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Poststernotomy wound Management by Debridement and Pedicle Flaps Reconstruction

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Rezumat

Managementul defectelor post-sternotomie prin debridare și acoperire cu lambouri pediculate

Infecția şi dehiscența postoperatorie la nivelul sternului reprezintă complicații severe, deseori amenințătoare de viață, ale chirurgiei cardiotoracice. Rata mortalității poate ajunge şi la 50%. În ultimii 30 de ani au fost descrise numeroase lambouri pentru acoperirea defectelor sternale.
Obiective: Lucrarea de față evaluează experiența autorilor în managementul acestei afecțiuni, din ultimii 7 ani, subliniind importanța selecției lamboului de acoperire şi complicațiile postoperatorii.
Rezultate: Au fost incluşi în studiu 15 pacienți. Cele mai utilizate lambouri pentru acoperire au fost lamboul de muşchi pectoral mare (5 cazuri) si cel de muşchi drept abdominal (4 cazuri). La 4 pacienți au fost utilizate ambele lambouri. Într-un caz a fost utilizat lamboul de muşchi latissim dorsi, iar în alt caz, lamboul omental. Din totalul celor 15 pacienți, 8 au prezentat diverse complicații locale: serom (2 cazuri), hematom (1 caz), infecție necesitând debridarea locală şi tratament antibiotic (2 cazuri), necroza parțială a lamboului (2 cazuri), hernie abdominală (1 caz). Mortalitatea perioperatorie a fost de 13.3% (2 cazuri). Cauza mortalității în această perioadă a fost insuficiența multiplă de organe ca urmare a sepsisului.
Concluzii: debridarea precoce şi acoperirea defectelor rezultate sunt cele două principii fundamentale ale managementului defectelor septice sternale, mai ales în cazurile la care este extrem de importantă vindecarea rapidă a plăgii şi recuperarea postoperatorie. Abordarea individuală a fiecărui pacient, precum şi selecția adecvată a metodei de reconstrucție reduc semnificativ morbiditatea și mortalitatea postoperatorie.

Cuvinte cheie: sternal reconstruction, sternal wound dehiscence, rectus abdominis flap, pectoralis flap, omental flap

Abstract

Background: Sternal wound infection and sternal dehiscence are very serious, sometimes life-threatening complications of cardiac surgery, which require immediate attention. The mortality rate can reach 50%. During the past 30 years, various flaps for coverage of sternal wounds have been described.
Objective: The authors' objective was to evaluate their 7-year experience with flaps used for coverage of poststernotomy wounds, with an emphasis on flap selection and postrepair complications.
Results: The records of 15 patients were reviewed. The most common coverage techniques were pectoralis major flap (n=5) and rectus abdominis flap (n=4). Four patients had both of these flaps. One patient had a latissimus dorsi flap, and another one had an omental flap. Eight of the 15 patients experienced a local complication; these included seroma (n=2), hematoma (n = 1), infection requiring debridement and antibiotics (n = 2), partial flap necrosis (n = 2) and abdominal hernia (n=1). The perioperative mortality rate was

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13.3% (n = 2), and all deaths were attributable to multiple-organ deficiency due to sepsis.
Conclusions: Early debridement and coverage of the remained defects with flaps are the two main principles in the management of poststernotomy infected wounds, especially in situations where rapid wound healing and recovery are extremely important. Individual approach to each patient and proper selection of the method of reconstruction significantly reduces the postoperative morbidity and mortality rate.

Key words: sternal wound, infection, dehiscence, reconstruction, coverage options, muscular flap, musculocutaneous flap

Introduction

Median sternotomy, described by Julian et al in 1957, is the most frequently used approach for surgical treatment of cardiac diseases affecting the anterior mediastinum (1). Although dehiscence of this incision is not commonplace, when it occurs, it represents a severe complication that may lead to mediastinitis and sepsis. In the presence of sternal infection and mediastinitis mortality rate could reach 50 percent (2,3). Therefore, treatment must be applied immediately and aggressively.

