

A Study of deep inferior epigastric artery-based rectus abdominis flap in covering various defects



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ABSTRACT

Background: Flaps based on deep inferior epigastric (DIE) vascular system; local, regional or free flaps: can be designed with different tissue compositions to cover a wide variety of defects. **Aims and Objectives:** The versatile utility of DIE flap was analyzed in this study. **Materials and Methods:** All patients who underwent a reconstruction using the DIE-based rectus abdominis muscle (RAM) flap between May 2016 and November 2017 were studied. Indications for the procedure, outcome, complications and donor site morbidity were all observed. **Results:** We conducted 11 DIE artery-based RAM flap procedures. Face (25%) and Perineum (25%) were the main recipient areas, followed by hip, thigh, leg, ankle, and lower back (8.6%). Primary closure without prolene mesh was done for donor site management in 41.6% cases and in the rest of 58.4% cases, closure required prolene mesh reinforcement. Not a single case suffered complete flap necrosis, five (41.6%) flaps had complete survival, four (33.3%) flaps underwent partial necrosis and in two (18.2%) cases there was partial loss of split-thickness skin grafts. Among the donor sites in the 11 cases, eight (72.7%) had no complications, among remaining three (33.3%) cases one each had complications such as wound dehiscence, discharge, ulceration, and pain. **Conclusion:** This flap can be used in various manners, it provides cutaneous cover that can be used anywhere. It can be used as a pedicled flap for perineal, inguinal, upper thigh regions and as a free flap, resurfacing anywhere from head to foot including the sole. It is versatile in the orientation and low donor site morbidity.

Key words: Transverse rectus abdominis myocutaneous flap; Deep inferior epigastric artery flap; Free myocutaneous flap; Perforator flap

INTRODUCTION

The rectus abdominis muscle (RAM) flap and its various modifications are quite frequently used in reconstructive surgery. Rectus abdominis flaps, whose blood supply is mainly provided by superior and deep inferior epigastric (DIE) vessels (type 3), are suitable not only for local transfer but also as free flaps. Based on abundant anastomoses of DIE vessels with other vessels such as superior epigastric

vessels, lower inter costal vessels, sub-costal vessels, lumbar vessels, superficial epigastric vessels, and superficial and deep circumflex iliac vessels, rectus abdominis flap may be designed as a vertical flap, transverse flap, or an Oblique flap. The RAM flap was first described by Holmstrom in 1979 that based the flap on its inferior pedicle, the DIE artery (DIEA). The RAM based on its inferior pedicle provides a reliable flap for defects of the anterior pelvis and groin (Mathes and Bostwick). The RAM flap gained

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popularity with the work of Hartrampf et al.,¹ with its utilization as a pedicle flap based on its requirement.² Later, surgeons found RAM based on its inferior pedicle to be a reliable flap for defects of the anterior pelvis and groin as well.³ The rectus abdominis flap, based on the DIEA, is a composite flap and comprises muscle, over lying fascia and skin. It provides a large superior pedicle, the superior epigastric artery, in breast reconstructions. Later with the advancements in the field of microsurgery, this flap proved an attractive option even for head-and-neck reconstructions as the DIEA and its venae comitantes provide a long pedicle and recipient vessel match with facial vessels in the neck.⁴ The object of this study is to demonstrate the wide applications of this flap and to demonstrate that learning the harvest technique of this one single flap would be enough to tackle reconstructive challenges in any region of the body.

Currently, the DIEA perforator (DIEP) flap is considered the gold standard in breast reconstructions in which large flaps with high volume of soft tissue are used. Many variations based on the inferior epigastric artery, including perforator flaps, were described. Subsequently this flap was used in breast reconstruction (Hartrampf et al., 1982) as a donor for free-tissue transfer (Pennington) and to repair defects in the groin (Mathes and Bostwick). A thorough knowledge of the anatomy of the abdominal wall can aid in harvesting different combinations of tissues, based on different sources of blood supply, while producing reliable reconstructions with minimal chances of hernia formation and esthetically displeasing results at the donor site.

Aims and objectives

Study the different dispositions of Deep Inferior Epigastric Artery and its perforators in relation to Rectus Abdominis muscle b. Study the versatility of use of DIEA based flaps in covering defects in different body parts.

MATERIALS AND METHODS

The study was conducted at the Department of Plastic Surgery, Medical College and Hospital, Kolkata. Patients attending at plastic surgery outpatient department/emergency room and admitted to plastic surgery department of MCH and referred cases from general surgery, oncosurgery, ENT, and others were the study population. Informed consent of the patients was taken in all cases.

