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The dissection of the rectus abdominis myocutaneous flap with complete preservation of the anterior rectus sheath☆

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Summary Harvesting the rectus abdominis myocutaneous flap results in defects in both the rectus abdominis muscle and the anterior rectus sheath, which may be circumvented by dissecting a perforator flap (DIEP flap) instead. However, the latter is associated with a reduction in the number of myocutaneous perforators nourishing the flap, which has been hypothesised to lead to an increased risk of partial flap failure. We present a technical modification that maintains all the feeding perforators within the flap while fully preserving the anterior rectus sheath. The anterior rectus sheath is incised along a line connecting the perforators. A muscle cuff including all the feeding perforators was raised with the flap. This technique was used in 20 consecutive patients. Nine patients underwent free TRAM flap transfers for breast reconstruction (10 flaps), and 11 patients underwent thoracic-wall reconstruction with a superiorly based pedicled flap. The median follow-up was 11 months. One patient with a pedicled flap developed a partial failure that required surgical revision; all other flaps healed spontaneously. One patient in each subset had preoperative abdominal-wall laxity that was partly corrected after surgery; no abdominal bulging or hernia occurred in the other patients. Our results suggest that the technical modification presented here may enable the surgeon to dissect a rectus abdominis myocutaneous flap with maximal perforator-related flap perfusion and minimal donor-site morbidity. An advantage over the DIEP flap is that this technique is applicable to both free and pedicled flaps.

The rectus abdominis myocutaneous flap was first described by Holmström in 1979[1] and thereafter popularised by Hartrampf et al.[2] Harvested as either a pedicled or a free flap, it has played an eminent role in soft-tissue reconstructions in the upper trunk, in particular, in breast reconstructions with autologous tissue.[3–7]

The dissection of a TRAM flap results in defects of both the rectus abdominis muscle and the anterior rectus sheath, which may cause considerable donor-site morbidity, including abdominal bulging or hernia[4–8] and weakening of the muscle.[9–11] It has

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been shown that the rate of these complications is related to the amount of abdominal-wall tissue harvested with the flap.[12] Consequently, dissection techniques were developed with the aim of reducing the abdominal-wall defect,[5,7,12–14] which finally culminated in the introduction of the DIEP flap.[15]

However, this evolution also decreased the number of myocutaneous perforators nourishing the flap to as few as a single perforator. Under these circumstances, the perfusion of the flap may be less reliable. Consequently, it has been recommended that the application of this technique be restricted to a selected group of cases, with large-volume reconstructions, obesity, smoking, scarring due to previous abdominal surgery and the absence of any suitable perforator being exclusion criteria.[16–18]

Here, we present our experience with a technical modification that enables the dissection of the rectus abdominis myocutaneous flap in a manner that preserves the entire anterior rectus sheath, without limiting the number of perforators nourishing the flap. This technique was applied in both pedicled and free rectus abdominis myocutaneous flaps.

Patients and methods

In this prospective study, we included 20 consecutive patients receiving 21 rectus abdominis myocutaneous flaps dissected with the anterior-rectus-sheath-sparing technique between February 2000 and August 2002. No exclusion criteria were applied that may have favoured any other flap or dissection technique. The series comprises a free TRAM flap subset (10 flaps in nine patients) and a pedicled flap subset (11 patients). The patient data are summarised in Table 1.

A free TRAM flap was used for breast reconstruction after mastectomy for breast cancer in eight patients (three primary reconstructions and five secondary reconstructions) and for benign lesions in one patient (bilateral subcutaneous mastectomy). Five patients underwent a simultaneous reduction mammaplasty or mastopexy on the contralateral healthy side to achieve symmetry.

A pedicled flap was used for thoracic-wall reconstruction following sternectomy for recalcitrant sternal osteitis in 10 patients, and after resection of an infiltrating axillary metastasis of a malignant melanoma in one patient. Sternal osteitis was diagnosed by clinical examination, CT scan and laboratory analysis, and the diagnosis was verified by microbiological examination. A median sternotomy had been performed in three patients for valvular repair and in seven patients for coronary artery bypass. Nine patients had undergone previous debridement, refixation and irrigation of the infected sternum.

