

Donor-Site Complications and Remnant of Rectus Abdominis Muscle Status after Transverse Rectus Abdominis Myocutaneous Flap Reconstruction

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Background: Transverse rectus abdominis myocutaneous (TRAM) flap reconstruction after mastectomy in breast cancer patients has become one of the milestones in breast reconstruction. There are several techniques that have been used in an attempt to minimize untoward complications. We present the whole muscle with partial sheath-sparing technique that focuses on the anatomy of arcuate line and the closure of the anterior abdominal wall techniques with mesh and determine factors associated with its complications and outcomes.

Methods: We retrospectively and prospectively review the results of 30 pedicled TRAM flaps that were performed between November 2013 and March 2016, focusing on outcomes and complications.

Results: Among the 30 pedicled TRAM flap procedures in 30 patients, there were complications in 5 patients (17%). Most common complications were surgical-site infection (7%). After a median follow-up time of 15 months, no patient developed abdominal wall hernia or bulging in daily activities in our study, but 6 patients (20%) had asymptomatic abdominal wall bulging when exercised. Significant factors related to asymptomatic exercised abdominal wall bulging included having a body mass index of more than 23 kg/m².

Conclusion: Pedicled TRAM flap by using the technique of the whole muscle with partial sheath-sparing technique combined with reinforcement above the arcuate line with mesh can reduce the occurrence of abdominal bulging and hernia. (*Plast Reconstr Surg Glob Open* 2017;5:e1387; doi: 10.1097/GOX.0000000000001387; Published online 29 June 2017.)

INTRODUCTION

From GLOBOCAN data, it was estimated that in 2012 there were 14.1 million new cancer cases and 8.2 million cancer-related deaths. The most frequent diagnosis for the cause of cancer deaths among women is breast cancer in both developed and developing countries.¹ Surgery is one of the milestones in breast cancer treatment, but in some patients it can cause morbidities and poor cosmetic outcomes. Within the past several decades, however, breast cancer treatment has changed attitudes toward breast

reconstruction after mastectomy due to its psychological, emotional, and social benefits.²⁻⁴

Autologous tissue reconstruction has satisfied patients more aesthetically than implant reconstruction because it resembles a soft and naturally ptotic breast.²⁻⁴ For this reason, transverse rectus abdominis myocutaneous (TRAM) flap reconstruction has become one of the milestones in breast reconstruction for many years. It was first described for breast reconstruction after mastectomy in 1982 by Hartrampf and Bennett.^{5,6} Although it has good aesthetic results, the donor-site's long-term morbidities are still major concerns such as decreased trunk flexion capacity, abnormal contour of lower abdominal wall, abdominal bulging, and hernia.^{7,8} There are many reconstructed and abdominal wall defect closure techniques such as the pedicled TRAM, free TRAM, deep inferior epigastric perforator (DIEP) flaps, preservation of the rectus muscle and anterior rectus sheath, 1- or 2-layer fascial closure, the use of relaxing incisions, and synthetic mesh, that have been used in an attempt to minimize untoward complications.

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Received for publication March 7, 2017; accepted May 4, 2017.

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DOI: 10.1097/GOX.0000000000001387

Disclosure: The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.

However, these complications still occurred with an incidence rate ranging from 0% to 55%.⁷⁻¹⁵

Abdominal muscle strength was associated with morbidities after TRAM flap reconstruction. Muscular atrophy can occur in both the donor and normal sides of abdominal muscles due to postoperative immobilization.¹⁶ The indirect measurement of muscle strength is muscle size evaluation, which provides information about muscle morphology and functions. Ultrasonography is an accurate noninvasive method for measuring cross-sectional area (CSA) or thickness of muscles.^{17,18} Compared with computed tomography or magnetic resonance imaging, ultrasound imaging is less expensive, more available, and capable of visualizing muscles in dynamic and static conditions.^{17,19}

In 2015, Rietjens et al.¹⁵ reported techniques of TRAM flap reconstruction that focused on the anatomy of arcuate line and the closure of the anterior abdominal wall techniques with mesh that can be performed to minimize donor-site morbidities. There were no instances of abdominal wall hernia and bulge during follow-up (median 13 months). In our study, we have applied principles of this technique in TRAM flap reconstruction more than 2 years. The purposes of this study were to determine the morbidities of whole muscle with partial sheath-sparing pedicled TRAM flap reconstruction such as donor-site morbidities, flap morbidities, and to identify factors associated with these morbidities.

