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Flap-based breast reconstructions

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Breast cancer reconstruction is generally broken down into two major categories: Implant based and autologous. Both can provide excellent aesthetic results in the well selected patient although the decision ultimately comes down to the patient under the guidance of a reconstructive plastic surgeon. Implant based reconstruction is beyond the scope of this text, rather we will discuss autologous based reconstructive options. Broadly classified, tissue based reconstruction can be categorized as local or free tissue transfer. The general theme is the use of excess or expendable tissue in order to reconstruct breast defects. Studies have shown women are more satisfied with autologous based reconstruction compared to implanted based [1]. In this chapter we will discuss different tissue flap options in the reconstructive plastic surgeons armamentarium, special considerations and how it relates to the oncologic breast surgeon.

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History

Breast reconstruction has predated todays modern management with the first reported pedicle flap in 1887. Aristide Verneuil described a breast reconstruction using the the contralateral breast transferred on a pedicle [2]. In 1895, Vincent Czerny was the first to report on post mastectomy reconstruction when he transplanted a back lipoma to the breast after mastectomy [3]. The first true pedicled flap was described in 1906 by Iginio Tansini using the latissimus dorsi. With the advent of microsurgical techniques in 1973, free tissue transfer became a viable option for breast reconstruction. The first reported free tissue transfer for breast reconstruction was performed by Fujino, in 1975, with the superior gluteal artery myocutaneous flap for breast aplasia [4]. Since this time there has been a surge in donor sites used for oncologic breast reconstruction and they continue to evolve with time as knowledge of microsurgical principles continue to grow.

Flaps

Pedicled flaps

A pedicled flap is described as a composition of tissue that is transferred to a recipient site which is supplied by a vascular pedicle at the donor site. These flaps are useful for breast reconstruction in individuals who are not good candidates for microsurgical approaches, those who require shorter operative times and potentially shorter hospital stays. The two workhorse pedicled flaps are the latissimus dorsi and the transverse rectus abdominus myocutaneous flap (TRAM).

The latissimus dorsi is a large, broad muscle which functions to adduct, extend and internally rotate the arm. It is supplied by the thoracodorsal branch of the subscapular artery, originating from the axillary artery. It takes origin along the spinous process of vertebrae T7-L5, thoracolumbar fascia, iliac crest, ribs 3 and 4 and inferior scapula and inserts on the intertubercular groove of the humerus [5].

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The flap is typically taken with a cutaneous skin paddle from the back and can be versatile in its design. The muscle is dissected free from its origin and may even be released from its insertion to extend its reach.

The flap is a good option for women with small to medium size breasts although it may not supply sufficient volume for larger breasted individuals. However, an implant may be used with the latissimus flap when additional volume is needed. Additionally, extended latissimus dorsi flap has been instrumented when larger volumes are required. Disadvantages include need for lateral positioning, potential for widened donor scar, breast animation if the thoracodorsal nerve has not been severed, seroma and functional impairment. Seroma rate is reported as high as 47% with risk factors including age greater than 50 and nodal disruption [6]. Lastly, this flap should be used cautiously in young, athletic females as it is known to cause physical derangements for up to a year postoperatively and in some cases permanent [7].

The TRAM flap is robust musculocutaneous flap composed of the vertically oriented rectus abdominus muscle with an overlying horizontal soft tissue paddle from the lower abdomen. The rectus abdominus produces abdominal wall flexion. It takes its origin from the iliac crest and inserts onto the costal cartilages of ribs 5–7 as well as the xiphoid. It is supplied from both the superior and inferior epigastric arteries although the latter being dominant. This type of flap takes advantage of well documented perfusion zones, introduced by Hartrampf, which permit predictable zones of tissue to be moved to the breast for volume augmentation [8].

Surgical access is through a lower abdominal "abdominoplasty type" incision. The muscle is freed from its origin and insertions as well as the anterior and posterior rectus sheath. Lastly, a tunnel is made beneath the breast to allow for the tissue to pass. Typically, the contralateral rectus is used to minimize kinking of the pedicle.

