Development of a low cost laparostomy technique.

Two years experience in the Trauma Center of Cesena, Italy

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BACKGROUND: *In the last few years laparostomy has become an even more useful option for the surgeon due to the development of the experience in the critical abdominal trauma and in the severe surgical urgencies as PANE and peritonitis with the introduction of Damage Control as surgical strategy to prevent the abdominal compartimental syndrom (ACS). After a laparostomy the surgeon needs to provide a delayed fascial closure to achieve the best outcome for the patient. The aim of this paper is to illustrate the experience and the results after the introduction of a modified laparostomy technique in our surgical activity.*
METHODS: *Protection of intestinal content, aspiration under sub-athmospheric pressure, control in quality and quantity of the drainage and skin temporary closure, rappresent the four principles of the PACS tecnique. In order to evaluate the rate of delayed fascial closure and the rate of ACS onset, we have retrospectively studied 31 patients over a period of 2 years treated with open abdomen with an amount of 36 PACS performed. Routinely IAP measurament was also performed.*
RESULTS: *ACS was developed in no patients. IAP was measured on average at 19. DFC was achieved in 33 PACS of 36 (91.7%) after 5 days on average (20 hours as minimum; 20 days as maximum). Aspected mortality (SAPSII) in ICU for these patient was 76.5% on average. On 31 patients, 20 (64.5%) died and 11 (35.5%) survived.*
CONCLUSION: *PACS seems to be an effective, easy and low cost technique for the management of open abdomen*

KEY WORDS: Laparostomy, Open abdomen, VAC

Introduction

The use as a surgical option of a laparostomy increased progressively in recent years. The consolidation of experience in the field of major abdominal trauma with the introduction of Damage Control and the subsequent extension of these strategies to the context of serious surgical emergencies, along with advancements in the intensivist field and deepening of knowledge on the abdominal compartment syndrome, make it sure that today surgeon must confront with a new category of critically ill patients: those in which the abdomen is left open temporarily. From the pathophysiological point of view, we know that in certain pathological conditions (haemorrhage, sepsis) a reduced clearance of extracellular fluid space tends to lead to a swelling of the intestinal wall, which may reach a thickness many times greater than normal, with potentially leading to impaired perfusion of the intestine. We also know that the peritoneal surface is highly vascularized and colonized by inflammatory cells. This leads to a marked local and systemic inflammatory response, which lead to the development

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of a systemic inflammatory response syndrome (SIRS), which in turn can develop into a multi-organ dysfunction syndrome (MODS). The premature closure of the abdomen can exacerbate the inflammatory response and potentially accelerate the development of the syndrome. A key role is played by intra-abdominal pressure (IAP). The pressure inside the abdomen depends on the volume of abdominal contents, the distensibility of the abdominal wall and diaphragm. From the pathophysiological point of view, increased IAP is directly proportional to the peritoneal inflammatory response, in turn connected to the trauma and abdominal sepsis. When the IAP increases to values above 25 mmHg is established the compartment syndrome, which is a potentially lethal complication in case of uncontrolled intra-abdominal hypertension. The diagnosis of intra-abdominal hypertension is made indirectly by measuring bladder pressure [1]. Since the indirect monitoring of bladder pressure is the only way to detect abnormal increases in IAP and recognize the onset of compartment syndrome, this measurement is performed in all patients with major trauma and those in which has been taken Damage Control. Today, in 15-18% of trauma patients undergoing laparotomy the abdomen is left open [2].
Retrospective studies have shown a significant improvement of the surving of patients with open abdomen, to the detriment, however, an increase of complications, not previously reported [2], probably because before the patients didn't survive the initial injury. Complications can be minimized through a full understanding of pathophysiological mechanisms and then by adopting appropriate measures: protection of abdominal contents, minimal exposure of the viscera; fascial closure technique that reduces the maximum tension; facilitation of surgical re-exploration; control of quality and quantity of fluids losses. Issues to medical care concerning the management of losses and transudates, or postures, are a real problem, which affects the first postoperative period of these patients in ICU. The delayed closure of the fascia is the main objective to be achieved to reduce the rate of morbidity and improve outcomes for patients. If we are forced to leave open the fascial plane and then slip in the condition of hernia planned, we know that these patients will experience a subsequent surgical repair of this debilitating condition and that the path will be complicated and not without a mortality rate. Are many procedures currently used by surgeons to temporarily leave the abdomen open, usually selected on the basis of personal experience and / or material availability. However to date there is no clear consensus on what can be considered the best technique or device. We also know that [3], some synthesis techniques to leave temporary open the abdomen are more related to others with a higher percentage of delayed closure of the band. For nearly two years was developed in the Trauma Center in Cesena a laparostomy technique based on the principle of Vacuum Assisted Closure, and whose cardinal principles are summarized in the acronym as follows: Protection of the viscera; Aspiration at negative pressure of secretions; Control and measurement of fluid losses; Skin closure. The objective of PACS technique is to prevent the compartment syndrome in critically ill patients suffering from traumatic or septic pathologies and get the highest percentage of direct delayed fascial closure. All this conjugated to speed, manageability and low cost. The purpose of this paper is therefore to illustrate this technique and analyze the results after 2 years of use in the Trauma Center in Cesena, compared with those in literature.