Current management of poststernotomy wound infection involves wide debridement of devitalized, infected soft tissues and bone fragments, continuous antibiotherapy, and coverage of the defect with well-vascularized tissues. Muscular and musculocutaneous flaps (*Table 1*) provide good vascularity and, consequently, resistance to infection. They also allow primary recovery, even under difficult local conditions. Moreover, they ensure high durability and a satisfying aesthetic appearance for this particular area (4-6). The greater omentum (7,8) is normally used for thoracic wall reconstruction in cases where muscular flaps have been overused as a coverage option, because it can hardly fill a tridimensional defect and cannot assign structural stability to the thoracic wall. Free flaps are intended for exceptional cases in which other local reconstruction methods have been exhausted, or when the wound is so large that coverage with only local tissues would be impossible (9). Recently, the introduction of negative-pressure wound therapy, known as vacuum-assisted closure (VAC), has led to some promising results (10,11).

In the current report, the authors review their 7-year experience with the flaps most commonly used for sternal wound reconstruction with an emphasis on the type of flap selection and postoperative complications. Relevant data from the literature is also presented.

Table 1. *Flaps used for coverage of sternal wounds*

Location	Type of flap
Upper half of sternum	Pectoralis major muscular flap
	Pectoralis major musculocutaneous flap
	Rectus abdominis muscle flap
	Rectus abdominis musculocutaneous flap (VRAM)
	Latissimus dorsi muscle flap
	Latissimus dorsi musculocutaneous flap
	Omental flap
Lower half of sternum	Pectoralis major muscle flap
	Pectoralis major musculocutaneous flap
	Rectus abdominis muscle flap
	Rectus abdominis musculocutaneous flap (VRAM)
	Omental flap

Patients and Methods

This retrospective study includes all patients (n = 15) who underwent treatment of poststernotomy wound complications at The Emergency Hospital for Plastic, Reconstructive Surgery and Burns in Bucharest, Romania, from January 2005 through September 2012. There were 10 men and 5 women, with an age range of 42 to 83 years (mean, 56 years). In all 15 patients, the sternal wounds developed after a median sternotomy procedure performed for open heart surgery and were referred to Types II and III according to Pairolero and Arnold classification of sternal wounds infection proposed in 1984 (13). Patients with only superficial sternal wound infection, without cellulitis, costochondritis or osteomyelitis, (ie, type I wound according to Pairolero and Arnold classification), were not included in this study. Culture results showed that, in most cases, the responsible organism was *Staphylococcus aureus* (10 of 15) and *Staphylococcus epidermidis* (2 of 15). In two cases both microorganisms were isolated.

The data reviewed for each patient included age, nutritional, pulmonary, and cardiac status; and the specific location of the sternal defect. The poststernotomy wound was localized in the upper two-thirds of the sternum in 3 patients, in the lower third of the sternum in 5 patients, and in the entire sternum in 7 patients (*Table 2*).

Twelve patients were referred to Type II and three patients to Type III of sternal wound defects according to Pairolero and Arnold classification.

Surgical approach

The surgical approach under general anesthesia consisted of wide debridement of all necrotic tissues and coverage of the remaining defect, either immediately in a single-stage (n = 12) or in a multi-stage surgery (n = 3). All patients referred to Type III of sternal wound infection underwent a single-stage surgery. Three out of twelve patients with Type II of sternal wound defects underwent debridement and reconstruction in the same session. Other 9 patients from this

Table 2. *Sternal defect location and types of flaps used for reconstruction*

Location of sternal defect	No. of cases	Flaps used for coverage
Upper two-thirds of sternum	3	Latissimus dorsi muscle flap with fasciocutaneous extension (1 case) Bilateral pectoralis major muscular flap (2 cases)
Lower third of sternum	5	Rectus abdominis musculocutaneous flap (4 cases) Pectoralis major flap + rectus abdominis flap (1 case)
Entire sternum	7	Bilateral pectoralis major muscular/musculocutaneous flap (3 cases) Pectoralis major flap + rectus abdominis flap (3 cases) Omental flap (1 case)

group had multi-stage surgery (range from two to five). Suction drainage was used in 10 patients after reconstruction, and was maintained for a variable period of time, but not more than five days. An instillation-aspiration system with antiseptic solutions was used early in the series (n=5).We concluded that continuous instillation does not ensure obliteration of the dead space after flap reconstruction.

