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OUR EXPERIENCE USING THE VERTICAL RECTUS ABDOMINIS MUSCLE FLAP FOR RECONSTRUCTION IN 12 PATIENTS WITH DEHISCENCE OF A MEDIAN STERNOTOMY WOUND AND MEDIASTINITIS

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Abstract. The vertical rectus abdominis (VRAM) flap has been used for reconstruction of sternal defects, particularly in the inferior third, since it was first described 20 years ago. We describe 12 patients with mediastinitis or chronic sternal osteomyelitis after sternotomy treated between 1994 and 1997, nine performed at the Royal Hospitals Trust, London. Sternal osteomyelitis and mediastinitis after median sternotomy is an uncommon (0.4%–8.4%) but often fatal condition. Vascularised pedicles are the treatment of choice, and VRAM flaps were used in all cases. We report good long-term outcome with a follow up of 2–5 years, and no long-term morbidity relating to the VRAM reconstruction. We had only one partial failure of a flap. The operations were largely done in hospitals away from the plastic surgical unit in extremely sick patients, which illustrates the importance of multidisciplinary management to reduce hospital stay, mortality, and morbidity. We argue that early involvement of plastic surgical specialists in the treatment of sternal dehiscence is essential to ensure a successful outcome.

Key words: VRAM, sternal dehiscence, mediastinitis, sternal osteomyelitis.

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The median sternotomy wound has successfully provided optimum exposure of the heart and the great vessels for four-and-a-half decades. It was first described by Julian and Lopes-Belio in 1957 (13). The price paid has been mediastinitis, despite its low incidence (range 0.4% to 8.4%) (22, 27, 31). This complication carried a high mortality rate until recently, with up to 80% reported in the 80s (23); reports are now as low as 7% (25, 34). The incidence of sternal bone necrosis and chronic osteomyelitis is reported in the same range (34). For survivors of both these conditions there are the attendant cosmetic and functional morbidities (4, 15, 26, 30).

Management of sternal wound dehiscence has become increasingly successful over time. Shumaker and Mandelbaum in 1963 described the strategy of sternal debridement and continuous antibiotic irrigation (32). Thurer et al. modified this in 1974, using open wound irrigation with povidone iodine (33). Lee et al. introduced the first vascularised omental flaps in 1976 (16). Mathes and Bostwick followed this in 1977 by describing their use of the vertical rectus abdominis (VRAM) flap (20). These techniques have proved highly successful in managing failed cases of rewiring and irrigation, and increasingly have been used as the primary reconstructive procedure. They were soon broadened to include pectoral and latissimus dorsi flaps (7, 14). The superiority of muscle flap reconstruction over irrigation alone in management of dehisced median sternotomy wounds was confirmed by Rand et al. in their prospective study in 1998 (29).

The aim of this paper is to describe a series of 12 VRAM flap sternal reconstructions. We examine the speed of referral to the plastic surgical unit and the requirement for multidisciplinary coordination to optimise the patient's treatment.

We use the term sternal dehiscence to include both short and long term breakdown of median sternotomy wounds with or without mediastinitis and sternal osteomyelitis.

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Table I. *Organisms cultured from wounds*

Infecting organism	No. of infected patients
Staphylococcus aureus	5
Methicillin-resistant *S aureus*	4
Coagulase-negative staphylococcus	5
Pseudomonas spp	1
Mixed organisms	1
Corynebacterium spp	1
No growth	1

PATIENTS AND METHODS

A total of 6039 sternotomies were done at The Royal Hospitals Trust between February 1994 and March 1997. During this period 10 patients were referred to the plastic surgical department for flap reconstruction. This represents 0.2% of all the sternotomies done during that period. Of these, nine patients were given VRAM flaps and one a right pectoral advancement flap. Patients were identified from hospital operative records.

Two further cases of VRAM reconstruction were performed in Linkoping, Sweden, and one in Zurich, Switzerland, by the senior author. These have been included in this series. Those patients who responded to simple debridement and rewiring have not been included in this series. The patient for whom the pectoral flap was used has also been omitted.

