The open abdomen treatment (or laparostomy) is a surgical strategy, resulting from the decision of leaving the peritoneal cavity open anteriorly. Hence, the viscera are exposed and temporarily covered by different methods. Today, open abdomen management is particularly indicated in patients affected by severe abdominal trauma or diffuse intra-abdominal infection, and in patients with acute mesenteric ischemia or severe necrotizing pancreatitis. Indications which could be summarized in the so-called "hostile abdomen" (1); finally, laparostomy may be the solution for the most dangerous complication of these conditions: the abdominal compartment syndrome.

Open abdomen technique sometimes needs a number of peritoneal cavity revisions, and in the post-operative phase it requires an accurate knowledge of surgical pathophysiology, an appropriate intensive care support and an extraordinary nursing presence. The increasing diffusion of the above-mentioned diseases and the abdominal multivisceral lesions after road accidents are expected in the near future to increase use of this surgical option.

James Hogarth Pringle, Australian surgeon well-known for his proposal to clamp the hepato-duodenal ligament during liver resection (Pringle maneuver), graduated in medicine from Edinburgh University and he was appointed surgeon to the Glasgow Royal Infirmary. Thereafter, at the beginning of XX century, Pringle treated a lot of liver traumas and major abdominal vascular lesions by gauze packing, therefore, he left the abdomen open for subsequent delayed revisions. In the Annals of Surgery (1908), he resumed his frustration under these situations:

"Rupture of the liver is fortunately an accident not often met with but one which, when it is seen, may be associated with a condition of the patient as serious as anyone can meet in the surgical practice. While small lacerations of the liver substance may be, and no doubt are, recovered without surgical interference; if lacerations are extensive and vessels of any magnitude are torn hemorrhage will, owing to the structural arrangement of the liver, go on continuously and by the time such a patient comes under the care of a surgeon, the general state is almost invariably bound to be extremely grave from the hemorrhage alone or from hemorrhage and shock combined. This is perhaps especially the case in that class of injury due to contusing violence in which there is often gross injury inflicted on parts other than the liver and when shock is liable to be more severe than in localized injuries caused by sharp instruments" (2).

Nevertheless, the adoption of packing resulted in many treatment failures and its diffusion had been early stopped, because of uncontrollable bleeding after gauze removal and subsequent severe sepsis.

In 1913 Halsted reintroduced this method: in order to reduce the bleeding risks, he placed some foils of gutta percha between viscera and gauze (3). In reviewing the experience over the period of the Second World War, during the Hunterian Lecture at the Royal College of Surgeons of England in 1969, 19th June Alexander Walt, Chairman of Department of Surgery of Wayne State University of Detroit, stated that there was virtually no place in modern surgery for gauze packing and delayed
to resuscitate”, the new concepts of extended. Given the improved understanding of the mechanisms leading to the so-called “failure
tic option only for patients with severe abdominal trauma; subsequently its applications have been
extended. Given the improved understanding of the mechanisms leading to the so-called “failure to resuscitate”, the new concepts of intra-abdominal hypertension and compartment syndrome were defined. In this way, the cooperation with the intensive care teams and, hence, the multidiscip-
licity opened new, complex and intriguing perspectives.

In 1993 Michael F. Rotondo, at the University of Pennsylvania School of Medicine, codified the damage-control laparotomy (9): its assumptions support the “paradigm shift”, according to the Open Abdomen Advisory Panel (OAAP) of University of Louisville (10), which occurred over the past 20
years in patients requiring emergency abdominal surgery: from immediate definitive closure toward an abbreviated (or damage-control) laparotomy, after which the abdomen is left open.