Materials and Methods

PACS technique is based on four cardinal principles, which are, as we have seen, the protection of the viscera, the negative pressure suction of secretions, the control of quality and quantity of the fluids losses and finally the synthesis of the skin. Each of these points is essential for the proper functioning of PACS laparostomy.

Protection of the Viscera

Represents the first major target and for this purpose we uses the Bogota Bag, the same normally used for storing and transporting kidneys for transplant after removal from the donor. Before placing in site, we cut string closure. The Bogota Bag is then applied in contact with the viscera within the peritoneal cavity, without being attached to the wall. It's important that it be large enough to cover the entire abdominal cavity. It is not fenestrated. Prevents intestinal loops to attach to the abdominal wall and /or to the possible medication (Fig. 1).

Fig. 1

Negative pressure suction of secretions

Above the Bogota Bag is positioned a green flannel double. A chest tube drainage nr. 32 is then left on the flannel and covered with a second green flannel. The drainage tube exits the abdominal wound to the section where there are no holes and is connected to an Aqua-Seal in place suction at -25 cm H_2O (18.4 mmHg). The suction control chamber previously filled with 25 cm of water, is responsible for ensuring that negative pressure does not exceed this limit and remains constant. Although the value of negative pressure used may seem low compared to the more than 100 mm Hg used by other systems actually allow to drain out the full amount of transudate and / or loss of abdominal compartment, keeping the dressing dry for all the postoperative period. At the same time the presence of transudate between loops helps to maintain a physiological humidity (Figg. 2, 3).

Fig. 2

Fig. 3

Control and measurement of fluid losses

The chest drainage tube then connects to the intake system consists of an Aqua-Seal, filled with water to a negative pressure -25 cm H_2O (18.4 mmHg) and connected to suction. The collection chamber Aqua-Seal allows both to quantify the losses and assesses them qualitatively (Fig. 4).

Skin closure

The fascial plane is not sutured to avoid any effect on abdominal pressure. We proceed to the synthesis of a single-layer with skin suture "a mattress" with silk No. 2. With this suture is completed PACS laparostomy, resulting in a tightly sealed sufficient to contain negative aspiration applied to it. A dressing is then placed on the sutured skin (Fig. 5).

Fig. 4

Fig. 5

Table I

Trauma	9	29%
Peritonitis stercoraceous	9	29%
Necrotic-Haemorrhagic Pancreatitis	6	19,4%
Bowel infarction	5	16,1%
Intestinal obstruction	1	3,2%
Hemoperitoneum	1	3,2%

