Negative pressure therapy alone or with irrigation in the management of severe peritonitis

Ann. Ital. Chir., 2017 88, 5: 412-417
pii: S0003469X17027208

Mauro Andreano, Vito D'Ambrosio, Guido Coretti, Paolo Bianco, Simona Ruggiero, Umberto Robustelli, Maurizio Castriconi

Department of Emergency Surgery, AORN "A. Cardarelli", Naples, Italy

Negative pressure therapy alone or with irrigation in the management of severe peritonitis

BACKGROUND: *Ogilvie was the first to publish on open abdomen (OA) for the treatment of the damages caused by penetrating abdominal wounds in war events. Research improved those devices that allow a controlled, homogeneous and continuous extraction of contaminated fluids from all abdominal recesses, which are nowadays the base of the "Open Abdomen" technique.*
MATERIALS AND METHODS: *From August 2012 to February 2016 at the Department of Emergency Surgery of Cardarelli Hospital in Naples, 40 patients affected by Severe Peritonitis have been treated with OA technique. 13 (32,5%) were treated with only the suction-drainage system, 27 patients (67,5%) were treated with suction drainage and irrigation system. Abthera® device was used in all patients.*
RESULTS: *The duration of treatment was 15 days in the first group, with 7 device's substitutions, while in the second group it was about 10 days with 4 substitutions*
At the end of the procedure we were able to perform primary fascia closure in 7 cases (53,8%) in the first group and in 23 cases (85.2%) in the second group. 4 patients (30,8%) died in the first group, and 7 (26%) in the second.
CONCLUSION: *The suction/irrigation method seems to be appropriate to use in case of a surgical emergency that causes severe peritonitis. It is associated not only with lower death rates but also with better parameters, that are more frequently worse during prolonged treatments. Irrigation of abdominal cavity causes also less retraction of fascia recti which leads to a higher rate of direct fascia closure.*

Key Words: Emergency surgery, Irrigation, Open abdomen, Peritonitis

Introduction

Ogilvie was the first to publish on "Open Abdomen". In the 40's he issued the results of this surgical procedure for the treatment of injuries caused by penetrating abdominal wounds in the course of war events.

A step further has been made in the 90s, when the treatment with open abdomen
was associated with negative pressure, at first, in a very simple and empirical way (vacuum pack) and, subsequently, with an advanced device such as the Vacuum-Assisted Closure (VAC). Building on the success of this technique, the industry has increasingly improved
suction systems. In the new millennium, a sophisticated device that allow a continuous, computer controlled and homogeneous extraction of contaminated fluids from all abdominal recesses had been developed. The next step consists in adding to the suction mechanism an irrigation tube, in order to perform a peritoneal lavage.
The authors report their initial experience in handling complex abdominal peritonitis with negative pressure open system (NPWT) with peritoneal lavage.

Pervenuto in Redazione Aprile 2017. Accettato per la pubblicazione Giugno 2017
Correspondence to: Guido Coretti, University "Federico II" of Naples, AOU "Federico II", Via S, Pansini 5m 80131 Naples, Italy (e-mail: guidocoretti@gmail.com)

