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Abdominal Wall Reconstruction with the Two-step Technique: Procedure Optimization and Three-year Follow-up in 26 Surgeries

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Background: Complex or recurrent abdominal wall defects may be the result of trauma, infection, tumor resection, or a previous failed attempt at closure, among other causes. This article describes a new surgical technique that better addresses these defects and provides safety and efficacy data from 26 consecutive surgeries with a 3-year follow-up.

Methods: Prospective study in 18 men and 8 women with serious abdominal wall defects, who were surgically operated on using the two-step technique, which includes a first regenerative and closure step using a vacuum device (vacuum-assisted closure), and a second reconstructive step that does not require the use of any type of surgical mesh. The safety and efficacy results were evaluated through clinical examinations and questionnaires. The severity of patient-experienced pain and both patient and surgeon satisfaction were quantified on a scale from 0 to 10 points. The statistical calculations focused on the mean (m), range (r), and percentage (%).

Results: The mean complete surface area of the abdominal wall defects was 250.2 cm^2 (r = 78–770 cm^2). The patient and surgeon satisfaction rates at the time of hospital discharge were m = 9.0 (r = 3–10) and m = 9.4 (r = 8–10), respectively. After 3 years, these rates were m = 7.2 (r = 3–10) and m = 9.8 (r = 9–10), respectively. No relevant complications were observed in any stage of the study and no recurrence was observed 3 years later. The main complaint of patients was the presence of hypertrophic scars from the surgical wound (57% of cases).

Conclusion: The two-step technique is an excellent alternative for the repair of complete abdominal wall defects of up to 800 cm^2 because it allows serious complications to be avoided, prevents recurrences, and shows high rates of both patient and surgeon satisfaction. *(Plast Reconstr Surg Glob Open 2019;7:e2182; doi: 10.1097/GOX.0000000000002182; Published online 16 May 2019.)*

INTRODUCTION

The various techniques currently available for the reconstruction of large abdominal wall defects carry the risk of frequent complications and recurrences, and do not provide sufficiently satisfactory results. Such defects may be complete, affecting the entire abdominal wall and exposing the bowels, or incomplete, with a thin layer covering the abdomen. Several factors must be considered when choosing the appropriate surgical treatment, such as the size of the defect, the area involved, the presence or absence of infection, the experience of the surgical team, and any prior surgeries, associated injuries, or prior patient illness.[1,2]

In many abdominal wall defect cases, a primary closure is generally not feasible, and a temporary abdominal closure using vacuum-assisted closure (VAC; KCI Company, United Kingdom) is indicated to prevent mortality. The literature offers several options for definitive abdominal closure, including synthetic mesh, porcine dermis, nonvascularized fascial grafts, human acellular dermal matrix, human dura mater allograft, rotation flaps, myocutaneous pedicle flaps, free flaps, component separation of the rectus muscle (with or without release of the interface between the external and internal oblique fascias), and tissue expansion, among others. However, all of the above are commonly associated with complications, such as subsequent adhesion formation, enterocutaneous fistulas, intestinal obstruction, infection, and recurrence.[2]

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In 2007, our department began to practice a new two-step technique (TST), with excellent results. The preliminary results were reported in 2015 without sufficient details and had minimal repercussions in the medical community of plastic surgeons.[2] However, after some development, the TST has become our first-choice technique to repair large and complete abdominal wall defects with an extension of up to 800 cm^2, since then we have abandoned previously preferred techniques that achieved inferior results. Between 2007 and 2018, we treated 72 patients using this surgical technique, and have not observed cases of recurrence or relevant complications.

The objective of this study is to describe the optimized version of the TST in detail and to evaluate its safety and efficacy in a prospective series of 26 consecutive surgeries.

MATERIAL AND METHODS

Patients

Many patients were initially attended to by hospital emergency care staff, and received all necessary life support care. They were also started on analgesics and antibiotic treatment, which were maintained throughout their entire hospital stay. The hospitalization time before surgery was variable depending on the case.

A prospective clinical study was planned to evaluate the results in 26 patients surgically treated in our department between October 2012 and December 2014. The patients agreed to complete very simple questionnaires, authorize the dissemination of photographic images for scientific purposes, and attend successive follow-up visits and a final control visit after 3 years.

The following data, among others, were recorded in clinical histories: age, sex, etiology of the defect, size of the defect, prior illnesses, history of tobacco use, body mass index (BMI), number of previous abdominal surgeries, intraoperative complications, short-term postoperative complications, hospital stay related to surgery, and long-term complications. Patients with a history of coagulation disorders or diabetes, with a defect size larger than 800 cm^2, or a BMI > 35 were excluded, and patients with psychiatric or personality disorders which could interfere with the evaluation of results or adherence to the study.