The patients' ages ranged from 57 to 75 years (median 63). There were 10 men and two women. Ten patients had had coronary artery by-pass grafts (CABG), one had had lung reduction, and one had had a thoracic aortic aneurysm repaired. Seven patients had sternal osteomyelitis without mediastinitis (the discovery of devitalised bone on debridement or prolonged wound drainage) and four had mediastinitis (clinical diagnosis).

One patient had had three sternal revisions before referral; another patient had had two. Eight patients had had one revision. In most cases revision involved rewiring of the sternal bone. Twelve VRAM flaps were used in these patients.

At the time of referral (Table I), wound fluid from eight patients grew one or more pathogenic organisms.

Preoperative morbidity is shown in Table II. In most of the patients (8/12), the left internal mammary artery had been used for coronary revascularisation. The remaining two patients who had had CABG had saphenous vein grafts.

Two patients had required early repeat sternotomy; one after cardiac arrest for further CABG and another for re-exploration because the internal mammary artery was bleeding.

Six patients required treatment in the intensive care unit (ICU) before flap reconstruction, the median being 19.5 days (range 1–36).

The median time before the initial breakdown after sternotomy was 9 days (range 4–23).

The shortest recorded time before referral for sternal breakdown was one day, and the longest 24 days (median 8). The median delay before reconstruction after CABG was 27 days (range 7–39).

Follow up

All patients were followed up postoperatively for between two and five years to identify further sternal relapse and long-term functional outcome, including donor site morbidity. Information was gathered by telephone from the patients' general practitioner and from the hospital outpatient notes.

Surgical reconstructive technique

The VRAM flaps were based on the superior epigastric vessel, but intercostal perforators were preserved in all cases. In no case had the internal mammary artery on the side of the flap been harvested. The technique of raising and rotating the flap has been well described (20). Our VRAM flaps were harvested with a skin paddle, which was used to fill the skin defect at the sternal wound. Meticulous debridement of necrotic

Table II. *Preoperative morbidity*

Data are numbers of patients except where otherwise stated.

Type of operation	Our study ($n = 12$)
Coronary artery bypass graft	10
Valvar repair or other	2
Preoperative risk factors	
Mean age (years)	65
Range (years)	(57–79)
>65	5
ICU before reconstruction	6
Diabetes	4
Active smoker	3
Ex-smoker	7
Previous sternotomy	1
Previous coronary artery bypass graft	1
Obesity	6
Hypertension	8
Chronic obstructive pulmonary disease	2
Peripheral vascular disease	1
Left ventricular failure*:	
Normal	2
Mild-moderate	6
Severe	1
Postoperative risk factors	
Rewiring	7
Emergency repeat sternotomy	2
Reoperation (within 15 days)	10

* Only 9 of the 12 patients had the ejection fraction recorded in the notes.

Table III. *Results of VRAM reconstruction of sternal wound dehiscences*

Case No.	Age	Sex	Reason for sternotomy	Emergency repeat sternotomy	Sternal condition	ICU (days before flap)	ICU (days after flap)	Delay after CABG until referral (days)
1	68	F	CABG	No	Mediastinitis	0	7	16
2	74	F	CABG	No	Mediastinitis	1	4	29
3	65	M	CABG	No	Sternal osteomyelitis	21	70	30
4	61	M	CABG	Yes	Acute dehiscence	27	5	26
5	62	M	Lung reduction	No	Acute dehiscence	36	1	36
6	57	M	CABG	Yes	Sternal osteomyelitis	8	1	16
7	61	M	CABG	No	Sternal osteomyelitis	18	5	18
8	64	M	CABG	No	Mediastinitis	0	4	9
9	60	M	CABG	No	Mediastinitis	0	2	14
10	79	M	CABG	No	Sternal osteomyelitis	0	N/R	13
11	67	M	CABG	No	Sternal osteomyelitis	0	3	23
12	60	M	Repair of aortic aneurysm	No	Sternal osteomyelitis	0	3	N/R
Mean	65					19	10	21
Median	63					19.5	4	18

Key: CABG = coronary artery bypass grafting, ICU = intensive care unit.

sternal bone and costal cartilage was done in all cases. In nine cases one surgeon used 1/0 nylon tension sutures to support the sternal defect and to protect the skin paddle from lateral stretch forces (cases 1, 3, 6–11).

