Victor Hugo has stated that “nothing is more powerful than an idea whose time has come”. The idea of open abdomen – referring to the situation where the abdominal contents have been deliberately exposed and left open under a temporary coverage – is more than hundred years old but has gained wide acceptance in the last 20 years or so in managing complex abdominal problems caused by trauma and acute disease process including surgical complications.

One might even say that its use represents a paradigm shift, a fundamental change in the basic concepts and experimental practices of a scientific discipline, as identified by the American physicist and philosopher Thomas Kuhn in his 1962 book “The structure of scientific revolutions”. But perhaps we need to be a little more modest and call it not just an important tool in our daily practice, but a new way of thinking.

Open abdomen is encountered with increasing frequency in trauma and emergency surgery, and is often the price to be paid for saving severely ill or injured patients. The so called hostile abdomen is sometimes the unwanted consequence of open abdomen often associated with multiple reoperations where the abdominal cavity is open and scarred into one solid mass with fragile small bowel loops adhered to each other, often complicated with enteroatmospheric fistulae and retraction of the abdominal wall edges.

It is important that surgeons treating these patients have a good grasp of the indications for leaving the abdomen open, various techniques and their pitfalls both at the initial stage when the abdomen is left open, as well as at the later stage, when decisions about the fascial closure method and timing must be made. Not one solution is good for every patient. Therefore this book on open abdomen is timely, based on latest scientific knowledge and at the same time provides an excellent and practical overview of the various and complex aspects of the open abdomen.

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INTRODUCTION AND HISTORICAL PERSPECTIVES
Open abdomen (OA) treatment after trauma and emergency surgery is a common therapeutic choice for acute care surgeons to temporize the surgical treatment of complex injuries and pathologies. Currently, between 10% and 15% of trauma laparotomies use damage control surgery (DCS) techniques. The fascial edges and the skin are purposefully left open to avoid intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS), to allow planned re-exploration, or to treat severe intra-abdominal infection in a stepwise approach. Despite technical advancements, OA is associated with significant morbidity and mortality, and more precise knowledge of the indications and strategies of this surgical option is recommended. Open abdomen management must be adapted to underlying abdominal injuries or pathologies and must take into account the patient's physiology. The challenge is to save the patient's life and to minimize serious consequences such as severe fluid and protein loss that can lead to nutritional insufficiency and a catabolic state, to avoid complications such as enterocutaneous fistulas (EAF) with the leak of enteric content in the OA field, and finally to prevent the loss of the abdominal domain due to fascial retraction with the development of frozen abdomen and huge ventral hernias. The purpose of this book is to provide the surgeon with all the necessary knowledge to manage a patient with an OA. Indications, techniques used for temporary abdominal closure (TAC), treatment of frozen abdomen with or without an enteric fistula, strategies for definitive closure and intensive care problems will be summarized in the next paragraphs. Most of the technical issues reported in this book derive from the daily clinical experience and most of the indications need to be considered not as a dogma, but “expert opinions”. Nevertheless, these opinions are supported by an accurate revision of current literature and discussed and developed in the course of the International Consensus held in Milan, Italy, in December 2014. The authors are grateful to the work done by all panelists and in particular to the irreplaceable contribution of the international experts Thomas M Scalea, Ari Leppaniemi, Sharon Henry and Walter Biffl. Finally, the authors thank the Acelity Company of San Antonio Texas, which kindly supported this initiative without any interference on the scientific content of the book.

HISTORY OF OPEN ABDOMEN

Traditionally, three main indications for OA have been proposed: infection, trauma, and abdominal compartment syndrome (ACS). In the next paragraphs, a short history of these applications is reported.