Evaluation of the Abdominal Wall Defect

The wound was initially debrided. Ulcer size and shape were then plotted planimetrically by copying their shape on an Opsite foil[3] with a waterproof marker. The Opsite was then placed on a graphic table and layouts were transferred to a computer using SigmaScan software, to automatically calculate the perimeter and area of an abdominal defect in pixels. SigmaScan Pro is an image analysis package for scientists, engineers, and technicians which provides a method to measure distances across any object that can be photographed or scanned.

Surgical Technique

A simple TST is used to treat abdominal wall defects, which involves the use of a vacuum device (step 1) and inner layer reconstruction with de-epidermization and inversion of the edges (step 2). Contrary to other conventional techniques, no type of mesh is used with the TST, which instead uses a vacuum device (VAC) and silicone dressing to prevent intestinal damage and perforations. During step 1, the patient remains connected to the VAC device for 2 weeks. Once this period has elapsed, we proceed to the second reconstructive phase (step 2).

Step 1

In the operating room, the patient is put under general anesthesia and monitoring, and the entire compromised area and adjacent tissue are disinfected. Afterward, the internal edges of the defect are approximated with 1-0 Vicryl (to prevent the external displacement of the abdominal rectus muscles), using mattress sutures. The abdominal defect is covered with a Mepitel Silicone Dressing (Molnlycky, Gothenberg, Sweden), so that the silicone dressing slides under the Vicryl suture to protect the bowels. The VAC is placed above the dressing at a pressure of –85 mm Hg. The integrated VAC Therapy System promotes wound healing through topical negative pressure. Delivering negative pressure (a vacuum) at the wound site through a unique, proprietary dressing helps to draw the wound edges together, removes infectious materials, and actively promotes the formation of granulation tissue. These mechanisms of action (macrostrain and microstrain) lead to fast and effective wound healing and improved patient quality of life in a cost-effective way.[4–7] The skin at the edge of the defect is protected with Duoderm (ConvaTec, Deeside, United Kingdom). The Mepitel dressing and the VAC dressing are both changed 2 times per week. After 1 week, the silicone dressing is removed and the pressure of the VAC is increased to –125 mm Hg. The duration of the first step of the surgery is between 1 and 2 hours (Fig. 1).

Step 2

With the patient in the operating room and under monitoring, the VAC is removed, and an outstanding formation of granulation tissue can be observed in the abdominal defect. A de-epithelization of 5 cm in width is performed around the entire edge of the abdominal defect. From the external edge of the de-epithelized band of tissue, a vertical incision as deep as the abdominal rectus muscle fascia is made. The dissection is extended, taking into account the width of the wall defect to be covered. The flap is inverted to cover the central abdominal defect. The edges are approximated with 1-0 Vicryl sutures using interrupted stitches. After suturing the flaps, the cutaneous closure is performed with 2-0 Monocryl sutures and 3-0 Monocryl continuous subcutaneous sutures. Finally, the wound is covered with a sterile dressing and an abdominal tubular binder is put in place for 1 month. The duration of this second surgical step is around 3 hours (Fig. 2).

Postoperative Care

Patients were monitored closely for complications. The drains were removed when less than 20 ml was drained in a 24-hour period. Patients were mobilized as soon as pos-