The following factors were taken into account when selecting the individual approach to each patient's sternal wound management and the choice of coverage method:

- local inflammatory conditions, extension and severity of infection, and timing of presentation of the infection according to Pairolero and Arnold classification (1984);
- location of the wound after debridement (upper two thirds, lower third, entire sternum);
- size and depth of the wound after debridement; and
- the patient's general condition, comorbidities, previous surgeries, etc.

The methods used for coverage were as follows (*Table 2*):

- bilateral pectoralis major muscle flap (5 cases; 33.3%);
- pectoralis major muscle and rectus abdominis muscle flaps (4 cases; 26.7%);
- rectus abdominis musculocutaneous (VRAM) flap (4 cases; 26.7%);
- latissimus dorsi muscle flap (1 case; 6.7%); and
- omental flap (1 case; 6.7%).

Results

All fifteen patients were followed up from two months to seven years (mean, 2.6 years). Overall, the average length of stay in the hospital was 20.8 days, with a range from 11 to 34 days.

Among the 15 study participants, 8 (53.3%) experienced a local complication after sternal wound debridement and reconstruction (*Table 3*). Two patients had a seroma (13,3%) and one had hematoma (0.66%). In both cases seromas were treated by the needle aspiration at the bedside. The extensive hematoma was evacuated in the operating room on the first postoperative day. Two patients (13.3%) had an infection at the recipient site that required local debridement and antibiotic treatment. Both of them at admission were referred to Type II sternal wound infection according to Pairolero and Arnold classification and had debridement and reconstruction in the same surgery. Two patients (13.3%) had partial flap necrosis (one vertical rectus abdominis musculocutaneous (VRAM) flap and one latissimus dorsi muscle flap. In both cases the necrotized tissue was excised and the flaps re-advanced with good follow up. One patient developed abdominal hernia related to VRAM flap harvest. Later on, the abdominal wall was re-enforced with polypropylene mesh. The other 7 cases (46.7%) evolved to complete healing, without complications.

There were no intraoperative deaths in our series. The perioperative mortality rate (death within 30 days of surgery)

Table 3. *Local complications*

Complication	No. of cases	Type of flap used for reconstruction
Hematoma	1	Bilateral pectoralis major muscle flaps
Seroma	2	Omental flap (n=1) Pectoralis major muscle flap + rectus abdominis muscle flap (n=1)
Infection	2	Pectoralis major muscle flap + rectus abdominis muscle flap (n=1) Pectoralis major muscle flap (n=1)
Partial necrosis of the flap	2	Latissimus dorsi muscle flap with fasciocutaneous extension (n=1) Rectus abdominis musculocutaneous (VRAM) flap (n=1)
Abdominal hernia	1	Rectus abdominis musculocutaneous (VRAM) flap

was 13.3% (2 cases). In these two cases, death was caused by the multiple-organ deficiency resulting from sepsis, confirmed by the presence of mediastinitis (both patients had Type II of sternal wound infection and underwent one stage surgery).

Discussion

Before the 1960s, infected sternal wounds were typically treated by debridement and open granulation. Then, in 1963, Shumacker and Mendelbaum (12) treated mediastinitis through aggressive debridement, rewiring, and antibiotic irrigation using catheter, which reduced the mortality rate to 20%. In 1976, Lee et al initiated the use of wide bone and cartilage debridement, followed by transposition of the greater omentum (7). Jurkiewicz and colleagues (4,5) took this to the next level by introducing the concept of muscle flap as a reconstruction method for an infected sternal wound. Today, muscular and musculocutaneous flaps have become the standard treatment for reconstruction of sternal defects because they fulfil the basic criteria for an optimal solution in such cases: safe recovery, stable and long-term coverage, and a more natural cosmetic appearance.

