The Management of the Open Abdomen - A Literature Review

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Rezumat

Managementul abdоменului deschis - recenzie a literaturii

O componentă esențială a conceptului de „Damage control surgery”, laparostomia, este procedura prin care abdomenul este abandonat în mod deliberat deschis, conținutul visceroperitoneal fiind protejat temporar prin multiple mijloace tehnice. Clasificarea actuală: Grad 1, fără aderențe viscero-parietale sau fixitate a peretelui abdominal (lateralizare), împărțit în: 1A curat, 1B contaminat și 1C fistulă enterală - pielea se consideră curată); Gradul 2, care dezvoltă fixarea se împarte în: 2A curat, 2B contaminat și 2C fistula enterală; Gradul 3, „abdomen înghețat”, se împarte în: 3A curat și 3B contaminat; Gradul 4, definit ca fistulă entero-atmosferică, este o fistulă permanentă asociată cu prezența țesutului de granulație și a unui “abdomen înghețat”. Indicațiile abdomenului deschis sunt: intervenția chirurgicală de control al leziunilor, sindromul de compartiment abdominal, peritonita, pancreatita acută severă, urgențele vasculare. Închiderea temporară a abdomenului se poate realiza prin următoarele metode: închiderea a tegumentului, „Bogota bag”, tehnica Sandwich opus, plasă sintetică absorbabilă, plasă neabsorbabilă sau fermoar comercial, “vacuum assisted closure”, fiecare cu propriile avantaje și dezavantaje. În ceea ce privește închiderea definitivă, aceasta poate fi realizată prin tehnici care nu folosesc plase sintetice. Tehnica de separarea a componentelor peretelui abdominal, anterioară sau posterioară ar trebui considerată procedura de reparare electivă în defectele parietale după laparostomie. Deși au fost publicate mai multe studii, încă nu există un consens în literatură de specialitate cu privire la poziționarea materialului protetic în raport cu planurile parietale. Unii autori sugerează rezultate mai bune față
An essential component of the concept of "Damage control surgery", laparostomy is the procedure by which the abdomen is deliberately abandoned open, the visceroperitoneal contents being temporarily protected by multiple technical means. Actual classification: Grade 1, without visceroperitoneal adhesions or fixity of the abdominal wall (lateralization), divided into: 1A clean, 1B contaminated and 1C enteral fistula - cutaneous skin is considered clean; Grade 2, which develops fixation is subdivided into: 2A clean, 2B contaminated and 2C enteral fistula; Grade 3, "frozen abdomen", is divided into: 3A clean and 3B contaminated; Grade 4, defined as enteroatmospheric fistula, is a permanent fistula associated with the presence of granulation tissue and a frozen abdomen. Indications of the open abdomen are: damage control surgery, abdominal compartment syndrome, peritonitis, severe acute pancreatitis, vascular emergencies. Temporary abdominal closure may be achieved by following methods: skin only closure, “Bogota bag”, oposite Sandwich technique, absorbable mesh, non-absorbable mesh or commercial zipper, vacuum assisted closure, each with its own advantages and disadvantages. Regarding the definitive closure this can be achieved by non mesh and mesh mediated techniques. Component separation technique anterior and posterior should be considered the elective repair procedure in parietal defects after laparostomy. Although several studies have been published, there is still no consensus in the literature on the positioning of prosthetic material in relation to parietal planes. Some authors suggest better results (relative to the rate of recurrence and complications) for implantation in the “sublay” position. Open abdomen is an important tool in the arsenal of the emergency surgery. Classification, indications, methods of temporary abdominal closure are evolving, as well as management of enterocutaneous fistulas and fascial closure, therefore permanent update is neccessary to offer patients the best care.

Key words: open abdomen, laparostomy, vacuum assisted closure, enterocutaneous fistula, temporary abdominal closure
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 (3). In the early 1980s, in the context of severe abdominal sepsis, Duff et 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 (4). After 1990, correlated with the understanding of the pathophysiology of the abdominal compartment syndrome (ACS) and the promotion of the damage control strategy in the management of the polytrauma patient, multiple techniques of temporary closure of the abdomen appear: Bogota bag (5), marlex zipper (6, 7), velcro adhesive sheets, absorbable and non-absorbable mesh (8) and sandwich technique (9).