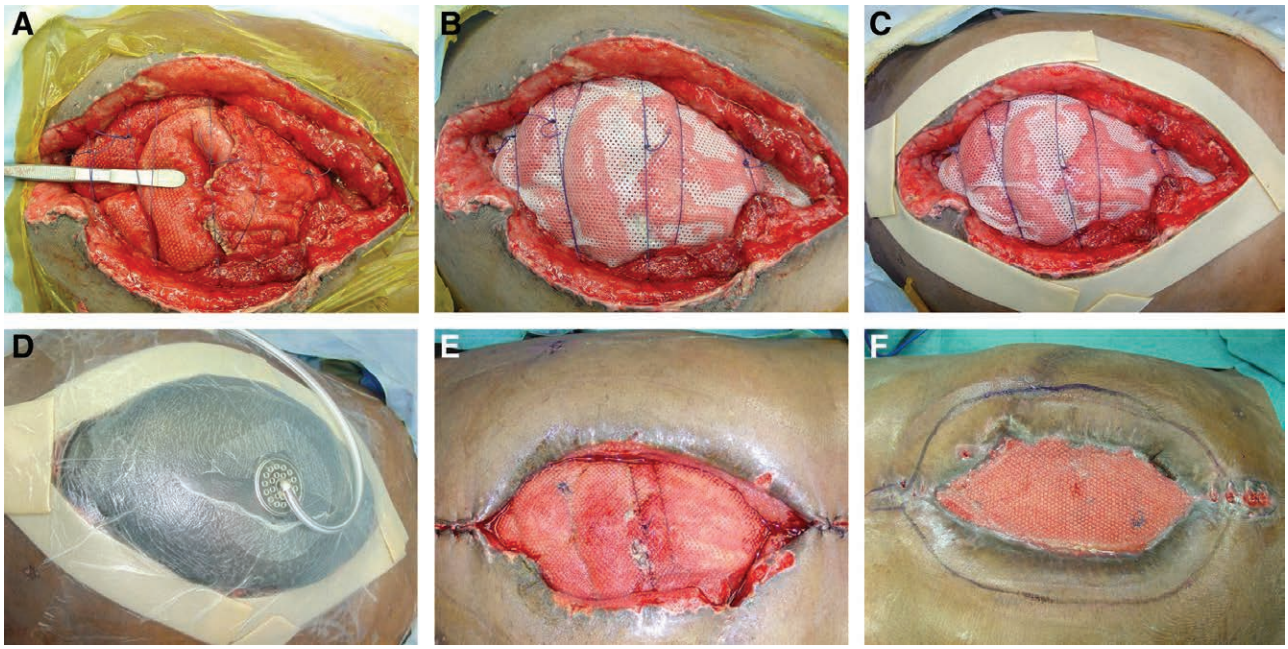

Fig. 1. Series of images from step 1 (patient 1 of Table I). A, The internal edges of the wound are sutured with 1-0 Vicryl to reduce wound size and prevent lateral contracture of the rectus muscle. The silicone dressing is applied between the Vicryl sutures and the bowels to protect them from damage and perforations. B, The silicone dressing is kept in place for 1 wk and then removed. C, The Duoderm dressing is applied at the edges of the wound to protect healthy skin from possible harm caused by the VAC dressing. The VAC dressing is initially applied to the wound at –85 mm Hg for 1 wk, and then is increased to –125 mm Hg for the second week, to remove exudates, reduce edema, and increase vascularity, reducing the wound size and activating the formation of granulation tissue on top of the bowels (D). Afterward, the wound appears clean and smaller. Granulation tissue (E) can be seen covering the bowels. A band of 5 cm in width is designed around the wound edges to prepare the site for step 2 (F).

