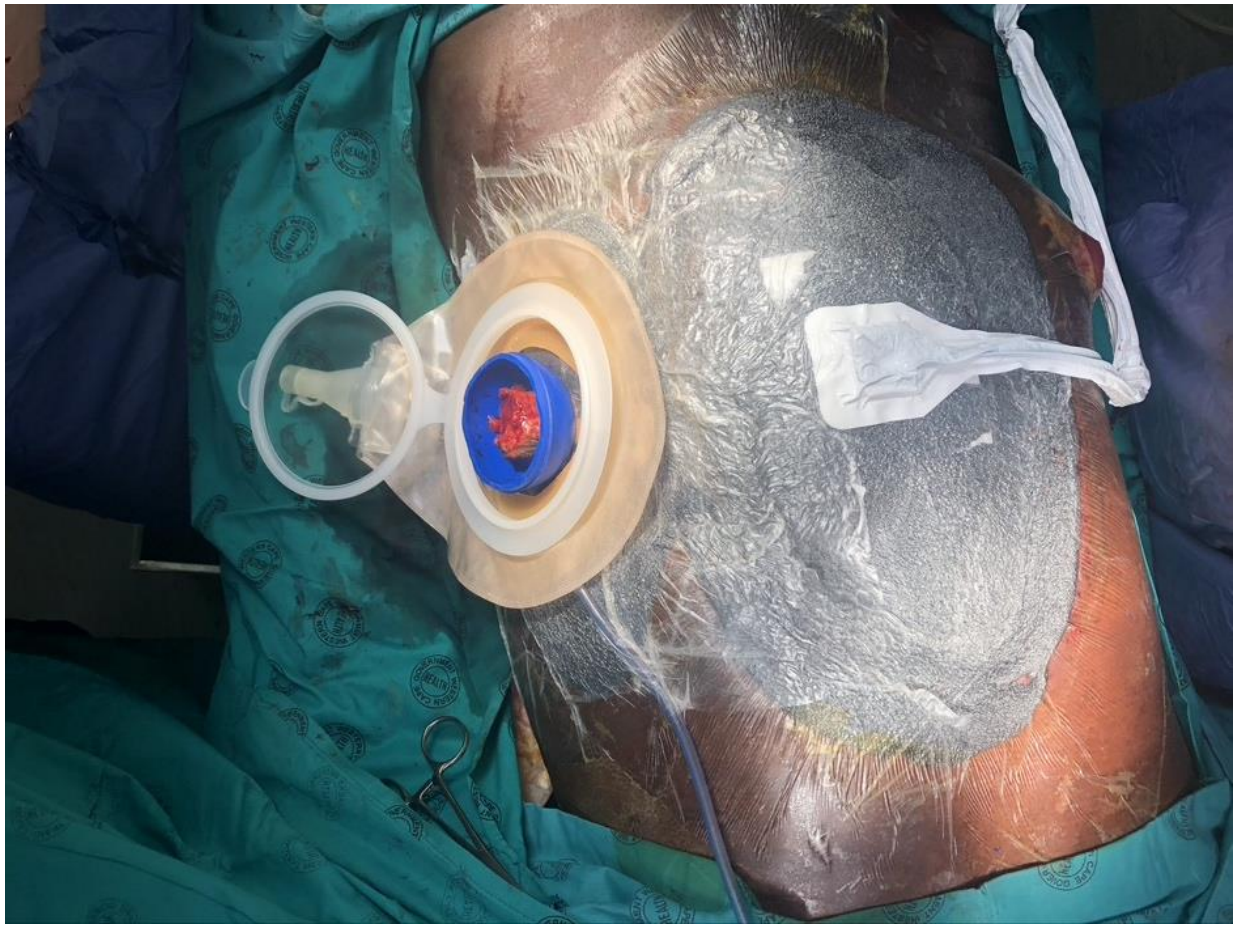
  Does not allow for consistent tension (requires fascial sutures)