Materials and Methods

From August 2012 to February 2016 at the Department of Emergency Surgery of Cardarelli Hospital in Naples, 66 patients have been treated with open abdomen (OA) technique. 40 patients suffered, from severe peritonitis with generalized sepsis. 24 of them were males (60%) and 16 females (40%).
The average age was 52 years (range 33-72).
BMI ranged from 24 to 32 Kg/m^2.
Only 13 patients (32.5%) were treated with the suction-drainage system while 27 of them (67.5%) were treated also with the irrigation one.
The main part of the patients suffered from Tertiary and Secondary Peritonitis. 5 patients suffered from Pancreatitis, 4 patients had anastomotic leaks while other mesh migration. Only one patient had an ileal perforation. Table I shows diseases of the two groups of patients.
In all the patients the treatment was assured by the Abthera® device.
Our indication to OA treatment was represented by severe peritonitis with impairment of the general state. Parameters used in the initial assessment were: hemodynamic instability, presence of coagulopathy, hypothermia and metabolic acidosis.
Before 2014 the type of tratment performed was only suction. It has become our policy to use suction-drainage with irrigation, from 2014 on.
A dressing was replaced every 48-72 hours. A standard pressure of -125 mmHg was applied. A maximum pressure of -50 mmHg was applied in case of presence of anastomosis or hemorrhagic diathesis.
We used normal saline or dextrose 5% for peritoneal lavage. 300 cc of saline solution was instilled in 55 second and then aspired in 2h, after a standby time of 10 minutes Therefore 3600 cc of liquid was infused in the 24 hours.
Total parenteral nutrition (20/30 Kcal per Kg each day) was used during the treatment and switched as soon as possible to enteral nutrition. Wide spectrum antibiotics were administered at first and switched to target therapy after antibiogram, performed on peritoneal liquid collection. Before and after surgery two different antibiotics were used: Cefuroxime 1.5 g IV 30 to 60 minutes and Metronidazole 1.5 mg/kg IV infused over 30 to 60 minutes and completed 1 hour before the initial incision. After surgery Cefuroxime 750 mg IV or IM was administered every 8 hours when the procedure is prolonged. Metronidazole 7.5 mg/kg IV infused over 30 to 60 minutes at 6 and 12 hours after the initial dose [1,2]. I g Meropenem every 8 hours was administered in case of necrotizing pancreatitis.
Antibiotic therapy was prolonged for ongoing infections, proved by both clinical and laboratory parameters such as White Blood Cell count (WBC) and C-reactive protein (CRP) .
The P-POSSUM score (Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity), was the reference score used in this series. This is the most common score used one for emergency surgery to predict postoperative mortality [3]. As a rule, every patient who underwent OA treatment was managed for at least 48 hours in Intensive Care Unit (ICU) Local and general parametres were used to assess the degree of sepsis during the tratment. The general parameters were: WBC, Hemoglobin (HB), Procalcitonin, CRP, body temperature, diuresis, blood pressure, heart rate.
The local parameters were: blood supply of the intestine, and more precisely regarding the colour and its wall thickness; collection of fibrin, presence of abscesses; presence of Frozen Abdomen. The local and general parametres were evaluated at each device's replacement

Table I - *Surgical Emergencies*

Diagnosis	I Group (Suction)	II Group (Suction + Irrigation)	Number of patients
Pancreatitis	1	4	5
Mesh Migration	3	1	4
Anastomotic leak	2	2	4
Ileal Perforation	1	0	1
Secondary Peritonitis	3	8	11
Therthiary Peritonitis	3	12	15
TOT	13	27	40

Results

The duration of treatment was on average 12 days and the device was replaced 5 times.
In the first group, the average was 15 days, with 7 substitutions of the dressing, in the second group the average was 10 days with 4 replacements of it.
The length of stay in ICU was on average 5 days in the first group (range 3-7) and 3 days in the second group (range 2-4). Excluding the 11 patients who died, the length of stay in hospital was on averege 20 days for the first group of patients and 15 days for the second.
After completion of the procedure we were able to achieve primary fascia closure in 7 cases (53,8%) in the first group and in 23 cases (85,2%) in the second group. When this was not possible, we had postponed the definitive closure of fascia on a second operation. In case of multiple treatments (> 3) we used special precautions such as the application of a polypropylene mesh to prevent the natural retraction of the fascia. (Whittman Patch Surgical Technique). In 3 patients who couldn't have a direct closure, we used porcine dermal collagen biologic mesh. 4 patients (30,8%) died in the first group, and 7 (26%) in the second. In the first group one patient

TABLE II - *Results*

	I Group (13 Patients)	II Group (27 Patients)
Exitus	4 (30,8%)	7 (26%)
Healing	9 (69,2%)	20 (74,1%)
Days of treatment	15	10
Direct fascia closure	7 (53,8%)	23 (85,2%)
Substitutions	7	4

suffered from pancreatitis, one from tertiary peritonitis and two from stercoral peritornitis. In the second group, five patients died from stercoral peritonitis, one suffered from mesh migrations with consequent ileal perforation, and one from peritonitis secondary to peritoneal dialysis.