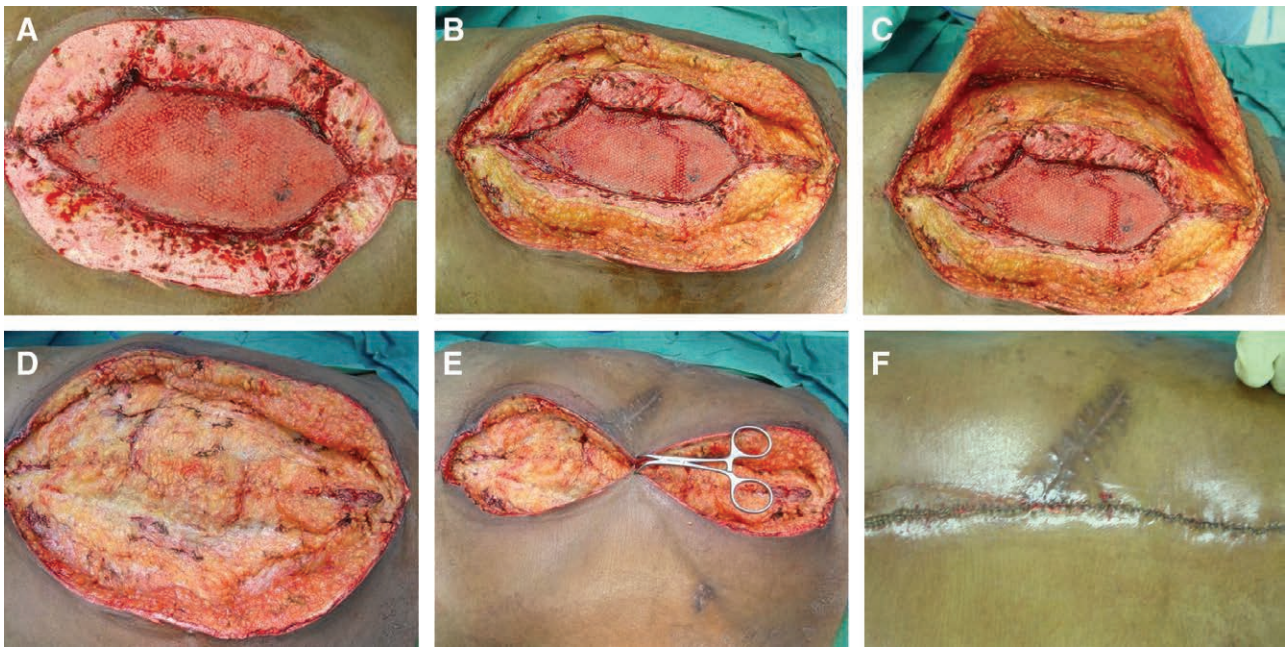

Fig. 2. Series of images from step 2 (Patient 1 of Table I). A, De-epithelization of 5 cm in width around the abdominal wound. A vertical incision can be seen at the outer border of the wound, as deep as the rectus muscle fascia. B, The flap is dissected toward the center of the abdominal wound, preserving a minimum of 1 cm of thickness at the base of the flap. C, Lateral dissection can be seen at the level of the rectus muscle flap. D, Display of the flap to cover the central section of the abdominal wound using 1.0 Vicryl sutures can be seen. E, The edges of the skin wall defect are partially closed with 2-0 Monocryl interrupted stitches. F, Total skin closure is completed with 3-0 Monocryl continuous stitches.

sible to prevent circulatory complications due to compression, and discharged once the drains had been removed. During the in-home postoperative period, antibiotic coverage (amoxicillin/clavulanic acid) was prescribed and continued for 1 week, along with anti-inflammatory drugs and analgesics (diclofenac sodium and paracetamol), which were alternated every 4 hours. Anticoagulants were not indicated, to prevent the risk of bleeding, although the early mobilization was taken into close consideration to prevent deep vein thromboses.

All patients were re-evaluated 1 week after hospital discharge, and the tubular binder was required for a minimum of 3 additional weeks, in a permanent manner, in addition to the daily bandage redressing by home healthcare personnel.

Evaluation of Safety, Complications, and Adverse Effects

Patients were regularly evaluated until fully healed, and the duration of hospital stay and downtime were recorded.

Each patient was asked to score the level of pain experienced from the beginning of postoperative care following the first step of the surgery until the time of their hospital discharge. A grading scale of 11 points (0–10) was used, where 0 points indicated the absence of pain and 10 points indicated the maximum pain possible (pain scale).

In the clinical histories, spaces were provided to note possible adverse effects or complications during each step, in the first and second postoperative stages and for a period of 3 years. Possible early complications such as potential seroma formation, hematoma, and infection were particularly taken into account. Possible later complications during the follow-up period such as potential recurrence, hernias, sensitivity alteration, hypertrophic scars, and keloids were particularly taken into account. Recurrence was defined as any abnormal protrusion or defect at the site of the previous surgery.

Evaluation of the Efficacy and Level of Satisfaction

At the time of hospital discharge, the patient was asked to evaluate their level of satisfaction with the surgical results, using a grading scale of 11 points (0–10), where 0 points indicated complete dissatisfaction and 10 points indicated complete satisfaction [Patient Satisfaction Scale-1 (PSS-1)].

Upon finalizing the study, after a period of 3 years, the patient was asked to evaluate their level of satisfaction with the surgical results, using a grading scale of 11 points (0–10), where 0 points indicated complete dissatisfaction and 10 points indicated complete satisfaction (PSS-2).

At the time of hospital discharge, the surgeon who conducted the surgery, an expert in various surgical techniques for abdominal wall reconstruction, scored his level of satisfaction with the surgical results, using a grading scale of 11 points (0–10), where 0 points indicated complete dissatisfaction and 10 points indicated complete satisfaction [Surgeon Satisfaction Scale-1 (SSS-1)].

Upon finalizing the study, after a period of 3 years, the surgeon evaluated his level of satisfaction with the surgical results, using a grading scale of 11 points (0–10), where 0 points indicated complete dissatisfaction and 10 points indicated complete satisfaction (SSS-2).

Statistical Analysis

The series data and the results obtained were analyzed using descriptive statistics, taking the arithmetic mean or average (m) as the main measure of the central tendency, and the range (r) as the principal measurement of dispersion. Percentages (%) were indicated as complementary descriptive parameters when they were of interest.

RESULTS

All 26 patients concluded the study; there were no deaths or withdrawals. A total of 18 men and 8 women were evaluated, with a mean age of 44.1 years (r = 20–79 years) and a mean BMI of 27.7 kg/m^2 (r = 21–34 kg/m^2). Of the 26 patients, 11 were smokers (42%). The most frequent etiology of the abdominal defects was trauma (17 cases; 66%). The remaining cases were due to secondary peritonitis to multiple processes (8 cases; 30%) or to congenital causes (1 case; 4%). The mean surface area of the complete abdominal wall defects was 250.2 cm^2 (r = 78–770 cm^2). The mean hospital stay related to the surgery was 26.4 days (r = 21–33 days). The mean recovery time, from the second step of the surgery until the patient returned to regular daily activities, was 28.7 days (r = 22–41 days). The main descriptive data and the results of the series are shown in Table I.

