

Open Abdomen after Severe Acute Pancreatitis

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Abstract

The need for surgical decompression for abdominal compartment syndrome is becoming more frequent in patients with severe acute pancreatitis, especially in association with massive fluid resuscitation at the early stages of the disease. Decompression can be achieved with either a full-thickness laparostomy that can be performed through a vertical midline or transverse subcostal incision, or by performing a subcutaneous linea alba fasciotomy. Following a full-thickness laparostomy the open abdomen can be best managed with some form of negative abdominal pressure dressing. During dressing changes every 2–3 days, every attempt should be made to gradually close the fascial incision starting from edges, but avoiding recurrent abdominal compartment syndrome. Gradual closure is more likely to succeed in association with a negative fluid balance. Peripancreatic exploration or necrosectomy is seldom required at the initial laparostomy, unless performed for late onset abdominal compartment syndrome associated with infected peripancreatic necrosis. Primary fascial closure should always be attempted. If impossible and there is no need for subsequent abdominal re-exploration, the open wound should be covered with split-thickness skin grafting directly over the bowel loops. After a maturation period of 9–12 months definitive repair of the abdominal wall defect is performed utilizing the components separation technique, mesh repair, or a pedicular or microvascular tensor fascia lata flap. Knowledge of the available decompression and reconstruction options is essential for individualized management of patients with severe acute pancreatitis and abdominal compartment syndrome. More research and comparative studies are needed to determine the most successful methods to be used.

Key Words

Acute pancreatitis · Open abdomen · Abdominal compartment syndrome · Laparostomy · Emergency surgery

Eur J Trauma Emerg Surg 2008;34:17–23

DOI 10.1007/s00068-008-7169-y

Introduction

Open abdomen or laparostomy is a condition where the abdominal incision has been deliberately left open to promote the management of the underlying disease, or to prevent the development of intra-abdominal hypertension (IAH) and its clinically significant extreme form, the abdominal compartment syndrome (ACS). Occasionally, necrotizing infections require excision of the abdominal wall resulting in an abdominal wall defect unmanageable with primary fascial closure.

Analogously to the open management of an incised abscess to promote adequate drainage, open management with frequent dressing changes to facilitate the clearance of infection was used as a treatment option in patients with severe peritonitis or pancreatitis from the late 1970s onwards [1–5]. Patients with severe acute pancreatitis (SAP) underwent surgical interventions to achieve control of the infection source, the infected peripancreatic necrosis. If the source control at the initial operation was incomplete and if repeated measures to achieve it were needed, the abdomen was left open between procedures and usually covered with moist gauze dressings or some other form of temporary coverage of the abdominal contents. Gradually the cavity decreased in size and often healed by secondary intention after formation of granulation tissue. Even in the case of an enteric fistula secondary to the open

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Received: November 27, 2007; accepted: December 16, 2007;
Published Online: January 30, 2008

abdomen treatment, expectant management often resulted in acceptable results.

A reappraisal of managing life-threatening hemorrhage mainly in the liver by temporizing measures such as perihepatic packing was popularized by Stone et al. in 1983 [6]. After temporary controlling of bleeding and enteric contamination, the abdominal wall was covered with a plastic silo or equivalent, and definitive closure was postponed until the planned reoperation 24–48 h later with definitive repair of all injuries and restoration of the continuity of the gastrointestinal tract. The increasing use of damage control surgery in the abdomen and the inability not uncommonly to close the abdomen at the second operation has increased our knowledge of early and delayed treatment of the open abdomen.

Finally, the adverse effects caused by IAH on many critical organ functions has been widely recognized in many clinical conditions including SAP, and it has been suggested that a large part of the patients with SAP dying of early multiple organ dysfunction syndrome (MODS) in effect die of unrecognized and untreated ACS caused by massive fluid resuscitation, capillary leak and visceral edema [7–11].

The prevention or treatment of ACS is today the commonest cause of open abdomen in many centers treating trauma and emergency surgical patients. In a recent analysis from the Meilahti Hospital, University of Helsinki, the most common underlying causes for open abdomen were SAP (35%), damage control for abdominal trauma (22%), ruptured abdominal aortic aneurysm (20%), abdominal sepsis (14%) and bowel ischemia (8%). In 37% of the patients, open abdomen resulted from the treatment of manifest ACS, and in the remaining the vast majority resulted from preventing the development of ACS by leaving the abdomen open (Leppäniemi A, unpublished data).

