

Original Article

Acellular allogenic dermis combined with VSD for repair of abdominal wall defect: a case series

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Abstract: Objective: To explore the clinical application of acellular allogenic dermis combined with VSD in repairing abdominal wall defect combined with abdominal infection. Methods: Clinical data of 5 cases of abdominal cavity infection with abdominal wall defect admitted in the Burn Department of Quanzhou First Hospital from January 2019 to January 2022 were collected for this study. The abdominal cavity was closed temporarily after debridement and VSD in the early stage, and the abdominal wall defect was repaired by acellular allogeneic dermis combined with autologous split-thickness skin graft in the second stage. The changes of infection indexes (WBC, CRP, PCT, Lac) before and after treatment and the clinical therapeutic effect were observed. Results: In the 5 observed cases, the infection index decreased significantly, the intra-abdominal pressure was normal, and there was no abdominal wall hernia, intestinal adhesion, intestinal obstruction or any other complications. The wound of abdominal wall defect achieved stage 1 healing, the local scar tissue only has slight proliferation, and the appearance was satisfying. There was no recurrence in 6 months follow-up. Conclusion: Early use of VSD can effectively control abdominal infection and reduce the occurrence of intestinal fistula or other complications. In the later stage of treatment, acellular allogenic dermis combined with autologous split-thickness skin graft can effectively repair abdominal wall defect.

Keywords: Defect of abdominal wall, abdominal infection, acellular dermal matrix (ADM), vacuum sealing draina (VSD)

Introduction

As an important component of the abdominal cavity, the integrity of the abdominal wall not only maintains the position of the abdominal organs, but also maintains the intra-abdominal pressure and protects the viscera organs [1]. The causes of abdominal wall defect include trauma, infection, tumor resection, and deformity etc. [2]. The abdominal wall defect caused by abdominal wall trauma combined with abdominal infection can easily lead to intestinal necrosis, peritonitis and other complications, and even multiple organ dysfunction syndrome, which can be life-threatening. It is difficult to repair abdominal wall defects, especially those complicated with abdominal infection, rupture of intestinal cavity and organ injury. Direct suture or skin flap repair is usually used

in clinical repair, but the therapeutic effect is not good, and it is easily complicated with abdominal hernia, intestinal obstruction and other complications [3]. From 2018 to 2020, we treated 5 patients with abdominal wall defect caused by abdominal wall trauma complicated with abdominal infection. In the early stage, after VSD the abdominal cavity was closed temporarily, and in the later stage, acellular allogenic dermis combined with autologous split-thickness skin graft was used to repair the abdominal wall defect, and satisfactory clinical results were achieved.

Data and methods

Patient background

From January 2019 to January 2022, there were 5 cases of abdominal wall defect caused

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by abdominal wall trauma complicated with abdominal infection that were admitted in the Department of Burn, Quanzhou First Hospital, including 4 males and 1 female with a mean age of (34.6±10.4) years old (range from 22-48). The causes of abdominal wall defect for these 5 cases were all due to abdominal wall muscle rupture combined with intestinal rupture and abdominal infection. Specific defect sites included 3 cases of anterior abdominal wall central district and lateral inferior region (M+L), 1 case of anterior abdominal wall central district and lateral superior region (M+U), 1 case of anterior abdominal wall central district, lateral superior region and lateral inferior region (M+U+L). The defect area ranged from 120 cm² to 300 cm² with an average of (212±68.3) cm². The pathogenic examination of wound secretion in 5 cases all showed bacterial infection, with 3 cases of *Escherichia coli*, 1 case of *enterobacter cloacae* and 1 case of *Enterococcus Faecalis*. This study is a retrospective clinical analysis and had been approved by the Ethics Committee of Quanzhou First Hospital. All patients signed an informed consent form.