Due to more advanced reconstructive options, the pedicled TRAM is not a commonly used flap for breast reconstruction. It does, however, remain an option for those who are not deemed candidates for microsurgical reconstruction or those who have failed microsurgical reconstruction. It provides an excellent source of soft tissue to mimic a natural appearing breast shape and leaves an aesthetic scar with a simultaneous abdominoplasty. Disadvantages include high risk of flap insufficiency with ensuing variable tissue loss as well as abdominal weakness and or hernia. Abdominal bulge and or hernia are reported up to 20% which is related to rectus fascia denution with flap harvest [9]. Because the dominant blood supply must be sacrificed, surgical delay, in which the dominant inflow is removed leaving only the minor, may be required to increase the viability of the flap.

Free flap

A free flap is described as a subset of tissue which is microsurgically transferred to a distant location with microsurgical techniques. Where pedicle flaps are regionally limited, free flaps offer the ability to broaden a flaps usefulness and allow a creative new construct. Since the first microsurgical free tissue transfer in 1973, by Daniels and Taylor, breast reconstruction has evolved from merely coverage to superior aesthetic results. Flaps continue to evolve and so too does the reconstructive milieu.

Preoperative imaging, with CTA, can be useful for surgical planning to aid in donor site flap dissection, especially if the patient has had previous surgery at the site. Microsurgical anastomosis is typically performed at the internal mammary artery and vein at the level of the second or third interspace with a 9–0 or 10–0 nylon and a venous coupler. In this location, the vessels are easily accessible in the surgical field and allows a shorter pedicle for inset. The costochondral junction is typically removed with a rongeur to allow adequate visualization under the microscope although rib sparing techniques are used at some institutions. There are no functional limitations after removing the cartilage, other than postoperative pain, as long as the underlying pleura is not violated. In cases where the internal mammary vessels are not suitable, such as severe radiation injury, the thoracodorsal vessels may be used, although this is not as ideal for flap positioning. For intraoperative venous congestion or need for more optimal venous outflow, an additional vein may be coapted, or supercharged, in order to facilitate venous drainage from the flap.

Average time for free flap reconstruction is variable and is dependent on the experience of the plastic surgeon but averages between six to twelve hours. Typical postoperative course consists of one night in the surgical intensive care unit for hourly flap monitoring as majority of flap failures occur in the first twenty-four hours. The venous anastomosis is usually the culprit of flap failures and if recognized expeditiously can be salvaged by operative revision.

There are a variety of flap monitoring techniques but the most common is physical exam and external doppler evaluation. External signs of venous congestion include engorged, dark flap with robust capillary refill and dark continuous bleeding on needle stick. Signs of arterial compromise include a pale, cool, mottled flap with delayed bleeding on pinprick. Additional monitoring includes internal venous doppler or transcutaneous oxygen monitoring. Patients are typically monitored in the inpatient setting for four to seven days postoperatively and are discharged home with close follow up.

Absolute contraindications for free flap reconstruction include inability to withstand theoretical long opera-

tive times and hypercoagulable state. Relative contraindications include advanced age, diabetes, smoking and obesity [10].

Abdominal based flaps

Abdominal based free flaps make up the workhorse for breast reconstruction. In the evolution of abdominal based flaps, the first to emerge was the free TRAM. This flap is based on the inferior epigastric artery and vein (comitante).

Muscle Sparing TRAM (msTRAM) was the next flap in the evolution of abdominal based flaps. This allowed less muscle to be sacrificed during flap harvest and in theory reduces abdominal wall morbidity. The DIEP (Deep Inferior Epigastric Perforator) flap (Fig. 1 and 2), introduced in 1994, allows the highest amount of muscle to be spared by basing the flap on perforators from the inferior epigastric vessels [11]. Disadvantages are longer operative times due to more meticulous dissection and higher risk of vascular insufficiency. All above flaps involve violation of the anterior rectus fascia which can risk formation of postoperative abdominal bulge and hernia. Bulge/hernia formation are reduced as fascia is spared and may be minimized by the use of mesh in certain patients. Individuals undergoing free abdominal flap reconstruction are more likely to perform sit ups compared with pedicle flaps [12]. Also, there is no upper abdominal bulge from tunneling.

