OPEN ABDOMEN AND DAMAGE CONTROL SURGERY: WHEN AND WHY

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Open abdomen management

The **Open Abdomen (OA) management** is a surgical approach in which the abdominal fascial edges of the paired rectus abdominus muscles are left intentionally un-approximated (laparostomy), thus allowing a regular inspection and drainage of intracavitary content

OA has been proposed to be effective in preventing or treating deranged physiology in patients with severe injuries or critical illness, but it must be recognized as a non-anatomic situation that has potential for severe side effects while increasing resource utilization

2009 classification system		Amended classification system	
1A	Clean OA without adherences between bowel and abdominal wall or fixity (lateralization of the abdominal wall)	1A	Clean, no fixation
1B	Contaminated OA without adherence/fixity	1B 1C	Contaminated, no fixation Enteric leak, no fixation
2A	Clean OA developing adherence/fixity	2A	Clean, developing fixation
2B	Contanimated OA developing adherence/fixity	2B 2C	Contaminated, developing fixation enteric leak, developing fixation
3	OA complicated by fistula formation	3A 3B	Clean, frozen abdomen contaminated, frozen abdomen
4	Frozen OA with adherent/fixed bowel, unable to close surgically, woth or without fistula	4	Established enteroatmospheric fistula, frozen abdomen

Open abdomen classification (Bjorck 2009-2016)

Open abdomen management

The first description of the open abdomen belongs to Andrew McCosh in 1897

In 1940 Ogilvie describes "the use of a double sheet of light canvas sutured into place with interrupted catgut suture in **abdominal war wounds** that could not be closed primarly"

In 1979, Steinberg published the analysis of a series of 14 patients with **diffuse peritonitis** and septic condition where the abdomen was left open with gauze packs for 48-72 hours, the wall being permanently sutured later

In the early 80's in the context of **severe abdominal sepsis**, Duff ed al. proposed the open abdomen technique as an extreme solution, with a mortality rate of 39% considered acceptable compared to the final primary closure of the abdominal wall.

After 1990, correlated with the understanding of the pathophysiology of the **abdominal compartment syndrome** and the promotion of the damage control strategy in the management of the polytrauma patient, multiple techniques of temporary closure of the abdomen appear


The Management of the Open Abdomen - A Literature Review

Marius Anastasiu[1]*, Valeriu Şurlin[2], Mircea Beuran[3]

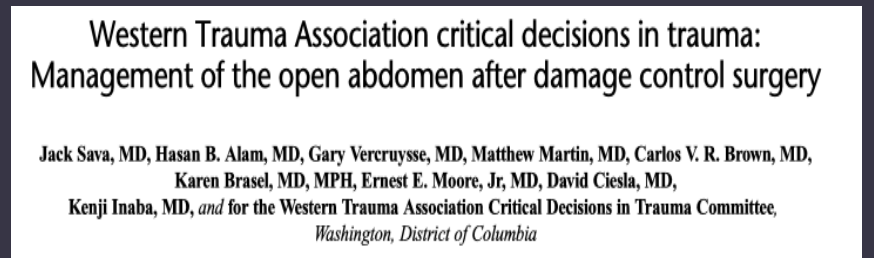
Damage Control Surgery strategy

Damage Control Surgery (DCS) is a surgical strategy that is applied to critically ill patients with severe impairment of functional reserve induced by traumatic or non-traumatic events.

The rationale for this strategy is to:

- **rapidly control** the conditions at risk for survival
- recover the patient's **functional reserve**
- **postpone the definitive correction** of the lesions to a later time

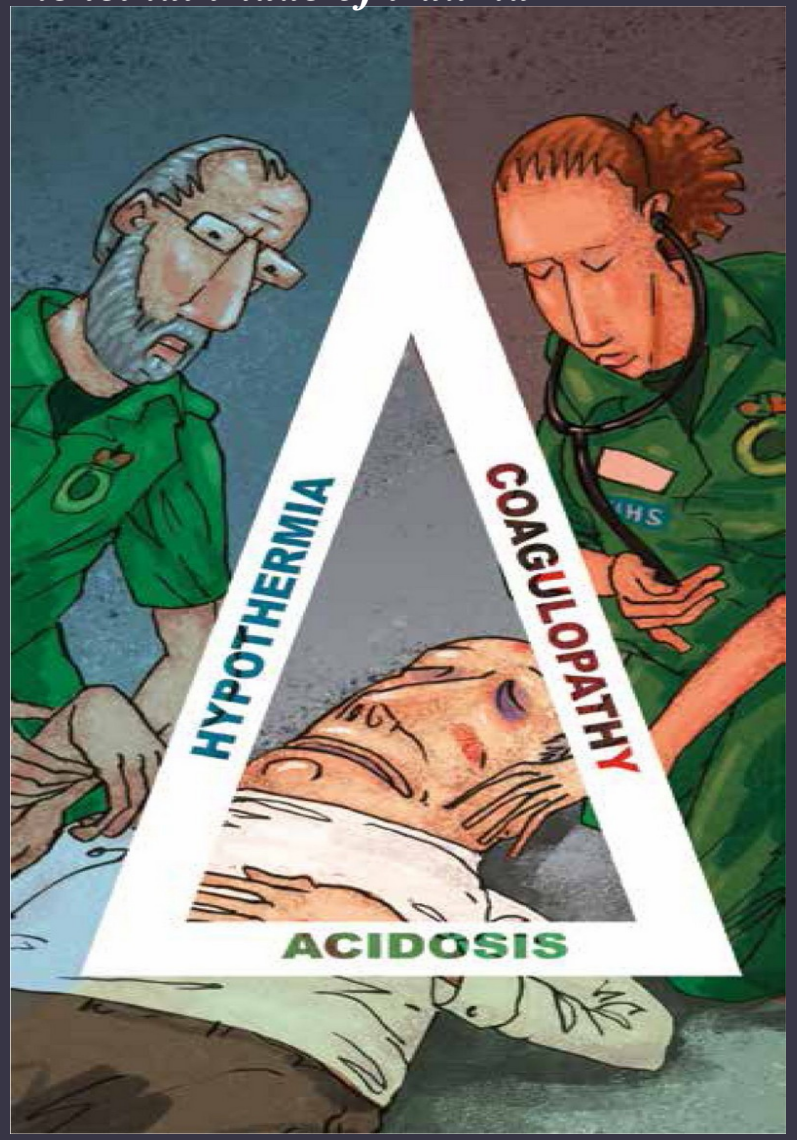
In the broader context of the Damage Control Surgery strategy, there are multiple situations that causally and pathophysiologically justify the use of the Open Abdomen as an extreme measure in the therapeutic algorithm of life-threatening conditions