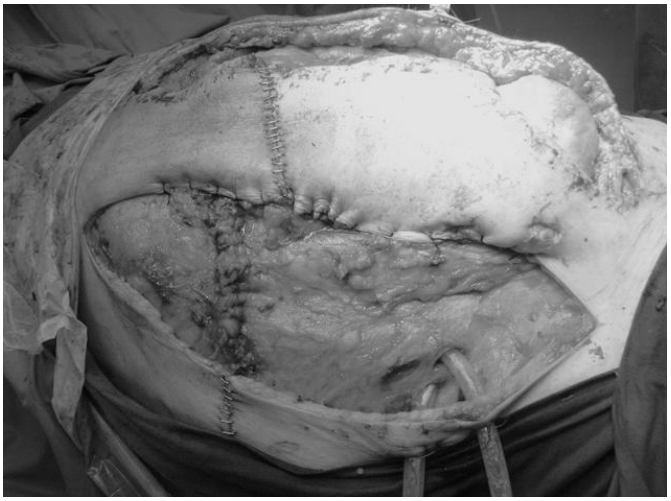

Fig. 6

On all these patients was carried out monitoring of IAP by measuring the intra-vescical pressure. Out of a total of 1008 patients operated in emergency during the period 1/1/2008 - 31/12/2009 were treated with open abdomen, 31 patients (3%). Of these 24 (77.4%) were males and 7 (22.6%) females of mean age of 63 years. As Table I shows the underlying conditions. Were made a total of 36 laparostomies. In 3 patients laparostomy was repeated two times, three times in 2 patients and 1 patient five times. Patients who have had to repeat the basic laparostomy had a non traumatic pathology: necrotic-emorrhagic pancreatitis 2 patients, intestinal infarction nr. 2 patients. In 2 patients (6.5%) is the death occurred before they can run the reoperation. The average duration of the intervention was 107 minutes, while the average duration of the reoperation was 134 minutes. The average interval between I and II intervention was 60 hours with a peak early in a patient series of 408 hours and a minimum of 20 hours. The delayed closure of the fascia was obtained using a variant of the components separation technique (CST) alone [4] or, when necessary, coupled with the creation of sliding skin flaps (SSF). The CST technique provides for the mobilization of the floor plan from skin and subcutaneous fascia bilaterally towards mid-lateral to the anterior axillary line. Unlike CST, we pay attention to the preservation of periumbilical anastomotic circle for a radius of about 3 cm. around the navel. The front fascia of the rectum and not the aponeurosis of external oblique muscle, as in the CST technique, is bilaterally incised longitudinally, allowing the medial portion of the front fascia of the rectum to get close by sliding over the muscle below to the midline without excessive tension, allowing in the mean while to cover a good distance. Where this was not enough use was made in addition to the creation of flaps of skin sliding plane. Instead of suturing the front fascia of the rectum at the end of the linea alba with contralateral, it was sutured to the medial longitudinal skin incision exhaust ipsilateral. Opening in the medial-lateral direction, exposing the front fascia of the rectum, it was possible to suture the skin to skin flap contralateral similarly prepared (Fig. 6).

Results

No patient developed compartment syndrome. The IAP was maintained by an average of 19 with a peak of 23. The delayed fascial closure was obtained in 33 PACS with a percentage of closure of 91.7%. Even in the patient reoperated 6 times with 5-PACS implementation, has been achieved the delayed fascial closure, accompanied with skin incisions (SSF). In three cases in which it was not possible to close the fascia, 2 patients (6,5%) died before the second intervention for reasons related to the underlying disease (intestinal infarction). In 1 patient operated for necrotic-hemorragic pancreatitis, female and obese, we performed only the closure of the cutaneous plane, referring to a subsequent hospitalization at a distance of 1 year the hernia repare. The delayed closure of the fascia was obtained on average after 5 days with a minimum of 20 hours and a maximum of 20 days. The expected mortality in ICU for these patients according with SAPS II, averaged 76.5%. 20 out of 31 patients (64.5%) died in ICU and 11 (35.5%) survived. Of the 11 surviving patients only one had undergone a second PACS. The initial disease of this subgroup is shown in table II. The delayed fascial synthesis was

Table II

Trauma	4	36.4%
Peritonitis stercoraceous	4	36.4%
Necrotic-Haemorrhagic Pancreatitis	2	18.2%
Hemoperitoneum	1	9.1%

Table III

Trauma	5	25%
Peritonitis stercoraceous	5	25%
Bowel infarction	5	25%
Necrotic-Haemorragic Pancreatitis	4	20%
Intestinal obstruction	1	5%

TABLE IV

Necrosis of skin flaps	Necrotic-Haemorragic Pancreatitis Peritonitis stercoraceous	2	6,4%
Gastric perforation	Trauma	1	3,2%
Disembowelment	Peritonitis stercoraceous	1	3,2%
Foreign body granuloma	Trauma	1	3,2%
Pancreatic fistula	Necrotic-Haemorragic Pancreatitis	1	3,2%
Hematoma	Peritonitis stercoraceous	1	3,2%