Preoperative treatment

A: After admission, all patients underwent wound infection etiological examination and drug sensitivity test. All patients who had positive bacterial culture were treated with sensitive antibiotics for 7-10 days. Other patients who had negative bacterial culture were treated with empirical choice of antibiotics in the perioperative period to prevent infection. B: Patients were fasted, and intravenous fluid infusion was used to maintain water and electrolyte balance and internal environment stability with parenteral nutrition support. C: Acid inhibition to prevent stress ulcer, nutrition support for myocardium and protection of organ function were implemented. D: Wound care: debridement, dressing change, the wound was rinsed with 3% hydrogen peroxide solution (100 mL Guangdong Hengjian Pharmaceutical Co., Ltd.), normal saline (500 mL, Fuzhou Haiwangfu Pharmaceutical Co., Ltd.), 0.1% iodophor (500 mL, Shanghai Likang disinfection high-tech Co., Ltd.) solution and biological dressing with active factor (20 mL, Changsha Hairun Biology Co., Ltd.) for 1-2 times per day.

Surgical treatment

The first stage: laparotomy + intestinal rupture repairment and wound debridement + VSD treatment: A: A midline incision was made to explore the intestine and organs, expose the damaged intestine, and probe the bowel for an accurate lateral anastomosis, then the sero-muscular layer was sutured and strengthened with several stitches to ensure the anastomotic stoma was smooth and the mesenteric gap was well sutured with complete hemostasis. B: Open the necrotic skin and fascia, thoroughly expand the wound and remove the necrotic tissue. After hemostasis, the wound was rinsed repeatedly with 3% hydrogen peroxide solution, warm saline, 0.1% iodophor solution and biological dressing with active factors until the rinsing fluid was clean and bleeding was stopped completely. C: The surface of the abdominal cavity was covered with a VSD (15 cm × 10 cm Wuhan Weisdi Medical Science and Technology Co., Ltd.) dressing, and drainage tubes were placed in the abdominal cavity, pelvic cavity and intestinal space. The drainage tube opening was placed in the VSD dressing and the gap between VSD material and the surrounding normal skin was sealed with a semi-permeable membrane to create a sealed wound area. A negative pressure device was attached to make sure there was no air leakage in the sealed wound area to ensure smooth drainage. After operation, 20-40 KPA negative pressure was applied for continuous suction, and 40 mL normal saline (40 mL of active factor biological dressing per 500 mL normal saline) was used for continuously drip irrigation to keep the wound area moist and avoid the blockage of drainage tube to ensure adequate drainage.

The second stage: acellular allogeneic dermis combined with autologous split-thickness skin grafting: The wound bed was well prepared after removing the VSD dressing on the abdominal wall. Next, the wound repeatedly rinsed with warm saline and 0.1% iodophor solution and the bleeding was stopped completely. Acellular allogenic dermis (20 cm × 15 cm Beijing Jieyalife Biological Technology Co., Ltd.) was transplanted on the surface of the defect abdominal wall. Specifically, the dermal tissue was pressed down to the wound surface and the acellular allogenic dermis exceed 3 cm

Table 1. Comparison of infection index (WBC, PCT and CRP)

	N (n)	WBC (10 ⁹ /L)	CRP (mg/L)	PCT (ng/mL)
Day 1	5	25.12±4.95	159.92±27.52	6.08±1.27
Day 7	5	12.78±2.27	36.56±8.74	0.76±0.15
P Value		<0.01	<0.01	<0.01

Note: WBC: White Blood Cell; PCT: Procalcitonin; CRP: C-Reaction Protein.

beyond the wound border. The acellular dermal tissue was implanted in the space below the normal abdominal wall with absorbable suture and it was stably fixed with no bulge into the intestinal canal. A 0.2 mm thick autologous tissue of similar size to the defect area was taken from the thigh for grafting. The autologous tissue was transplanted on the acellular allogenic dermis basement membrane, sutured and fixed with silk thread and packed with long thread. The thigh skin donor area was wrapped with oil dressing and followed with sterile dressing.

Statistical analysis

All statistical analyses were performed with IBM SPSS Statistics for Windows, Version 23.0 White Blood Cell (WBC), C-reactive protein (CRP), Procalcitonin (PCT), Lactic acid (Lac). The data were analyzed using t-test, P values of <0.05 were considered statistically significant.