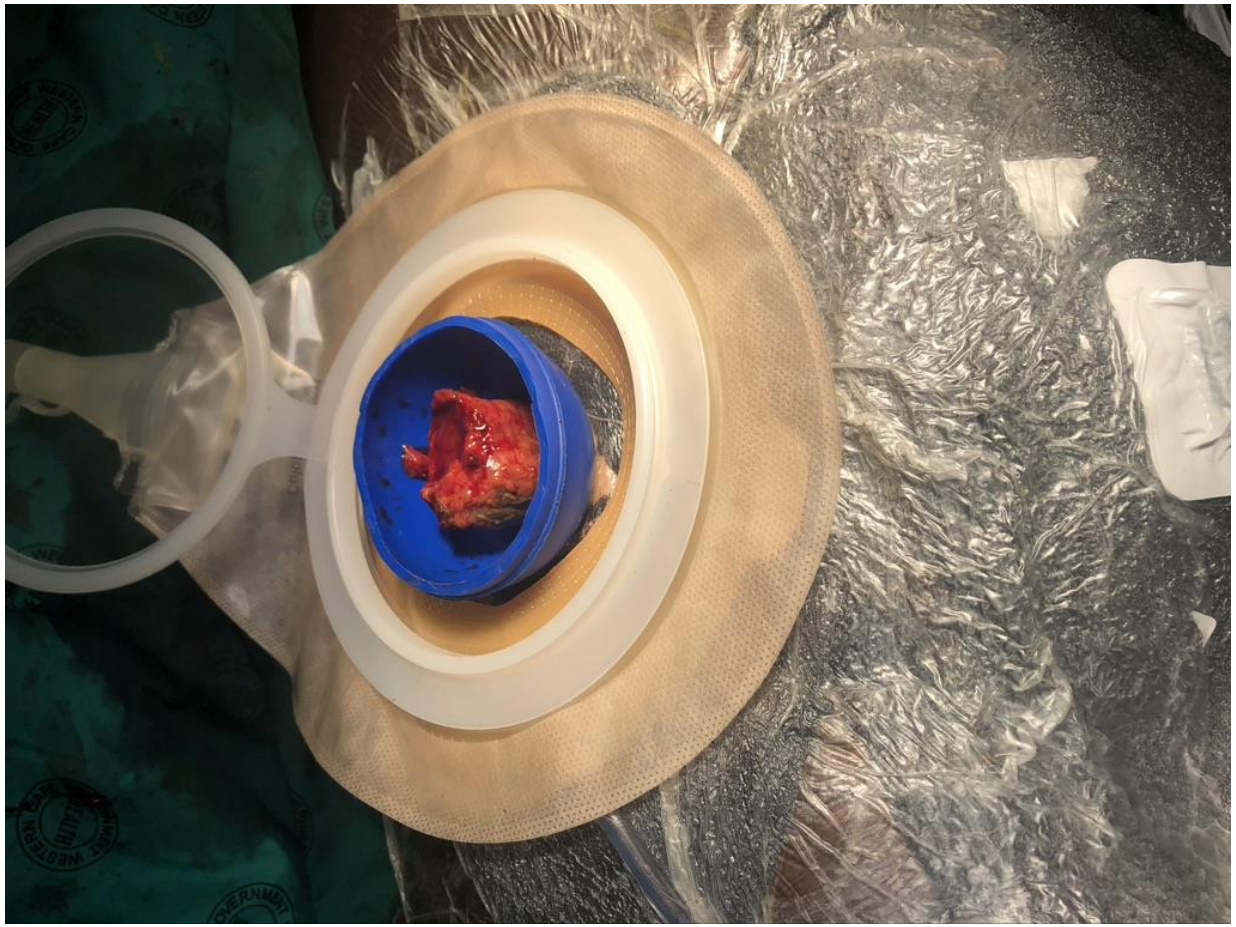
  Prevent Retraction when placing Opsite



Adjuncts: Alternative Closure

- Closure options





The Failures





Thank You!