Our present treatment algorithm mirrors that of many other authors (4,5,14-16). The first stage consists of wide excision and debridement of necrotic, devitalized tissues, bony and cartilaginous fragments, and blood clots, followed by removal of osteosynthesis and suture material. We have to acknowledge that two cases of local postoperative infection and two perioperative deaths early in the series occurred due to late and, probably, inadequate debridement of the sternal wound. In another stage, the resultant defect is covered with well-vascularized tissue to ensure a stable long-term recovery and achieve a look that is as natural as possible. It is desired to perform both stages in the same surgery. However, if local condition cannot be significantly improved after the first debridement, the additional ones should be performed delaying the final closure with flap. The number of surgeries depends of the evolution of the infected sternal wound and patient's general condition.

Among the many flap options described in the literature, we selected the following ones for our series of patients: pectoralis major muscle flap, rectus abdominis muscle or musculocutaneous flap (alone or in conjunction with pectoralis major muscle flap), latissimus dorsi muscle flap, and omental flap.

Pectoralis major muscle flap

Use of the pectoralis major muscle flap in sternal wound coverage was initially described by Arnold and Pairolero in 1979 (17) and Jurkiewicz et al in 1980 (4). This flap is large enough to cover sternal defects, especially those located in the upper and middle third of the sternum (5,18). The vascular sources are represented by a dominant pedicle, the thoracoacromial artery (anterior branch of the axillary artery), and numerous segmental pedicles from the internal thoracic artery (arising from the subclavian artery). These perforating branches can ensure muscle survival if the dominant pedicle is divided. They can also ensure survival of the overlying cutaneous territory when it is elevated as a musculocutaneous flap on the thoracoacromial pedicle.

The pectoralis major flap can be used as an advancement flap, with a thoracoacromial pedicle, or as a "turnover" flap, based on perforators of the internal thoracic artery (4,14,18,19). Recently, the "tri-pedicled" pectoralis major flap has been described, which can be used to cover the entire sternum, especially long and narrow defects (15).

Presently, many authors consider the pectoralis major muscle flap as the first option for sternal wound coverage, especially for defects located in the upper two-thirds of the sternum (16). The major limitation of this flap is its inability to cover the lower third of the sternum (4,5,16).

In the present study, the pectoralis major flap was used in 9 cases solely or in conjunction with the rectus abdominis muscle flap (*Table 2*). In three cases the pectoralis major flap was used bilaterally being dissected from the sternum, detached from the skin and humerus and, advanced on the thoraco-acromial pedicle (*Fig. 1*). The donor site is extensive, especially in bilateral harvest of the pectoralis major muscles. Despite the use of active drainage, in one case hematoma occurred and was evacuated in the operating room on the first postoperative day. In two patients with defects in the upper two-thirds of the sternum these flaps successfully covered the entire defect providing good healing with full recovery and no complications. However, in one patient with entire sternum defect, the pectoralis major muscle was sutured to the lower wedge of the wound under tension, further leading to dehiscence and development of the focal infection in this area. The occurred defect was treated by debridement and subsequent secondary suturing. We concluded, that this muscle sometimes doesn't offer enough material to fill the entire sternum defect after wide debridement. Further for coverage of such defects comprising the entire sternum we have used the unilateral pectoralis major flap and unilateral rectus abdominis muscle flap (14).

Rectus abdominis muscle flap

The rectus abdominis muscle flap was first described by Hartrampf and colleagues in 1982 (20). This flap is large enough to cover defects in the lower third of the sternum and can reach as high as the sternal notch.