Lastly, the SIEA (Superficial Inferior Epigastric Artery) flap is the most recently described abdominal based flap for breast reconstruction. It mitigates the abdominal morbidity as it does not violate the rectus fascia [13]. It is based on the superficial epigastric artery and vein. The vein is the dominant venous outflow to the abdominal wall subcutaneous tissue. However, the artery is not always present and often times is small which makes the flap unattractive unless proper preoperative imaging confirms usability [14].

Prior abdominal procedures do not preclude women from undergoing abdominal based breast reconstruction. Recent studies have shown no difference in flap success, however, there was a slightly higher risk of wound healing complications at the donor site [15].

Gluteal based flaps

The two most common gluteal based flaps are the S-GAP (Superior Gluteal Artery Perforator) flap and I-GAP (Inferior Gluteal Artery Perforator) flap. These flaps are typically chosen in nulliparous women with inadequate abdominal tissue. Both are perforator flaps which minimize sacrifice of the gluteus maximus muscle. They can provide a large volume of tissue for breast reconstruction with good shape and projection.

The S-GAP typically is the preferred choice for gluteal based flaps at many institutions. The pedicle, superior gluteal artery, is found coursing from a point one third the distance from the posterior superior iliac spine to the greater trochanter. The flap is marked in a horizontal orientation at the superior lateral aspect to minimize contour deformity.

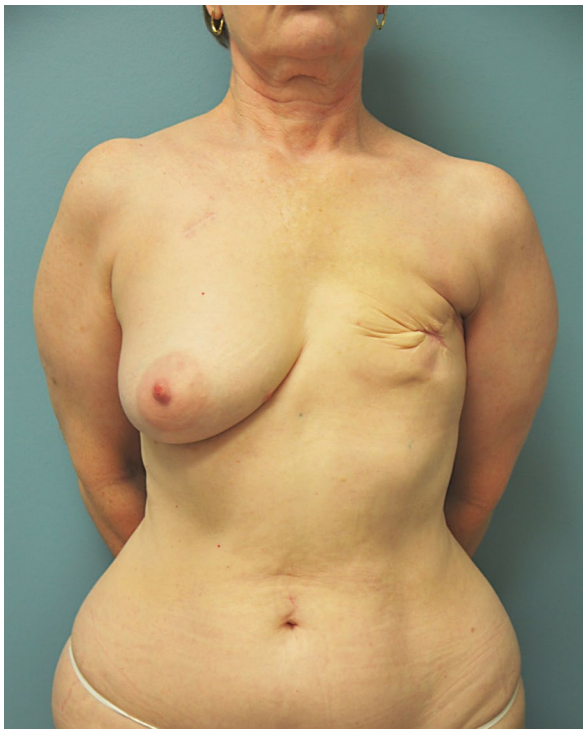

Figure 1. Before DIEP

Figure 2. After DIEP (see text for details)

The pedicle to the I-GAP is the inferior gluteal artery. The skin paddle is designed 1cm above the gluteal fold in an elliptical fashion to avoid distortion of the fold. Both flaps are closed primarily with final incisions, ideally, hidden within the bikini line [16].

The patient may be placed in a lateral decubitus position or prone for dissection. Dissection is technically challenging and becomes more tedious for heavier women as dissection proceeds into a small deep cavity. Disadvantages include contour deformities, pain with sitting, nerve injury and neuropathic pain [17].

Thigh based flaps

The thigh offers a myriad of tissue types and redundancy which allows for multiple reconstructive choices, including the breast. Although not typically first line flaps, multiple thigh based flaps have been described for breast reconstruction. Listed below, from most common to least common, are relevant thigh based flaps. The text is not all inclusive but attempts to capture the most utilized flap options.