Methods of Decompression

Although percutaneous drainage of pancreatic ascites can, in some cases, decrease intra-abdominal pressure (IAP) at least temporarily, surgical decompression is the most reliable method to relieve IAH and restore vital organ functions, especially in the pulmonary, cardiovascular and renal systems.

There are three options for surgical decompression in patients with no recent abdominal incision (that often is the case in SAP). A long vertical midline incision is most commonly used and it has been showed to decrease IAP effectively [12, 13]. It is rapid and easy to perform, but it is associated with a high risk of intestinal fistulas



Figure 1. Transverse laparostomy in severe acute pancreatitis with abdominal compartment syndrome.

and in many cases failure to close the fascia requiring complex reconstructive surgery at a later stage [14].

Transverse laparostomy is a promising alternative and isolated reports have shown its effectiveness in reducing IAP [15] (Figure 1). There might be a higher rate of primary fascial closure at the initial hospitalization period but no comparative studies exist. Although it takes slightly longer to perform than midline laparostomy, same principles of managing the open abdomen can be applied without additional equipment. The major disadvantage could be the loss of abdominal and back extensor muscle functions, if fascial closure could not be achieved. This might require complex reconstruction procedures including innervated free flaps that not only restore continuity but also the functional integrity of the abdomen [16].

A third alternative used in SAP is the subcutaneous linea alba fasciotomy, where the fascia is incised through three small skin incisions leaving the rest of the skin and the peritoneum intact [17]. Although it eliminates the open abdomen, it might not be always effective enough, as suggested by our own experience in eight patients so far, where the decrease of IAP was sufficient in five patients. In addition, the subcutaneous fasciotomy always results in a ventral hernia requiring repair later on. However, clinical experience also shows that the open abdomen itself is harmful to the patient. It is a “catabolic drain” that through the large, exposed surface area aggravates loss of fluid and protein with ensuing need of calories and proteins, and also seems to maintain a state of persistent inflammation in the body, sometimes accompanied by a secondary superficial infection beneath the dressings [18]. Avoiding the completely open abdomen might improve the clinical, nutritional and

infection situation when the “catabolic drain” of the open wound is avoided.

Pancreatic Exploration and Necrosectomy during Decompression

In SAP, infected pancreatic necrosis is an established indication for surgical necrosectomy, ideally postponed until 4 weeks after the onset of symptoms and performed most commonly through a transverse midline incision [19]. Because ACS usually commences during the first few days of the disease and the (usually) sterile necrosis is unripe, there are no indications to explore the pancreas or the peripancreatic spaces further. In addition to causing significant bleeding, it could also introduce an infection to the peripancreatic space [10, 12].

Although both midline and transverse incisions could later be utilized for necrosectomy, transverse subcostal incision is more commonly used and could be justified for decompression when concomitant necrosectomy is planned or anticipated in patients with late-onset ACS.

Management of the Laparostomy

The ideal cover of the abdominal contents after laparostomy should protect the viscera, avoid fistulas, be easy to apply and remove, allow easy nursing care, should not damage the fascia or the skin, be readily available and inexpensive, and maintain the abdominal domain. Although several commercial and non-commercial alternatives exist today, none of them fulfills all the criteria mentioned above.

The current treatment of the open abdomen has evolved through a few principles recognized fairly recently; the importance of preserving the accessibility and domain of the abdominal cavity, the feasibility of gradual closure of the abdominal wall, and novel methods to treat the ensuing “planned” hernia, if primary fascial closure fails.

The easiest method to cover the abdominal viscera after decompression is the use of a plastic silo (“Bogota bag”) which is inexpensive, readily available and which preserves the intact fascia when sutured to the skin edges. However, because the plastic silo or some other form of temporary abdominal closure allows the edges of the abdominal wall to retract laterally, the abdominal cavity loses part of its volume resulting in difficult fascial closure under significant tension especially, if the closure is delayed beyond the first week.