Efficacy Results

The results of both the PSS and SSS are indicated in Table 1. Figures 3–7 show results from 4 representative cases of the sample.

Only one of the 26 patients was not sufficiently satisfied at the time of hospital discharge, whereas all the results were considered highly satisfactory by the surgeon. The mean satisfaction was 9.0 points (r = 3–10 points) in the patient sample, whereas the mean satisfaction of the surgeon at the time of the hospital discharge was 9.4 points (r = 8–10 points). In the evaluation after 3 years, 96% of the patients reported sufficient satisfaction with the result, with a mean satisfaction level of 7.2 points (r = 3–10 points). The surgeon qualified all the results as excellent, with a mean satisfaction level of 9.8 points (r = 9–10 points). The most frequent unsatisfactory aspect reported by the patients was the presence of a hypertrophic scar of the surgical wound.

Adverse Effects and Complications

Despite the complexity and high risk of many of the treated cases, and contrary to what might be expected, none of the possible serious complications were observed.

During the short- and long-term control periods after surgery, all patients were evaluated through manual palpation and their performance of physical movements, which put pressure on the repaired abdominal wall area to verify its stability. A CT scan was not performed on all patients, but only on those for whom a failure of the abdominal wall resistance was suspected, and bulging or failure in the sur-

Table 1. Descriptive Data and Evaluation of the Series

N	Sex	Age	BMI	Etiology	Size*	Pain Scale	PSS-1	PSS-2	SSS-1	SSS-2
1	M	45	28	T	450	4	10	7	8	10
2	M	33	25	P	442	7	6	8	10	10
3	M	63	27	P	154	2	9	7	10	10
4	M	32	22	T	102	4	10	6	10	10
5	M	51	23	P	130	3	10	10	10	10
6	M	34	24	P	300	3	7	7	8	10
7	F	68	32	T	280	0	10	7	10	10
8	M	55	34	T	620	4	6	3	8	10
9	M	28	29	C	680	3	8	7	10	10
10	F	24	22	T	126	5	10	5	10	10
11	F	57	34	T	255	3	9	10	10	9
12	M	38	23	P	144	3	3	5	10	10
13	F	40	28	P	78	4	9	6	8	10
14	F	79	30	P	175	2	10	10	8	10
15	M	34	21	T	149	3	10	8	10	9
16	M	27	33	T	104	1	10	7	9	9
17	M	48	26	T	89	1	10	10	10	10
18	M	63	34	T	236	3	9	7	8	10
19	F	71	28	T	385	2	10	6	10	10
20	M	41	31	T	770	3	9	10	8	10
21	M	20	26	T	220	5	10	8	10	10
22	F	33	29	P	108	8	10	10	10	10
23	M	46	27	T	205	4	10	7	10	9
24	M	38	31	T	128	3	9	7	10	9
25	F	50	30	T	135	1	10	6	10	10
26	M	29	23	T	240	2	10	5	10	10

C, congenital; F, female; M, male; N, patients, P, peritonitis; PSS, patient satisfaction scale; SSS, surgeon satisfaction scale; T, trauma.
*Size of the defect in cm^2.