Western Trauma Association critical decisions in trauma:
Management of the open abdomen after damage control surgery

Jack Sava, MD, Hasan B. Alam, MD, Gary Vercruysse, MD, Matthew Martin, MD, Carlos V. R. Brown, MD,
Karen Brasel, MD, MPH, Ernest E. Moore, Jr, MD, David Ciesla, MD,
Kenji Inaba, MD, *and* for the Western Trauma Association Critical Decisions in Trauma Committee,
Washington, District of Columbia

Damage Control Surgery strategy

The lethal triade of trauma



(WSES Guidelines 2018 - Grade 2A)

In polytrauma patients are strong predictors of severity requiring a damage-control laparotomy and performing a laparostomy:

- persistent hypotension
- acidosis (pH<7.2),
- hypothermia (T<34° C)
- coagulopathy

Indications for the implementation of a DCS approach are also:

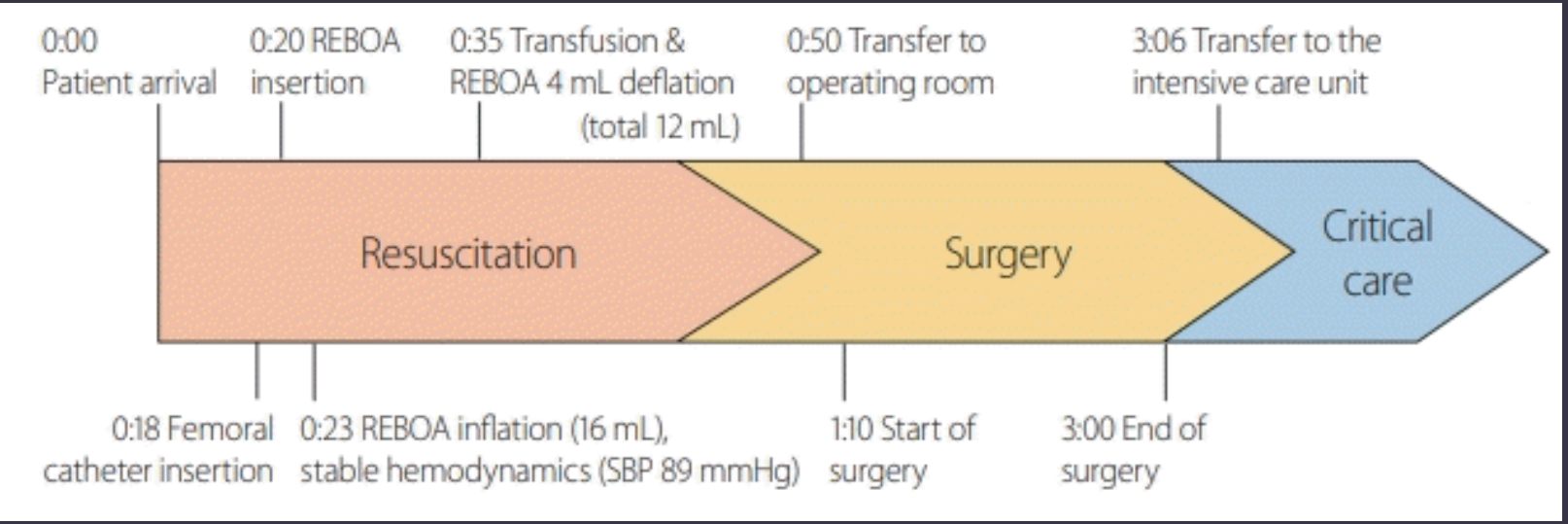
- Surgical times foreseen for definitive repair >90 min
- High-energy torso trauma
- Major vascular lesions
- Multi-district injuries
- Transfusion need > 10 units