The introduction of the vacuum pack in 1995 started a new area [20]. More than just an elegant containment solution, this technique, by utilizing a polyethylene sheet tucked between the parietal peritoneum and the bowel, prevented the formation of adhesions between the abdominal wall and the bowel delaying the onset of a “frozen abdomen” where loops of bowel adhere to each other by granulation tissue.

In 2001, a logical step was taken by introducing the concept of vacuum-assisted wound management to treat patients with open abdomen [21]. Already in 1997, it was shown that the application of negative pressure enhances the healing and closing of wounds by promoting granulation tissue formation and reducing bacterial contamination [22]. The application of vacuum-assisted wound closure techniques to open abdomens not just helped the nursing care, but seemed also to reduce the complications associated with the traditional open abdomen management methods. Even in the management of the most severe complication of the open abdomen, the exposed enteric fistula, vacuum-assisted wound management seems to be able to control the fistula secretion allowing the wound around it to heal [23, 24].

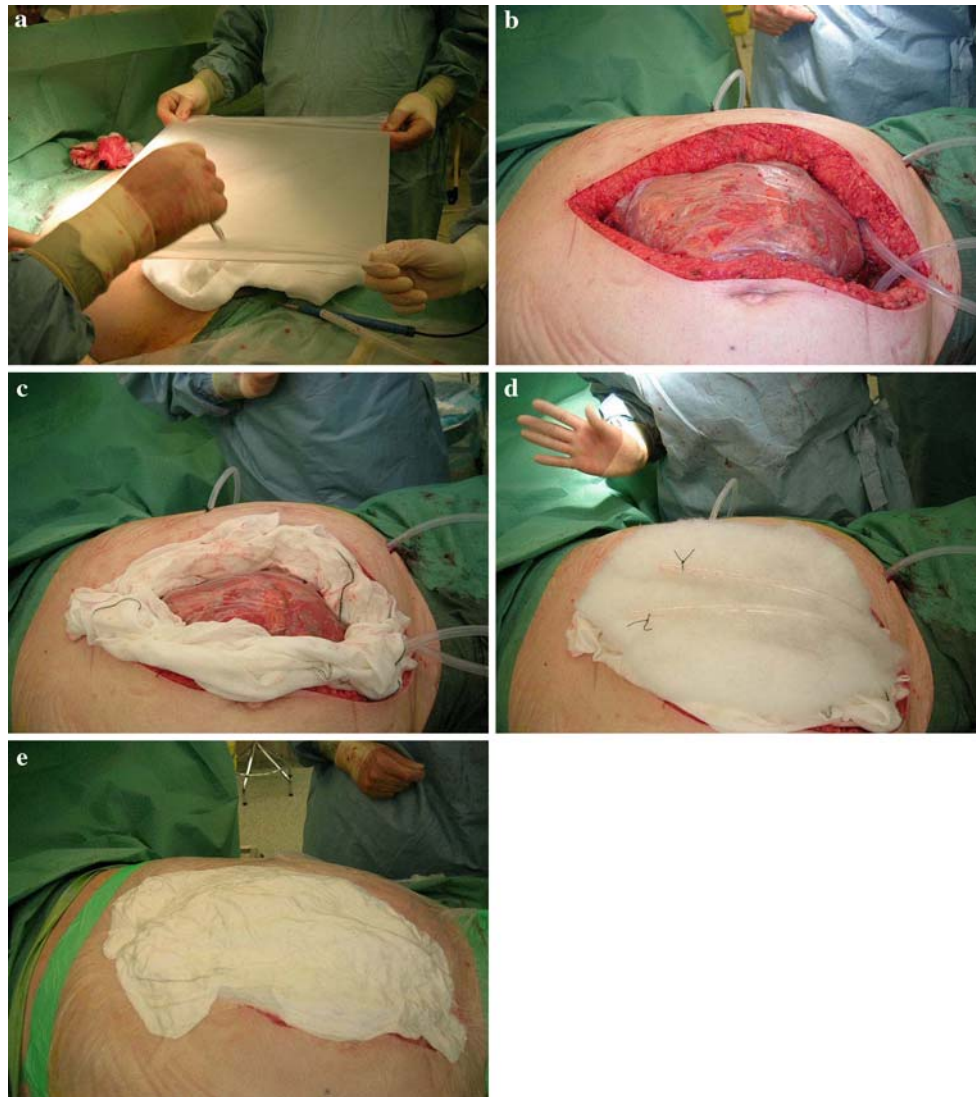
The currently available temporary abdominal closure techniques can be divided into four groups [24].