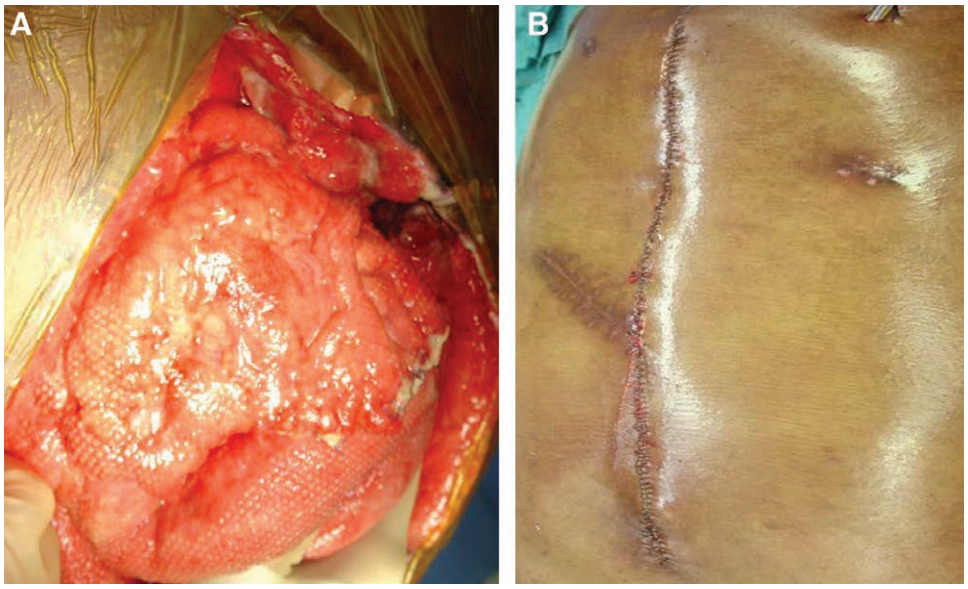

Fig. 3. Images corresponding to patient 1 (Table I, Figs. 1 and 2). Size of the defect: 450 cm^2. Etiology: fall from height/abdominal compartment syndrome. A, Initial condition. B, Immediately after the completion of step 2, the surgery wound appears well closed without signs of tension.

gically repaired abdominal area was not observed in any of these patients.

In the convalescence period after step 2, 2 isolated cases of partial wound dehiscence were observed due to infection, which were resolved by the closure of the defect, resulting in scarring from the second attempt. No additional types of complications were observed in any of the other cases, with the exception of hypertrophic scars.

The main adverse effect highlighted by the patients was abdominal discomfort or pain, which was well tolerated with analgesic guidelines adapted to each case. The mean level of pain indicated by the patients during the entire hospitalization period following the first step of the surgery was 3.2 points (r = 0–8 points).

In the visit 1 week after discharge, proper wound evolution was observed. The majority of patients reported mild, occasionally moderate, pain in the wound area, which was perfectly tolerable with the prescribed analgesic.

In medium-term follow-ups and the 3-year evaluation, no additional complications were observed beyond scar-

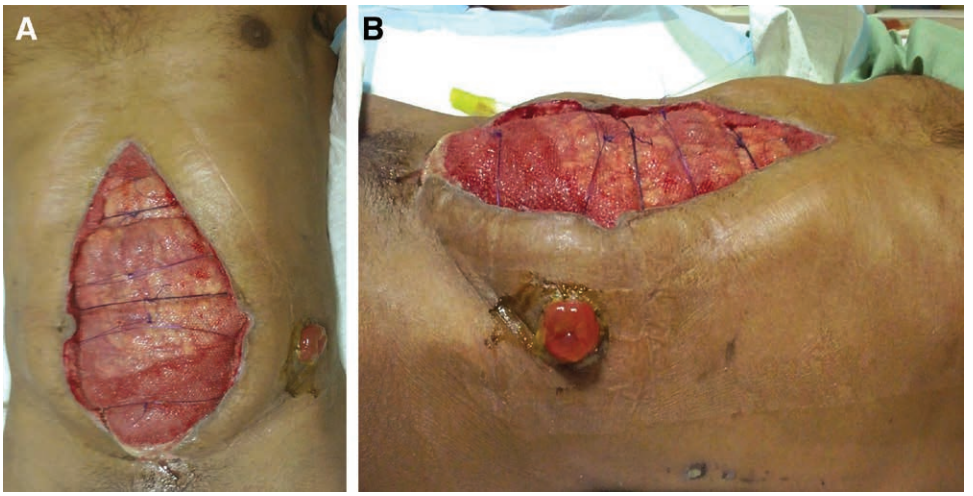

Fig. 4. Images corresponding to patient 5 (Table I). Size of the defect: 130 cm^2. Etiology: abdominal pain due to perforated rectum. A, Abdominal wall defect immediately before step 1 of the surgery. Note the total loss of muscle protection with protruding bowels. B, Frontal view of the wall defect at the end of step 1 of the surgery. Smaller wound area without noticeable lateral contraction of the rectus muscle. C, The protruding bowels are clearly seen in the lateral view, reflecting the notable extension of the abdominal wall defect.