Damage Control Resuscitation

The rapid correction of serious physiological alterations that immediately put the patient's life at risk is a fundamental step before the next surgery

Therefore, together with the surgical act, the Damage Control strategy also provides for hemodynamic stabilization and rapid correction of hypothermia, metabolic acidosis and coagulopathy through the application of a series of medical protocols aimed at restoring normal body homeostasis, which they go by the name of Damage Control Resuscitation (DCR)

- **Phase 0:** pre-hospital rescue and resuscitation phase in DEA



Damage Control Resuscitation

- **Phase 1:** first shortened laparotomy surgery (about 60 minutes), in which the objectives are to control abdominal bleeding and contamination, minimizing the additional trauma created by the surgeon

At the end of the first shortened laparotomy surgery, the surgeon decides to intentionally leave the edges of the abdominal muscle band free and apply a temporary closure of the abdomen in order to

- decompress
- prevent abdominal compartment syndrome
- facilitate a subsequent surgical approach

The Temporaray Abdominal Closure (TAC) should ideally protect the viscero-abdominal contents, prevent evisceration, remove intra-peritoneal septic exudate, prophylaxis of entero-cutaneous fistula facilitate planned laparotomies and achieve optimal conditions

Technique	Equipment	Advantages	Disadvantages
Skin only closure	Skin staples, towel clips or sutures	Cheap, available, minimises heat and fluid floss	Damage to the skin, risk of evisceration, no control of fluid loss, may develop ACS
"Bogota bag"	Sterile 3 litre saline bag cut and shaped and sutured to fascial edges	Cheap, available, minimises heat and fluid loss	Damage to the fascial edges, risk of evisceration, no control of fluid loss. Allows some assessement of intestinal viability
Opsite Sandwich technique	Polyethylene sheet, opsite dressings, abdominal packs, 2 suction drains and wall suction	Cheap, available, minimises heat and fluid loss is controlled and measurable	Incomplete fluid control and need for available wall suction
Absorbable mesh	Vicryl or similar MESH	Abdorbable mesh, infection resistance, protects from evisceration, can be skin grafted	High rate of subsequent incisional herniation
Non absorbable mesh or commercial Zipper	Commercial Whitmann patch	Abdominal re-exploration is easy, maintains abdominal domain, gradual abdominal closure possible	Commercial equipment required and repeated operation needed for closure
Vacuum assisted Closure	commercial kit	Prevents loss of abdominal domain, collects and monitoris fluid loss, decreases ACS, no damage to skin and or abdominal fascia	Expensive commercial equipment required.Usually requires general anesthesia to change the kit

Sartelli M, Abu-Zidan FM, Ansaloni L, Bala M, Beltrán MA, Biffl WL, et al. "The role of the open abdomen procedure in managing severe abdominal sepsis sepsis: WSES position paper". World J Emerg Surg. 2015;10:35

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[Intervention Review]

Negative pressure wound therapy for managing the open abdomen in non-trauma patients

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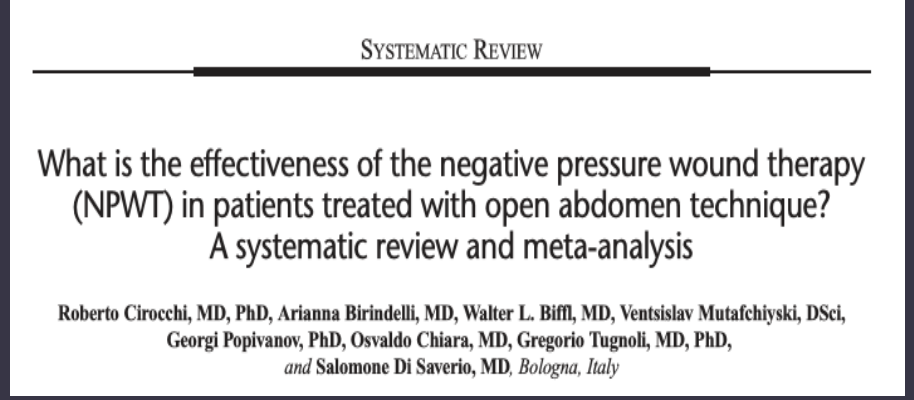


SYSTEMATIC REVIEW

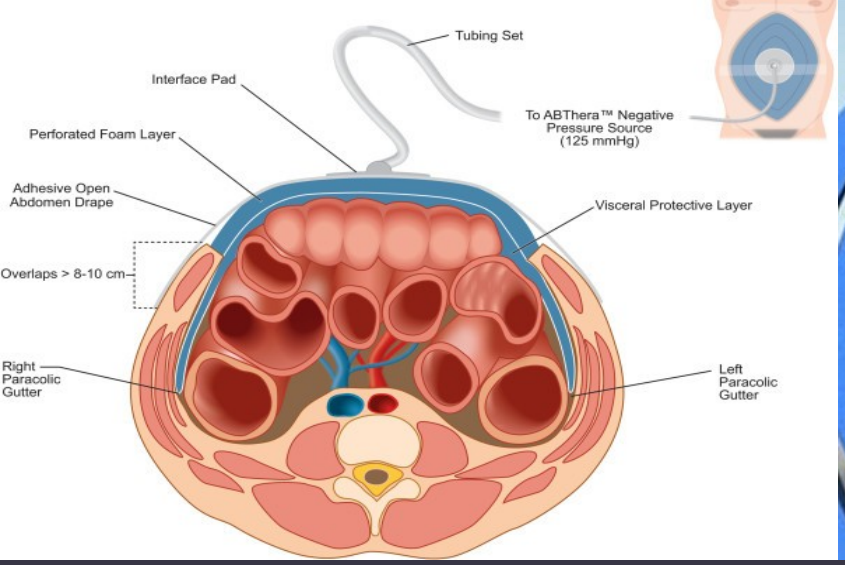
What is the effectiveness of the negative pressure wound therapy (NPWT) in patients treated with open abdomen technique? A systematic review and meta-analysis