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 open abdomen (10, 11).

### Classification of Open Abdomen

In 2007, the World Society of the Abdominal Compartment Syndrome (WSACS) reviewed and developed a Guideline for the Management of ACS (12). Following this step of rethinking and standardizing the definitions, Björck proposes in 2009 the preliminary version of an open abdomen classification (13) which he amends in 2016 as a result of the experience and results published by several surgical teams. Essentially, it is a revision of some items from the 2009 classification, changes highlighted comparatively in Table 1 (14).

The purpose of this classification is the evolutionary assessment of the patient’s clinical status, the standardization of guidelines and recommendations for open abdomen management and last but not least the homogeneous assessment of research results communicated on various samples of patients with complex lesions and various co-morbidities. The following amendments have been proposed: Grade 1, without visceroperitoneal adhesions or fixity of the abdominal wall (lateralization), divided into: 1A clean, 1B contaminated and 1C enteral fistula - cutaneous skin is considered clean); Grade 2, which develops fixation is subdivided into: 2A clean, 2B contaminated and 2C enteral fistula; Grade 3, "frozen abdomen", is divided into: 3A clean and 3B contaminated; Grade 4, defined as entero-atmospheric fistula, is a permanent fistula associated with the presence of granulation tissue and a frozen abdomen.

### Indications of Open Abdomen

In the broader context of the Damage Control Surgery (DCS) strategy, there are multiple situations that causally and pathophysiologically justify the use of the open abdomen (OA) as an extreme measure in the therapeutic algorithm of life-threatening conditions. This concept is configured to achieve several major objectives: control of peritoneal septic bleeding and

<table>
<thead>
<tr>
<th>2009 classification system</th>
<th>Amended classification system</th>
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</thead>
<tbody>
<tr>
<td>1A Clean OA without adherences between bowel and abdominal wall or fixity (lateralization of the abdominal wall)</td>
<td>1A Clean, no fixation</td>
</tr>
<tr>
<td>1B Contaminated OA without adherence/fixity</td>
<td>1B Contaminated, no fixation</td>
</tr>
<tr>
<td>2A Clean OA developing adherence/fixity</td>
<td>2A Clean, developing fixation</td>
</tr>
<tr>
<td>2B Contaminated OA developing adherence/fixity</td>
<td>2B Contaminated, developing fixation</td>
</tr>
<tr>
<td>3 OA complicated by fistula formation</td>
<td>3A Clean, frozen abdomen</td>
</tr>
<tr>
<td>4 Frozen OA with adherent/fixed bowel, unable to close surgically, with or without fistula</td>
<td>4 Established enteroatmospheric fistula, frozen abdomen</td>
</tr>
</tbody>
</table>

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**Table 1.** Open abdomen classification system (14)
contamination, prevention of abdominal compartment syndrome (ACS) and facilitating re-exploration through a "planned re-laparotomy" (15).

Certainly, the very good results of the intensive support measures, the development of more and more efficient commercial devices in Temporary Abdominal Closure (TAC) and the prevention of specific complications, have contributed to the widening of indications in traumatic and non-traumatic pathology (16).

**Open Abdomen in Trauma**

In polytrauma patients, persistent hypotension, acidosis, hypothermia (T < 34°C) and coagulopathy are predictors of severity requiring a Damage-control laparotomy and performing a laparostomy (WSES Guidelines 2018 · Grade 2A).

The risk factors that can lead to the installation of compartment syndrome (ACS) are: the presence of retroperitoneal hemorrhage or packing in major lesions of the parenchymal visera 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 (17). Other factors have been described in the genesis of ACS: associated liver cirrhosis and respiratory failure (18). In this context, the open abdomen (OA) remains the saving gesture concomitant with other procedures in the therapeutic algorithm: nasogastric aspiration, colonic decompression, prokinetic agents, adequate mechanical ventilation, sedation or neuromuscular blockade, control of volume resuscitation (18,19,20).