Infection is the oldest indication with the concept of treating the septic abdomen like an abscess which is drained and left open, with the natural healing process occurring from the bottom. A second concept is the staged reconstruction in an infected field, deferring intestinal anastomosis after septic source control. The first report was by McCosh, which in 1897 described eight patients with generalized peritonitis (six from appendicitis, one from a perforated gastric ulcer and one from an ovarian abscess). The wound was left partially open and the intestine protected by a compress of gauze, to favor the spontaneous drainage of infected secretions from the abdomen. Many years later, Ogilvie outlined the beneficial effects of the open management of war wounds, introducing some kind of temporary closure with a sheet of light canvas and Vaseline-impregnated gauze swabs over exposed viscera. The author published five years later that the same concepts used in war-wounds may be useful in the treatment of generalized peritonitis. The first significant case series of OA in peritonitis was published by Steinberg in 1979, from Ohio University. Fourteen patients were left open with gauze packs on the viscera. After 48-72 hours, the gauze was removed and the abdominal wall was closed. The overall mortality was only 7.1%. Two years later, Duff et al. presented a series of 18 patients, 14 with an enteric fistula at presentation. The abdomen was left open to granulate and eleven patients survived, with secondary closure of fascial layer in two, coverage with skin graft in five, and sponta-
neous healing and closure in four patients. Many methods were proposed for temporary closure, such as the Marlex zipper (Hedderich 1986), Velcro adhesive sheets (Wittmann 1990) and absorbable mesh (Ivatury 1989). Mechanical and physiological problems with the OA have gradually become apparent: evisceration with loss of domain, fluid and protein loss (the “catabolic drain”), enteroatmospheric fistula and complex wound management. For these considerations, OA in the late 1980s was considered as a last resort treatment. In the 1990s, two new approaches for severe peritonitis were compared: planned relaparotomy (PR) and relaparotomy on demand (ROD). In the PR strategy, during the index operation, the surgeon decides to leave the abdomen open and in two days the patient is re-operated for cleaning the cavity; this procedure is repeated until closure. In the ROD approach, the surgeon makes a definitive operation and the patient is re-operated only if there is a good reason (for example collections or leaks demonstrated by computed tomography scan). A randomized non-blinded clinical study by van Ruler et al. concluded that the ROD strategy is associated with a shorter hospital and ICU length of stay and lower costs, but the study failed to demonstrate a difference in mortality between the two options. At the beginning of the 21st century, the introduction of negative pressure devices for TAC started a new era. The active removal of septic fluid is a promising concept and some experimental studies have shown increased clearance of inflammatory cytokines with a reduction in the inflammatory response. Negative pressure wound therapy (NPWT) has opened up new perspectives for the treatment of severe peritonitis, resolving or mitigating some of the potential risks of the open abdomen.

Trauma and abdominal compartment syndrome (ACS) are the second and third main indications for OA, and are closely related. Leaving the abdomen open is a part of the temporized approach to the most severe injuries, known as damage control surgery (DCS). One of the first reports about the use of OA in trauma was in 1904 when the Finnish surgeon Richard Faltin operated on the Russian Governor Bobrikov, who had been shot by a patriot. After hemostasis and small bowel resection, Dr Faltin left a hole in the wound with gauze to control the bowel repair, but the patient died soon after. In 1908, Pringle published a paper on the control of bleeding after liver rupture using compression and packing, as an evolution of a technique first described by French surgeons. After 70 years, many surgeons, such as Lucas, Calne, Feliciano and Stone, resumed the concept of liver and abdominal packing after trauma for major coagulopathy, but the abdomen remained closed (under tension) at the end of operation and re-laparotomy was planned one or two days later for de-packaging. Burch proposed shortening the time of laparotomy and the use of multiple towel clips, closing only the skin of the abdominal wall. Rotondo and Schwab first coined the term damage control surgery to describe the technique of initial control of bleeding and contamination in penetrating abdominal trauma, followed by a period of recovery in the ICU and definitive re-exploration after a couple of days. After the initial operation, only the skin was closed with a running suture. The OA was formally included as a part of DCS after the role of abdominal hypertension was recognized in the trauma patient. Sugrue et al. published one of the first clinical reports about the effects of decompressive TAC using mesh on renal and respiratory physiology. In Australia in 2002, the World Society for Abdominal Compartment Syndrome was founded and published recommendations for the prevention or treatment of the negative effects of increased intra-abdominal pressure. One of the main statements is that “surgical decompression should be performed in patients with ACS that is refractory to other treatment options (grade 1B)” and “presumptive decompression should be considered at the time of laparotomy in patients who demonstrate multiple risk factors for intra-abdominal hypertension or ACS (grade 1C)”. The TAC technique evolved over the years. The first generation was abdominal closure with the skin only (running suture, towel clips) or with a synthetic cover (mesh) or plastic bag (the so-called Bogota
bag). Second generation TAC implemented the vacuum pack technique, first described in the 1990s by Barker et al. The current third generation involves negative pressure wound treatment (NPWT) applied to the OA, with specifically designed commercial devices. The first consistent clinical series in 48 trauma patients using NPWT in OA was published by Stone et al., who reported a successful fascial closure rate of 72%. Nowadays, 10% to 15% of severely injured patients undergo OA, both for the prevention or treatment of ACS or to temporize surgical treatments. The use of TAC with negative pressure has become the standard of care in modern trauma centers. The history of OA has been a revolution for the acute care surgeon and has significantly changed some strategies in critical situations. It is relatively easy to leave the abdomen open and to plan a stepwise surgical approach of the underlying disease or injury when a definitive surgical treatment appears to be disproportionate for the patient conditions. However, although the indications for OA in trauma patients have been identified and many studies have reported improvements in outcomes with the damage control approach, in secondary and tertiary peritonitis, the role of leaving the abdomen open and temporizing surgical treatment still has to be defined by appropriate comparative studies.

In the next sections, the indications and techniques for OA are presented. Each chapter is introduced by the statements established by the International Consensus Conference of Milan. The Grade of Recommendation (GoR) and Level of Evidence (LoE) are based on the Grading of Recommendation Assessment, Development and Evaluation (GRADE) hierarchy criteria.

REFERENCES