- (1) Non-absorbable meshes, rough textile structure (polypropylene)
- (2) Non-absorbable meshes, impervious surface (Goretex, Silicone)
- (3) Staged management with absorbable meshes without vacuum assistance
- (4) Topical negative pressure techniques

The use of an absorbable mesh is attractive, and can be helpful in preventing evisceration of the edematous intestinal loops and reducing the risk of fistula formation. However, if the abdomen can not be closed primarily, the scar tissue following the absorption of the mesh could complicate future removal of the subsequent split-skin graft during abdominal wall reconstruction after a planned hernia approach.

A variety of “self-made” topical negative pressure dressings have been introduced with some variation but utilizing an identical principle. The negative abdominal pressure dressing (NAPD) used at the Meilahti Hospital consists of the following layers of sterile components: soft organ donation plastic bag pierced with multiple small scalpel incisions, moist laparotomy pads on top of the plastic sheet and on the sides to protect the subcu-

Figure 2. Negative abdominal pressure dressing (NAPD). a) Piercing of the double layer organ donation bag. b) Placement of the bag over the viscera and beneath the wound edges. c) Protecting the subcutaneous tissue with moist laparotomy pads. d) Placement of the dacron gauze and silicon drains used to create negative pressure. e) Airtight seal of the wound with adhesive plastic dressings.



taneous fat on the wound edges, dacron gauze, two silicon drain tubes brought in caudally through the skin over the dacron, a layer of dry laparotomy pads and airtight closure of the whole wound with 1–2 adhesive plastic dressings (Figure 2). The drains are connected through a Y-connector to a chest drainage device with the negative pressure set at 25 cmH₂O, or to wall suction if higher pressures are needed.

Redressings are performed every 2–3 days. Primary closure of the fascial layer is attempted in all cases, either as a one-step procedure or gradually during redressings (Figure 3). No attempt at premature exploration of the lesser sac or retroperitoneal space is attempted. If primary fascial closure is not possible and the need for further re-exploration is deemed unlikely, the exposed bowel is covered with a split-skin graft.

If peripancreatic necrosectomy is deemed necessary for infected necrosis as shown by positive peripancreatic bacterial cultures or gas bubbles seen on CT scan, the existing decompressive incision is used, extended if necessary, and following necrosectomy the open abdomen treatment is continued as previously. Once the need for re-explorations has subsided, the plan for definitive closure is selected depending on the degree of retraction of the abdominal wall edges.

Definitive Closure

Every time the abdomen is left open, the primary aim is to achieve fascial closure as soon as possible without causing recurrent abdominal compartment syndrome or other complications associated with premature clo-



Figure 3. Gradual closure of the fascia from both wound edges after transverse laparotomy.

sure [18]. The fascial closure can be achieved with four different methods or a combination thereof: one-stage fascial closure at the second operation, gradual fascial closure during multiple operations, fascial closure with the components separation technique [25], or fascial closure with a mesh prosthesis. The development of the concept of vacuum-assisted closure has greatly improved fascial closure rates.

When re-explorations are not any longer needed and if primary fascial closure is not possible, a planned hernia approach aims at skin coverage with subsequent delayed abdominal wall reconstruction. The skin closure is most often achieved with autologous split-thickness skin grafting over the exposed bowel. Instead of allowing the bowel surface to granulate before skin grafting, early application of the skin graft over the bowel seems to enhance the tuning down of the inflammatory process sustained by the large raw surface, and to make the subsequent reconstruction process easier.

Planned Hernia and Abdominal Wall Reconstruction

The maturation of the skin graft requires about 9–12 months, after which the grafted skin can be easily removed from the bowel surface without additional iatrogenic lesions (Figure 4). Large abdominal wall defects can be reconstructed with pedicular or microvascular flaps. The most commonly used is the tensor fascia lata (TFL)-flap [26]. With smaller defects, the components separation technique or a mesh repair can be also used for late repair provided that there is enough original skin for skin closure.