Today, this technique is very common and it is properly considered a safe treatment option for emergency surgery: often laparostomy can be cautiously indicated in order to assess the evolution of abdominal process (both infection and ischemia), without any clear signal of abdominal hyper-
tension or wall defect impossible to close. In fact, up to date the indications for open abdomen
include mesenteric ischemia, severe and diffuse peritoneal infection, uncontrollable bleeding from venous lesions (after trauma or not), large wall defects (from necrotizing infection also) and deve-
lopment of compartment syndrome (intra-abdominal pressure > 20 mmHg with worsening hypother-
mia, acidosis and coagulopathy) (11,12).

Consistently with the above-mentioned definition of “paradigm shift”, we observe that more than half of the publications dedicated to the issue of “open abdomen” can be found in the literature only from 2005 at the moment of this editorial. Our experience is consistent with this data: from 1988 we treated by laparostomy 123 patients, 79 patients (64%) from 2005 to today. However, also in our
practice open abdomen approach has been used on the basis of the surgeon’s experience (the “clinical judgment” according to Alexander Walt), rather than defined guidelines. In fact, the OAAP acknow-
ledges that to date no recommendations for open abdomen treatment is based on unquestionable evidence and most of them derive from “expert opinions” (or from small observational studies).

In 2002, Moshe Schein (general surgeon of Bronx-Lebanon Hospital Center of New York), author
of the well-known book "Schein’s common sense emergency abdominal surgery", doubted whether open abdomen treatment (particularly for intra-abdominal infection) could be ever supported by the evi-
dence (13). He pointed out that proper randomized controlled trials which compare open abdomen
versus conventional surgical approaches are almost impossible to perform. In fact, the great vari-
ability of patients and the emergency surgical indications are not compliant with the slow and rigo-
rous randomization process. Therefore, the author suggested only a classification for “surgical ab-
domen”, according to “clinical judgment”: abdomen which cannot be closed (for major loss of ab-
dominal-wall tissue or extreme visceral or retroperitoneal swelling), and abdomen which should not be closed (for planned re-evaluations or prevention of compartment syndrome). Finally, Schein left two provocative questions without answers: is open abdomen beneficial? Additionally: when to stop open abdomen management?

We can answer to these questions according to our experience: laparostomy is effective beca-
use in our series mortality was < 25% (29/123), in a patients population with a mortality rate steady around 30% and up to 50% (13). Moreover, consistently with our conclusions, in a recent report about treatment of severe necrotizing pancreatitis (14), we would answer that the abdomen should be closed as soon as possible, but only when the peritonitis sources, the peritoneal toilet, the swelling of viscera (as well as their edema and vitality) are controlled.

Regarding to the first answer, also the OAAP does not advance any doubt, and it defines the open abdomen as approach to abdominal catastrophes that saves lives (10). Indeed, in the view suggested by Schein, in most abdominal emergencies we have no alternatives to open abdomen.

The timing for closure of abdomen represents a more complicated issue. Time for closure is clo-
Open abdomen management: why, when and how?

sely related to patient’s conditions and to some effects of treatment itself. Reviewing “achievements and challenges” of open abdomen (15), Rao Ivatury of Medical College of Virginia clarified these aspects. “Patient’s conditions” would mean the multi-organ failure deriving from the inflammatory cascade due to injury (sometimes also from a prolonged laparostomy). Instead, among the “effects of treatment”, we should include the protein loss (i.e., the need of enteral feeding), the enter-atmospheric fistulas, the intra-abdominal pressure control, and long-term complications (e.g., ventral hernia). Finally, we must add the treatment costs (surgery, anesthesiology, ICU): a factor that cannot affect the closure timing, but is closely related to treatment duration.