Results

Surgical outcome of patients

The infection index of all 5 patients decreased significantly after surgery (all P<0.01, **Table 1**). There were no intestinal fistula, intestinal obstruction, intestinal adhesion or abdominal wall hernia. Acellular allogeneic dermis and autogenous split-thickness skin graft all survived, and the suture was removed 7 days after skin grafting. The wounds of abdominal wall defect achieved stage 1 healing and the skin donor site of the thigh also healed well. Patients were then discharged. During the 6-month-follow-up, the patients had no obvious scar hyperplasia, abdominal pain, abdominal distension, intestinal obstruction or abdominal wall hernia, and their defecation was normal. Patients were also satisfied with the wound appearance.

Representative case

A 27-year-old male was referred to Quanzhou First Hospital due to “abdominal distention and

abdominal pain after traffic accident”. The diagnosis was abdominal closed injury: 1. Intestinal rupture; 2. Infection and necrosis of the skin and soft tissue of the abdominal wall; 3. Abdominal wall defect; 4. Severe infection of abdominal cavity. The patient had extensive skin swabbing and ecchymosis in the middle and left abdomen, local skin blackening, scattered tension blisters and blood

blisters, obvious inflammatory reaction around the wound, and it spread to the left chest wall, left waist and left thigh. Abdominal CT showed free gas below the diaphragm, broken and discontinuous peritoneum, broken and partially defected rectus abdominis, and abdominal wall hernia (**Figure 2**). The operation was performed and it was found that part of the peritoneum was missing in the midsection of the abdomen, part of the intestinal canal was exposed, resulting in a hernia on the abdominal wall, an intestinal rupture in the descending colon, and infection in the peritoneum and the lower abdominal wall (**Figure 3**). After primary debridement, the abdominal cavity was temporarily closed with a VSD dressing and a drainage tube was left in place for continuous irrigation and vacuum drainage after operation, by which the infection of abdominal wall and abdominal cavity was effectively controlled. Part of the peritoneum and rectus abdominis was absent, part of intestinal canal was exposed, and fresh tissue grew on the surface of the intestine (**Figure 4**). The abdominal wall defect was repaired with acellular allogeneic dermis and large split-thickness skin graft (**Figure 5**). On the 14th day after operation, the acellular allogeneic dermis and the large layered skin graft were ruddy in color and survived well, and the wound achieved Stage I healing. No recurrence of abdominal wall defect, abdominal wall hernia, intestinal adhesion, intestinal obstruction was found during 6 months’ follow-up. The local scar growth was slight, and the appearance was basically satisfactory (**Figure 6**).

Discussion

According to the degree of defect, the abdominal wall defect is divided into three types [4]: type I involving only skin and partial subcutaneous tissue loss; type II mainly involving abdominal muscle and peritoneal tissue loss, with intact skin integrity of the original abdominal wall; and type III involving full thickness abdom-

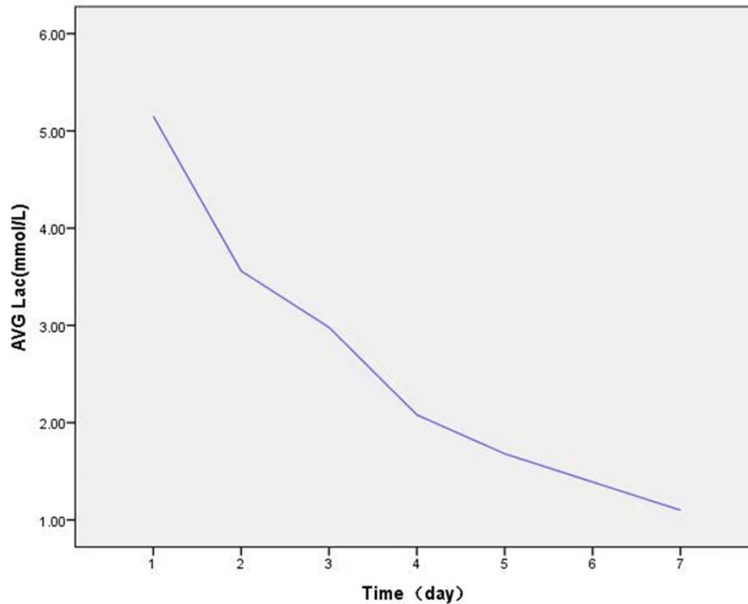


Figure 1. The content of lac in the course of treatment. Lac: Lactate.