PATIENTS AND METHODS

From November 2013 to March 2016, 38 patients underwent 38 immediate ipsilateral pedicled TRAM flap reconstructions. However, only 30 patients were included in this study due to 2 patients' deaths from metastasis breast cancer, 5 patients' loss to follow-up, and 1 patient who refused to join in this study. Patients' age, weight, height, body mass index (BMI), menopausal status, associated comorbidities (diabetes mellitus, hypertension, and dyslipidemia), and smoking history were recorded as patient risk factors. Surgical factors, including previous abdominal surgery, types of surgical procedure, operating times, and outcomes of reconstruction were also recorded. Exclusion criteria were patients who had other techniques for TRAM flap reconstruction and patients who refused to join in this study. Surgical outcomes focused on the incidence of fat necrosis, flap loss, abdominal bulging, and hernia.

The fat necrosis was defined as any palpable firm lesion of the flap that persisted more than 3 months after surgery without recurrent tumor. An abdominal wall hernia was defined as a protrusion of abdominal contents through abdominal wall with fascial defect, and an abdominal wall bulging was defined as any asymmetrical abdominal contour that occurred after TRAM flap reconstruction without an associated fascial defect.^{20,21} All patients signed an informed consent for breast reconstruction before the operation. All TRAM flap reconstructions were performed by 3 surgeons who used the same techniques for these procedures and patients were followed up at breast clinic according to the guideline and were clinically examined

for the presence of abdominal bulging, hernia, and other complications. Ultrasonography was performed to evaluate abdominal muscle sizes at least 3 months after surgery.

OPERATIVE TECHNIQUE

Flap Elevation

An incision is made as a standard elliptical incision at the lower abdomen. The superior and inferior part of abdominal wall is dissected above anterior rectus fascia to the level of bilateral costal margins and the level of inferior incision, respectively. The abdominal flap is dissected in the direction from lateral to medial part of the flap, identifying the arterial perforators along the way. The lateral border of the rectus muscle is always clearly identified. We routinely preserve anterior rectus fascia 2 cm from its lateral border and 1 cm from the linea alba or the first perforator visualized on the pedicle side. This will preserve the linea semilunaris and its fibrous part for mesh fixation during abdominal closure. The rectus abdominis muscle is dissected from anterior and posterior rectus fascia. The level of arcuate line is identified before harvesting the flap at distal cut edge of the rectus muscle. We routinely transverse clamp at this level of rectus muscle with Kocher clamps to ensure that remnant rectus muscle and fascia do not retract below this landmark (Fig. 1). This lower point necessitates repair to ensure abdominal strength. The anterior fascia and rectus abdominis muscle are transversely divided as close to the arcuate line as possible (Fig. 1). The inferior epigastric vessels can be visualized, clipped, and cut. The perforating vessels both below and above the umbilicus must be precisely identified to preserve a part of anterior rectus fascia, which will facilitate suture of the abdominal wall defect with mesh. In our previous 2013 series, the distal edges of anterior fascia and muscle were then sharply incised the full width below the arcuate line. The distal cut edge of the rectus muscle often retracted far from the arcuate line, making it difficult to suture the distal rectus end to the posterior sheath at the level of the arcuate line.

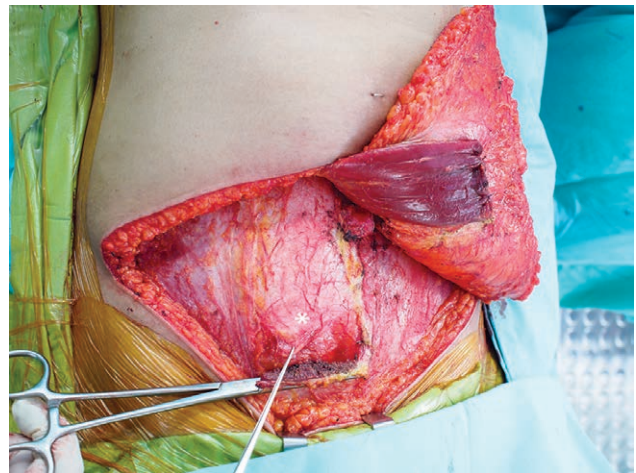


Fig. 1. Kocher clamp was applied at this level of rectus muscle to ensure that remnant rectus muscle and fascia did not retract below this landmark. (* shows the arcuate line.)

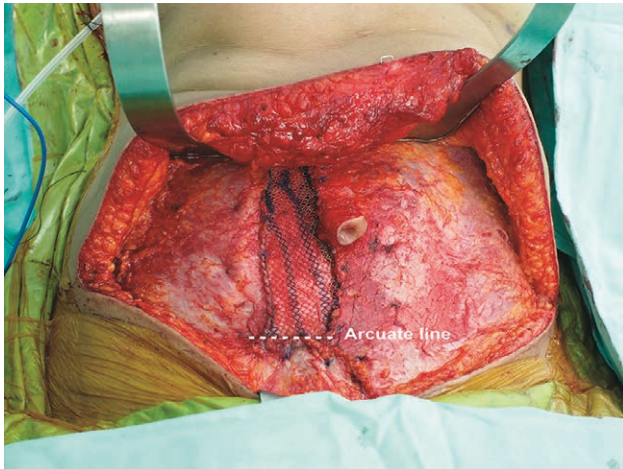


Fig. 2. Arcuate line: posterior rectus sheath is reinforced with polypropylene mesh and sutured to the cut edge of the rectus muscle and anterior sheath at the level of the arcuate line.