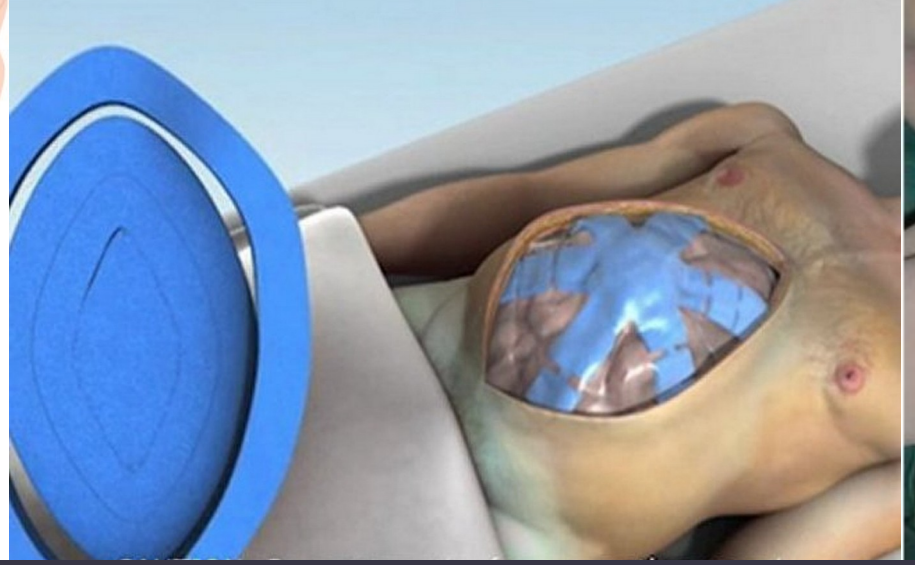
Roberto Cirocchi, MD, PhD, Arianna Birindelli, MD, Walter L. Biffl, MD, Ventsislav Mutafchiyski, DSci, Georgi Popivanov, PhD, Osvaldo Chiara, MD, Gregorio Tugnoli, MD, PhD, *and* **Salomone Di Saverio, MD**, *Bologna, Italy*

Negative pressure wound therapy (NPWT) is currently the most recommended method of temporarily closing the abdomen.

Firstly proposed by Barker and Brock in 1995 vacuum pack is a "sandwich" technique in which the visceral block is covered with a polyethylene window foil, the overlying space delimited by the fascial edges, being filled with soft gauze fields and 2 drain pipes connected to the suction system, the tightness being made by an external adhesive foil (opsite sandwich technique)

Aspiration at a pressure of 125 mmHg is initiated for 48 hours continuously and then applied intermittently in conjunction with individual circumstances