The most common thigh based flap is the TUG (Transverse Upper Gracilis) flap. It is a musculocutaneous flap based on the medial femoral circumflex vessels, a branch of the profunda system. The patient is placed in a prone, frog leg position and a semilunar flap design is created as would a medial thigh lift with the final incision hidden within the groin crease. Either the entire gracilis or the proximal aspect of the muscle is taken with the flap in order to capture the musculocutaneous perforators which keep the skin paddle viable. The flap is best utilized in smaller breast individuals. It allows a natural breast cone to be created and also allows the nipple areola complex (NAC) to be reconstructed in the same stage, if desired [18]. Specific donor site complications include scar widening, eversion of the labia if the deep fascia is not captured and wound dehiscence.

The profunda artery perforator (PAP) flap is a perforator based flap which takes advantage of excessive posterior thigh tissue beneath the gluteal fold. The pedicle is based on perforators from the profound femoris pedicle and runs from the medial to lateral thigh. The flap design is made as an ellipse from beneath the gluteal fold to the lateral boundary of the iliotibial band. Dissection can be carried out in a supine frog leg position although is technically easier prone. The wound is closed in layers to blend with the gluteal fold and should not affect gluteal contour [19].

The ALT (Anterolateral Thigh) flap is a flap that has a vast array of reconstructive utility, including breast reconstruction. It has a consistent and reliable vascular pedicle, the descending branch of the lateral femoral circumflex, a branch of the profound femoris. The flap is marked as an ellipse on the longitudinal axis between the anterior superior iliac spine (ASIS) and the lateral patella. The pedicle enters within the second third of the flap. Dissection of the pedicle lies between the rectus femoris and vastus lateralis. The donor site is closed in a linear fashion, primarily, as long as the flap width is within 8cm. Donor site complications include a contour deformities and unsightly scar [20].

The lateral transverse thigh flap was developed based on an alternative need for a well vascularized flap based on abundant fat. It is based on the lateral femoral circumflex, a branch of the profunda femoris. Positioning is midway between lateral decubitus and prone. A horizontally based ellipse is marked over the lateral thigh or "saddlebag" region, from the ASIS to the lateral inferior buttocks. A skin island of 7cm in vertical height can allow for primary closure. Seromas are common at the donor site given the large amount of dead space. Additional donor site complications include visible outer thigh scar and inadequate soft tissue bulk [21].

Waist based flaps

The last category of flaps for breast reconstruction is waist based flaps. These constitute the Rubens flap and the LAP (Lumbar Artery Perforator) flap. These flaps are uncommonly used and are mainly discussed for historical significance.

The Rubens flap takes advantage of the fact that women have a sizable fat collection located at the flank overlying the iliac crest. The flap is based on cutaneous perforators from the deep circumflex iliac system. The patient is placed supine and a large ellipse of tissue is marked over the bony hip. The original musculocutaneous dissection included external and internal oblique as well as transversalis. The donor site was closed with care to reconstitute muscular abdominal wall continuity. Donor site complications include large scar burden with asymmetry if the contralateral side is not addressed as well as potential for abdominal wall hernia due to inadequate repair [22].

The LAP flap is a fasciocutaneous perforator flap based on the second lumbar artery as it exits the back musculature. The patient is placed in a lateral decubitus position and an elliptical skin paddle is marked from the posterior midline with axis towards the ASIS. Dissection is quick and spares muscle. The scar is hidden within the underwear lines. Donor site complications include asymmetry with need to address the contralateral side and hypoaesthesia in the L1 and L2 dermatomes [23].

Partial breast reconstruction flaps

For the individual undergoing partial breast resection, lumpectomy or segmental mastectomy, a significant contour deformity may result. Additionally, delayed effects of radiation may cause distortion of overall breast shape and leave an unnatural aesthetic contour. Local perforator based flaps are useful in this situation as they can restore the breasts natural shape by taking advantage of expendable soft tissue for auto augmentation. The most common flaps

used are the thoracodorsal artery perforator flap (AP), intercostal artery perforator flap (ICAP) and the serratus anterior artery perforator flap (SAAP). These flaps are taken from the upper lateral thoracic region after a handheld Doppler localizes the dominant perforator. The procedure is performed in the lateral decubitus position with the arm abducted to 90 degrees. The flap can be used with a cutaneous skin paddle or de-epithelialized and buried for only volume enhancement. The donor site is closed primarily over a drain and typically concealed within the bra line [24].