obtained in 10 (90.9%) of 11 patients survived after 2 days on average with a minimum of 21 hours and a maximum of 3.5 days. In the group of 20 patients died, 1 patient underwent 5 PACS, 1 patient 3 PACS and 2 patients 2 PACS. The intial disease was as follows (Table III). The delayed fascial closure was obtained in 18 (90%) of 20 patients survived after an average of 2.8 days, with a minimum of 20 hours and a maximum of 20 days. Overall, in the group of 31 patients where the PACS was performed, we recorded complications in 7 patients (22.6%). They are listed in Table IV together with underlying diseases. Of the 7 patients who had complications, five (71.4%) have survived. The gastric perforation and evisceration complications were linked to two patients who died. The 2 patients in whom there was necrosis of the skin flaps were treated with VAC Therapy and later by skin grafting during the same hospitalization, with results in recovery. In these patients was necessary to reconstruct the abdominal wall by combining the separation component technique and the technique of sliding the skin plan as previously exposed. The district subcutaneous hematoma was caused by puncture to try to evacuate collection serosa, in patients with delayed fascial synthesis performed in according by component separation technique. The therapy was surgery with evacuation of hematoma and hemostasis. The pancreatic fistula was treated conservatively with external drainage and result in the full recovery after 3 months. The foreign body granulomas have occurred after discharge in a boy of 10 years, of slim build, treated with Damage Control for hemoperitoneum caused by liver injury. The treatment was surgical removal of the suture used for the synthesis fascial (PDS LOOP). In any case it was necessary to provide for the dressing change in the first post-operative period. The amount of drained was an average of 1,320 cc/24 hours. Thanks to skin closure patients were posture according to the customs of the local ICU with the exception of taking the prone position.

Discussion and Comments

The rationale for leaving the abdomen open is to temporarily expand the space of the peritoneal cavity to reduce the intra-abdominal pressure and facilitate the planned re-laparotomy in polytrauma patients or in cases of secondary peritonitis [5]. Because of major complications (entero-cutaneous fistula, hernia), the abdomen should be left open temporarily only if clearly needed. [6-8]. The mortality reported in the case of entero-cutaneous fistula in the course of open abdomen varies from 30 to 50% [9]. Generally, the experience in trauma, is subsequently transferred to patients with secondary peritonitis [10]. The laparostomy thus became an additional procedure to re-laparotomy only in recent times, when IAP and the prevention of compartment syndrome on the one hand and the need to drain a further peritonitic process changed the surgical strategy in a small group of patients. All patients with laparostomy spend at least part of stay in ICU The primary objective of both the surgeon and the intensivist is to minimize this time and moved back as soon as possible to the patient surgery department. Experience shows that the anesthesia team is particularly touted as relief efforts and special care for such patients, so that support by the surgeon is essential even if time-consuming at the bedside.
Communication and discussion on the clinical level are crucial for successful treatment [11]. In Table V are shown schematically with their characteristics techniques of fascial closure reported in the literature [3] The Bogota Bag [12] opened and sutured to the skin or band plan is an easy method of application that protects peritoneal content from evisceration, but does not monitor the intestinal transudate and is not of any support for the abdominal wall. Based on clinical and experimental evidence of the effectiveness of sub-atmospheric pressure in stimulating granulation wounds difficult (principle of the VAC) has developed several laparostomy techniques, based on this principle. They are generally described as follows:
– Positioning of omentum on viscera;
– Placement of a polyethylene sheet on properly perforated viscera;
– Placing two Fanelle on polyethylene;
– Positioning of two Jackson-Pratt drains on flannels;
– Additional two flannels;
– After thorough drying margins affixing adhesive plastic sheet under tension;
– Connecting drainage aspiration with a wall of about 100-150 mmHg except in cases where the intake system is acting in the vicinity of intestinal anastomosis or vascular organs or intestinal trauma and risk of fistula.

The PACS laparostomy has developed these principles basically trying to change some points in order to optimize the technique. Experience has shown that it is not necessary to pierce the Bogota bag to allow drainage of excess transudate. The advantage of not pierce the Bogota in either of its two layers, is basically the way to keep the viscera contents into the peritoneal cavity in a sterile naturally humidified withouf contamination. At the time of relaparotomy we can appreciate the simplicity with which you access the cavity. If the objective is to