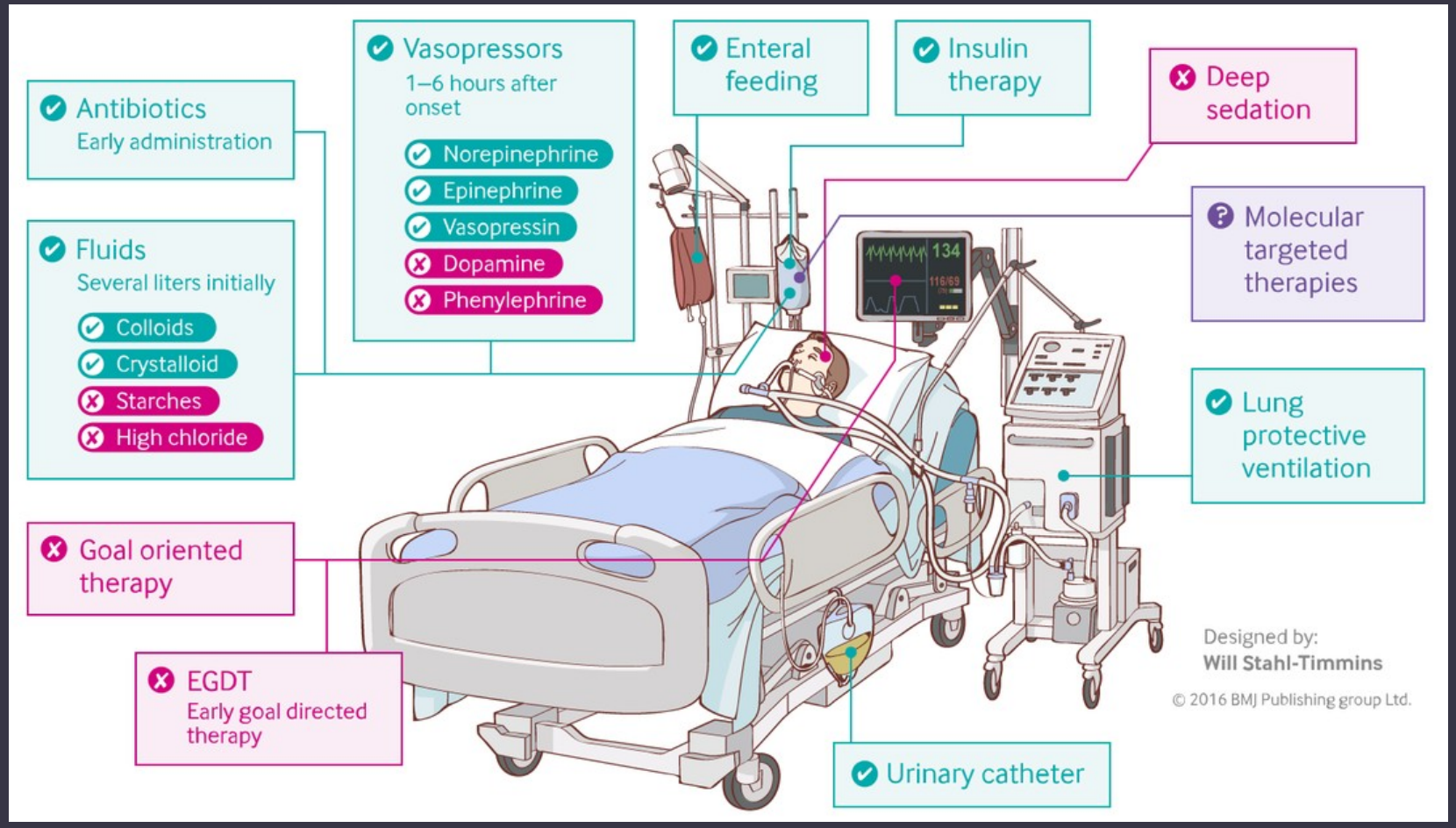
By using absorbent sponges, have the advantage of reducing the indication of frequent change of soft material fields,reducing intestinal edema and increase local blood perfusion, which accelerates the growth of granulation tissue and reduces local microbial growth.

Superior results can be obtained if the VAC was combined with the Dynamic Retention Suture (ABRA) technique (3 to 5 vessel-loops). In the Cochrane reviews examined the primary closure rate was about 75% with an incidence of entero-cutaneous fistula of about 7% and a mortality of about 25%

NPWT combined with fascial traction is recommended as the standard method in temporary closure (2018 WSES Guide - Grade 1B)

Damage Control Resuscitation

- **Phase 2: ICU resuscitation phase** dedicated to restoring the patient's normal physiology, stabilizing the patient and rapidly interrupting the synergistic effects of the "killer triad"



Damage Control Resuscitation

- **Phase 3: Second surgery** only after obtaining the patient's stabilization , the patient, approximately 24-48 hours after the first surgery, will be able to undergo a new surgical procedure aimed at restoring anatomical integrity

Mesh-mediated closure are techniques not recommended in temporary abdominal closure and reserved for final closure only (Grade 2C).
In this decision making context the Ramirez "components separation technique" should be considered the elective repair procedure in parietal defects consequent to laparostomy, with a 75% success rate

The association of NPWT with a procedure that uses "biological bridging mesh" facilitates the appearance of tissue granulation and healing.

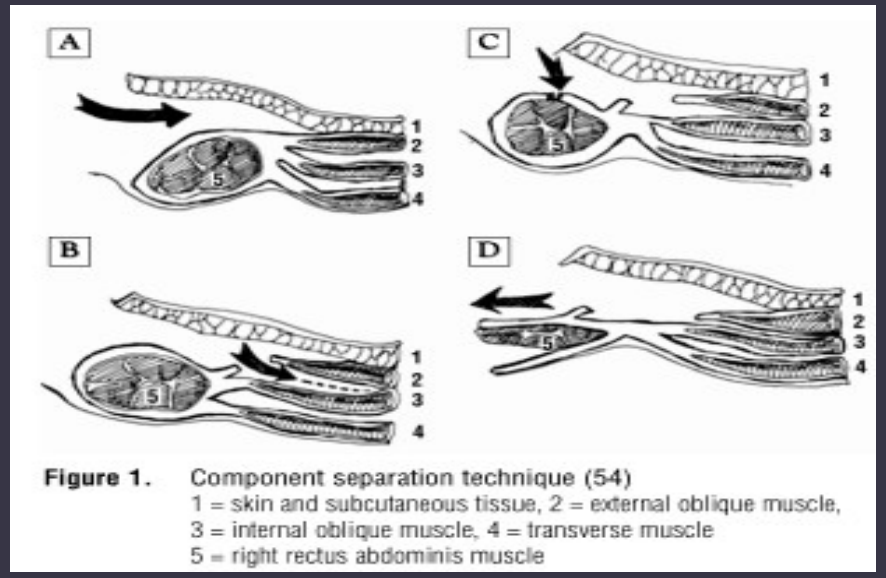


Figure 1. Component separation technique (54)
1 = skin and subcutaneous tissue, 2 = external oblique muscle, 3 = internal oblique muscle, 4 = transverse muscle
5 = right rectus abdominis muscle