inal loss. The defect of the abdominal wall is divided into three regions [5], specifically: the median region (M Region), the outer upper quadrant (Area U), the outer lower quadrant (Area L). The division of the U region and L region is by the transumbilical horizontal line. The most common site of abdominal wall defect seen in clinic is the M region, and the more common type of defect is type II [6]. In this group of cases, the defect area of abdominal wall in 5 patients mainly involved 2 or even 3 areas, and the defect in M area appeared in different degrees. According to the degree of injury, 4 cases were type II and 1 case was type III. The main cause of injury in this group was car accident trauma. The midline region of abdomen was often impacted by external force. At the same time, all cases were accompanied with intestinal rupture, diffuse contamination of subcutaneous tissue with intestinal contents, and extensive infection of abdominal cavity and subcutaneous soft tissues, culminating in abdominal wall defects.

The reconstruction of the abdominal wall defect should be decided according to the extent of the defect and the infection of the abdominal cavity [7]. Type I abdominal wall defects can be repaired by autologous skin grafting [8]. Type II and III defects, especially the larger ones, need to be repaired by tissue flaps, such as latissi-

mus dorsi, gracilis, tensor fasciae latae muscle, etc. [9]. In recent years, with the development of microsurgical techniques, free flaps have been widely used to repair large abdominal wall defects such as anterolateral thigh flaps and latissimus dorsi musculocutaneous flaps [10]. The large trauma area and long operation time requires high skill, especially the design, incision and anastomosis of free blood vessels, which are related to the survival of the flap. In comparison, the success rate of free flap repair was lower than other methods. In this group of patients, post-traumatic abdominal wall defects, extensive contusion of skin and soft tissues around

the wound, accompanied by intestinal rupture and abdominal infection, easily cause vascular embolism, edema and infection [11], which are not conducive to skin flap transplantation.

Abdominal wall injury, infection, or abdominal wall defect with intestinal rupture and organ injury are complex abdominal wall defects [12]. To repair this, temporary abdominal closure, autogenous tissue flap transplantation and implantation material repair are chosen [13]. Vacuum sealing drainage (VSD) has been used in the treatment of abdominal wall defect, intra-abdominal high pressure, abdominal space syndrome and so on. VSD technique was used to close the abdominal cavity temporarily to maintain the temperature, humidity and intra-abdominal pressure [14]. The drainage tube was fixed in the VSD dressing. The drainage tube was continuously rinsed and drained by negative pressure after operation to remove the ascites which is rich in protease and reduce inflammation. It is helpful to reduce local tissue edema and control abdominal cavity infection [15]. The intra-abdominal pressure was normal after operation, the level of lactate fell back to normal in a short time (**Figure 1**) and the infection index decreased significantly. The intra-abdominal infection was effectively controlled in a short time. Enteral nutrition can help restore gastrointestinal function, avoid

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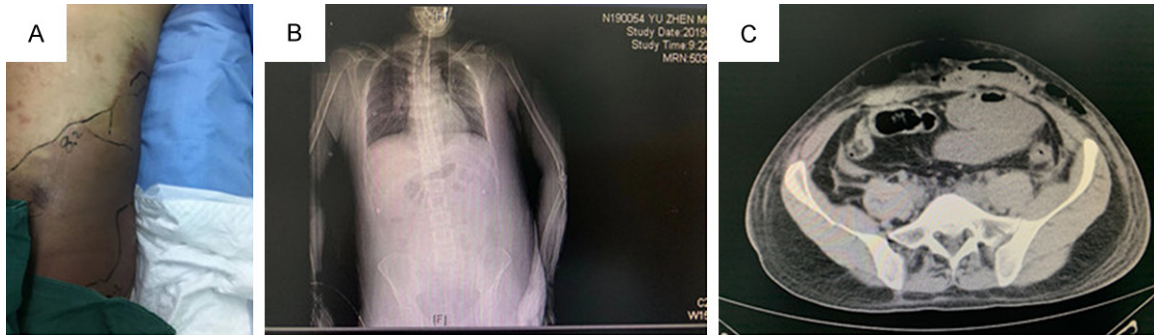


Figure 2. Abdominal wall injury and CT imaging after trauma. A. Skin ecchymosis of middle and left lower abdominal wall, local skin blackening, necrosis, scattered tension blisters and blood vesicles; B, C. Abdominal CT showed free gas under the diaphragm, abdominal peritoneal discontinuity rupture, rectus abdominis muscle rupture, partial defect, abdominal wall hernia, bilateral para-colon ditch and small amount of effusion fluid in pelvic, and left psoas major hematoma formation with peripheral exudation changes.