Inclusion criteria

Inclusion criteria were as follows: All patients having suitable defects requiring DIEA based RAM flap and its various modifications, attending to Plastic Surgery

Department, Medical College, Kolkata, were included in the study.

Exclusion criteria

Exclusion criteria were as follows: Those patients having peripheral vascular diseases, uncontrolled diabetes, gross obesity and older than 70 years of age, and patients with history of lower abdominal surgery and irradiation were excluded from the study.

The study was conducted from May 2016 to November 2017.

Totally 11 patients with soft-tissue defects were the sample size.

History taking and clinical examinations were carried out to confirm the diagnosis clinically and to get ascertain the applicability of inclusion and exclusion criteria in the patient before allocating the patient in the study population. The whole of the surgical procedure including advantages and disadvantages of this reconstructive procedure were explained to the patients. This study is a descriptive (observational) type of study, institution-based prospective study.

Following study tools were used:

- Patients' informed consent
- Pro forma for relevant history and clinical examination of the primary defect for which the procedure of reconstruction was performed
- Doppler ultrasound probe (hand-held) was used to locate the perforators. Markers, tapes to design the flap pre and intra operatively, microsurgical instruments and loupes for magnification during dissection and microvascular anastomosis
- Predetermined pro forma for tabulation of data.

RESULTS

The mean age was 49, 33 years with a standard deviation of 11.11 years (range 28–68 years). There were 66.6% males and 33.3% females. Comorbidities were present in 66.6% of cases. Multiple etiopathogenesis of soft-tissue defects with post-tumor resection being maximum (66.6%) followed by trauma (25%) and post-infective pathology (8.3%) (Table 1). Face (25%) and perineum (25%) being the main recipient areas of tissue defects followed by hip, thigh, leg, ankle, and lower back (8.6%) each (Table 2).

Size of flap – The mean flap size in our study was 15.5×9.5 cm.

In our study, pedicled flap as done in 58.3% cases and free flap coverage were done in 41.7% cases (Table 3).

Vertical rectus abdominis myocutaneous (VRAM) flap were done in 33.3% cases of which 25% were VRAM myocutaneous and 8.6% was VRAM muscle flap only. In 16.6% cases, the pedicled flap consisted of both vertical and transverse component and in 8.6% cases a BERAM flap was used (Figure 1). Among the cases where free flap coverage were done, 25% cases used free myocutaneous flap (Figure 2), 8.6% cases used DIEP flap and 8.6% cases used free muscle flap only. Preoperatively, Doppler (hand held) was used to locate perforators in DIEP flaps.

Donor site management - Primary closure was done for donor site in 41.6% cases and the rest 58.4% cases required closure with prolene mesh reinforcement. The average operative time in our study was 4.3 h.

Flap Survival - Complete Flap survival was observed in 41.6% cases, 33.3% cases reported partial necrosis and in 25.1% cases partial loss of grafted skin has occurred in our study. In the partially necrosed flap, necrosis was present peripherally probably due to dissection beyond vascular angiosome. No case of complete flap necrosis was reported.

Complications - In our study of 11 cases there was no cases of complete flap necrosis, five (41.6%) flaps had complete survival, four (33.3%) flaps underwent partial necrosis, and in two cases, there is partial loss of split-thickness skin grafts (Table 4).

Complications in RAM flap and its incidence.

There is no significant statistical association between complications with comorbidities (P-value obtained by Pearson's Chi-square test >0.05).

Donor site complications - Among the donor sites in the 11 cases, 7cases (66.6%) had no complications. Of the remaining (33.3%) cases one each had complications like wound dehiscence, discharge, ulceration and pain.

There is no significant statistical association between complications and types of flap used (P-value obtained by Pearson's Chi-square test >0.05).

DISCUSSION

All the patients were preoperatively evaluated for any prior abdominal surgery (to be assessed for the abdominal wall vascular integrity). Pre-operative multidetector computed tomography angiography was done to map perforator anatomy.⁵ The skin paddle was designed based on perforators in the periumbilical region. Transverse or vertical incision made over the RAM (depending on the case). The RAM and underlying DIE vessels were exposed

Table 1: Various etiology and frequency of soft-tissue defects needed coverage

Various etiology of soft tissue defect	Frequency
Post-tumor resection	66.6%
Trauma	25%
Post-infective pathology	8.4%

Table 2: Anatomic sites of using RAM flap

Anatomic sites	% of cases
Face	25%
Perineum	25%
Other sites (hip, thigh, leg, ankle, lower back)	8.6% each