RESULTS (Table III, Fig. 1)

After reconstruction all patients were treated in the ICU, where they remained between one and 70 days (median 4). The total duration of treatment in hospital after CABG ranged from 25 to 115 days (median 51) postoperatively, which was 8 to 85 days (median 17) after VRAM flap reconstruction.

A total of three patients developed complications after reconstruction and all three had been in the ICU before flap reconstruction. The median time to wound healing after reconstruction was 15 days (range 13–27).

The postoperative mortality rate related to wound closure or septic complications within one month of reconstruction was one out of 12. Two patients died prior to discharge. Case 1 died seven days after reconstruction of acute sepsis (methicillin-resistant *staphylococcus aureus*) associated with mediastinitis, this is included in the postoperative Fig. 1. Case 3 died 74 days after reconstruction from his cardiovascular disease, for reasons unrelated to his sternotomy and is not included as a postoperative mortality. On post mortem his wounds were found to be healed.

There was one incidence of 40% flap loss (case 2) that lead to wound dehiscence. Direct closure was attempted, which also failed, and bilateral pectoral rotation flaps were used. The wound healed successfully 21 days after this procedure.

Long-term follow-up data has been obtained of between two and five years. There have been no long-term problems reported relating either to the sternal region or to the donor site in the abdomen.

DISCUSSION

We report the outcome of 12 patients in whom the VRAM flap was used for reconstruction of sternal dehiscence. Although the pectoral flap may provide good cover for many sternal defects, our defects were mainly in the inferior third of the sternum. This area is notoriously difficult to reach with pectoral flaps, as described by Jurkiewicz et al. in 1980 (14).

Current publications have suggested that pectoral flaps are the most popular methods of reconstruction for sternal dehiscence (6, 9, 11, 12, 14, 22, 23, 28). However, many papers present other methods including omental flaps (18, 21, 34, 35), latissimus dorsi flaps (7), and VRAM flaps (5, 8, 10, 19, 24). Recently, the number of VRAM flaps being reported has decreased, and this trend is reflected in the experience of Emory University Hospital, Atlanta, during the past 20 years as described by Jones et al. (12).

The management of sternal dehiscence with VRAM flaps was first described by Mathes and Bostwick (20) in 1977, who found that they produced excellent cover. The versatility of the flap was also described by Neale et al. (24) in their management of sternal osteomyelitis, claiming that it was a superior alternative to other flaps, being able to fill almost any sternal defect.

In 1986 Majure et al. (19) described their series of 18 reconstructions with VRAM and pectoral flaps. Dissatisfied by the cosmetic results of the pectoral flaps (the first four patients), they used VRAM flaps alone where possible to produce the best cosmetic results.

Number of rewirings or wound revisions	Complications of flaps	Outcome and healing time (days)	Time to discharge after flap (days)	Hospital stay (days)
1	0	Died of sepsis	8	25
1	40% ischaemic loss, required pectoral flaps	N/A	85	113
3	0	Died day 74, healed by day 19	80	115
0	Sinus discharge at home	16	16	38
1	0	14	18	53
1	0	14	15	36
0	Small dehiscence and sinuses	13	48	65
1	0	18	18	56
1	0	27	30	46
1	0	21	9	72
2	0	14	8	38
1	0	14	14	48
		17	29	59
		14	17	51

Notably, however, in larger defects they would still also use pectoral advancement flaps in combination.

Iacobucci et al. described a series of 10 patients with sternal osteomyelitis (10). In particular, they emphasised the usefulness of the VRAM flap in providing cover for the inferior third of the sternum.

More recently, in 1997, Grant et al. (8) described the VRAM flap in reconstructions in children, particularly for those sternotomies that could not be closed for haemodynamic reasons.

Our study shows that 10 out of the 11 surviving patients healed without revision after VRAM flaps. The exception was one whose wound dehisced (which was treated by bilateral pectoral advancement). Three of the four cases of mediastinitis treated with VRAM flaps survived.

We did not discharge our patients as soon as the Emory group (Table IV), and we believe this is because of the greater morbidity among our patients. This is illustrated by the large number who required nursing in the ICU before VRAM reconstruction. These patients also had more reduced or poor ejection fractions (Table II).