Figure 4. The pinch sign showing that the skin graft has matured and is ready to be removed.

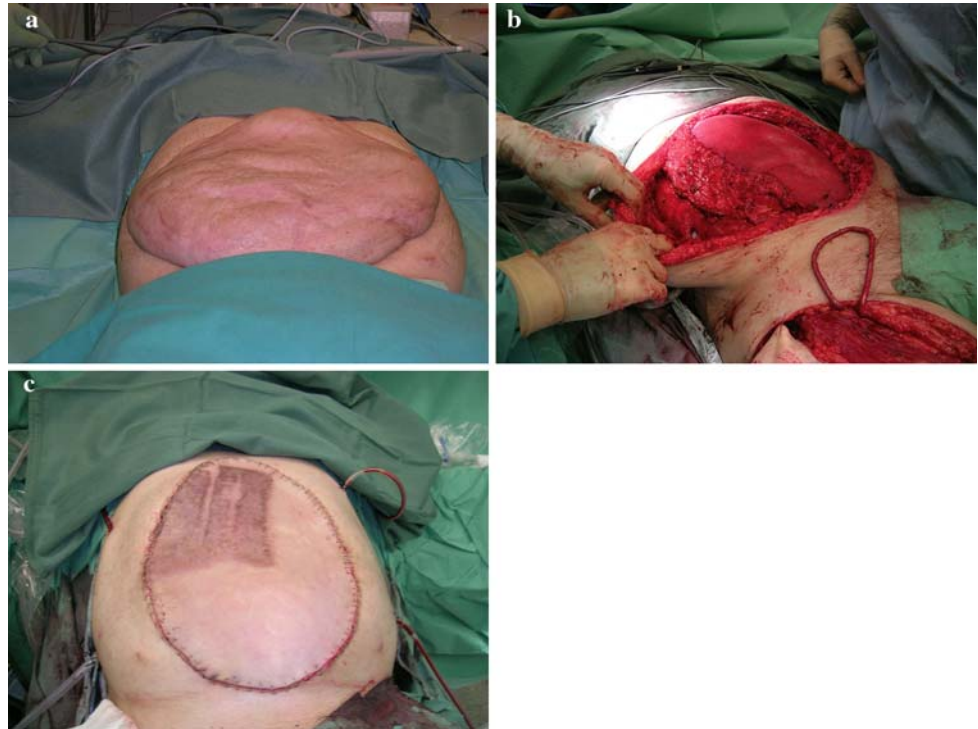
A modification of the microvascular TFL-flap has been used at the Helsinki University Hospital to reconstruct so far 18 large abdominal wall defects. The musculofasciocutaneous TFL-flap is harvested, the ipsilateral great saphenous vein is divided distally above the knee and the distal end anastomosed end-to-side to the common femoral artery creating an arteriovenous (AV) loop (Figure 5). The loop is tunneled subcutaneously, divided, and the arterial and venous anastomoses to the flap vessels are performed. The repair can be combined with a mesh or a components separation repair.

The hernia following subcutaneous linea alba fasciotomy can most often be repaired utilizing the components separation technique. Alternatively, a standard mesh repair is feasible. In a prospective study comparing components separation technique with mesh repair (e-PTFE patch) in 39 patients with giant midline hernias, 7/18 patients in the prosthesis group required mesh removal because of infection. Although there were more reherniations in the components separation group (10/19 vs. 4/18), they were smaller in the components separation group that was the technique favored by the authors [27].

The importance of early aggressive closure of the abdomen whenever feasible was demonstrated in a recent study utilizing a combination of vacuum pack, vacuum-assisted wound management and human acellular dermal matrix in 37 patients showing promising early results with no major complications [28].