Scheduling a "second-look operation" may be another indication of keeping the abdomen open in the context in which the index intervention has been stopped or shortened for hemorrhagic reasons and/or shock; when there are obvious signs of evolutionary enteral ischemia that have required resections without anastomosis and digestive continuity is expected to be restored after 24-72 hours, but also when the packing material must be removed (15).

In most cases with enteral lesions (contusions or penetrating trauma) when the diagnosis is delayed or when anastomotic dehiscence occurs there is also abdominal sepsis, a lesional context when the indication of an open abdomen becomes perfectly justified (16).

The presence of military conflicts and the use of an arsenal that includes high-speed weapons, face emergency surgery with complex destructive visceral or abdomino-parietal injuries, with high loss of muscular-aponeurotic head and where the reasonable solution remains the open abdomen and a way to temporarily close (Temporary abdominal closure) until reconstructive procedures become feasible (21).

**Open Abdomen in Non-Trauma Patients**

**Peritonitis**

In severe abdominal sepsis, OA and the staging of surgical procedures remain a strategy validated by at least 3 conditions. First of all, the objective inability to control the source of septic contamination through a single operation (22). The second eventuality is the state of shock and major metabolic imbalances that make it impossible to continue the operation or practice digestive anastomoses (23). The last argument is the significant visceral edema that increases the risk of ACS and justifies OA and a temporary closure technique (TAC) (24).

**Severe acute pancreatitis**

Beginning in the 1970s, most surgeons understood that removal of peripancreatic, necrotic, and infected tissue was difficult to achieve in a single operative stage, which is why they proposed OA and drainage of the collection resembling an abscess with a different location until final control of the septic source. It has been shown that the still high rate of mortality in severe forms of pancreatitis is due to the non-recognition of conditions leading to ACS and multivisceral insufficiency (MOP) as
well as the random, non-standardized application of drainage techniques (25,26).

Peripancreatic necrosis infection remains a major indication for surgical necrosectomy when percutaneous drainage techniques are incomplete (27) but never performed earlier than 4-6 weeks (walled-off pancreatic necrosis is expected) (28).

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 (29).

**Vascular emergencies**

Open abdomen (OA) is recommended as a highly factual procedure in rupture of the aortic aneurysm (Grade 1C) and considered as a strategy associated with surgical management of mesenteric ischemia (Grade 2C) (WSES Guidelines 2018).

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. The onset of compartment syndrome is reported in 8-20% of cases with a mortality rate of 30-50% (30).

Mesenteric ischemia (arterial/venous) may be a consequence of thromboembolism or regional hypoperfusion, and principles of therapeutic management include 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. Although the indications are not yet standardized, the impossibility of closing the parietal without tension, the loss of more than 5l of perioperative blood and the use of the occlusive aortic balloon, may be justified indications in major vascular emergencies (31,32). When using a vascular graft, the risk of its infection in OA conditions remains very low (33).

Another indication of OA in the management of mesenteric ischemia is the facilitation of a second-look laparotomy for the assessment of enteral viability and / or the practice of an anastomosis resection (33).

**Fascial Closure**

Essentially, the abdominal fascia should be closed when the risk of abdominal compartment syndrome (ACS) is fined, the source of abdominal sepsis is controlled, and iterative re-laparotomy procedures are no longer anticipated.

Chronologically, the fascial closure procedure can be performed in 2 moments, defined in the medical literature as early closure (early fascial closure) in the first 4-7 days before the moment of laparostomy and late closure (delayed fascial closure) completed after 7 days from the index operation (34).

Priority, after achieving the objectives that validated the indication for laparostomy, remains the early and definitive closure of the abdominal fascia to prevent enterocutaneous fistula and avoid fascial retraction with the appearance of large postoperative events.

Chen Y et al (2014) comparatively analyze in a systematic review and meta-analysis (35) the advantages of early closure over delayed fascial closure by emphasizing a lower mortality rate (12.3% vs 28%) and a decrease in complications postoperative (RR, 0.68, p <0.0001).