RAM: Rectus abdominis muscle

Table 3: Various types of RAM flap

Type of flap	% of use
VRAM myocutaneous flap	25
VRAM muscle flap	8.6
Pedicle flap with vertical and transverse component	16.6
Pedicle BERAM flap	8.6
Free myocutaneous flap	25
Free DIEP flap	8.6
Free muscle flap	8.6

RAM: Rectus abdominis muscle, DIEP: Deep inferior epigastric artery perforator

Table 4: Complications of RAM flap with incidence

Different complications	Relative %
Partial necrosis of flap	4 cases–33.3%
Partial loss of STSG	2 cases–20.8%

RAM: Rectus abdominis muscle, STSG: Split-thickness skin grafts



Figure 1: Design and marking of deep inferior epigastric artery flap [first one-vertical oriented (Vertical rectus abdominis myocutaneous), second one-transverse]

by incising the rectus sheath. The DIEA and vein were carefully dissected. The dissected perforator vessels were selectively clamped to ensure optimum blood supply. To reduce lateral thermal burn injury, vessel clips and microbipolar cautery were used. During flap harvesting, the fasciocutaneous flap was dissected off the posterior rectus sheath carefully preserving the perforators. The muscle was included in the flap completely or partially (Figure 3). DIE vessels dissected till its origin for extra length.⁶



Figure 2: Free Vertical rectus abdominis myocutaneous flap for face defect follow-up after 4 weeks

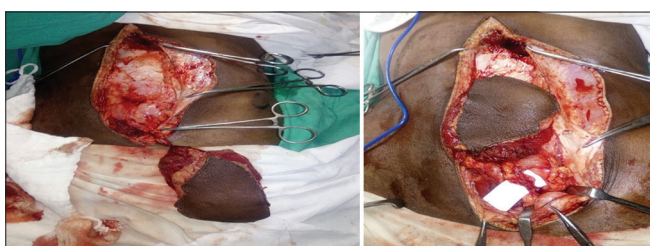


Figure 3: Dissected rectus abdominis muscle flap (pedicled)



Figure 4: Pedicled rectus abdominis muscle inset at a perineal defect (2 weeks post-operative) well healed abdominal donor site

Pedicled flap was transferred to recipient site via subcutaneous or intraabdominal tunnel (Figure 4). For free flaps, microvascular anastomosis was done where fibrin glue reinforcement was helpful in selected cases.⁷

Donor sites were closed meticulously—either suture only or with a prolene mesh reinforcement to prevent incisional hernia (Figure 5). Proper post-operative monitoring done to ensure flap viability, donor site healing and to check complications like venous congestion.

The design and size of the flap vary greatly depending on the surgical technique utilized and the characteristics of

the donor and recipient areas. It is preferable to include periumbilical perforators in the design. These perforators are larger and provide better supply to the skin of the abdominal wall (Figures 6 and 7). In most situations, the superior incision is placed at the umbilicus level and sacrifice some of the periumbilical perforators, allowing for a more esthetically pleasing incision line. The most commonly employed design of the skin portion of the flap is the transverse lower abdominal skin flap, similar to the skin resection of an abdominoplasty.⁸ The superior margin of the skin island is usually 2 cm above the umbilicus (in order to include the periumbilical perforators) and the inferior margin is above the pubic hairline.⁹ Free Myocutaneous flap based on the DIEA: When this type of reconstruction is employed, its vascularization is abundant and reliable, permitting use of the entire inferior abdominal skin. Perforator Flap based on the DIEA: Despite its sufficient arterial supply, venous congestion is occasionally noted on the opposite side of the DIEA.

Advantages of DIEA based rectus abdominis flap

Reliable vascular supply, long pedicle, large size skin paddle.¹⁰ Versatility in reconstruction of different body parts (head-neck, chest, perineum etc.). The final outcome is quite acceptable esthetically.¹¹ In similar situations, other than DIEA flap, other musculocutaneous flaps such as Anterolateral Thigh (ALT) flap, Latissimus Dorsi can be used. Advantage of DIEA over other two is, it provides a more durable skin and good muscle bulk, and also longer and stout pedicle. But donor site morbidity will be least in case of ALT.¹²

Other reconstructions

In other types of reconstructions, the flap design will depend on the defect to be repaired. Flaps with vertical or oblique skin islands can be designed. If the design is oblique, it is possible to utilize the skin portion above the rib cage that has the advantage of being thinner and consequently more suitable for remodeling the flap.¹³ This flap is designed transversely over the anterior portion of the lower costal margin laterally all the way to the level of the midaxillary line. If volume is necessary, a major or minor portion of the rectus muscle can be included in the flap, always bearing in mind the fact that about 20–30% of the muscle volume is usually lost due to denervation of the muscle. If the planned flap is purely muscular, it can be dissected through a paramedian incision placed longitudinally and centered over the rectus muscle with a lateral extension in the caudal portion that aids in exposure of the DIEA.