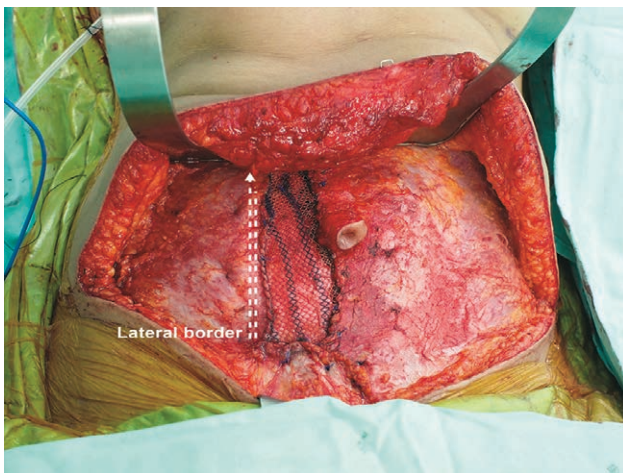


Fig. 3. The medial and lateral part of anterior rectus sheath: running horizontal mattress suture followed by an over and over stitch.

Closure of the Abdominal Wall Defect

We use polypropylene mesh (Ethicon ULTRAPRO) to close the anterior sheath fascial defect. The mesh is sutured to the medial and lateral remnant of the rectus sheath in layers, beginning with 3 or 4 interrupted sutures at the edge of posterior layer to fix mesh with posterior rectus sheath. The polypropylene mesh is run from the arcuate line up to the costal margin. Before taking off the Kocher clamps, the posterior rectus sheath is reinforced with mesh, which is sutured to the cut edge of the rectus muscle and anterior fascial sheath at the level of the arcuate line (Fig. 2). A key point is that horizontal mattress sutures be used without excessive tension. The medial and lateral part of the anterior rectus fascia is then sutured onto the mesh and posterior fascia with a running horizontal mattress suture followed by an over and over stitch (Fig. 3). This additional layer of fascia and row of sutures will improve the integrity of the abdominal wall, especially when the patient is awake during the recovery period. Another row of reinforcement sutures above the arcuate line, suturing the distal rectus and anterior sheath to the mesh and posterior fascia should also help in preventing abdominal contour abnormalities. To centralize the umbilicus, we use an interrupted vertical row of figure-of-eight sutures for plicating the contralateral anterior sheath fascia. The abdominal wall is fixed by 4 interrupted sutures between anterior rectus sheath and subcutaneous tissue of the upper part of the abdominal wall, 2 sutures at 6 and 12 o'clock of umbilicus, and 2 sutures at both lateral sides of umbilicus, before closing the lower abdomen to reduce tension of the abdominal skin closure.

Ultrasonographic Techniques

Ultrasound was performed by using high-spatial-resolution U.S. machines (iU22; Philips Medical Systems, Bothell, Wash.) with an L12-8 linear array transducer by 2 radiologists who have 10 and 7 years of ultrasound experience.

For measuring the size of the rectus abdominis muscle, the transducer was placed over the belly of the rectus abdominis muscle and oriented transversely perpendicular to the midline of the abdomen; the transducer was placed on the skin without applying any pressure.¹⁶ Images of the rectus