Therefore, the time for definitive closure of abdomen represents the result of the (unstable) balance between the clinical judgement of the surgeon and the changes in the clinical (and abdominal) conditions. In this context, the OAAP suggests that the process of closing the wound should begin at the first return to the operative room. In fact, the aim of the first procedure is to facilitate the access to abdominal cavity (better by laparotomy extended from xiphoid to pubis), the viscera exploration, and the bleeding/infection sources control and, at the same time, to reduce intra-abdominal pressure. Instead, the goal of first surgical revision of abdomen (planned 24-48 hours after the first operation) is to check viscera, to remove packing and to proceed to the reconstructive phase (anastomoses, stoma, etc.), as well as to begin the abdomen closure or, more frequently, to perform a temporary closure. This solution allows subsequent revisions without lesions for the abdominal wall and its components. Surgeons should conclude revisions with a temporary closure in order to protect abdominal contents, to prevent evisceration, to manage fluid loss and to avoid damage to the fascia in view of definitive closure. This last phase can be completed (also in several steps) after having verified resolution of viscera edema (or ischemia), of infection and of intra-abdominal hypertension by repeated controls.

The abdominal closure can take advantage of many tools and devices that shorten the time to closure. Though useful, they further complicated the methodological aspects of studies on open abdomen. This is so true that all the OAAP recommendations (except for the extension of laparotomy and the early enteral feeding) regard the abdominal closure, temporary or definitive, and the available devices. When surgeons select laparotomy management, they should be conscious that the skin-only closure techniques cannot be used anymore (due to the high risk of recurrent intra-abdominal hypertension). Instead, they should be able to use the different devices with versatility. Among devices for temporary closure, surgeons should know different options: 1) Bogotà bag (a silo made from a sterile, plastic intravenous bag sutured to the skin); 2) mesh (absorbable or not, sutured to the fascial edges); 3) negative pressure techniques (that exert a continuous or intermittent negative pressure by a suction source on a synthetic sheet in contact with the viscera).

The device satisfying all the needs of an ideal temporary closure does not exist yet. Recent literature (10,16) reports that the use of Bogotà bag does not preserve domain nor contribute to eviscerate management, and it is not free from the risks of abdominal infection and hypertension. Again, the synthetic repair materials (mesh) prevent evisceration, but their use can often result in enter-atmospheric fistulas, as well as in recurrent abdominal infection and hypertension. The negative pressure systems represent the best devices, and their prolonged use can also promote the formation of granulation tissue, which is the basis for a definitive closure by “second intention” healing in selected cases. Moreover, with regard to definitive closure, the Bogotà bag and the non-absorbable mesh (as a bridge between the retracted fascial edges) are contraindicated, and the use of absorbable mesh resulted in discouraging outcomes. With these premises, the negative pressure systems are the only devices with a good safety profile for both temporary and definitive closure of the abdomen. Among repair materials, the only biological mesh (for example, from human or porcine acellular dermal matrix) would be safe and effective for definitive closure (although not completely evaluated in clinical practice). These materials seem to resist infections and to promote granulation tissue on mesh scaffold, even when used as a bridge between the fascial edges.

Finally, another surgical option could be to delay definitive closure, resulting in a ventral hernia to be repaired later. However, the decision about the fascial defect reduction and the definitive closure should be made within two weeks from the first laparostomy (10). Again, this timing has been suggested by literature according to the good common sense, the “judicious” arrangement between a prolonged open abdomen and the clinical and surgical patient conditions. Therefore, the mean time to closure - as well as patients outcome - varies widely (from 3 to 46 days according to the literature (17,18).
In our experience (mean time to closure: 12 days), we observed two extreme cases with the laparostomy prolonged until 80 days and in both cases with success. This episodic data does not have any scientific value, but indicates that open abdomen issue is inadequate for codifications and classifications. Recently, we replied to Björck et al. who presented a surgical classification of different technical patterns occurring during the laparostomy management (19,20). They proposed this classification in order to predict the clinical appropriateness of the indication, and the timing of primary delayed fascial closure. Instead, we pointed out that, if possible, we could predict the right time for closure only after the identification of reliable clinical indicators of a successful final outcome. These indicators should not be exclusively technical or surgical (20).

In order to identify these predictive factors, recently we began to collect the detailed data of our open abdomen series deriving from a 20-year experience, hoping that this retrospective database could provide results reliable in clinical practice.

References

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