Damage Control Surgery strategy

The DCS is nowadays adopted:

- to prevent and to treat the development of an abdominal compartment syndrome (ACS)
- in the cases in which a «second look» of the abdominal cavity is needed
- in the case of development of an abdominal sepsis and impairment of vital functions

Non-traumatic events in which DCS is indicated are:

- abdominal sepsis
- abdominal compartment syndrome
- severe peritonitis or pancreatitis,
- some vascular emergencies such as ruptured abdominal aortic aneurysms or intestinal ischemias.

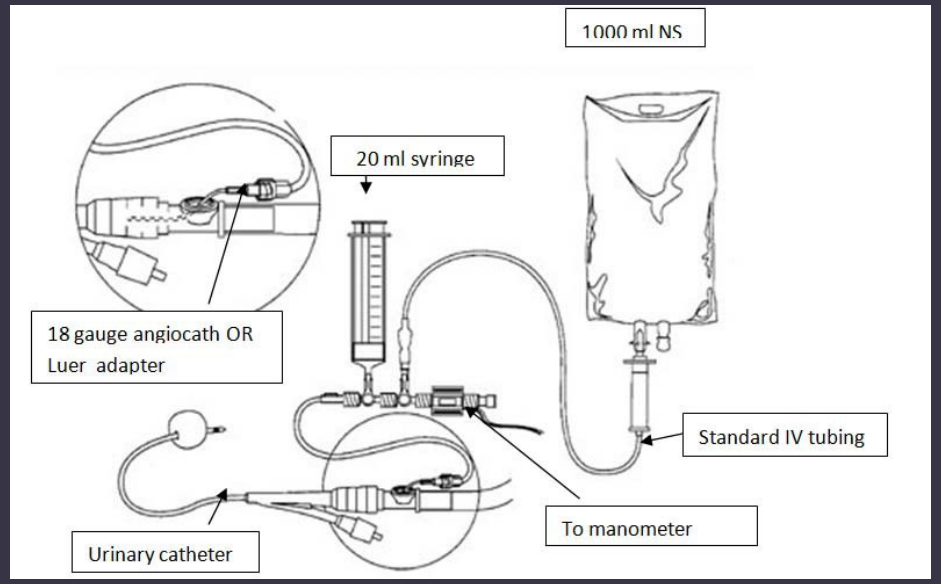
Abdominal Compartment Syndrome (ACS)

ACS is a pathological condition that occurs following the increase in intra-abdominal pressure

- The IAP value considered normal is 5-7 mmHg
- Intra-abdominal hypertension (IAH) > 12 mmHg
- ACS is defined by IAP values persistently above 20 mmHg associated with at least one new onset organ dysfunction.

The method of choice for measuring IAP is the detection of **intravesical pressure**, carried out through a Foley catheter

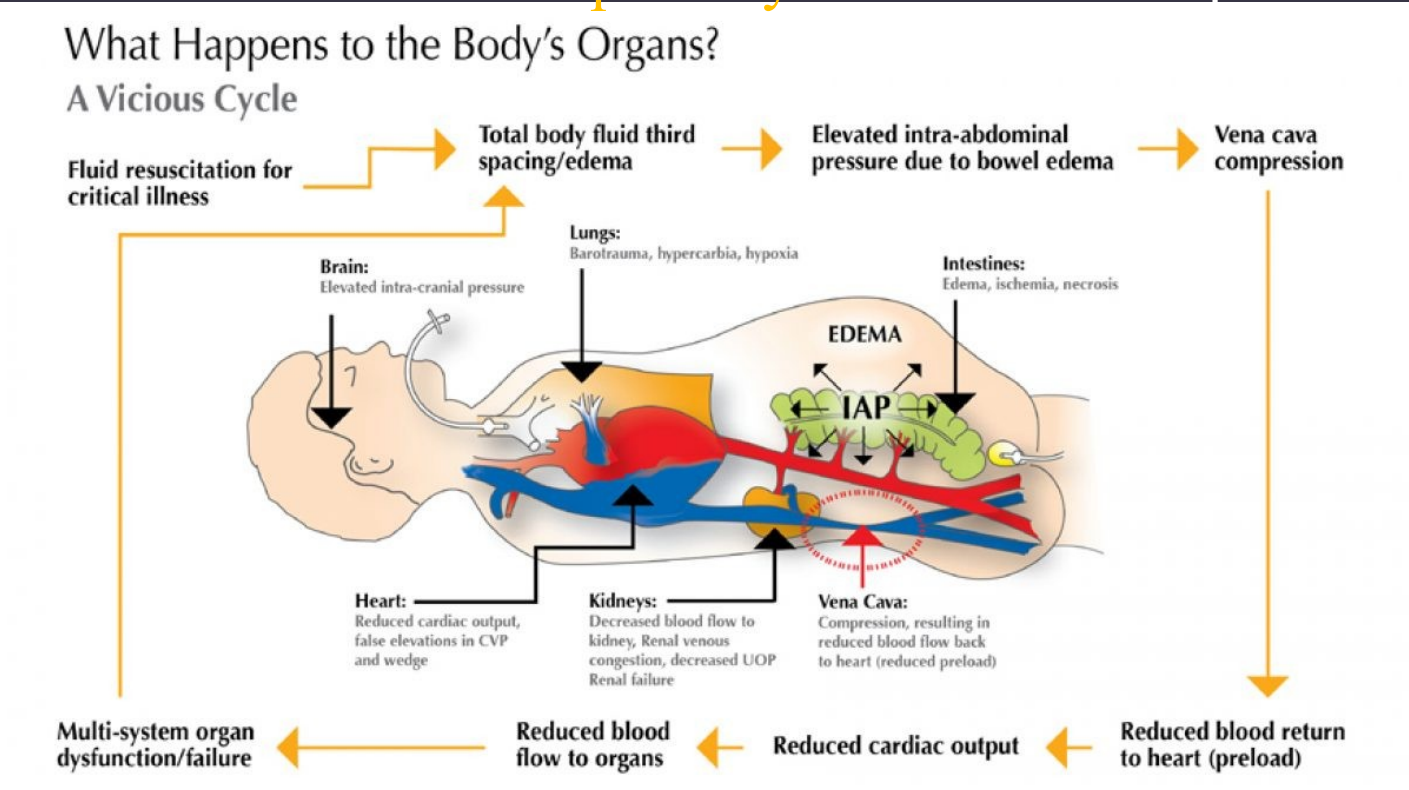
The reading of the IAP value is carried out after having instilled 25 mL of physiological solution in the bladder