TABLE V

Technique	Short description	Mechanism of action
Vac-Assisted Closure	System with suitably perforated sheet of plastic to protect visceral and plastic adhesive for creating and maintaining vacuum	The negative pressure module helps to stimulate granulation tissue and to drain excess fluid
Vacuum Pack	A sheet of sterile plastic perforated covers the viscera, in turn covered with two flannel which is positioned between a drain which is connected to the negative pressure. The vacuum is maintained by a sheet of adhesive plastic.	The negative pressure stimulates granulation tissue and helps to drain excess fluid.
Witmann patch	Two sheets of Velcro is stitched on both edges and then closed in the middle.	The technique allows easy access to the peritoneal cavity and progressive reapproximated margins.
Dynamic retention sutures	The viscera are laminated with a Bogota bag type. Transverse sutures are placed through a catheter and large-diameter full-thickness abdominal wall.	The sutures passed so live permit to hold the fascial plane with the purpose to obtain a progressive reapproximated margins. May be associated with a Vacuum.
Plastic Silo (Bogota bag)	A lot for organ removal in 2 layers is sutured to the fascia or the skin and only open in the middle.	A simple technique for easy access to the cavity.
Mesh / sheet	A network-absorbed or not absorbed or sheet of plastic is sutured / or band. Examples of the network are the network of Dexon, Marlex, and Vycril. Examples are the Silastic sheets and sheets of silicone.	The network or the plastic sheet can be reduced in size to reapproximated margins. The networks can be removed or not absorbable within the left end of the open abdomen.
Loose packing	The fascial defect is covered by simple dressing.	The technique prevents fascial retraction.
Skin Approximation	The skin is closed over the defect with fascial suture.	The skin provides a natural hedge viscera but prevents fascial retraction.
Zipper	A network with a zipper sterile margin is sutured between the fascial.	The technique is similar to the mesh / sheet and provides easy access to the peritoneal cavity.

drain excess fluid which otherwise create major problems of contamination and nursing of these patients, it could be shown during this experience that a single chest tube nr. 32 positioned under the sandwich technique described above performs its function properly and can be naturally connected to the Aqua-Seal in the same way we proceed for the drainage of a pleural cavity. The use of the Aqua-Seal is due to its simplicity, in its safe use and easy availability. There are two objectives that are achieved: sub-atmospheric suction pressure never superior than - 25 cm H_2O (18.4 mmHg) and removal of excess fluids and their conveying in a clean room where they can be observed and precisely and simply quantified. Since the purpose of this laparostomy is not to induce and stimulate granulation tissue in the abdominal wall, but to adequately manage the opened abdomen pending planned reoperation, we could demonstrate that you do not need to use a greater sub-atmospheric pressure with the risk of visceral injury, as reported in the literature [11]. With regard to prophylaxis of IAP and / or compartment syndrome we have observed that suturing the skin layer only at this early stage of SIRS does not produce such a high tension of the tissue, which leads to a pathological increase of intra-abdominal pressure. In contrast to leave the patient to the intensivist team with skin sutured offers important advantages for what concerns the nursing and the posture of the patient in ICU. In more advanced stages when more re-interventions were necessary and tessues are in the throes of full-blown and advanced SIRS, there is no further indication for laparostomy PACS, as described. In fact, we have verified in this experience that in about 10% of cases it seems no possible to achieve the goal of a delayed closure of the band. In these cases, the gold standard becomes to stimulate granulation of the tissue in the abdominal wall to achieve healing by secondary intention of the defect wall, creating the so-called programmed hernia. To support this goal, if you do not have access to a VAC specific for the abdominal wall, the technique PACS can be modified as shown below:

– The skin is not sutured. Instead of synthetic skin apply a sheet of plastic adhesive type Steri-Drape to seal the

Fig. 7

dressing typical PACS to maintain the vacuum and allow the application of negative pressure drainage;
– To obtain a higher suction pressure, (40-100 mmHg) suction control chamber of the Aqua-Seal is left empty and connected directly to a wall manometer that allows it to gauge the regulation, as illustrated in the instructions of the appliance (Fig. 7).

With these modifications the PACS becomes in effect a system that works on the principle of Vacuum Assisted Closure. PACS laparostomy experience presented here allowed to obtain a delayed fascial closure in almost all cases treated who survived. We know that this is an important advantage for the patient in terms of morbidity and mortality [13-16]. On the basis of a recently published retrospective study, which analyzed the complications of 344 patients undergoing abdominal damage control, we can assume that the complications are mostly related to two variables:
– the method used for abdominal closure;
– the timing of the closure.

Basically, as regards the closure of the abdominal wall, we put the patient into three groups:
Group 1: These are patients who are unable to achieve fascial closure with or without the use of recordings of wastewater flow and the various mobilization plans. Represent 65% of all patients in three groups. On average, we proceed to the synthesis fascial within 4 days during the second or third step.
Group 2: Patients who proceed to abdominal closure by synthesis of single plane leaving the skin or fascial defect using prosthetic riassorbili. This is 29% of total.
Group 3: Patients who undergo delayed closure (median 14 days) band by affixing non-absorbable implants. Represent the smallest group amounted to around 6%.
In patients who survived the abdominal closure (25% of those undergoing the procedure) there were complications distributed according to the following percentages: 9% in group 1, 53% in group 2 and 60% in group 3. Complications were as follows:
– Wound infections;
– Abscesses;
– Entero-cutaneous fistula.