Figure 3. Exploratory laparotomy during the operation. A. A partial defect of peritoneum and partial exposure of intestinal canal in the midsection of abdomen resulted in hernia of abdominal wall, and an intestinal rupture was found in the descending colon. B. Rectus abdominis segment fissure, defect, abdominis large intestinal content pollution, part of the abdominis muscle has been necrotic. C. The left abdominal wall was enlarged, and a lot of intestinal contents were found in the lower abdominal wall, which were severely contaminated, with fascia suffering severe infection and necrosis.

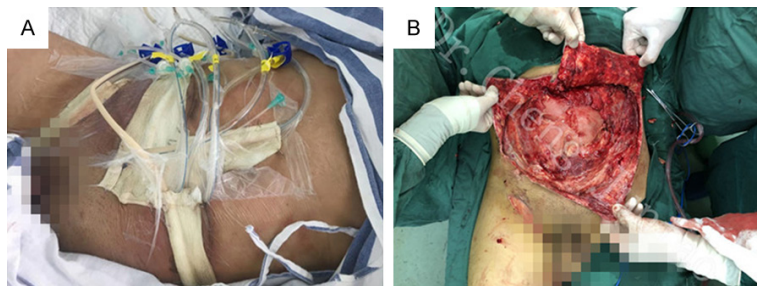


Figure 4. Postoperative condition of primary operation. A. After stage 1 debridement, the abdominal cavity was closed temporarily with VSD dressing and a drainage tube was placed. B. After covering with VSD material and continuous irrigation and drainage, the abdominal wall and contaminated wounds in abdominal cavity were significantly improved, the wound infection was effectively controlled, the wound tissue was fresh and grew well, and the base of the wound was ready for transplantation. VSD, Vacuum Sealing Drainage.

intestinal flora imbalance, intestinal obstruction, intestinal fistula and other complications

[16]. In this group, gastrointestinal peristalsis was recovered within 24 hours after the initial intestinal repair, intestinal nutrition was obtained within a short time, gastrointestinal function was recovered early, and no intestinal obstruction, intestinal fistula and other complications occurred. VSD can also improve the blood perfusion of local tissues and promote the proliferation of healthy tissues, which are conducive to wound repair [17]. After VSD dressing and drainage, a lot of fresh granulation tissue grew on the abdominal wall and the surface of intestinal cavity, which provide a good wound bed for

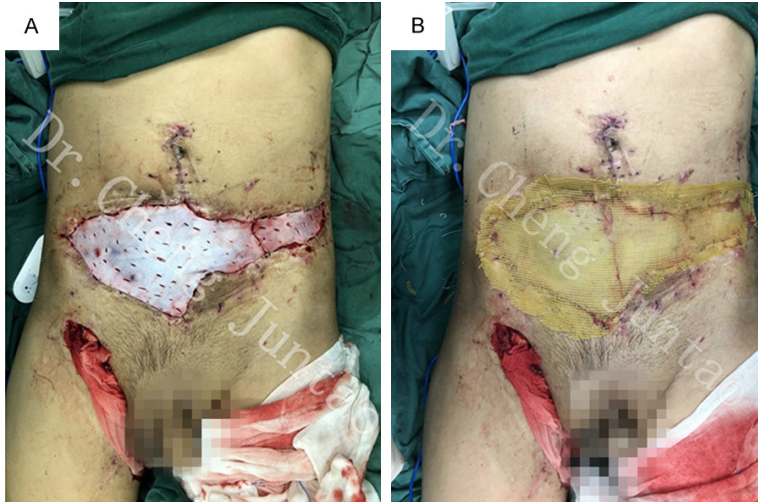


Figure 5. The wound of abdominal wall was closed and repaired. A. Acellular allogenic dermis was transplanted to the defect area of abdominal wall. The autogenous dermis tissue was transplanted to the surface of intestinal cavity. B. Large autologous grafts were implanted on the surface of acellular allogenic dermis basement membrane, holes were punched to enhance drainage, and silver-ion antibacterial dressing was applied with a long line packed with pressure dressing.