The rectus abdominis muscle has 2 dominant pedicles: superior and inferior. The superior pedicle is represented by the superior epigastric artery (terminal branch of the internal thoracic artery), and the inferior pedicle is represented by the inferior epigastric artery (branch from the external iliac artery). There are multiple vascular connections between these 2 dominant pedicles and numerous musculocutaneous perforators, many of which are concentrated in the periumbilical area. These connections serve to sustain the overlying tegument. The rectus abdominis muscle flap is raised on the superior pedicle

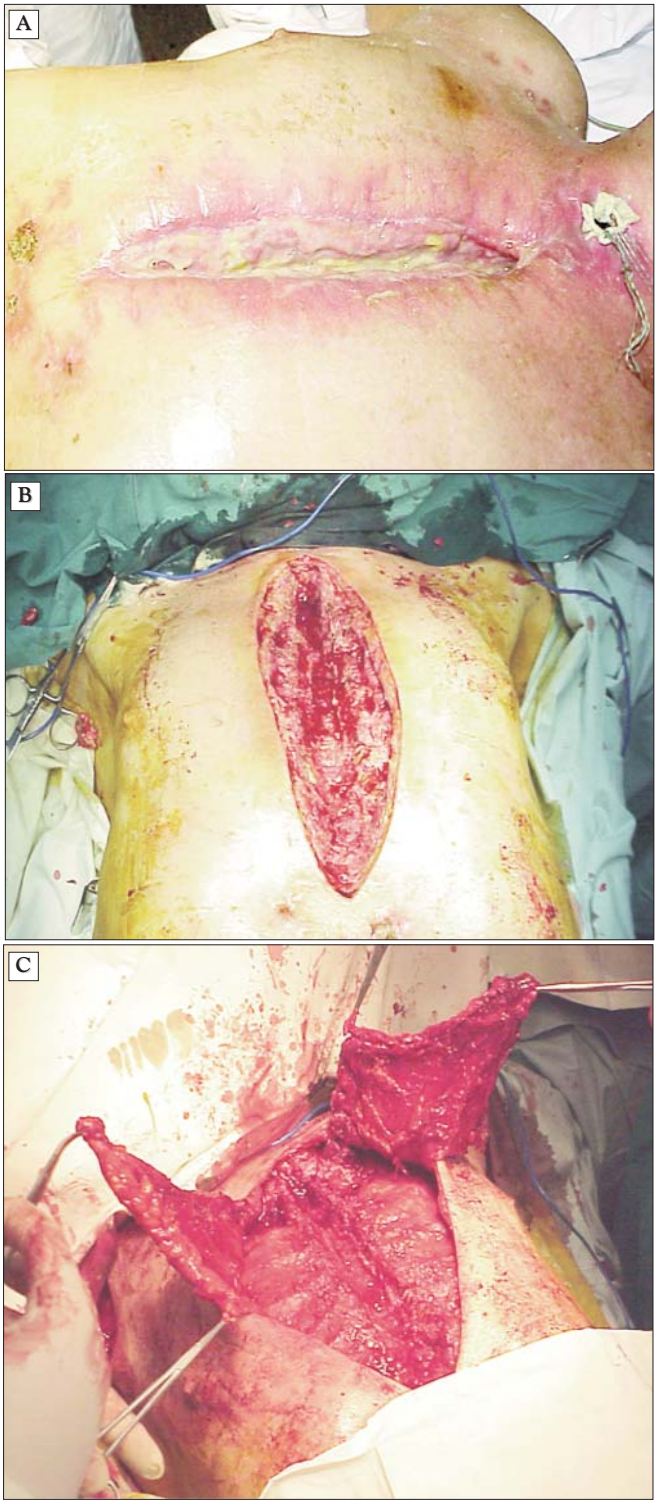

Figure 1. ***(A)*** *A 75-yer old male with poststernotomy infected wound 3 weeks after aorto-coronary by-pass (Type II according to Pairolero and Arnold classification).* ***(B)*** *Remaining defect of the entire sternum after complete debridement.* ***(C)*** *Intraoperative view shows bilateral elevation of the pectoralis major flap*