Management of the nipple

The nipple is the aesthetic focal point of a normal appearing breast and is typically the final stage of breast reconstruction. A normal nipple is typically situated at the most projected portion of the breast which follows the proportion 45:55, upper pole to lower pole [25]. However, in breast reconstruction the nipple is placed in such a position to match the contralateral side or, in the cases of bilateral reconstruction, individualized based on patient and surgeon preferences. Nipple reconstruction is typically performed with a variety of local flaps although implants including autologous, allogenic and synthetic have been described [26]. Tattoo can be used for the areola or the nipple areola complex if additional reconstruction not desired. The most challenging aspect of creating a nipple is maintaining projection. Local flaps have a high rate of retraction, clinically seen up to 50%. There is no gold standard for nipple reconstruction but at our institution, the keyhole flap is most commonly used.

Special considerations

Vasoactive medications

Flap based reconstruction carries with it the potential for flap compromise and in the worst case scenario, total flap loss. Most studies agree that flap loss is usually a result of technical error [27]. There are many factors that can affect the viability of a flap, some of which we will describe.

Papaverine is an antispasmodic which has many clinical uses in medicine, and in microsurgery is used as a topical smooth muscle relaxant when applied directly to blood vessels. Lidocaine is a well-known local anesthetic. 4% lidocaine is used as a topical spasmolytic to augment flap flow in persistent vasospasm.

Historically, vasopressor use in flap based surgery was looked at as a means for flap failure. However, recent literature showed that intraoperative use of vasopressors did not affect the rate of flap loss or reoperation [28]. The thought is that an attenuated pressor response occurs after surgical sympathectomy, which occurs during vessel dissection [29]. Dobutamine was found to improve flap flow and both dobutamine and norepinephrine improved free flap skin blood flow [30]. Phenylephrine and epinephrine both decreased flap flow [31]. Although vasopressor use is considered generally safe, the majority of reconstructive plastic surgeons consider it to be a relative contraindication.

Anticoagulation

As most flap failures are attributed to flap thrombosis, much attention is paid to prophylaxis. Aspirin, heparin and dextran are the three most common anticoagulants used in flap based reconstruction. Use of these can be quite variable between plastic surgeons as there are no standard recommendations. Generally, most administer heparin and or aspirin preoperatively and some degree of heparin intraoperatively. With the exception of dextran, studies comparing various anticoagulation regimens have shown similar reduction in rates of flap thrombosis and flap loss [32].

Dextran, a complex polysaccharide from sucrose, has been used to prevent flap thrombosis by reducing blood viscosity having effects on aggregating properties of blood. Unfortunately, dextran has a significant side effect profile, including anaphylaxis, pulmonary and cerebral edema and volume overload. Additionally, dextran has shown no effect on flap survival thus it is not recommended for use in preventing flap failure [33].

Radiation

Radiation therapy plays an important role in breast cancer treatment as it decreases local recurrence and increases overall survival [34]. Unfortunately, radiation can effect breast reconstruction in the immediate and delayed settings. Although looked at with controversy, immediate breast flap reconstruction with postoperative radiation has found to be safe. There is no significant differences in early or late complication rates, regardless of radiation exposure or flap types. Additionally, there are no differences in local recurrence or metastasis of those undergoing adjuvant radiation with and without immediate breast flap reconstruction [35]. This implies that reconstruction does not negatively affect radiation delivery. Breast flaps with postoperative radiation also require less revision procedures compared to preoperative radiation therapy. Those who undergo preoperative radiation therapy required more contralateral procedures for symmetry [36].

Lymphedema

Lymphedema has been reported in the literature to result after lymph nodes are removed from around the axillary vein [37]. It is found in 5.6% after sentinel lymph node biopsy and 20% after axillary dissection, peaking one to two years after surgery [38]. It can also result from breast cancer extirpations and radiation. Diagnosis can be made by physical examination and volume measurements. Main treatment modalities revolve around complex decongestive therapy and appropriate skin care. Controversy exists over indications for surgical

treatment and must be individualized. Traditional surgical treatments were ablative in nature, mainly to debulk the extremity. These aggressive procedures are radical and have fallen out of favor given their morbidity. More recently, physiologic procedures have been developed which aim to restore the continuity of the lymphatic system. Lymphovenular bypass and microvascular lymph node transplantation have emerged as viable treatment options in treating lymphedema [39]. Donor nodal basins for vascularized transfer include the superficial inguinal and supraclavicular lymph nodes [40]. The literature has also hypothesized that autologous breast reconstruction reduces risk of lymphedema by acting as a local bridge after node dissection [41]. Further research is needed but is very promising.