In the free TRAM flaps, a horizontal skin paddle including all four zones was incised. The flap was dissected free from the anterior rectus sheath by meticulously visualising and preserving all myocutaneous perforators on the side of the vascular pedicle (Fig. 1). The anterior rectus sheath was then incised using a vertically oriented zigzag incision connecting the perforators. The incision was extended to the groin for pedicle dissection. In some cases, the distribution pattern of the perforators required additional horizontally oriented branching incisions; between one and three minor perforators were sacrificed, if they were positioned between adjacent major perforators. Between six and nine perforators were always included in the flap. Subsequently, the incised but fully preserved anterior rectus sheath could be detached from the muscle. The rectus muscle was split along its fibres lateral to the entry point of the most lateral perforator, thus defining the lateral border of the muscle cuff raised with the flap, and leaving a lateral strip of muscle in place (approximately one-third to one-quarter of the muscle circumference). All perforators were included in the muscle cuff. After harvesting the flap, the anterior rectus sheath was closed by duplication and by using a running nonabsorbable Everett suture. The thoracodorsal artery and vein were chosen as recipient vessels in nine cases and the circumflex scapular artery and vein were chosen in one case. The flap was shaped according to the needs of the patient. Skin and fat from zone IV were included in the flap in seven cases.

In the sternal-osteitis patients, a vertical myocutaneous flap was used with a skin paddle of about 25 cm × 7 cm, centred over the right rectus abdominis muscle. All perforators were meticulously dissected free in the epifascial plane, including the supraumbilical ones. Usually, between nine and 13 perforators could be identified. Incision and closure of the anterior rectus sheath were performed as described above. The entire rectus abdominis muscle was harvested with the flap.

Postoperatively, the flaps were monitored clinically and by temperature control. The free TRAM flap patients received 10% dextran 40 (B. Braun Medical AG, Emmenbrücke, Switzerland) at 50 ml/h until the fourth postoperative day. Mobilisation and respiratory physiotherapy were initiated as soon as

Table 1 Patient data (where appropriate, values are given as a range with the median in parentheses)

	Free TRAM flap ($n = 9$)	Pedicled rectus abdominis myocutaneous flap ($n = 11$)
Age (years)	37–67 (56)	61–85 (66)
Sex (male/female)	0/9	6/5
Risk factors		
Diabetes mellitus	0	8
Arterial hypertension	1	6
Smoking	1	5
Obesity	4	8
Irradiation	4	0
Chemotherapy	5	2
Lower abdominal operations	3	3
Indication		
Breast reconstruction	9	0
Sternal infection	0	10
Thoracic-wall reconstruction	0	1
Operative time (min)	300–495 (395)	135–240 (180)
Follow-up (months)	3–33 (10)	3–20 (11)