**Temporary Abdominal Closure**

Ideally, this procedure should protect the viscero-abdominal contents, prevent evisceration, remove intraperitoneal septic exudate, prophylaxis of enterocutaneous fistula, preserve muscle-aponeurotic capital, facilitate planned laparotomies and achieve optimal conditions (9,21,36,37). Unfortunately, none of the temporary closure techniques can achieve these goals alone.

In the last 20 years, multiple surgical procedures to complete the temporary closure (TAC) have been proposed, the option to one or the other of which being a continuous and responsible challenge of the surgical team. The decision must be adapted to the patient's
biological condition, prevention of post-laparostomy complications and available financial resources (38,39). Temporary closure techniques (TACs) can be classically grouped into 3 categories: skin-only closure, patch closure and vacuum-assisted closure (40).

In 2015, Sartelli and a multicenter team published in the World Journal of Emergency Surgery (11) a critical comparative analysis of TAC procedures that is illustrated in Table 2.

Skin-only closure uses either a single skin suture (frequently surjet) or operator field tweezers (towel clips). Although several recent publications (consensus conferences and guidelines) propose the abandonment of this technique (21) attributing to the procedure ischemic necrotic and infectious skin complications, a relatively high rate of persistent ACS (18.5%) and a moderate risk of entero-cutaneous fistula (6%), in hostile and economically precarious environments can offer a number of advantages: fast closure, cheap, low mortality rate, prevents excessive loss of intraperitoneal fluids while maintaining visceral temperature.

The "Bogota bag" technique imagined by Oswaldo Borraez in 1984, popularized in the literature by Mattox (41), has similar advantages to skin-only closure but does not prevent muscle-aponeurotic retraction resulting in major difficulties of late parietal closure (Delayed fascial closure). The primary closure rate reported in the literature varies within very wide limits, 12-82% (36).

Patch-closure techniques (Mesh, Witmann patch or Zipper) create parietal tension-free and facilitate intraperitoneal re-exploration. The prosthetic material can be removed in re-laparotomies and the parietal tension can be adjusted by median plication. Classically the adjustments are made every 24-48 hours until the fascial edges are close to about 2-4 cm offering the possibility of primary closure (42,43). The use of devices for dynamic modeling of fascial tension allowed the primary closure to be achieved at intervals exceeding 50 days (44).

Various types of materials have been proposed, starting with polypropylene (which is attributed to an increased rate of entero-atmospheric fistula, continuing with polytetrafluoroethylene (ePTFE) less adherence to the visceral content and ending with absorbable meshes (polygactin and polyglycolic acid) at a rate. The use of non-absorbable TAC nets is associated with a primary closure rate of 33-89% (20).

Witmann describes in 1990 the technique

Table 2. Critical comparative analysis of TAC procedures (11)

<table>
<thead>
<tr>
<th>Technique</th>
<th>Equipment</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Skin only closure</td>
<td>Skin staples, towel clips or sutures</td>
<td>Cheap, available, minimises heat and fluid loss</td>
<td>Damage to the skin, risk of evisceration, no control of fluid loss, may develop ACS</td>
</tr>
<tr>
<td>&quot;Bogota bag&quot;</td>
<td>Sterile 3 litre saline bag cut and shaped and sutured to fascial edges</td>
<td>Cheap, available, minimises heat and fluid loss</td>
<td>Damage to the fascial edges, risk of evisceration, no control of fluid loss. Allows some assessment of intestinal viability</td>
</tr>
<tr>
<td>Opsite Sandwich technique</td>
<td>Polyethylene sheet, opsite dressings, abdominal packs, 2 suction drains and wall suction</td>
<td>Cheap, available, minimises heat and fluid loss is controlled and measurable</td>
<td>Incomplete fluid control and need for available wall suction</td>
</tr>
<tr>
<td>Absorbable mesh</td>
<td>Vicryl or similar MESH</td>
<td>Absorbable mesh, infection resistance, protects from evisceration, can be skin grafted</td>
<td>High rate of subsequent incisional herniation</td>
</tr>
<tr>
<td>Non absorbable mesh or commercial Zipper</td>
<td>Commercial Whitmann patch</td>
<td>Abdominal re-exploration is easy, maintains abdominal domain, gradual abdominal closure possible</td>
<td>Commercial equipment required and repeated operation needed for closure</td>
</tr>
<tr>
<td>Vacuum assisted Closure</td>
<td>commercial kit</td>
<td>Prevents loss of abdominal domain, collects and monitors fluid loss, decreases ACS, no damage to skin and or abdominal fascia</td>
<td>Expensive commercial equipment required. Usually requires general anesthesia to change the kit</td>
</tr>
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that bears his name using a Velcro patch (8) that facilitates the re-exploration of the peritoneal cavity through the slit that separates the 2 superimposed sheets in the middle. The method remains prohibitive in terms of costs (about 1440 USD / patient) with a primary closure rate of 65.7-100% and an incidence of entero-cutaneous fistula of 0-42% (43,45).