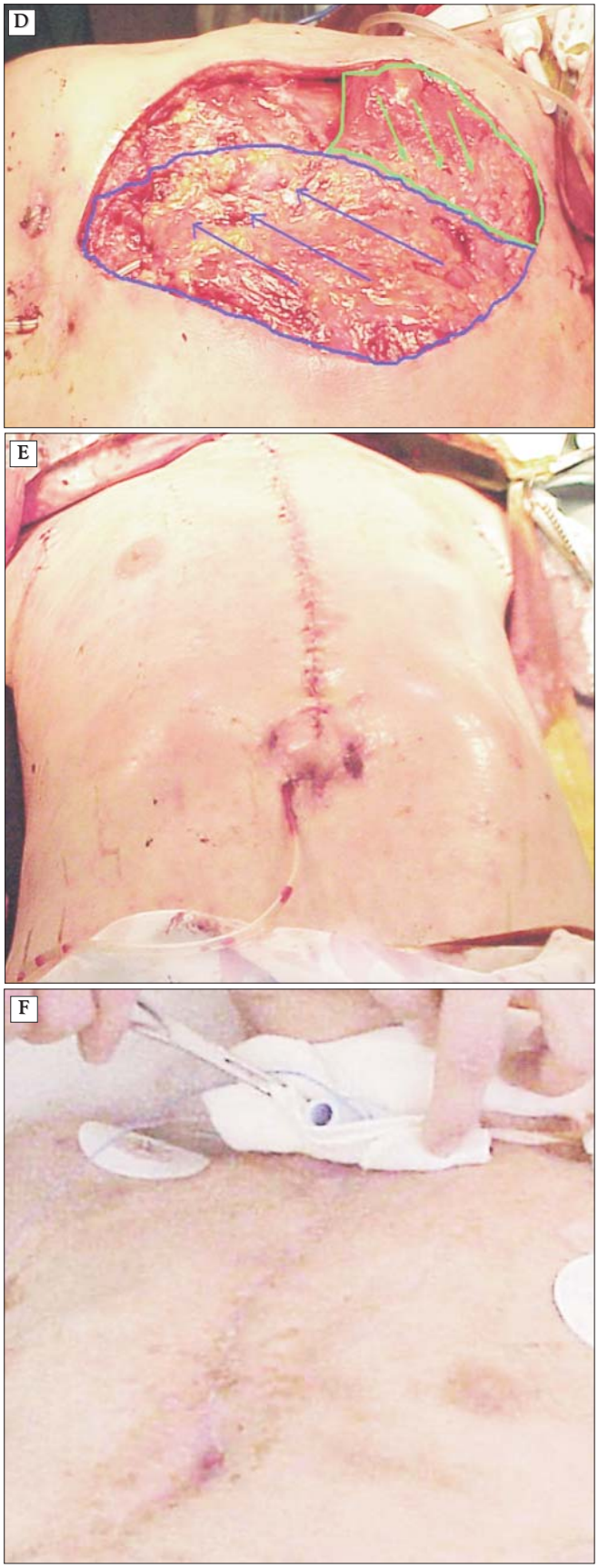

Figure 1. ***(D)*** *Intraoperative view shows positioning of the flap.* ***(E)*** *Immediate postoperative appearance.* ***(F)*** *One month following closure*