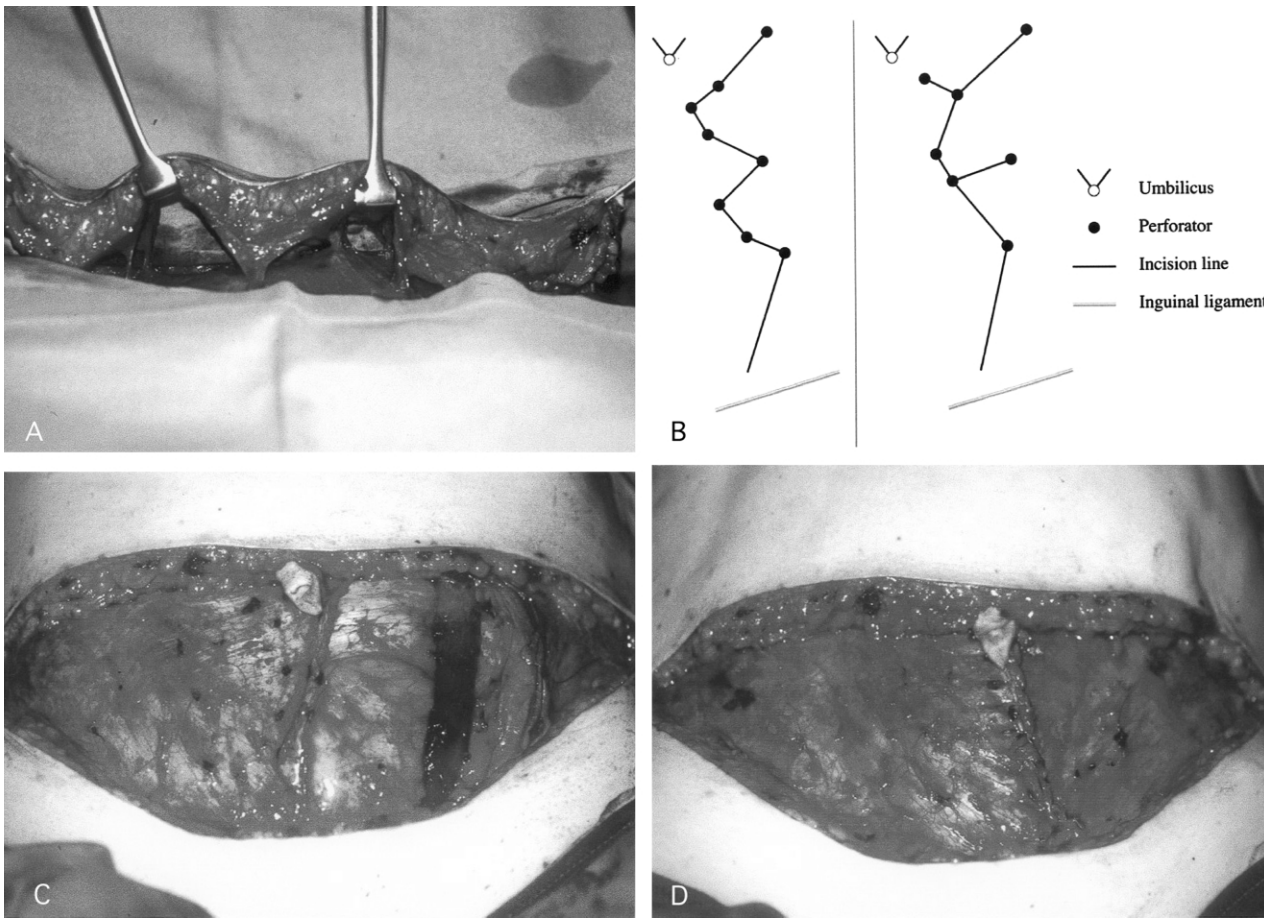

Fig. 1 The dissection of the free TRAM flap with full preservation of the anterior rectus sheath. (A) All the perforators supplying the skin paddle on the side of the vascular pedicle are exposed in the epifascial layer. (B) The anterior rectus sheath is incised in a line along the perforators. Depending on the distribution of the perforators, this may require additional branching incisions. The incision is extended to the groin to give access to the vascular pedicle. The anterior rectus sheath can then be detached from the rectus abdominis muscle without leaving a defect. (C) A muscle cuff surrounding the perforators is included in the flap, leaving a lateral strip of muscle in place. (D) The fully preserved anterior rectus sheath is closed by duplication without tension and without the use of an inlay mesh.

the patient was extubated. An abdominal garment was prescribed for six weeks in all patients.

The data were assessed prospectively. The postoperative results were obtained from physical examination in our outpatient clinic. Flap complications were classified as total or partial flap failure, the latter including skin and fat necrosis. Partial flap losses were further subdivided according to the need for revisional surgery.

Results

In the pedicled-flap subset, one patient died 60 days postoperatively owing to a disseminating endocarditis after valvular repair, and the patient with malignant melanoma died of systemic disease nine months postoperatively. Two patients developed pneumonia secondary to prolonged postoperative intubation. No systemic complications, such as pulmonary embolism, pneumonia or deep vein thrombosis, were observed in the free-flap subset.

All free flaps survived without surgical revision of the microvascular anastomosis. Additional surgery was required owing to necrosis of the original breast skin after skin-sparing mastectomy in two cases, infection of both the reconstructed breast and the abdominal donor site in one case and persistent abdominal seroma formation in two cases (Table 2). One patient developed minor marginal necrosis of the contralateral flap skin, which was related to an over-extended vertical incision in the midline of the flap to achieve a cone-shaped breast mound.

In the pedicled-flap group, one patient required further surgery because of a haematoma in the abdominal-wall donor site, caused by oral anticoagulation therapy. An inlay mesh was then needed to reinforce the abdominal-wall closure. One case of partial skin and fat necrosis required surgical debridement and secondary closure; one case of minor skin necrosis healed spontaneously within three weeks.