Schaverien et al., studied the abdominal perforator flaps based on a cutaneous branch of the DIEA (DIEP flaps).¹⁴ They proposed that the arterial perforator should: (1) be



Figure 5: Late Post-operative appearance of abdomen closure -- Vertical rectus abdominis myocutaneous flap and transverse rectus abdominis musculocutaneous flap

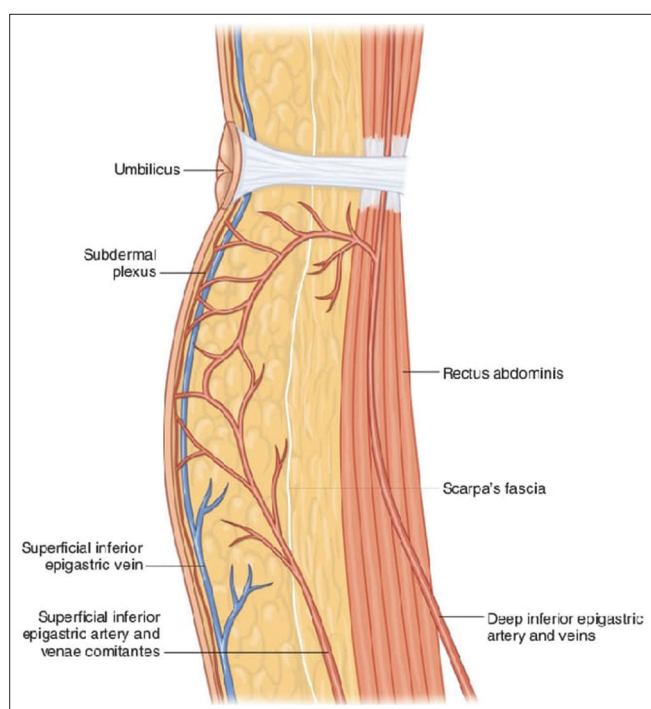


Figure 6: Anatomical disposition of deep inferior epigastric artery deep superior epigastric artery, [courtesy: Flaps and Reconstructive Surgery. Mardini]¹⁶

more than 1.0 mm large; (2) run a straight intramuscular course, parallel to the rectus abdominis fibers, with no large muscular branches; and (3) have only a short portion running immediately under the anterior rectus abdominis sheath. They classified the course and ramification pattern of the DIEA into six patterns, depending on whether the anastomosis was cited in the medial or lateral branch and the level at which the branches originated. They classified the course and ramification pattern of the DIEA into six patterns, depending on whether the anastomosis was cited in the medial or lateral branch and the level at which the branches originated.¹⁶

Munhoz et al., studied the importance of lateral row perforator vessels in DIEP flap harvesting. Thirty DIEP flaps from 15 fresh cadavers were used. Lateral row

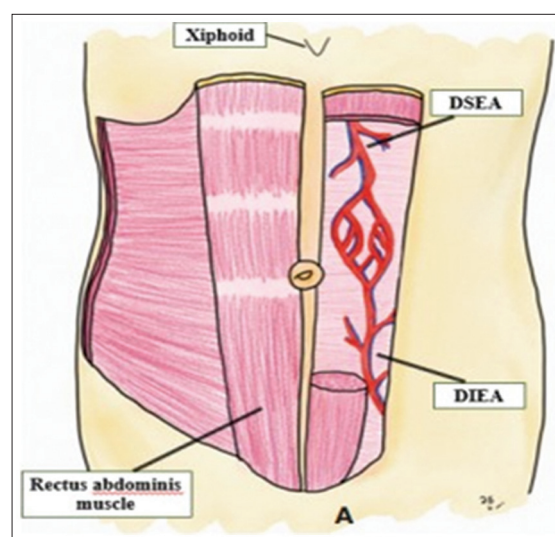


Figure 7: Anatomical disposition of deep inferior epigastric artery deep superior epigastric artery, [courtesy: Flaps and Reconstructive Surgery. Mardini]¹⁶

perforators presented a rectilinear intramuscular course, which was shorter than that of the medial row perforators. This anatomical characteristic favors dissection with reduced operative time and vascular lesion morbidity, resulting in an important anatomical parameter for DIEP flap harvesting.