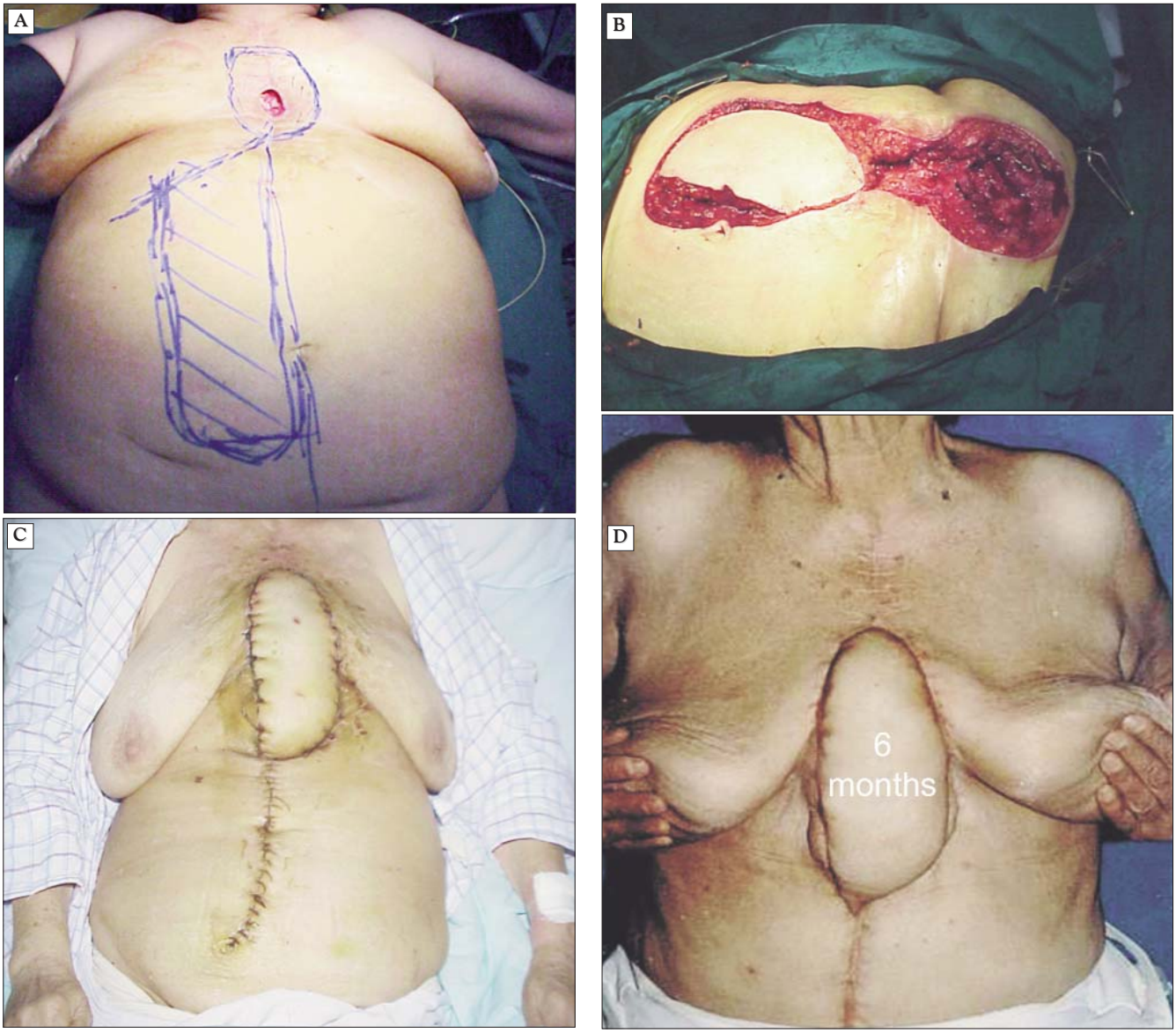

Figure 2. ***(A)*** *A 67-year-old female with Type III poststernotomy wound according to Pairolero and Arnold classification two months after aorto-coronary by-pass. The defect was outlined preoperatively, and right rectus abdominis musculocuneous (VRAM) flap was planned.* ***(B)*** *Intraoperative view shows elevation of the VRAM flap on the right superior epigastric artery.* ***(C,D)*** *Postoperative appearance of the VRAM flap at 2 months* ***(C)*** *and 6 months after reconstruction* ***(D)***

(the superior epigastric artery). Therefore, its usage for covering sternal defects in patients whose internal thoracic artery was previously used for coronary bypass is considered a relative contraindication (14,21). However, some authors believe that this flap may be adequate even in such circumstances because of the collateral circulation in the musculophrenic and anterior intercostal arteries (22). Another disadvantage of this flap is the risk of abdominal hernia formation (18).