Discussion

The set of surgical procedures, which fall within the broad section of the techniques to "open abdomen", have seen over time a continuous and often controversial conceptual revision, up to the current definition of indications and application methods.
The main directions are represented by clinical conditions of extreme severity, resulted by abdominal trauma, abdominal sepsis, severe pancreatitis [4], or even to those conditions that can determine an abdominal hypertension, that leads to abdominal compartment syndrome [5,6].
The set of surgical methods, stretched to obtain a clinical stabilization, are currently defined as "Damage Control Surgery" (DCS). Initially was indicated as the "gold standard" in the treatment of major abdominal trauma characterized by instability [7] (the classical lethal triad of hypothermia, acidosis and coagulopathy). The definitive surgical treatment of the main clinical condition is performed once achieved patient stabilization. The original concept of DCS it is to gain control of bleeding. In case of intra-abdominal microbial contamination, the technique of OA determines an abdominal decompression and facilitate subsequent surgical procedures through the "temporary abdominal closure"(TAC) [8]. Much has been written about the treatment of trauma injuries and international guidelines nowadays codifie for its management. On the other hand the treatment of abdominal sepsis is still in a phase of discussion [9].
The abdominal sepsis can be classified into: a) primitives, b) secondary and c) tertiary [10].
The primitive sepsis is relatively rare and are more common in the childhood or in cirrhotic patients, its onset is due to a bacterial migration into the cavity, with no evidence of either any lesion of the alimentary tract structure and or intraperitoneal sources of infection [11].
The secondary peritonitis are the result of a microbial contamination which follows a perforation or a primitive acute inflammation of a viscera (appendicitis, cholecystitis). These are the most common.
The tertiary, eventually, are the result of a persistence of a septic intraperitoneal inflammation (superior to 48 hours), which follows the surgical treatment of a secondary form. A very high mortality rate (30% to 64% in a revision of literature) is related to this type of peritonitis [12].
Common mechanisms of the inflammatory response during the peritoneal infection can lead to a complex reaction that starts from the production of inflammatory mediators such as tumor necrosis factor (TNF-α) and interleukins 1 and 6 (IL1 and IL6).This reaction can give rise to the onset of disease in other viscera at distance (heart, kidney, lung) leading to a state of septic shock [13]. A study of 2014 "Complicated intraabdominal infections worldwide observational study" (CIAOW study) describes the epidemiological, clinical characteristics and their treatment profiles of intraperitoneal infection and reports an overall mortality around 10.5%. On the other hand the mortality in the subgroup with severe sepsis and shock was around 36.5% [14]. Surgery could have been not definitive if hemodynamic instability and signs or symptoms of impairment of general condition were present, whatever the cause of the peritonitis [15].
Three are the main surgical approach strategies: a) relaparotomies "on demand", based on the clinical condition, b) a laparotomy programmed every 36-48 hours after the first operation or c) DCS procedures with OA through a "TAC" [16].
The choice between the first and the second (relaparotomies on demand or scheduled) does not lead to significant differences in mortality range. On the other hand the decision of when to resort to a relaparotomies is complex and it is generally determined by the evaluation of the overall clinical condition .The several variables can be influenced by concomitant or pre-existing factors (older age, diabetes mellitus, immune-suppression, organ diseases). Sometimes the choice of when to intervene may be wrong and therefore fatal. In a study of Koperna the raccomandation is to not delay relaparotomies over 48 h [17].
The choice of recourse in unstable patients, to DCS with OA and TAC, as recommended by the Surviving Sepsis Campaign [18], may be a viable option to assure as a priority the control of infection and also the prevention of abdominal compartment syndrome and definitive intervention deferral with possible visceral anastomosis.
Infection control, drainage of contaminated fluids and removal of septic foci leads to the chance to access the abdominal cavity with a scheduled intervals not exceeding 24-48 h after initial surgery , avoiding an excessive extension of the times in order to prevent intraperitoneal