Abdominal Compartment Syndrome (ACS)

Since the abdomen is a confined anatomical space, the increase in pressure damages circulation, compromising the function and vitality of the organs it contains

Also causes alterations in the cardiovascular and respiratory systems and in renal and splanchnic perfusion; associated liver cirrhosis and respiratory failure are also predictors of ACS



Abdominal Compartment Syndrome (ACS)

As defined by the *World Society of Abdominal Compartment Syndrome (WSACS)*,
SCA is distinguished on the basis of etiology into:

- Primary ACS: resulting from pathology of the intra-abdominal or retroperitoneal organs (trauma, rupture of aneurysms, severe pancreatitis, intestinal obstruction)
- Secondary ACS: due to the accumulation of fluids in the "third space" resulting in visceral retroperitoneal edema and ascites, in the absence of intra-abdominal causes
- Tertiary ACS: recurrence of an ACS condition after medical or surgical treatment of a primary or secondary ACS

Risk factors in trauma patients:

- The presence of retroperitoneal hemorrhage or packing in major lesions of the parenchymal viscera with the impossibility to control the hemorrhagic source
- The presence of post-traumatic ileus
- Decreased parietal compliance in obese patients or grade 3 parieto-abdominal burns
- Persistence of visceral edema following excessive volume resuscitation

Indications of DCS in trauma patients

The OA may be indicated when scheduling a **“second-look operation”** :

- the index intervention has been stopped or shortened for hemorrhagic reasons and/or shock-signs of evolutionary enteral ischemia with enteral resections without anastomosis and digestive continuity is expected to be restored after 24-72 hours
- when the packing material must be removed

The **abdominal sepsis** may also justify an OA:

- trauma with enteral lesions (contusions or penetrating trauma) when the diagnosis is delayed
- occurrence of an anastomotic dehiscence

The **complex destructive visceral or abdomino-parietal injuries** may require OA:

- military conflicts and use of high-speed weapons with high loss of muscular-aponeurotic head

Indications of DCS in No trauma patients

Peritonitis

- Objective inability to control the source of septic contamination through a single operation
- State of shock and major metabolic imbalances that make it impossible to continue the operation or practice digestive anastomoses
- Significant visceral edema that increases the risk of ACS and justifies OA and a temporary closure technique

Indications of DCS in No trauma patients

Severe acute pancreatitis

- Difficult removal of peripancreatic necrotic and infected tissue in a single operative stage, so then OA and drainage of the collection resembling an abscess with a different location until final control of the septic source must be carried on
- Peripancreatic necrosis infection remains a major indication for surgical necrosectomy when percutaneous drainage techniques are incomplete but never performed earlier than 4-6 weeks (walled-off pancreatic necrosis is expected)
- If ACS requires OA in the first days after the onset of pancreatitis, no exploration of the peripancreatic space is warranted, as there is a risk of infection with sterile necrosis and the onset of uncontrollable bleeding

Indications of DCS in No trauma patients

Vascular emergencies

- Rupture of the aortic aneurysm (Grade 1C)
- The combination of the hemorrhagic shock with the massive transfusions contributes to the appearance of an important edema of the retroperitoneal, mesenteric and parieto-enteral space, the appearance of ascites and ACS
- Considered as a strategy associated with surgical management of mesenteric ischemia (Grade 2C)

Mesenteric ischemia may be due to thromboembolism or regional hypoperfusion, management includes restoration of intestinal perfusion and control of enteral viability with possible resection of necrotic areas. In some prospective studies, the incidence of ACS is significantly reduced when OA is indicated prophylactically. Another indication is the facilitation of a second look laparotomy for the assessment of enteral viability and/or the practice of an anastomosis resection

Complications of open abdomen

The entero-atmospheric fistula (EAF) or exposed fistula is defined as a communication between the gastrointestinal tract and the atmosphere.