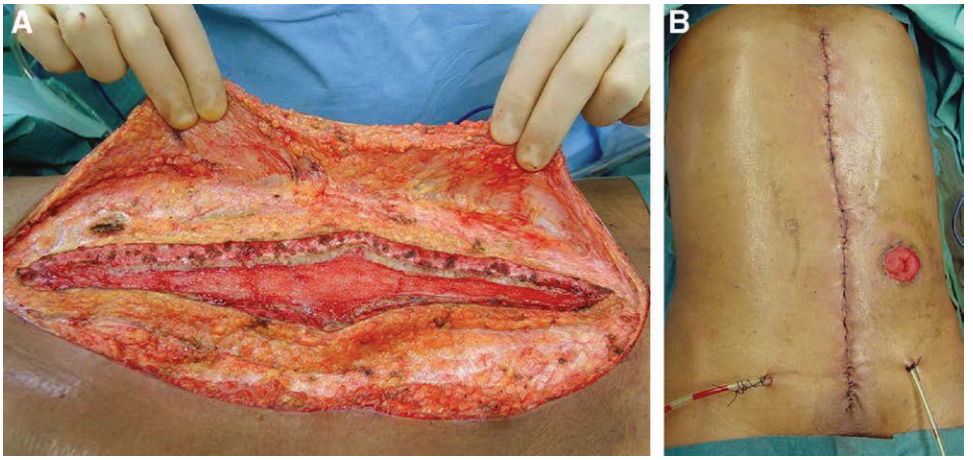

Fig. 5. Images corresponding to the same patient as Fig. 4. A, The flap is elaborated for skin closure. Note that the subcutaneous layer has been divided into 2 layers, for its display to advance to the edges of the abdominal defect. Mattress sutures in this layer will include the abdominal rectus muscle. B, Step 2 of surgery is completed.

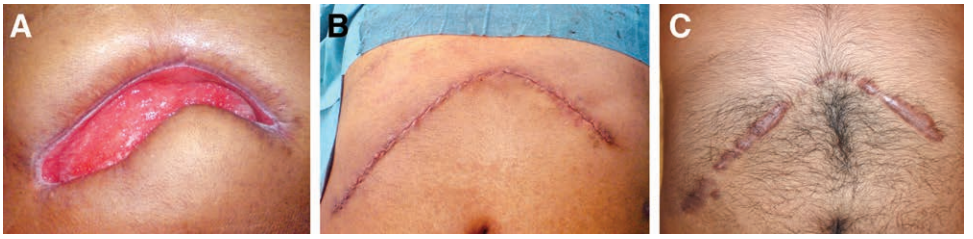

Fig. 6. Images corresponding to patient 4 (Table I). Size of the defect: 102 cm^2. Etiology: Road traffic accident with blunt abdominal trauma (GIV liver injury and splenic rupture). A, Initial status of abdominal wall defect of chronic evolution refractive to multiple attempts at closure using various techniques. B, Immediately after completion of step 2 of surgery. C, Status at 3-y control. Tissue repair has achieved good recovery without signs of scar widening; however, hypertrophic scar formation might be related to the dark skin phototype of the patient.

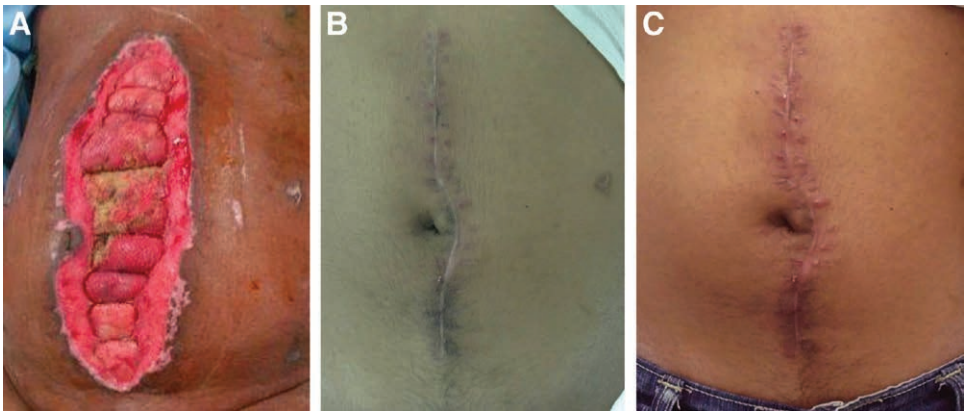

Fig. 7. Images corresponding to patient 6 (Table I). Size of the defect: 300 cm^2. Etiology: Blunt abdominal trauma with mesenteric injury A, In step 1 of surgery, 1.0 Vicryl sutures are seen before silicone sheath and vacuum device placement. B, One year after surgery, wound closure shows healthy tissue. No presence of abdominal wall weakness or bowel hernia is noticed. C, At 3-y control, good abdominal condition is solidly maintained. Despite patient weight gain, the anatomical shape of the abdomen maintains its good appearance.

ring. Of the 26 cases, 15 presented a hypertrophic scar of the surgical wound (57%), primarily in patients with larger defects and dark skin phototype (IV and V).