stickers phenomena and the risk of visceral lesions .[19]
The ideal method of TAC provides a good protection of the viscera, prevents an evisceration, facilitates the access in the abdominal cavity and permits, moreover, a continuous removal of intraperitoneal contaminated fluids.
The "Bogota bag" is one of the OA techniques proposed, but it is only a mechanical protection of the viscera from the outside, sometimes with extremely heterogeneous applications There are advantages and disadvantages for each procedure used in the past 10 years [20].
Currently the method known as "negative pressure therapy" is one that meets a greater consensus and find widespread applications [21].
The systems currently used is made by a set of devices known as "vacuum pack technique"; it is easily implantable and removable, and can coverage viscera, aspirre intraperitoneal fluid, prevent adhesions and allow, in addition, a high percentage of early abdominal closures [22]. Studies on animals have also shown that with this method, the removal of bacterial toxins from the peritoneal cavity and the downproduction of inflammatory mediators reduce the systemic response to inflammation damage and improve remote visceral lesions [23].
A study conducted by Finlay et al. in 2004 in which he describes the use of DCS in critical patients with OA techniques and temporary closing, describes a mortality rate of 7.1% in severe sepsis, compared to 64.5% of traditional treatments, and reports also the possibility of device's replacement after 3-5gg (24).
The method is still burdened by a high morbidity and the most common causes complications are ventral hernias, basically due to prolonged treatment and the more rare enteroatmospheric fistula [25-27].
Recent studies have shown that the association between a "vacuum assisted closure" and a fascial approach techniques (traction mediated mesh or sutures with dynamic retention) have significantly reduced these complications during prolonged treatment. Our series was a preliminary study and a long term follow-up has not yet performed. As a consequence we could not report any data about long term complications such as hernia rates and morbidity.
With the use of the latest suction systems we are witnessing a re-evaluation of the continuous or intermittent cleaning of the peritoneal cavity [28]. The method, frequently used in the past, was abandoned in time in the almost daily connection with the use of high volumes that made complex post-operative management.
Using the negative pressure current system you can obtain a good control of the perfusion liquid and a constant evacuation from the peritoneal cavity, compared to the past procedures involving the drainage with the chutes [29].
Some authors have reported the use of antiseptics or antibiotics solutions in perfusion liquid. Both are of doubtful utility. The first have caused toxicity phenomena, and the second caused bacterial resistance to drugs, if compared with only saline solution [30,31].
The washing technique most commonly used, and shown in the experience of the authors of this article, is an intermittent infusion of VAC -ultra system, which allows to program the amount of fluid and the frequency of infusions in coordination with the small tube system, a unique digital control system easily accessible and with constant monitoring of the functions [32].
The advantages of intraperitoneal perfusion can be easily identified: a) dilution of the mediating factors of the inflammatory response or of microbial load and its toxins, b) a reduction of the processes of formation of fibrin aggregates, c) less adhesion between the intraperitoneal viscera with a possible inhibition of adherence syndromes, although there is a lack of an adequately follow up.

Conclusion

The OA with the Vacuum Pack device together with the irrigation system seems to be appropriate to use in case of an emergency that causes severe peritonitis. It helps decreasing IL-6, IL-10, TNF-α and bacterial load, reducing abdominal inflammation and adhesions. According to our series, it not only leads to a low death rate but also improves local parameters. Comparing the two groups, data shows that patients treated with irrigation of the abdominal cavity seem to have slightly better results than the others. During this study, we also had the chance to appreciate a less frequent occurrence of Frozen Abdomen, which is associated with prolonged treatments. The irrigation system provides also a less retraction of fascia recti which leads to a higher rate of primary fascia closure.

Riassunto

BACKGROUND: Ogilvie è stato il primo a pubblicare studi sull "addome aperto" per il trattamento dei danni causati da ferite penetranti addominali nel corso degli eventi bellici. L'industria medica ha migliorato quei dispositivi che permettono un'estrazione continua di liquidi, controllata ed omogenea da tutti i recessi addominali, che sono oggi alla base della tecnica con "Addome Aperto".
MATERIALS AND METHODS: Da Agosto 2012 a Febbraio 2016 presso il Dipartimento di Chirurgia d'Urgenza, Ospedale Cardarelli di Napoli 40 pazienti, affetti da Peritonite grave sono stati trattati con tecnica ad "Addome Aperto", 13 (32,5%) sono stati trattati con il solo sistema in aspirazione mentre per 27 pazienti (67,5%) in aggiunta ad esso, è stato posizionato anche quello di irrigazione. In tutti i pazienti il trattamento è stato assicurato dal dispositivo Abthera®.
RESULTS: La durata del trattamento è stata di 15 giorni nel primo gruppo, con 7 sostituzioni, mentre nel secon-