Zhang et al., studied the reconstruction of leg defects using free RAM flaps with intermediate split thickness skin graft. From May 1998 to December 2002, 9 cases of defects on legs were repaired by use of unilateral free rectus abdominis flap with skin graft. The soft-tissue defects were accompanied by osteomyelitis or the exposure of bone or tendon. The defect size ranged 3 cm×4 cm to 8 cm×14 cm. The area of RAM flaps was 4 cm×6 cm to 8 cm×15 cm. All patients were followed up 6 months to 4 years after operation all rectus abdominis flaps survived with good appearances and functions. Tansatit et al., studied the Neurovascular anatomy of the DIEP flap for breast reconstruction to find out the most suitable perforator and cutaneous nerve for strategic design of the DIEP flap.

Their findings indicate that it would be more beneficial to use the lateral row perforators.

Schaverien et al., studied the comparison of outcomes and donor-site morbidity in unilateral free transverse rectus abdomen is musculocutaneous (TRAM) versus DIEP flap breast reconstruction. The aim of this study was to evaluate post-operative outcomes and long-term subjective functional deficit in patients following unilateral free TRAM compared with DIEP flap breast reconstruction. Sixty patients with breast reconstruction were included in the study. 30 of whom had undergone a DIEP flap, and 30 a free TRAM flap.

Takeishi et al., studied the Muscle sparing transverse rectus abdominis flap for breast reconstruction: A comparison with DIEP flap. Breast reconstruction using free TRAM flap can be divided into 4 muscle-sparing (MS) types: Conventional TRAM flap containing full width muscle as MS-0, while DIEP flap containing absolutely no muscle as MS-3. They include only the muscle portion between the medial row and lateral row perforator vessels in TRAM flap, which is designated as MS-2. Total 82 breast reconstructions using MS-2 free TRAM flaps done. All the flaps survived. Fat necrosis occurred in 8 cases, all corresponding to zone IV or zone II. In conclusion, MS-2 free TRAM flap is a useful technique for breast reconstruction considering the easy surgical techniques, length of the vascular pedicle that can be harvested, and the degree of freedom of the flap.

Wan et al., studied the inclusion of mesh in donor-site repair of free TRAM and MS free TRAM flaps yields rates of abdominal complications comparable to those of DIEP flap reconstruction.¹⁵ A retrospective review of all free flap breast reconstructions at the University of California, Los Angeles Medical Center from 2002 to 2007 was performed. Their conclusion was that incorporating mesh into rectus fascia repair in free and MS free TRAM flap cases significantly reduces the rate of post-operative abdominal complications to levels equivalent to those for DIEP flap reconstructions.

Bognár et al., studied the perineal soft-tissue reconstruction with VRAM flap following extended abdomino-perineal resection for cancer. The combined procedures between the colorectal and plastic surgical teams are very useful.

Macadam et al., studied the Quality of Life and patient-reported outcome in breast cancer survivors. A Multicenter Comparison of four abdominally based autologous reconstruction methods. Patients from five North American centers were eligible if they underwent reconstruction by means of the DIEP flap, MS free TRAM flap, free TRAM flap, or the pedicled TRAM flap. The results of this study

show that the DIEP flap was associated with the highest abdominal well-being and the lowest abdominal morbidity compared with the pedicled TRAM flap.

Limitations of the study

1. Average follow-up period in this study was 6–8 months. Final outcome would have been better evaluated if the duration was more than 1 year
2. If total no of patients were more, then efficacy of different reconstructive options would have been better evaluated.

CONCLUSION

We found that the RAM flap has a reliable vascular supply, long pedicle, large size skin paddle, which allows for its use in reconstruction of large defects in wide regions of the body. We have been able to demonstrate its versatility by using it in head and reconstruction and lower limb as free flaps and in the perineum and chest as pedicled flap. Its short harvest time allows its use successfully in combined onco-resection and reconstructive procedures. Even though perforator dissection is tedious when only skin component has to be used, the use of mesh provides a good adjunct to re-enforcing the abdominal wall.

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PC and SK- Concept and design of the study, prepared first draft of manuscript; **PC and DM-** Review of the literature and manuscript preparation; **SK and MPK-** Concept, coordination, statistical analysis and interpretation of results; **DM and SK-** Revision of the manuscript.

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