With regard to the fistula there was a relative frequency significantly lower (3%) in group 1 in which the fascia was closed directly in relation to group 2 (30%). The average time of formation of complication in the two groups was 21 days. There have been reports of delayed onset of fistula in 3 cases after more than one year. Regarding the timing, the rate of complications is significantly increased in patients closed after more than eight days after the first operation. In the subgroup of patients with end closed within eight days, only 12% had a complication compared to 52% of those closed after eight days. Only those with primary closure of the fascia (group 1) had statistically significant reduction of complications, and have shown significant differences between patients of the other two groups. It 'important to evaluate the outcomes of those patients who have had these complications (nr. 17): 6 died and 5 of the 6 died of causes linked to disease endoaddominale, with particular reference to the development of excessive tension and necrosis of tissues due to tissue abscess and fistula also. Infectious complications were more in those patients who are using absorbable or not absorbable prosthetic material. When the removal of abdominal packing was performed within 4 days there was a total complication rate of 25% rising significantly (40%) when the depacking is more late.

Conclusions

The PACS technique for managing an open abdomen was evaluated after two years of implementation in the Trauma Center of Cesena, on patients with traumatic and nontraumatic pathology. Given the criticality of these patients, the need to find a surgical simple and quick procedure, made with low-cost materials, normally present in all operating rooms and able to provide postoperative care in intensive care effective and appropriate to the type of patients, has stimulated surgeons in the development of PACS technique. Since the laparostomy is generally indicated in a select group of surgical patients, the numbers presented in this series are small, though comparable with other series in the literature. Based on the results presented, we seem to be able to conclude that its objectives with respect to the prevention of compartment syndrome and delayed closure of the band have been achieved. The simplicity of implementation, low cost, ease of management and maintenance are undoubtedly the most significant features of the PACS. The tech-

nique of fascial closure for separation of components modified as presented in this study and sometimes in more complex cases, coupled with the creation of the sliding skin flap, has reduced significantly the use of only skin closure, or the Vacuum Assisted Closure with the creation of planned abdominal hernia, certainly debilitating for the patient.

Riassunto

INTRODUZIONE: Il ricorso alla laparostomia come opzione chirurgica è aumentato progressivamente negli ultimi anni con l'introduzione del Damage Control e la successiva estensione di questa strategia all'ambito delle urgenze chirurgiche più gravi. L'obiettivo della laparostomia è quello di prevenire la sindrome compartimentale e ottenere nel contempo la più alta percentuale di chiusura fasciale diretta dilazionata. Tutto questo coniugato a criteri di velocità di esecuzione, semplicità di gestione e bassi costi. Lo scopo di questo lavoro è pertanto quello di illustrare la tecnica di laparostomia in uso presso il Trauma Center di Cesena e di analizzare i risultati ottenuti dopo 2 anni di utilizzo, confrontandoli con quelli presenti in letteratura.
MATERIALI E METODO: La tecnica usata rappresenta una modifica di quella descritta da Barker della Vacuum Assisted Closure, i cui principi cardinali sono riassunti nell'acronimo seguente: Protezione dei visceri; Aspirazione con pressione negativa delle secrezioni; Controllo quali-quantitativo delle perdite; Sintesi cutanea. Su un totale di 1008 pazienti operati in urgenza nel periodo 01/1/2008 – 31/12/2009 sono stati trattati con addome aperto 31 pazienti (0,03%) su cui sono state eseguite 36 PACS. La pressione intra-addominale è stata valutata routinariamente.
RISULTATI: Non si è verificato nessun caso di sindrome compartimentale addominale. Il valore medio di pressione endoaddominale è stato 19. La chiusura fasciale dilazionata è stata ottenuta in 33 delle 36 PACS eseguite (91,7%) dopo 5 gg di media (20 ore come minimo; 20 gg come massimo). La mortalità attesa in T.I. (SAPSII) per questi pazienti era 76,5% di. Dei 31 pazienti considerati, 20 (64,5%) sono morti e 11 (35,5%) sono sopravvissuti
CONCLUSIONI: La PACS sembra essere efficace, facile da eseguire ed a basso costo per il trattamento dell'addome aperto.

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