We used the vertical rectus abdominis flap in 8 patients to cover defects in the lower third of the sternum (n=5) and entire sternum (n=3). Four of them had the rectus musculocutaneous flap (VRAM) alone for lower third of the sternum (*Fig. 2*) and another four patients had rectus abdominis muscle flap + pectoralis major flap for entire sternum (n=3) and lower sternum (n=1). In one patient, distal minimal necrosis of the VRAM flap was noted, which was treated with excision of devitalized tissues and re-advancement of the flap. Another patient experienced an abdominal hernia after VRAM flap harvest.

Latissimus dorsi flap

The latissimus dorsi flap has been recommended for the coverage of upper two-thirds sternal defects. The point of rotation is represented by the posterior wall of the axilla, where the thoracodorsal pedicle enters the muscle. By sectioning the insertion and mobilizing the vascular pedicle, the rotation arch may be improved significantly. Furthermore, there is an

anatomical advantage in using the LDMF: its harvest does not disrupt collateral blood supply to the sternum and parasternal tissues (23). Among disadvantages are possible complications at the donor site (eg, seroma, hematoma) and the need to change the patient's position during surgery. As it is a pure island flap, the excessive tension of the vascular pedicle should be avoided to prevent flap necrosis.

In the present series, this flap was used in only one patient, whose defect involved the upper two-thirds of the sternum. Postoperatively, a partially necrotic distal area was noted, which was managed by excision of devitalized tissues and re-advancement of the flap.

Omental flap

In 1963, Chiricuță described the use of greater omentum as a "pedicle flap" for the reconstruction of thoracic defects resulting from radionecrosis, after breast cancer therapy (24). The omental flap was first described for sternal coverage by Lee et al in 1976 (7).

The greater omentum is vascularized through omental branches of gastroepiploic arteries, and the flap can be raised on either gastroepiploic pedicle. The rich vascular supply and the large amount of available soft tissue enable coverage of large, irregular defects (even the entire sternum) (25,26). Because harvesting of this flap requires a laparotomy, certain complications may occur, including injury to abdominal viscera, formation of ventral hernias, and spreading of the infection from the thoracic cavity to the abdomen (27). Moreover, this flap is contraindicated in patients who are in critical condition and in those with intra-abdominal adhesion after previous surgery. To decrease the risk of such complications, endoscopic harvesting of the omentum has been employed, but this technique is not widely used (15).

We used the omental flap in only 1 patient, whose defect involved the entire sternum. Small seroma occurred at the recipient site on the ninth postoperative day and was treated by needle aspiration at the bed side. The patient's further postoperative evolution was uneventful.

Other options

Other options for covering sternal defects include microvascular free muscle flaps, in particular the free vastus lateralis muscle flap, used alone or combined with the anterolateral thigh flap. The main disadvantage of this type of reconstruction is the prolonged operating time and donor site morbidity. However, the method is indicated especially for patients who have a large sternal defect, without other well-vascularized tissues to transfer (9,15).

Negative-pressure wound therapy (VAC) was introduced for the management of sternal dehiscence in 1997 (10,11). It can be applied to sternal wounds after initial debridement to encourage secondary healing in selected patients. Negative pressure has various beneficial effects on wound healing. It stimulates blood flow, reduces the size of the defect, reduces the exudate, promotes the granulation process and local inflammatory reaction, and stabilizes the sternum (10,11). We consider that VAC therapy is indicated in patients with Type II sternal wounds as an intermediate stage between initial debridement and definitive wound closure in order to reduce the risk of postoperative infection.

Conclusions

Sternal wound infection and sternal dehiscence are severe complications that may occur after cardiac surgery, often necessitating management in a plastic surgery setting. The approach to each patient should be highly individualized to select the proper treatment. We insist on early wide debridement of the sternal wound, advocating coverage of the created defect with pedicle flaps when the general and local conditions allow it. Despite the rather high rate of complications, the pectoralis major and rectus abdominis muscles are efficient and reliable for covering complex sternal wounds, particularly in situations where rapid wound healing and recovery are extremely important.

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