Zipper closure system published by Leguit in 1982 (46) allows the planned iterative exploration of the peritoneum with the indication of choice peripancreatic abscesses (47). The primary closure rate of the fascia varies between 50-100%.

Negative pressure therapy (NPT) is currently the most recommended method of temporarily closing the abdomen. In its classic sense proposed by Barker and Brock in 1995 (48) 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). The method is inexpensive, easy to apply and manage, protecting the viscer, facilitating the outflow of septic fluids, preventing visceroparietal adhesions and partially fascial retraction. Aspiration at a pressure of 100-150 mmHg is initiated for 48 hours continuously and then applied intermittently in conjunction with individual circumstances.

Barker reports in a study published in 2007 (49) a primary closure rate of 68.1% and an incidence of enterocutaneous fistula of 5%. VAC and ABThera commercial devices with minimal technical design changes (ABThera extends visceral draping to parachute gutters) achieve the same goal of fascial closure rate and fistula incidence but at significantly higher costs (ABThera sponge 350 USD and rental cost of suction machine 67.5 USD/day) (50). By using absorbent sponges, commercial NPWT devices have the advantage of reducing the indication of frequent change of soft material fields (used by the Barker technique).

Patients treated with Negative Pressure Wound Therapy (NPWT) have been shown to reduce intestinal edema and increase local blood perfusion, which accelerates the growth of granulation tissue and reduces local microbial growth (51).

Superior results were obtained if the VAC was combined with the Dynamic Retention Suture (ABRA) technique. In a prospective study combining both methods, Pliakos in a sample of 111 patients reported (52) a primary closure rate of 76.6%, an incidence of entero-cutaneous fistula of 7.2% and a mortality of 29.7%. In the 2018 WSES Guide, Coccolini et al (7) recommend NPWT combined with fascial traction as the standard method in temporary closure (Grade 1B). Similarly, Atema et al in a systematic review including 4358 patients, reported in the series in which NPWT was associated with mesh or suture-mediated fascial traction procedures a significant decrease in the incidence of entero-cutaneous fistula to 5.7% compared to NPWT used. the only one where the rate was 14.6% (53).

In conclusion, the priority for the reduction of mortality, complications and length of hospitalization remains the definitive early closure of the abdomen, this desideratum being directly influenced by the quality of the postoperative management in the intensive care unit and the TAC procedure adopted.

**Definitive Closure**

In the situation of prolonging the condition of the open abdomen, the lateralization by retraction of the abdominal fascia causes large parietal defects that fortuitously require complex surgical solutions. (53)

From a surgical point of view, the options for permanent closure of the abdomen after laparostoma can be grouped into 2 categories: non-mesh-mediated closure techniques and techniques that use prosthetic material (mesh-mediated closure).

Non-mesh-mediated closure are techniques not recommended in temporary abdominal closure (WSES Guidelines). They are reserved for final closure only (Grade 2C) (15).
this decision-making context, abdominal "components separation technique" should be considered the elective repair procedure in parietal defects consequent to laparostomy (54) with 75% success rate (55). Anatomically, the separation of the parietal components can be achieved by anterior or posterior approach.

In 1990, Ramirez et al proposed a technique for reconstructing large postoperative events with significant retraction of the fascial component, which they called the "Components separation technique." The intervention is based on the dissection and translation of the parietal planes in such a way that the coverage of the visceral mass is possible (54).