do gruppo è stata di circa 10 giorni con 4 sostituzioni. Dopo il completamento della procedura siamo stati in grado di eseguire una sintesi diretta della fascia dei Retti in 7 casi (53,8%) nel primo gruppo e in 23 casi (85,2%) nel secondo gruppo. 4 pazienti (30,8%) sono deceduti nel primo gruppo, e 7 (26%) nel secondo.

CONCLUSION: Il sistema di aspirazione / irrigazione sembra essere appropriato nel caso di un'emergenza chirurgica, che causi peritonite severa. Non solo riduce i tassi di mortalità, ma migliora anche i parametri locali, più frequentemente peggiori con trattamenti prolungati. L'irrigazione della cavità addominale favorisce inoltre una retrazione minore della fascia dei retti che porta ad un maggiore tasso di chiusura diretta della stessa.

References

1. Gilbert DN, Moellering RC, Sande MA, et al.: *The sanford guide to antimicrobial therapy,* 33rd ed. Hyde Park, Vermont: Antimicrobial Therapy, Inc; 2003:123-24.

2. Andreano M, D'Ambrosio V, Coretti G, et al.: *Primary anastomosis in emergency surgery of colorectal cancer: Our casuistry.* Ann Ital Chir, 2016; 87:438-41, PMID: 27842006.

3. Tyagi A, Nagpal N, Sidhu DS, et al.: *Portsmouth physiological and operative severity score for the Enumeration of Mortality and morbidity scoring system in general surgical practice and identifying risk factors for poor outcome*. J Nat Sci Biol Med 2017; 8 (1):22-5. doi: 10.4103/0976-9668.198342.

4. Coccolini F, Biffl W, Catena F, et al.: *The open abdpmen, indications management and definitive closure.* World J Emerg Surg, 2015; 10:32.PMID, 26213565.

5. Sugrue M. Buhkari Y, et al.: *Intra abdominal pressure and abdominal compartment syndrome in acute general surgery.* World Journal of Surgery, 2009; 33(6):1123-127. PMID: 19404708 DOI: 10.1007/s00268-009-0040-4.

6. Cheatham M, Safcsak K, et al.: *Is the evolving management of intra abdominal hypertension and abdominal compartment syndrome improving survival?* Crit Care Med, 2010; 38 (2):402.

7. Rotondo MF, Schwab CW, McGonigal MD. et al.: *Damage control: an approach for improved survival in exsanguinating penetrating abdominal injury*. J Trauma, 1993; 35(3):375-82. PMID: 8371295

8. Campbell A, Chang M, Fabian T, et al.: *Management of the open abdomen. From initial operation to the definitive closure*. The American Surgeon, 2009; 75(11):1-22 2. PMID: 19998714.

9. Guptas B, Kaushik R, et al.: *Peritonitis. The Eastern experience.* World J Emerg Surg, 2006; 1:13. PMID: 16759427.

10. Sartelli M: *A focus on intra adbominal infections.* World J Emerg Surg, 2010; 5:9. PMID: 20302628.

11. Calandra T, Cohen J, et al.: *International sepsis forum definition of infectionin ICU concensus conference.* Crit.Care Med, 2005; 33(7):1538-48. PMID: 16003060.

12. Misha SP, Tiwary SK, Mishra M, et al.: *An introdution of tertiary peritonitis.* J Emerg Trauma Shock ,2014;7(2):121-23. PMID: 24812458.

13. Levy MM, Fink MP, Marshall JC et al.: *SIS International sepsis definitions conferenc*e. Crit Care Med 2003;31:1250-56. PMID: 12682500.

14. Sartelli M, Catena F, Ansaloni L, et al.: *Complicated intra abdominal infections worlwide: the definitive data of the CIAOW study*. World J Emerg Surg, 2014;9:37. PMID: 24883079.