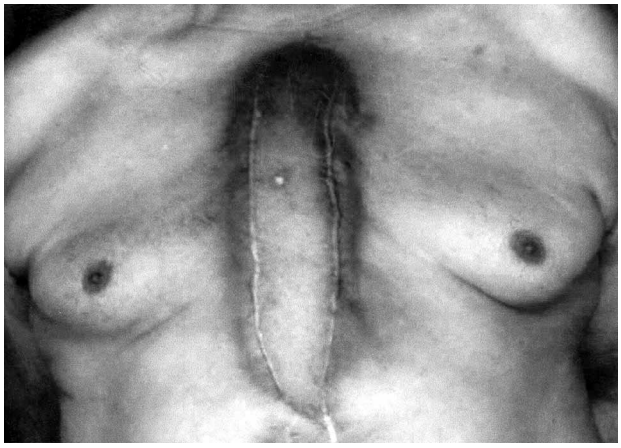

Fig. 1. Appearance of the flap after healing.

One contributing factor may be that our choice of VRAM flap reconstruction reduced the respiratory function of the patients. It is known that the rectus abdominis acts in concert with the diaphragm and in adults both are responsible for up to three quarters of respiration (4). Cohen et al. showed the functional superiority of pectoral muscle flap reconstruction over VRAM flap in the recovery of respiratory function, with the greatest improvement being seen postoperatively in the pectoralis group (4). However, they did not assess the respiratory function until approximately 10 months after reconstruction and they give us no information about the immediate postoperative phase that we are studying. Kohman et al. described an excellent respiratory recovery for all muscle flap reconstructions but they did not differentiate between VRAM and pectoral reconstructions (15). Ringelman et al. (30) studied the functional result of muscle flap reconstruction, and showed that 10/19 VRAM flaps developed ventral abdominal weakness. Within their group two cases developed true herniation. Interestingly, two out of three of their omental flaps developed epigastric hernias, and three pectoral flaps developed epigastric hernias, but no percentage was given. They also described a high rate of shoulder weakness in the pectoral group, and loss of the anterior axillary fold.

In our study, where recorded ($n = 10$), the median time for the cardiothoracic surgeons to refer the patient to a plastic surgeon, once the wound had broken down or shown evidence of deep infection, was eight days.

Table IV. *Our results compared with those reported from Emory University Hospital*

Data are number (%) and [total number] of patients except where otherwise stated.

	Our study ($n = 12$)	Emory University Hospital $n = [\ ]$ Total numbers differ between measurement
VRAM flap	12	202 (30) [675]
Other flaps	0	473 (71) [675]
Death rate	1	33 (8) [409]
Flap failures	0	0 [409]
Partial flap loss	1	7 (4) [186]
Recurrent wound infection	2	12 (7) [186]
Wound closure complications	1	35 (19) [186]
Overall morbidity	3	47 (25) [186]
Average time to discharge after flap (days)	Median 17 (range 8–85)	Mean 12.4 years 1993–1996 [not given]

This was a median of 18 (9–36) days after sternotomy, which is slightly longer than that reported from Emory University Hospital. They have a well-established early referral pattern, and most patients were seen between 14 and 21 days after sternotomy. They emphasised that the speed of referral is of great importance to the subsequent success of their reconstruction.

The issue as to when to refer sternal infections to the plastic surgical unit was discussed by Bray et al. (3). They put forward the case that sternal rewiring should be the initial line of management in sternal dehiscence, provided that sternal stability can be achieved. Importantly, they state that their patients were not severely unwell. They also did not suggest any predictive factors that could be used early to differentiate those patients that would not respond to this, 5/17, in their study.

Significantly, more of our patients had undergone prior sternal wound revision or rewiring by the cardiothoracic surgeons, 10/12 (83%), when compared to those of Emory (50%). They have positively correlated this event with an increased risk of recurrent sternal wound infection although their results did not reach significance. Of our 10 patients that had been previously revised or rewired, two (20%) developed flap wound complications, one of whom (10%) died from sepsis.

Probable risk factors have been identified in many studies over the past 30 years, both retrospective and prospective (1, 2, 12, 17, 25, 27). We have recorded many of these risk factors, seen in our own patients, in a description of our preoperative morbidity (Table II).

It is also interesting to note that all our flap complications arose in those patients who had been in the ICU before reconstruction.

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