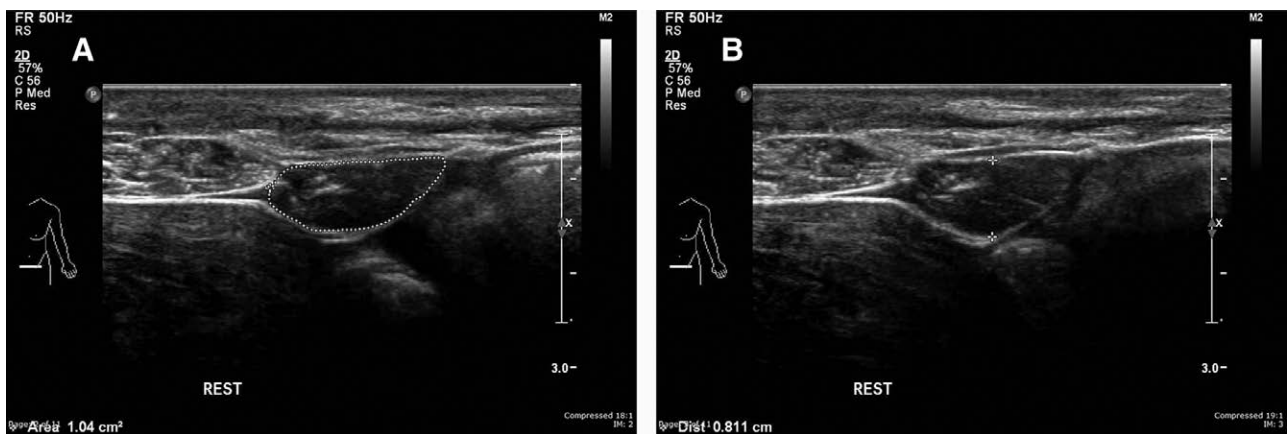


Fig. 4. Ultrasound images showed CSA (A) and thickness (B) of remnant rectus abdominis muscle at rest.

abdominis muscle were acquired at rest and during exercise to investigate the thickness and CSA of the remaining rectus abdominis muscle on the donor side and its contralateral normal side (Figs. 4–7). The exercise was performed with trunk flexion, to raise the trunk against gravity about 30 degrees in the supine position with the knees flexed.

The largest anteroposterior thickness of the rectus abdominis muscle was measured while cross section of the whole muscle was centered on the image. For exact measurements, the diameter was defined as between the inner layers of the rectus muscle sheets.¹⁹ All measurements are calculated electronically by the ultrasound machine.

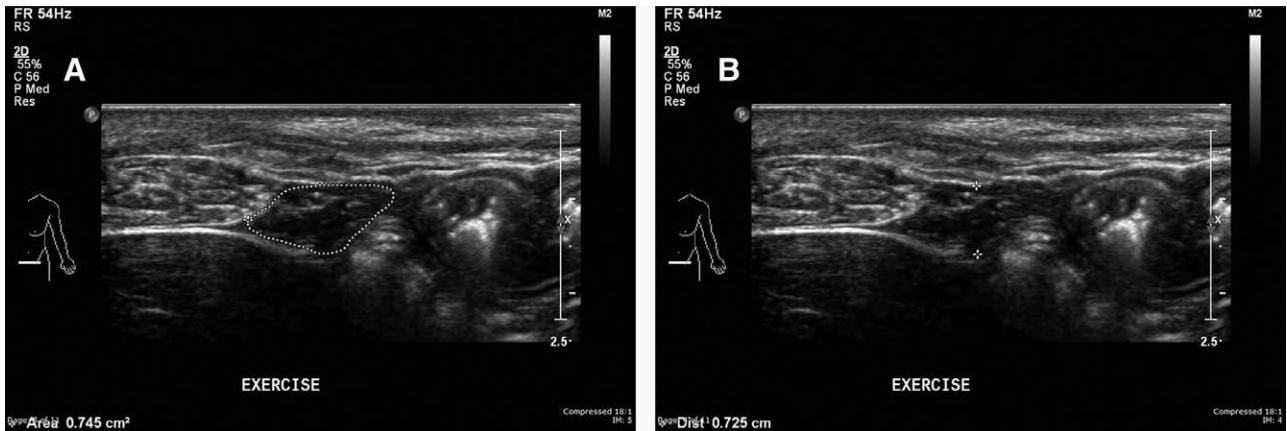


Fig. 5. Ultrasound images showed CSA (A) and thickness (B) of remnant rectus abdominis muscle when exercised.

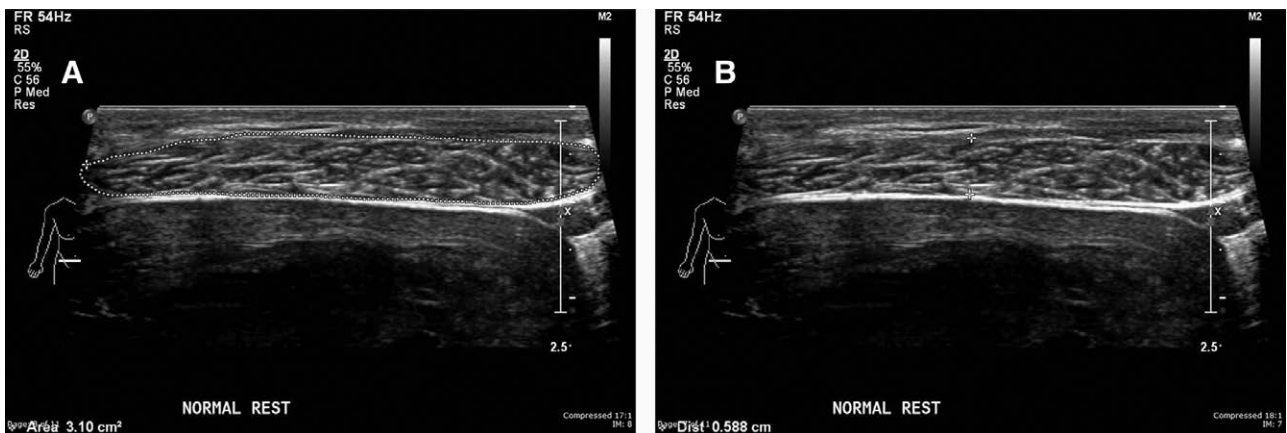


Fig. 6. Ultrasound images showed CSA (A) and thickness (B) of normal rectus abdominis muscle at rest.