A recent literature review of autologous tissue repair in large abdominal wall defects showed that the components separation method is the best documented procedure associated with a morbidity rate of 24% and recurrence rate of 18%. Repair with free fascia lata or

Figure 5. Giant planned hernia repair utilizing a combination of components separation, mesh and microvascular tensor fascia lata-flap. a) Preoperatively. b) Components separation and mesh replacement completed, the arteriovenous loop created; c) TFL-flap in place.



dermal grafts are an alternative but wound complications can be expected in 42% and recurrent hernia in up to 29%. Pedicled or free vascularized flaps are best reserved for complex situations [14]. Whatever method for abdominal wall reconstruction may be used, detailed knowledge of the anatomical aspects and meticulous attention to technical details are essential [29].

Our Current Practice

Indications for surgical decompression

- manifest ACS (IAP>35 mmHg) or IAP>25 mmHg and considerable difficulty in ventilating the patient adequately
- percutaneous drainage of ascites not helpful

Method for decompression

- IAP (and ventilatory function) always measured on the table immediately pre- and post-decompression
- if early onset ACS and IAP 25–35 mmHg, a trial of subcutaneous linea alba fasciotomy; if insufficient, proceed to full-thickness vertical midline laparostomy
- late onset ACS and possible need of necrosectomy; transverse subcostal laparostomy
- suspicion of associated bowel necrosis or perforation, or previous midline incision; vertical midline laparostomy

Management of the open abdomen

- negative abdominal pressure dressing changed every 2–3 days
- gradual closure from the wound edges as soon as possible, but avoiding recurrent abdominal compartment syndrome

Definitive closure

- if primary fascial closure is unsuccessful and reinterventions unlikely, early split-thickness skin grafting directly over the bowel loops (loops not separated at last two dressing changes but allowed slightly to adhere to each other)
- delayed abdominal wall reconstruction after maturation of the skin graft (usually 9–12 months) and recovery of the patient
- depending on the size of the defect, availability of original skin, possible additional procedures (ostomy closure), a components separation technique, mesh repair or tensor fascia lata flaps are used, sometimes in combination

Conclusions

Open abdomen is more and more frequently associated with ACS in patients with SAP. Early recognition of

ACS, adequate decompression when needed and utilization of the most appropriate method are crucial in the early stages of the disease. Management of the ensuing open abdomen requires knowledge of the negative abdominal pressure dressing techniques with the aim for primary fascial closure. If not achieved, early skin grafting with delayed reconstruction of the abdominal wall defect seems to be the safest option.

Acknowledgment

The author is grateful to the colleagues Erkki Tukiainen, Piia Hienonen, Panu Mentula, Petteri Lehtonen, Esko Kemppainen, who have helped in developing the current methods for managing the open abdomen in patients with severe acute pancreatitis.