DISCUSSION

Over the past century, various techniques for closing the abdominal wall have been used, each one indicated depending on the etiology, location, and extent (layers involved) of the defect, some using mesh[8–13] and some using flaps.[14–16] Since then, surgical ingenuity and technological advances have allowed new procedures, some of which were reported very recently with increasingly satisfactory results.[17–19] This study posits that the optimized TST has been effective and safe for the reconstruction of various large abdominal wall defects that presented notable surgical risk. The technique is also relatively simple once learned. The good results and lack of major complications and recurrences were also confirmed with the original technique,[2] but the changes introduced and evaluated in this series simplify the surgery, optimize the results, and reduce the hospitalization period. In the abdominal wall repair, we used the dermis—which is rich in collagen—to act as autologous mesh. The dermis is attached medially and bilaterally to the edge of the abdominal defect. Laterally, both sides are elevated and stitched together to cover the defect. In fact, the TST proved very effective during the period of prolonged control for patients who underwent the operation, and no abdominal bulging was noticed.

It should be recognized as a limitation of the study that the results were evaluated by the same surgeon who performed the surgery. The evaluation is based on their personal previous experience using other techniques when foreseeable complications existed beforehand. The results only emphasize a high degree of personal surgeon satisfaction with the results obtained and a good acceptance of the results by the patients who underwent the surgery. We have previously practiced other types of surgeries that produced foreseeable complications, such as a lateral abdominal wall hernia due to the dehiscence of the rectus muscle fascia used to cover the defect. Moreover, proposed surgical alternatives using artificial material could potentially cause rejection or infection.

The TST only uses sutures that are absorbed at different rates. According to manufacturer data, Monocryl suture has a low tissue reactivity, maintains high tensile strength, and has a half-life of 7–14 days. In contrast, Vicryl suture holds its tensile strength for approximately 2–3 weeks in tissue, and is completely absorbed within 56–70 days. The difference in these absorption times allows for an effective progressive closure, avoiding the risks and complications of permanent sutures.

The fact that the subcutaneous tissue, once unfolded using the maneuvers in step 2, which can be arranged on top of the newly formed layer of tissue granulation allows a sufficiently strong closure of the abdominal wall defect. The layer of fatty tissue reinforces the strength of the closure and helps to avoid recurrences, hernias, and dehiscence. The subcutaneous tissue, due to its elastic consistency, functions as buffering. This allows abdominal expansion and prevents tension from being applied to the suture lines. Covering with subcutaneous cellular tissue, as if it were a cushion, absorbs the vector forces of the abdominal muscles and buffers the peristaltic movements of the bowels.

The negative VAC pressure is incremented, due to early fragile bowels and the presence of edema (sensitive bowels). When the bowels are exposed, there is a high intra-abdominal pressure status. To avoid internal abdominal pressure, which can cause damage to the bowels, the low-pressure vacuum system is applied. After 1 week has elapsed, the intra-abdominal pressure is reduced as edema decreases. At this time, it is possible to increase the negative vacuum pressure to allow better and faster granulation tissue formation and reinforce coverage of the abdominal wall defect.

During the 3-year follow-up period, no significant complications or recurrences were observed. The level of surgeon satisfaction with the results has been excellent, and it has been sufficiently satisfactory for patients. The patients' main complaint was related to the appearance of the surgical scar. As time passes, patients tend to forget the importance of the abdominal defect and the high risks associated with it, and begin to consider the aesthetic aspect of the abdomen and the appearance of the surgical scar.

In contrast to previously achieved results,[2] keloids did not develop in any patients. The relatively high rate of hypertrophic scarring can be attributed to the dark cutaneous phototype of the majority of the patients (Fitzpatrick IV and V), which is associated with a higher predisposition to develop hypertrophic scars. These postsurgical scars can be diminished with various techniques, which can be recommended to the patients to improve the aesthetic aspect.[20,21] Small dehiscences were observed due to patient weight gain, but the closure of the wall defect was effectively maintained. The absence of recurrences during the study, in both patients who underwent this surgery for the first time and those who had experienced multiple failed attempts at closure with other techniques, is one of the most notable merits of the TST.

According to financial observations, the TST is lower in cost when compared with our initial technique,[2] due to the earlier patient discharge from the hospital. Additionally, a rapid return to usual daily activities after surgery impacts patient physical–psychological conditions and self-esteem. Moreover, a prolonged hospital stay for the frequent development of an abdominal wall defect does present potential complications.

The TST is practiced exclusively in our hospital in Dubai, using the materials and methods presented in this article, which we consider clearly advantageous for repairing large complete abdominal wall defects. The lack of recurrences and relevant complications in this series, and in other patients undergoing this surgery over a period of more than 10 years (72 patients in total), is one of the most compelling arguments for the continued use and result reporting of this technique.

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