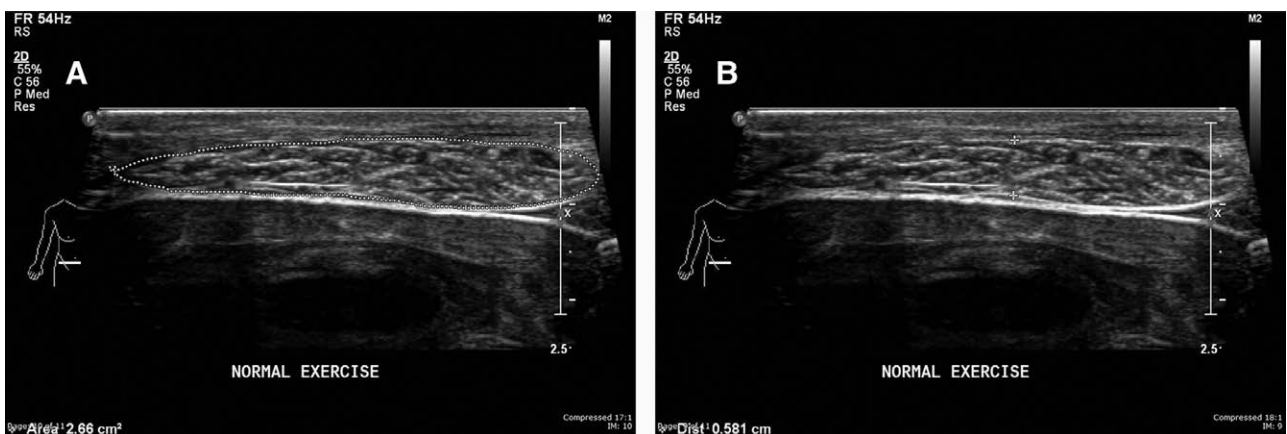


Fig. 7. Ultrasound images showed CSA (A) and thickness (B) of normal rectus abdominis muscle when exercised.

Table 1. Baseline Characteristics of 30 Patients Who Underwent Immediate Ipsilateral Pedicled TRAM Flap Reconstruction from November 2013 to March 2016

Characteristics	N (%); or Mean \pm SD; or N (Median, IQR)
Age (y)	44.23 \pm 7.29
BMI (kg/m ²)	22.65 \pm 2.78
Comorbidities	5 (16.67)
Diabetes mellitus	1 (3.33)
Hypertension	1 (3.33)
Asthma	1 (3.33)
Others	4 (13.33)
Previous abdominal surgery	4 (13.33)
Transverse line incision	3 (10)
Vertical line incision	1 (3.33)
Neoadjuvant chemotherapy	1 (3.33)
Postreconstructive chemotherapy	22 (73.33)
Postreconstructive radiation	10 (33.33)
Follow-up time (d)	458 (255, 785)
Operative data	
Operative time (min)	280 (230, 290)
Breast surgery type	
SSM	17 (56.67)
NSM	13 (43.33)
Axillary LN surgery (n = 27)*	
Sentinel lymph node biopsy	15 (55.56)
Axillary lymph node dissection	16 (59.26)
Breast reconstruction	
Ipsilateral TRAM flap	29 (96.67)
Ipsilateral TRAM flap with prosthesis	1 (3.33)
Pathological data	
Histology	
Invasive ductal carcinoma	24 (80.00)
Invasive lobular carcinoma	1 (3.33)
Mucinous carcinoma	1 (3.33)
Ductal carcinoma in situ	15 (50.00)
Others	3 (10)
Tumor size (cm)	3 (2.1, 5.5)
Grading (n = 28)†	
1	2 (7.14)
2	12 (42.86)
3	14 (50.00)
Lymphovascular invasion	10 (33.33)
Perineural invasion	2 (6.67)
Lymph node metastasis (n = 27)*	14 (51.85)
Ki-67 (%)	31.26 \pm 22.60
Immunohistochemistry subtype (n = 24)‡	
Luminal A	6 (25.00)
Luminal B	14 (58.33)
Non-luminal/HER-2 overexpression	2 (8.33)
Triple negative	2 (8.33)
Pathological staging (n = 28)†	
Stage 0	2 (7.14)
Stage I	6 (21.43)
Stage II	11 (39.29)
Stage III	9 (32.14)

*Two patients who were diagnosed for phyllodes and 1 patient for angiosarcoma were excluded from analysis.