15. Kiever JJ: *A dsecision rule to aid selection of pazients with abdominal sepsis requiring a relaparotomy*. BMC Surg, 2013; 13:28.

16. Van Ruler O, Boermeester MA, et al.: *Comparision of on demand vs planned relaparotomy strategy in patients with severe peritonis: A ramdomized trial.* JAMA, 2007; 298(8):865-72. PMID: 23870702.

17. Koperna T, Schulz F, et al.: *Relaparotomy in peritonitis: Prognosis and treatment of patients with persisting intra abdominal infections.*World J Surg, 2000; 24(1):32-37. PMID: 10594200.

18. Dellinger RP, Levy MM, Carlet JM, et al.: *Surviving sepsis campaign:internationa guidelines for mamagement of severe sepsis and septic shock*. Crit Care Med, 2008; 36(1):296-327.

19. Sartelli M, Abu-Zidan FM, Ansaloni L, et al.: *The role of the open abdomen procedure in managing severe abdominal sepsis: WSES position paper.* World J Emerg Surg, 2015; 10:35. PMID: 26269709.

20. Kreis BE, de Mol van Otterloo AJ, et al.: *Open abdomen mamagement: A review of its history and a proposed management algorithm*. Med Sci Monit, 2013; 19:524-33.

21. Kirkpatrick AW, Roberts DJ, Faris PD, et al.: *Active negative pressure peritoneal theapy after abbreviated laparotomy*. Ann Surg, 2015; 262(1):2015. PMID: 25536308.

22. Brock WB, Barker DE, Burns RP, et al.: *Temporary closure of open abdominal wounds: The vacuum pack*. Am Surg, 1995;61(1):30-5. PMID: 7832378.

23. Kubiak BD, Albert SP, Gatto LA, et al.: *Peritoneal negative pressure therapy prevents multiple organ injury in a cronic porcine sepsis and ischemia. Reperfusion model*. Shock, 2010; 34:525-534. PMID: 20823698.

24. Finlay IG., Edwards TJ, Lambert AW: *Damage control laparotomy.* Br J Surg, 2004; 91(1):83-5. PMID: 14716799.

25. Boele van Hensbroeck P, Wind J, Dijkgraaf MG, et al.: *Temporary closure of the open abdomen:a sistematic review on delayed primary fascial closure in patients with a open abdomen*. World J Surg, 2009; 33(2):199-207. PMID: 19089494.

26. Terzi C, Egeli T, Canda AE, et al.: *Management of enteroatmospheric fistulae*. Int Wound J, 2014; 11(1):17-21. PMID: 24851732.

27. Verdam FJ, Dolmans DE, Loos MJ, et al.: *Delayed primary closure of the septic open abdomen with a dynamic closure system.* World J Surg, 2011; 35(10):2348-55. PMID: 21850603.

28. Gabriel A, Shores J, Heinrich C, et al.: *Negative pressure wound therapy with instillation: A pilot study describing a new method for treating infected wounds.* Int Wounds J, 2008; 5:399-13. PMID: 18593390.

29. D'Hondt M, D'Haeninck A, Dedrye L, et al.: *Can vacuum. Assisted closure and instillation therapy (VAC-Instill therapy) play a role in the treatment of infected open abdomen?* Tech Coloproctol, 2011; 15:75-77. PMID: 21234637.

30. Sindelar WF, Brower ST, Merkel AB, et al.: *Randomized trial of intraperitoneal irrigation with low molecular weight povidone-iodine solution to reduce intrabdominal infectious complications*. J Hosp Infect, 1985; 6(A):103-14. PMID: 2860153.

31. Mueller TC, Loos M, Haller B, et al.: *Intra-operative wound irrigation to rduce surgical site infections after abdominal surgery: A sistematic review and mata-analysis*. Arch Surg, 2015; 400(2):167-81 5. PMID: 25681239.

32. Tao Q, Ren J, Ji Z1: *VAWCM-Instillation improves delayed primary fascial closure of open septic abdomen*. Gastroenterology Research and Practice. 2014 245182. PMID: 25548553.