In the previous approach, the skin and subcutaneous tissue dissected from the anterior sheath of the right rectus abdominis and the aponeurosis of the external oblique, the latter being sectioned at a distance of 2 cm, laterally from the right sheath of rectus abdominis. Subsequently, the external oblique muscle is split from the internal one, as much as possible; another relaxation incision at the level of the inner edge of the right rectus abdominis muscle allows a good relaxation of the musculo-aponeurotic planes facilitating the median suture (Fig. 1).

In the posterior approach, the right abdominal sheath is sectioned longitudinally allowing the cleavage between the posterior sheet and the muscular body; subsequently at the wide edge of the right muscle, the transverse aponeurosis is incised with the separation of the internal oblique from the transverse muscle.

Despite the very good results, especially in the large parietal defects, with a recurrence of the eventration of only 16% (56), the technique also has some imputable elements. Excessive lateral mobilization of the skin and subcutaneous tissue on the fascial plane generates an anatomical space prone to seromas and / or hematomas that can become secondary infection. Second, the transection of perforating vessels emerging from the epigastric vessels at the time of superficial plane cleavage can lead to parhial ischemia and soft tissue necrosis of the midline. Last but not least, dissection and sliding of the skin and subcutaneous tissue on the fascial plane can become difficult in the pre-existence of enterostomies (57).

Mesh-mediated closure. The WSES guidelines (2018) stipulate that the use of non-resorbable nets in the definitive closure of laparostomy is not recommended or should be accepted only in situations where there is no other alternative (Recommendation Grade 1B) while biological nets are electively recommended for large parietal defects with local microbism in patients with co-morbidities (Grade 2B) (38).

Remote follow-up of patients using "biological mesh bridging" showed a relatively high rate of herniated recurrence in discordance with excellent short-term results in curing the parietal defect. The term "bridging technique" defines the interposition of the prosthetic material between the fascial edges when the retraction lateralization of the fascia does not allow suturing with the patient's native material. In fact, in the absence of a protective layer between the wall and the visceral contents, the non-resorbable material will generate, following the inflammatory response and local microbism, adhesions, visceral erosions and the risk of entero-atmospheric fistula (58).

In a recent meta-analysis, Sharrock et al. (59) report a recurrent eventration rate of

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**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

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51% one year apart highlighting real differences between trauma patients and those with laparostoma indication for severe abdominal sepsis.

In another meta-analysis and systematic review, Atema et al. (2016) report a recurrence rate of ventral hernia of about 30% when using biological material vs. 7% for non-resorbable prosthetic material, stating that the results may be affected by the heterogeneity of the samples included in the study (60).

The association of NPWT with a procedure that uses "biological bridging mesh" facilitates the appearance of tissue granulation and healing (61).

Both et al. comparing the use of prosthetic material as an adjunct to parietal reinforcement in primary fascial closure vs. "bridging technique" highlights a significantly higher recurrence for the 2nd sample (8 vs 56%; p < 0.001) (62).

Although several studies have been published, there is still no consensus in the literature on the positioning of prosthetic material in relation to parietal planes. Some authors suggest better results (relative to the rate of recurrence and complications) for implantation in the sublay position (63).

Management of Enteroatmospheric Fistula

The entero-atmospheric fistula (EAF) or exposed fistula is defined as a communication between the gastrointestinal tract and the atmosphere (64).

It is perhaps the most dramatic complication in the evolution of the open abdomen with direct implications for mortality, duration and hospitalization costs (65). The incidence of EAF varies in the literature from 4.5 to 25% in the open abdomen of traumatic indication (66) and from 5.7 to 17.2% in non-traumatic laparostomas (53).

In the prospective multicenter study using the AAST Open Abdomen Registry, Bradley et al. identifies a number of predictive factors in the appearance of EAF: large intestinal resections, excessive volume load (> 5l/24h), increased number of intraperitoneal re-examinations, remanence of intra-abdominal sepsis, iatrogenic lesions at initial dissection, presence of non-prosthetic material absorbable in Temporary abdominal closure (TAC) and prolonged, unprotected exposure of the general mass (66,67).