It is perhaps the most dramatic complication in the evolution of the open abdomen with direct implications for mortality, duration and hospitalization costs.

The incidence of EAF varies in the literature from 4.5 to 25% in the open abdomen of traumatic indication and from 5.7 to 17.2% in non-traumatic laparostomas

2009 classification system	Amended classification system
1A Clean OA without adherences between bowel and abdominal wall or fixity (lateralization of the abdominal wall)	1A Clean, no fixation
1B Contaminated OA without adherence/fixity	1B Contaminated, no fixation 1C Enteric leak, no fixation
2A Clean OA developing adherence/fixity	2A Clean, developing fixation
2B Contanimated OA developing adherence/fixity	2B Contaminated, developing fixation 2C enteric leak, developing fixation
3 OA complicated by fistula formation	3A Clean, frozen abdomen 3B contaminated, frozen abdomen
4 Frozen OA with adherent/fixed bowel, unable to close surgically, woth or without fistula	4 Established enteroatmospheric fistula, frozen abdomen

Table 3. Classification of enteroatmspheric fistula

Anatomic location	
Proximal	Stomach, duodenum, jejunum, proximal ileus
Distal	Distal ileus, colon
Output volume	
Low	<200 mL/24 h
Moderate	200-500 mL/24 h
High	> 500 mL/24 h
Location inside the open abdomen	
Superficial	Drains on top of a granulating abdominal wound
Deep	Drains intestinal content inside the peritoneal cavity

Di Saverio S et al. “Classification, prevention and management of entero-atmospheric fistula: a state-of-art review” Langenbeck's Arch Surg. 2016;401:1-13

The **predictive factors** in the appearance of EAF:

- large intestinal resections,
- excessive volume load (> 5l/24h),
- increased number of intra-peritoneal re-examinations,
- remanence of intra-abdominal sepsis,
- iatrogenic lesions at initial dissection,
- presence of non absorbable prosthetic material in Temporary abdominal closure (TAC) and prolonged
- unprotected exposure of the general mass

Risk factors	Preventive measures
Bowel desiccation	-Protect the viscera with a fenestrated plastic sheet
	-Choose temporary closure systems that completely seal the abdominal cavity
Ischemic insult	-In case of NPWT, a trend toward lower suction pressures could avoid ischemic insult
Mechanical trauma	-Cover bowel with great omentum
	-Senior surgeon attending every dressing changes
	-Avoid any contact between temporary closure system and viscera
	-Avoid unnecessary aggressive tissue preparation and extensive debridement
	-Avoid prosthetic mesh application
Prolonged open abdomen	-Choose a temporary closure system able to prevent fascial retraction
	-Carefully plan dressing changes
	-Close abdomen as soon as possible

Preventive measures should include:

- early abdominal closure
- covering the enteral mass with epiploon / skin in TAC,
- banning the use of non-resorbable relation to the intestine
- or applying NPWT directly on the visceral mass

EAF **treatment:**

- The proximal bowel diversion is almost invariably impossible for mesentery retraction and edema, frozen abdomen, abdominal wall tissue loss or retraction so the target of the treatment is to completely divert the fistula output, protecting surrounding viscera and allowing clean granulation of the exposed bowel

- In general, it is recommended that the definitive surgical closure of EAF be delayed for 6-12 months during which time the inflammatory process and viscero-parietal lesions are resolved thus reducing the risk of enteral injury

- The surgery must oblige to resect the intestinal segment that communicates with the fistula, to restore digestive continuity and to cover the enteral mass through a parietal reconstructive procedure (Components separation technique or split- thickness skin graft)

Conclusions

OA management is mostly seen in trauma patients but the use of this technique and of OA-NPWT for non-trauma patients is increasingly becoming more common

In severe abdominal sepsis the OA may allow early identification of any remaining focus of infection, facilitate its elimination if surgically feasible or better mitigate its effect by appropriate surgical drainage.

Dynamic NPWT-TAC techniques may be effective in the removal of peritoneal fluid that may contain infected or cytokine-loaded (toxic lymph) fluid

Currently, the use of Vacuum-Assisted Closure therapy techniques followed by early closure of the abdominal fascia is, in most randomized trials, the *gold standard* for preventing the evolutionary complications of the OA

Conclusions

Because of the nature of the surgical pathology/injury, patients who are candidates for the OA may require multiple surgical interventions until either adequate control and/or definitive resolution of the index abdominal event has been achieved

This may be associated with significant complications, including enteroatmospheric fistulas, loss of abdominal wall domain and large abdominal wall hernias

For these reasons the use of OA remains very controversial and is a matter of great debate, as it is a non-anatomic situation with potential severe side effects and increased resource utilization

The lack of definitive data demands carefully tailoring the use of OA to each single patient, taking care to not overuse it

All possible precautions should be implemented to minimize complications

Results improve proportionate to the clinicians' team's experience with open abdomen management

Grazie per l'attenzione

Grazie per l'attenzione