†Two patients who were diagnosed for malignant phyllodes were excluded from analysis.

‡Two patients who were diagnosed for phyllodes, 1 patient for mucinous carcinoma, 1 patient as angiosarcoma, and 2 patients as pure ductal carcinoma in situ were excluded from analysis.

HER-2, Human epidermal growth factor receptor 2; IQR, interquartile range; LN, lymph node; NSM, nipple-sparing mastectomy; SSM, skin-sparing mastectomy.

Statistical Analysis

Data analysis was performed using Stata version 12 (Stata Corp, College Station, Tex.). Quantitative data were summarized as mean and SD and/or range. Qualitative data were summarized as counts and percentage and tested for differences between continuous variables using

Table 2. Abdominal Muscle Ultrasonographic Data from 30 Patients Who Underwent TRAM Flap Reconstruction

Ultrasonographic Data	N (%); or Mean \pm SD; or N (Median, IQR)
Time from surgery to ultrasound (d)	417.5 (156, 777)
Remnant muscle of donor site	27 (90.00)
Distance from ASIS (cm; n = 27)*	2.52 \pm 0.79
Donor site at rest	
Thickness (cm)	0.45 (0.37, 0.50)
CSA (cm ²)	0.82 (0.51, 1.02)
Donor site at exercise (Valsalva maneuver)	
Thickness (cm)	0.50 \pm 0.25
CSA (cm ²)	0.58 (0.49, 0.90)
Intact site at rest	
Thickness (cm)	0.92 \pm 0.16
CSA (cm ²)	3.81 \pm 0.88
Intact site at exercise (Valsalva maneuver)	
Thickness (cm; n = 29)†	1.09 \pm 0.24
CSA (cm ² ; n = 29)†	3.81 \pm 1.12
Donor side as a percentage of intact side (%)	
Thickness at rest	45.41 (38.21, 57.65)
CSA at rest	19.04 (13.42, 28.83)
Thickness at exercise (n = 29)†	48.53 \pm 27.51
CSA at exercise (n = 29)†	14.35 (10.86, 24.55)

*Three patients had not remnant of rectus abdominis muscle of donor site.

†One patient had unavailable data.

IQR, interquartile range.

Table 3. Postoperative Complications after TRAM Flap Reconstruction in 30 Patients

Complications	N (%)
Total complications	5 (16.67)
Total complications need reoperation	3 (10.00)
Flap complications	2 (7.14)
Fat necrosis	1 (3.33)
SSI	1 (3.33)
Reoperation	1 (3.33)
Donor-site complications	3 (10.00)
Abdominal skin necrosis	1 (3.33)
Wound dehiscence	1 (3.33)
SSI	1 (3.33)
Reoperation	2 (7.14)
Abdominal bulging	
Rest	0
Exercise	6 (20.00)

unpaired *t*-test and independent groups using Fisher's exact test. A two-sided *P* value of 0.05 or less was considered statistically significant.

RESULTS

In our study, patients were relatively young (mean age, 44 years), of normal configuration (mean BMI, \leq 23 kg/m²), with few underlying diseases; 87% were of premenstrual status and had no smoking history. Only 13% had a previous abdominal surgery, and average time from previous surgery was 24 months. Fifty-six percentage had left breast cancer and the most common location was the upper outer quadrant (60%). Sixty-eight percentage had early-stage breast cancer, 52% had lymph node metastasis, 80% of the cancers were invasive ductal carcinoma, 81% were hormone receptor positive, 30% were human epidermal growth factor receptor 2 positive, and only 8% were triple negative. All patients underwent ipsilateral unilateral TRAM flap reconstruction. Chemotherapy was given in 77%

Table 4. Relationship between Patients' Characteristics and Abdominal Bulging of Donor Site When Exercised