Preventive measures logically derive from amending these conditions: early abdominal closure, covering the enteral mass with epiploon / skin in TAC, banning the use of non-resorbable prosthetic material in direct relation to the intestine or applying NPWT directly on the visceral mass (68,69).

A recent review (Bruhin et al.) highlights the high incidence of EAF in the open abdomen in abdominal sepsis compared to non-septic open abdomen (12.1% vs. 3.7%) (70). Similar findings are reported in the published series. By Tavusbay in 2014 (71) for laparostomy of abdominal sepsis where the incidence of EAF was 54.5% closure rate using NPWT was 22%, the average duration of VAC therapy was 43.6 days and mortality was 44.4%.

Classification of entero-atmospheric fistula (EAF) is essential in establishing the therapeutic algorithm. Schein and Decker proposed a location-related classification in 1991 (72), but the most complete remains the classification published by Di Saverio et al. In 2015 (73) based on anatomical location (proximal/distal), fistula flow (low, moderate, high), superficial or deep exposure and number of fistulous orifices (Table 3).

Some general considerations may be predictable for the evolution of fistula. Thus, a superficial exposure with distal intestinal

| Table 3. Classification of enteroatmospheric 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 |
origin and low flow is more likely to close spontaneously than deep, multiple, high flow locations (74).

Based on these principles, the treatment must always be adapted to each patient, correlated with the biological status and characteristics of the fistula. Spontaneous closure is exceptional because the entero-atmospheric fistula has no anatomical trajectory and there is no vascularized tissue support to cover the fistulous orifice.

The main purpose of treatment should be to control the fistulous efflux and to facilitate the granulation of the underlying visceral bed. The essential components of the therapeutic strategy can be summarized in the acronym "SNAP": management of sepsis and skin, nutritional support, anatomical location and procedure to deal with the fistula (75).

Externalization and proximal surgical diversion of the fistula are practically impossible to achieve considering the mesenteric retraction, the inflammatory edema and the appearance of "frozen abdomen". For these reasons, EAF management should follow (73,74):

- output reduction by strictly parenteral feeding (at least in the first phase), proton pump inhibitors (PPI); the use of somatostatin / octreotide remains controversial,
- control and correction of hydro-electrolytic and acid-base imbalances,
- correction of hypercatabolic status.

Sepsis control

Protection of the visceral bed against the corrosive aggression of the intestinal secretions with the intention of granulation and preparation for the final treatment

Parenteral nutrition plays a key role in the management of these patients and should be initiated early by reducing local septic complications and balancing the nitrogen balance with protein supplements (WSES Guidelines 2018 · Grade 1C Recommendation).

Hypertabolic state is associated with muscle proteolysis, impaired immune function and the appearance of MOF (76).

Multiple fistulous efflux diversion techniques and types of protective dressings have been described in the literature, customized according to the patient and the characteristics of the fistula: "Floating stoma", Fistula and VAC tube, Baby bottle nipple VAC, Fistula patch and Fistula plug, Suspension stoma conversion (77-81). Any fistula intubation maneuver is a serious error, the final effect not being the flow control but the enlargement of the fistulous orifice (69).

The latest consensus conferences propose NPWT in conjunction with accessory devices that isolate the fistulous tract as the method with the best results in closing the EAF. (WSES Guidelines 2018 · Grade 2A Recommendation).

Occasionally, the fistula of small size and eccentric at the level of the dehiscent area can be covered with slipped skin fascia / flap, realizing the healing premises through the overlying vascularized tissue (69).

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 visceral-parietal adhesions 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) (82).

Management of open abdomen has undergone some amendments of the classification. Indications are generally still the "classic" ones. Many methods are recognized and accepted for the temporary abdominal closure. Each has its own specific advantages and disadvantages, choice bing made accordingly and to the specificity of each case. Definitive closure uses mesh and non mesh related tecines, both of them requiring a certain level of proficiency.
Conclusions
Open abdomen is an important tool in the arsenal of the emergency surgery. Classification, indications, methods of temporary abdominal closure are evolving, as well as management of enterocutaneous fistulas and fascial closure, therefore permanent update is necessary to offer patients the best care.

Conflict of Interest
The authors declare no conflicts of interests.

References