

Open abdomen management: why, when and how?

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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 manoeuvre*), 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

abdomen revision (4). However, 10 years later, during the *Founder's lecture*, Walt himself admitted that the “judicious” surgeon who chooses this method should in no way fear the whispered loss of his surgical manhood (5). In fact, in the same department, Charles E. Lucas and Anna M. Ledgerwood reintroduced the technique with a prospective study from 1968 to 1973 (6). Subsequent studies by Roy Calne of Cambridge (7) and by David V. Feliciano of Houston (8) were published confirming the possible value of the procedure.

More recent scientific reports have justified the treatment of different abdominal emergencies by open abdomen approach. In fact, the delayed surgical revision of the abdomen was a therapeutic 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 multidisciplinary nature 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 signs of abdominal hypertension 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 development of compartment syndrome (intra-abdominal pressure > 20 mmHg with worsening hypothermia, 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 acknowledges 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 evidence (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 variability of patients and the emergency surgical indications are not compliant with the slow and rigorous randomization process. Therefore, the author suggested only a classification for “surgical abdomens”, according to “clinical judgment”: *abdomen which cannot be closed* (for major loss of abdominal-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 because 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-

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 entero-atmospheric fistulas, the intra-abdominal pressure control, and long-term complications (e.g., ventral hernia). Finally, we must add the treatment costs (surgery, anaesthesiology, 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 laparostomy 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) *Bogotá 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 Bogotá bag does not preserve domain nor contribute to exudate 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 entero-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 Bogotá 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

1. Leppäniemi AK. Laparostomy: why and when? *Crit Care* 2010;14:216.
2. Pringle JH. Notes on the Arrest of Hepatic Hemorrhage Due to Trauma. *Ann Surg* 1908; 48:541-9.
3. Halsted WS. Ligature and suture material. Also, an account of introduction of rubber gloves, gutta percha tissue and silver foil. *Jour Am Med Assoc* 1913; LX: 1119.
4. Walt AJ. The surgical management of hepatic trauma and its complications. Hunterian Lecture delivered at the Royal College of Surgeons of England. *Ann R Coll Surg Engl* 1969; 45: 319-339.
5. Walt AJ. Founder's lecture: The mythology of hepatic trauma—or Babel revisited. *Am J Surg* 1978;135:12-18.
6. Lucas CE, Ledgerwood AM. Prospective evaluation of hemostatic techniques for liver injuries. *J Trauma* 1976; 16: 442-451.
7. Calne RY, McMaster P, Pentlow BD. The treatment of major liver trauma by primary packing with transfer of the patient for definitive treatment. *Br J Surg* 1979; 66: 338-339.
8. Feliciano DV, Mattox KL, Jordan GL Jr. Intra-abdominal packing for control of hepatic hemorrhage: a reappraisal. *J Trauma* 1981; 21:285-290.
9. Rotondo MF, Schwab CW, McGonigal MD, et al. 'Damage control': an approach for improved survival in exsanguinating penetrating abdominal injury. *J Trauma* 1993; 35: 375-382.
10. Open Abdomen Advisory Panel, Campbell A, Chang M, Fabian T, Franz M, Kaplan M, Moore F, Reed RL, Scott B, Silverman R. Management of the open abdomen: from initial operation to definitive closure. *Am Surg* 2009; 75:S1-22.
11. Balogh Z, McKinley BA, Holcomb JB, Miller CC, Cocanour CS, Kozar RA, Valdivia A, Ware DN, Moore FA. Both primary and secondary abdominal compartment syndrome can be predicted early and are harbingers of multiple organ failure. *J Trauma* 2003; 54:848-59.
12. Schecter WP, Ivatury RR, Rotondo MF, Hirshberg A. Open abdomen after trauma and abdominal sepsis: a strategy for management. *J Am Coll Surg* 2006; 203:390-6.
13. Schein M. Surgical management of intra-abdominal infection: is there any evidence? *Langenbecks Arch Surg* 2002; 387:1-7.
14. Cinquepalmi L, Boni L, Dionigi G, Rovera F, Diurni M, Benevento A, Dionigi R. Long-term results and quality of life of patients undergoing sequential surgical treatment for severe acute pancreatitis complicated by infected pancreatic necrosis. *Surg Infect (Larchmt)* 2006; 7:S113-6.
15. Ivatury RR. Update on open abdomen management: achievements and challenges. *World J Surg* 2009; 33:1150-3.
16. Diaz JJ Jr, Cullinane DC, Dutton WD, Jerome R, Bagdonas R, Bilaniuk JO, Collier BR, Como JJ, Cumming J, Griffen M, Gunter OL, Kirby J, Lottenburg L, Mowery N, Riordan WP Jr, Martin N, Platz J, Stassen N, Winston ES. The management of the open abdomen in trauma and emergency general surgery: part 1-damage control. *J Trauma* 2010; 68:1425-38.
17. Barker DE, Kaufman HJ, Smith LA, Ciraulo DL, Richart CL, Burns RP. Vacuum pack technique of temporary abdominal closure: a 7-year experience with 112 patients. *J Trauma* 2000; 48:201-6.
18. Vertrees A, Kellicut D, Ottman S, Peoples G, Shriver C. Early definitive abdominal closure using serial closure technique on injured soldiers returning from Afghanistan and Iraq. *J Am Coll Surg* 2006; 202:762-72.
19. Björck M, Bruhin A, Cheatham M, Hinck D, Kaplan M, Manca G, Wild T, Windsor A. Classification—important step to improve management of patients with an open abdomen. *World J Surg* 2009; 33:1154-7.
20. Rausei S, Dionigi G, Rovera F, Boni L, Dionigi R. Surgical classification of open abdomen: which clinical implications? *World J Surg* 2010; 34:599-600.