Patients Characteristics	Abdominal Bulging		P
	No (n = 24)	Yes (n = 6)	
	N (%); or Mean ± SD; or N (Median, IQR)		
Age (y)	43.42 ± 7.08	47.50 ± 7.88	0.2262*
Age < 45	13 (81.25)	3 (18.75)	1.0000†
Age ≥ 45	11 (78.57)	3 (21.43)	
BMI (kg/m ²)	22.09 ± 2.33	24.91 ± 3.52	0.0235*
BMI ≤ 23	17 (94.44)	1 (5.56)	0.0260†
BMI > 23	7 (58.33)	5 (41.67)	
Comorbidities	3 (60.00)	2 (40.00)	0.2540†
Previous abdominal surgery			0.1690†
Transverse line incision	22 (84.62)	4 (15.38)	
Vertical line incision	2 (50.00)	2 (50.00)	
Operative time (min)	265 (225, 290)	282.5 (280, 305)	0.2524‡
Operative time ≤ 280	15 (83.33)	3 (16.67)	0.6600†
Operative time > 280	9 (75.00)	3 (25.00)	
Neoadjuvant treatment	1 (100)	0 (0.00)	1.0000†
Chemotherapy exposure	16 (72.73)	6 (27.27)	0.1550†
Staging (n = 28)§			0.1410†
Stage 0 + I	8 (100)	0 (0.00)	
Stage II + III	14 (70.00)	6 (30.00)	
Positive LN (n = 27)¶	11 (84.62)	2 (15.38)	0.6480†
Ultrasonographic data			0.5010†
Remnant muscle of donor site			
No	2 (66.67)	1 (33.33)	
Yes	22 (81.48)	5 (18.52)	
Distance from ASIS (cm; n = 27)¶	2.45 ± 0.65	2.80 ± 1.30	0.3881*
Distance ≤ 3	21 (87.50)	3 (12.50)	0.0790†
Distance > 3	1 (33.33)	2 (66.67)	
Donor site at rest			
Thickness (cm)	0.48 (0.39, 0.56)	0.40 (0.31, 0.35)	0.0867‡
Thickness ≤ 0.45	10 (62.50)	6 (37.50)	0.0190†
Thickness > 0.45	14 (100)	0 (0.00)	
CSA (cm ² ; Median, IQR)	0.88 (0.56, 1.03)	0.50 (0.32, 0.68)	0.0735‡
CSA ≤ 0.82, n (%)	10 (66.67)	5 (33.33)	0.1690†
CSA > 0.82, n (%)	14 (93.33)	1 (6.67)	
Donor site at exercise (Valsava maneuver)			
Thickness (cm)	0.54 ± 0.26	0.34 ± 0.10	0.0713*
Thickness ≤ 0.43**	5 (50.00)	5 (50.00)	0.0090†
Thickness > 0.43**	19 (95.00)	1 (5.00)	
CSA (cm ²)	0.60 (0.52, 0.94)	0.40 (0.22, 0.58)	0.0660‡
CSA ≤ 0.72**	14 (70.00)	6 (30.00)	0.0740†
CSA > 0.72**	10 (100.00)	0 (0.00)	
Donor side as a percentage of intact side			
Thickness ratio at rest (%)	46.06 (39.00, 71.88)	42.37 (36.63, 45.92)	0.2649‡
Thickness ratio ≤ 45%	10 (71.43)	4 (28.57)	0.3780†
Thickness ratio > 45%	14 (87.50)	2 (15.50)	
CSA ratio at rest (%)	20.07 (15.19, 29.30)	15.09 (12.27, 23.21)	0.6591‡
CSA ratio ≤ 19%	11 (73.33)	4 (26.67)	0.6510†
CSA ratio > 19%	13 (86.67)	2 (13.33)	
Thickness ratio at exercise (%; n = 29)††	52.93 ± 29.29	31.65 ± 5.69	0.0031*
Thickness ratio ≤ 49%	11 (64.71)	6 (35.29)	0.0280†
Thickness ratio > 49%	12 (100)	0 (0.00)	
CSA ratio at exercise (%; n = 29)††	18.89 (10.86, 26.37)	11.48 (5.97, 21.94)	0.2156‡
CSA ratio ≤ 14%	10 (71.43)	4 (28.57)	0.3900†
CSA ratio > 14%	13 (86.67)	2 (13.33)	

Calculated with continuous value was categorized using the variable's mean or median.

*t Test.

†Fisher's exact test.

‡Wilcoxon rank-sum.

§Two patients who were diagnosed for malignant phylloides were excluded from analysis.

¶Two patients who were diagnosed for phylloides and 1 patient for angiosarcoma were excluded from analysis.

¶¶Three patients had not remnant of rectus abdominis muscle of donor site.

**Yuden's index cut off.

††One patient had unavailable data.

IQR, interquartile range; LN, lymph node.

of patients, of which 3% were given as neoadjuvant therapy. Anti-human epidermal growth factor receptor 2 therapy was given to 10% of patients because some patients had a financial problem. Radiotherapy was administered in 33% of patients (Table 1).

Patients were followed for a median time of 15 months (range, 6–29 months). Total complication occurred in 5 patients (17%); 2 (7%) were flap complications and 3 (10%) were donor-site complications. Most common complications were surgical-site infection (SSI; 7%). Only 3 patients

(10%) had complications that required secondary surgery; 1 patient had SSI, 1 patient had skin necrosis at donor site, and 1 patient had wound dehiscence. No patient developed abdominal wall hernia or bulging in daily activities in our study, but 6 patients (20%) had asymptomatic abdominal wall bulging when elevating their legs 30 degrees in supine position to evaluate strength of abdominal wall (Table 3).