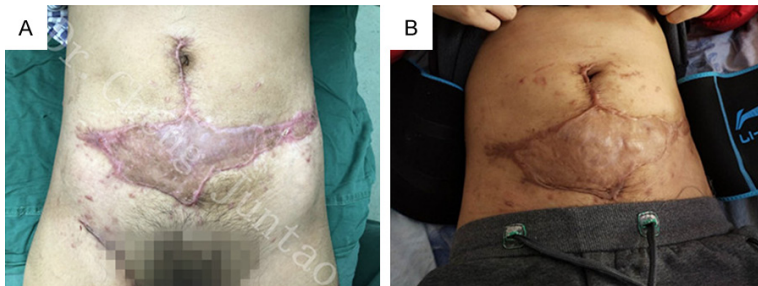


Figure 6. Postoperative condition of abdominal wall wound repair. A. On the 14th day after operation, acellular allogenic dermis and autograft skin were ruddy in color, survived well, and had no abdominal wall hernia; B. Six months after operation, local scar growth was slight, no abdominal wall hernia, intestinal adhesion, or intestinal obstruction etc., and the appearance was basically satisfactory.

wound repair. By observing the clinical curative effect of this group of cases, the authors think that when repairing the abdominal cavity infection after intestinal rupture and large-scale abdominal wall defect, the early VSD used to temporarily close the abdominal cavity is helpful to control infection, reduce complications and also wound repairment. Thus, it is an effective treatment strategy.

In recent years, there are many successful cases of using biological patch to repair and reconstruct abdominal wall defect, especially complicated abdominal wall defect with abdom-

inal infection [18]. Acellular allogenic dermis (ADM) is widely used to repair various kinds of acute and chronic wounds such as burn, plastic surgery and trauma [19]. The ADM material is allogenic tissue that retains its extracellular matrix and three-dimensional scaffold structure by removing the components that cause immune rejection using the acellular technique. ADM is characterized by its histocompatibility ability to rapidly vascularize and form its own tissue, which is highly resistant to infection [20]. It also acts as a scaffold to induce the growth of cells and tissues in the defect site, gradually recover tissue reconstruction and vascularization leading to repair and reconstruction of the defect [21]. There is also a report about ADM used in repairment of abdominal wall hernia, infective abdominal wall defect and other abdominal tissue defects [22]. In our practice, acellular allogenic dermis was embedded in the normal inferior ventral space. The vascularization of the dermis tissue surface and the normal peritoneum was beneficial to the reconstruction and redistribution of the peritoneum, as well as repairment of

the peritoneum defect and avoidance of the bulging of intestinal contents or abdominal wall hernias. The surface of the basement membrane is close to the autologous skin, which can promote the growth of the autologous skin, promote the differentiation and maturation of the epidermal cells, reduce the contracture of the skin and enhance the elasticity of the skin. Hence, it reduces the scar hyperplasia and improves the appearance and increases abdominal wall mobility after repair [23]. From the observation of this group of cases, the effectiveness of this method has also been proved.

Conclusion

The reconstruction of the abdominal wall defect requires closing the wound and restoring the function of the abdominal wall. The best choice is to use the musculofascial tissue with blood vessels and nerves to repair the defect tissue [24]. In clinic, when encountering a large abdominal wall defect (such as a big wound) which cannot be repaired immediately, and accompanied with other complex abdominal wall defects (such as severe trauma and severe abdominal infection), we use VSD to temporarily close the abdominal cavity and control the abdominal infection in early stage, then repair wound surface by acellular allogenic dermis combined with autologous split-thickness skin graft in late stage. It is a safe, simple and effective treatment protocol according to the clinical effect and short-term follow-up results. However, there are some deficiencies in this study, such as small sample size, short follow-up time and lack of basic research. Therefore, the indication, surgical standard and long-term effect of the protocol still need to be further clarified by large-sample, multi-center clinical research.

Disclosure of conflict of interest

None.

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