References

- Steinberg D. On leaving the peritoneal cavity open in acute generalized suppurative peritonitis. *Am J Surg* 1979;137:216–20.
- Bradley EL III. Management of infected pancreatic necrosis by open drainage. *Ann Surg* 1987;206:542–8.
- Fugger R, Schultz F, Rogy M, Herbst F, Mirza D, Fritsch A. Open approach in pancreatic and infected pancreatic necrosis: laparostomies and preplanned revisions. *World J Surg* 1991;15:516–21.
- Fugger R, Götzinger P, Sautner T, Mittlböck M, Rogy M, Adamer K, et al. Necrosectomy and laparostomy – a combined therapeutic concept in acute necrotizing pancreatitis. *Eur J Surg* 1995;161:103–7.
- Bosscha K, Hulstaert PF, Hennipman A, Visser MR, Gooszen HG, van Vroonhoven TJMV, et al. Fulminant acute pancreatitis and infected necrosis: results of open management of the abdomen and “planned” reoperations. *J Am Coll Surg* 1998;187:255–62.
- Stone HH, Strom PR, Mullins RJ. Management of the major coagulopathy with onset during laparotomy. *Ann Surg* 1983;197:532–5.
- Kron IL, Harman PK, Nolan SP. The measurement of intra-abdominal pressure as a criterion for abdominal re-exploration. *Ann Surg* 1984;199:28–30.
- Tao HQ, Zhang JX, Zou SC. Clinical characteristics and management of patients with early acute severe pancreatitis: experience from a medical center in China. *World J Gastroenterol* 2004;10:919–21.
- Leppäniemi A, Kemppainen E. Recent advances in the surgical management of necrotizing pancreatitis. *Curr Opin Crit Care* 2005;11:349–52.
- De Waele J, Hoste E, Blot S, Decruyenaere J, Colardyn F. Intra-abdominal hypertension in patients with severe acute pancreatitis. *Crit Care* 2005;9:R452–7.
- Keskinen P, Leppäniemi A, Pettilä V, Piilonen A, Kemppainen E, Hynninen M. Intra-abdominal pressure in severe acute pancreatitis. *World J Emerg Surg* 2007;2:2.
- Leppäniemi A, Johansson K, De Waele JJ. Abdominal compartment syndrome and acute pancreatitis. *Acta Clin Belg* 2007;62:5131–5.
- De Waele JJ, Hoste EAJ, Malbrain MLNG. Decompressive laparotomy for abdominal compartment syndrome – a critical analysis. *Crit Care* 2006;10:R51.
- de Vries Reilingh TS, Bodegom ME, van Goor H, Hartman EHM, van der Wilt G-J, Bleihrdt RP. Autologous tissue repair of large abdominal wall defects. *Br J Surg* 2007;94:791–803.
- Leppäniemi A, Mentula P, Hienonen P, Kemppainen E. Transverse laparostomy is feasible and effective in the treatment of abdominal compartment syndrome in severe acute pancreatitis in press.
- Pushpakumar SB, Wilhelmi BJ, van-Aalst VC, Banis JC Jr, Barker JH. Abdominal wall reconstruction in a trauma setting. *Eur J Trauma Emerg Surg* 2007;33:3–13.
- Leppäniemi AK, Hienonen PA, Siren JE, Kuitunen AH, Lindström OK, Kemppainen EA. Treatment of abdominal compartment syndrome with subcutaneous anterior abdominal fasciotomy in severe acute pancreatitis. *World J Surg* 2006;30:1922–4.
- Scott BG, Feanny MA, Hirshberg A. Early definitive closure of the open abdomen: a quiet revolution. *Scand J Surg* 2005;94:9–14.
- Werner J, Hartwig W, Hackert T, Buchler MW. Surgery in the treatment of acute pancreatitis – open pancreatic necrosectomy. *Scand J Surg* 2005;94:1130–4.
- Brock WB, Barker DE, Burns RP. Temporary closure of open abdominal wounds: the vacuum pack. *Am Surg* 1995;61:30–5.
- Garner GB, Ware DN, Cocanour CS, Duke JH, McKinley BA, Kozar RA, et al. Vacuum-assisted wound closure provides early fascial reapproximation in trauma patients with open abdomens. *Am J Surg* 2001;182:630–8.
- Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Ann Plast Surg* 1997;38:563–76.
- Erdmann D, Drye C, Heller L, Wong MS, Levin SL. Abdominal wall defects and enterocutaneous fistula treatment with the Vacuum Assisted Closure (V.A.C.) system. *Plast Reconstr Surg* 2001;108:2066–8.
- Becker HP, Willms A, Schwab R. Small bowel fistulas and open abdomen treatment. *Scand J Surg*. 2008 (in press).
- Ramirez OM, Ruas E, Dellon AL. Components separation method for closure of abdominal-wall defects: an anatomic and clinical study. *Plast Reconstr Surg* 1990;86:519–26.
- Lyle WG, Gibbs M, Howdieshell TR. The tensor fascia lata free flap in staged abdominal wall reconstruction after traumatic evisceration. *J Trauma* 1999;46:519–22.
- de Vries Reilingh TS, van Goor H, Charbon JA, Rosman C, Hesselink EJ, van der Wilt GJ, Bleihrdt RP. Repair of giant midline abdominal wall hernias: “Components separation technique” versus prosthetic repair. *World J Surg* 2007;31:756–63.
- Scott BG, Welsh FJ, Pham HQ, Carrick MM, Liscum KR, Granchi TS, et al. Early aggressive closure of the open abdomen. *J Trauma* 2006;60:17–22.
- Van Geffen HJAA, Simmermacher RKJ, Bosscha K, van der Werken C, Hillen B. Anatomical considerations for surgery of the anterolateral abdominal wall. *Hernia* 2004;8:93–7.

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