Ultrasonographic data showed that 3 patients (10%) could not identify remnant rectus abdominis muscle (2 in normal group and 1 in exercise abdominal bulging group). Mean distance from remnant rectus abdominis muscle to anterior superior iliac spine was 2.5 cm. All remnant rectus abdominis muscle were atrophied, but they still had little ability to contract by increase in thickness and decrease in CSA when performing the Valsalva maneuver (Table 2).

Factors related to asymptomatic exercised abdominal wall bulging were significantly related to BMI more than 23 kg/m², thickness of remnant rectus abdominis muscle less than 0.45 cm at rest and less than 0.43 cm at exercise (performed Valsalva maneuver), and thickness ratio of rectus abdominis muscle at exercise between donor and normal site less than 49%. Other factors, including age, comorbidities, previous abdominal surgery, operative time, chemotherapy, and ultrasonographic data showed evidence of remnant rectus abdominis muscle at donor site and did not influence abdominal wall bulging. However, ultrasonographic data including distant between remnant rectus abdominis muscle and ASIS more than 3 cm, CSA of remnant rectus abdominis muscle at rest, and exercise were trend to significance (P value < 0.1), which should be evaluated in multivariate analysis, but in our study, we could not calculate due to small number of patients.

DISCUSSION

In our study, the overall incidence of TRAM flap complications was 17%, which is similar to those of previous reports, which ranged from 0% to 55% for pedicled and free TRAM flaps.⁷⁻¹⁵ There was 1 patient (3%) who had fat necrosis but no flap loss in our study, but Kim et al.²² reported 14.2% of fat necrosis in their large Asian patient study, and Massenbourg et al.²³ reported that the prevalence of flap failure was 2.7% in TRAM flaps and 2.4% in free flaps for autologous breast reconstruction.²⁰ This might be because we had a small number of the patients in our study and all patients were nonsmokers. The incidence of donor-site complications in our study was 10% that is similar to previous reports, which ranged from 7.7% to 38% of pedicled TRAM flaps and from 17.9% to 24.7% of free TRAM flaps. No patient developed abdominal wall hernia or bulging in daily activities in our study, which is similar to Rietjens et al.¹⁵ but different from many previous studies that reported an incidence ranging from 0.3% to 44%.^{6,7,9,11,14,20-22,24} But 6 patients (20%) had asymptomatic abdominal wall bulging, when performing abdominal exercise, which patients cannot detect by themselves. This may indicate that the technique of transversely dividing the anterior fascia and rectus abdominis muscle combined with mesh reinforcement above the arcuate line may reduce the development of abdominal bulging and hernia. No patient in our study developed mesh infections or required mesh removal.

Many articles have shown the advantages of free TRAM flap in better perfusion and less morbidity of donor site from harvesting techniques. The article from Wu et al.²⁵ described less donor-site morbidity from superficial inferior epigastric artery (SIEA) flap compared with DIEP flap. This might be from harvesting techniques and motor nerve damage during the flap dissection. But in many situations, the pedicle TRAM flap might be an option, especially in the institutions that have some limitation in microvascular surgery. Hernia and bulging can happen in either pedicled or free flaps, as reported by Garvey et al.²⁶ in 4.6% of the cases.

Our study showed that factors that related significantly to asymptomatic exercised abdominal wall bulging included to BMI more than 23 kg/m², which is similar to Rossetto et al.,²⁴ but their data related to BMI more than 30 kg/m². Remnant rectus abdominis muscle of donor site was not significantly related to asymptomatic exercised abdominal wall bulging or hernia, which might be because of muscle atrophy. Distance between remnant muscle edge and ASIS less than 3 cm tended to relate to asymptomatic exercised abdominal wall bulging but is not statistically significant due to the limitation of our study size. Our findings show that age, underlying disease, operative time, chemotherapy, and previous abdominal surgery did not increase the risk of abdominal wall bulging and hernia.²⁷

Our study showed that ultrasonography can sharply evaluate muscle status in static and dynamic conditions of all patients. When compared with computed tomography or magnetic resonance imaging, ultrasonography is less expensive, more available, and capable of visualizing dynamic conditions of muscles.¹⁹ We suggest that ultrasonography is an alternative imaging for evaluating postoperative abdominal muscle status.

Limitations of our study included low patient sampling size and prospective cohort design, which inevitably introduced confounding biases due to confounding factors that were not available in the medical records. We did not evaluate abdominal muscle strength during the preoperative and postoperative periods. Further prospective studies comparing complications between this techniques and others would be the best way to identify the ideal technique for TRAM flap reconstruction.

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ACKNOWLEDGMENT

We wish to acknowledge Miss Nichakarn Kuphirun for English revision of the text.

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