Abdominal bulging was observed in a 67-year-old obese female who had undergone bilateral breast reconstruction and in a 66-year-old obese female after thoracic-wall reconstruction. In both patients, bulging had been present preoperatively owing to abdominal-wall laxity and was partly reduced postoperatively. No abdominal hernia was found in either group. None of the patients reported reduced physical activity related to weakening or discomfort at the abdominal donor site.

Discussion

Partial flap failure and fat necrosis are the most common severe local complications after abdominal myocutaneous (TRAM) or perforator (DIEP) flap surgery.[4-6,13,16-20] These complications are related to the perfusion of the adipocutaneous flap tissue via the myocutaneous perforators. It has been shown that DIEP flaps, which are nourished by only one to three perforators, may be at increased risk of partial flap failure and fat necrosis, in particular in large reconstructions, obese patients and smokers, and if there is abdominal scarring or no suitable perforators are present.[16-18] Therefore, these factors have been considered contraindications to a DIEP flap procedure. In our series, no such exclusion criteria were applied. In the free TRAM flap subset ($n = 10$) there was one minor partial flap necrosis, which healed spontaneously, which is within the range (7–15%) reported in the literature for partial skin and fat necrosis with or without the need for revisional surgery that occurs after free TRAM flaps.[5,6,16,17] However, the value of this comparison is debatable because of the varying evaluation criteria, surgical indications and methods. Moreover, partial flap failure may also be influenced by factors other than perforator-based perfusion.[21]

An appropriate validation of the influence of the number of perforators feeding the flap may be

Table 2 Complications after free and pedicled rectus abdominis myocutaneous flaps (numbers in parentheses are the number of complications necessitating revisional surgery)

	Free TRAM flap ($n = 10$)	Pedicled rectus abdominis myocutaneous flap ($n = 11$)
Flap complications		
Total flap necrosis	0	0
Partial flap necrosis	1 (0)	2 (1)
Donor-site complications		
Seroma	2 (2)	0
Haematoma	0	1 (1)
Infection	1 (1)	0
Hernia	0	0
Bulging	1 (0)	1 (0)

provided by the results in the pedicled-flap subset. In our unit, the vertical rectus abdominis myocutaneous flap is routinely used for thoracic-wall reconstruction after radical sternectomy for recalcitrant sternal osteitis. The pedicled-flap subset represents a group of high-risk patients who are particularly susceptible to partial flap failure. Recently, we reported a consecutive series of cases, in which the flaps were dissected by consistently sacrificing the lateral row of perforators in order to reduce the width of the abdominal-wall defect.[3] In that series, the incidence of partial flap loss necessitating surgical re-intervention was 23%, compared with 9% when using the present dissection technique.

No abdominal hernias or bulging that could be attributed to the harvesting of the flap were observed in our patients. A 20% abdominal-wall complication rate was reported in an early study on free TRAM flaps performed at our institution.[6] Now, as a result of more sophisticated dissection techniques, the incidence of abdominal-wall instability can be reduced to below 5%.[17,18,20] Such low incidences are achieved not only with DIEP flaps, but also with muscle-sparing dissection techniques for free TRAM flaps.[5,14,17] In this context, it is not possible to distinguish between the contributions of the remaining rectus muscle and the anterior rectus sheath to abdominal-wall stability, whereas our results suggest that preserving the anterior rectus sheath alone is sufficient. This hypothesis has been supported by a number of studies, which show that the incidence of abdominal bulging or hernia after TRAM flap harvest depends primarily on the method of fascial closure rather than on the amount of muscle removed.[12,14,17] A key role may be attributed to the tension applied to the fascial tissue, which is minimised after a DIEP flap and by the present technique owing to full preservation of the anterior rectus sheath.

However, it is conceivable that trunk flexion was weakened in our patients owing to the loss of rectus abdominis muscle tissue. If this occurred, it did not affect their physical activities, which may be reduced because of advanced age and impaired general health. On the other hand, it has been shown that, compared with harvesting the total muscle circumference, leaving parts of the rectus muscle in place may improve abdominal-wall competence, as in the free TRAM patients in our study.[22]

In conclusion, we present a technical modification for dissection of the rectus abdominis myocutaneous flap that provides maximal perforator-related flap perfusion while minimising the sequelae at the abdominal donor site. An advantage over the DIEP flap is that this technique is also applicable to superiorly pedicled flaps. It may be proposed for patients who do not qualify for a DIEP flap, owing to an increased risk of microcirculatory complications or because they may not benefit from preservation of the entire rectus abdominis muscle.

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