Polish perspective

In Poland, the evolution of flap-based breast reconstruction dates back to 1969 with the use of tubular flap by Kułakowski [42] and pedicled thoracoepigastric flap with endoprosthesis by Towpik in 1985 [43] in Warsaw Cancer Center. Towpik et al. introduced LD flap in 1986 and their modification defined as a "folded" LD island flap without an endoprosthesis in 1987 [44, 45]. The TRAM flap was initiated at the Warsaw Cancer Center in 1988 (Towpik et al.) [46]. They originated their own method of reconstruction with the use of delaying the TRAM flap — the island was raised first on the side contralateral to the muscle, dissected to approximately 1 cm beyond the midline. The perforators emerging through the anterior rectus sheath were identified and severed. On the side of the muscle, the island was raised to approximately 1 cm beyond the lateral aspect of the anterior rectus sheath. At this stage the island was supplied only by peri-umbilical musculocutaneous perforators form the epigastric arcade. Final breast reconstruction with delayed TRAM flap was performed after 7 days [46, 47]. The supercharged TRAM flap with microsurgical anastomoses of inferior epigastric vessels to the recipient vessels — thoracodorsal or internal mammary, at the mastectomy site, enhancing vascularity of the flap, was introduced in 1996 (Witwicki, Towpik and Mazur) [48]. Over the following few years, a further refinement e.g. free TRAM flap which contained only a small inferior portion of the rectus abdominis muscle with inferior epigastric artery and vein, with less functional impairment of the abdominal wall, was brought about [49, 50]. In 2000, DIEP flap with microvascular anastomoses to internal mammary vessels was implemented in the armamentarium of plastic and reconstructive cancer surgeons in Warsaw (Witwicki, Towpik et al.) [43], followed by Molski in 2002 at the Medical Center for Postgraduate Education in Warsaw. In Łódź, first DIEP flap breast reconstruction was started at the Polish Mother's Memorial Hospital-Research Institute in 2001 (under surgical supervision of Dr Pedro Cavadas from Valencia, continued by Zadrożny and Baklińska). In Wroclaw, pioneering free TRAM-based immediate breast reconstruction was performed by Jarliński in 1993. Between 1993 and 1998 thirty four free TRAM-based delayed breast reconstructions were successfully done (Dept of Plastic Surgery, District Railroad Hospital, involved plastic surgeons — Jarliński, Myczkowski, Knast, Kratochwil and surgical oncologists — Rząca, Czarnecki, personal communication with Jarliński).

To the best of our knowledge, despite professional expertise nowadays free flap breast reconstructions are lagging behind due to:

— extensive learning curve in comparison with implant-based breast reconstruction (with or without mesh/ /acellular dermal matrix);
— insufficient reimbursement by the National Health Fund in Poland.

Currently, the leading institution for microsurgery is the Institute of Oncology in Gliwice (Maciejewski et al.). Their first immediate face transplant and refinements of head and neck cancer reconstructions have had a high profile in recent years. Roughly speaking, in Poland 42 free TRAM, DIEP and SIEA breast reconstructions are performed annually [51] (also personal communication with Ulatowski — Medical Center for Postgraduate Education in Warsaw and Ulczok — Insitute of Oncology in Gliwice). Hopefully, these numbers will double in 2017. In comparison, in the neighboring country Germany, the total number for free flaps for breast reconstruction is about 1200, including 200 in Duesseldorf (Andree, personal communication).

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References

1. Uroskie TW, Colen LB. History of breast reconstruction. *Semin Plast Surg* 2004; 18: 65–69.
2. Eltahir Y, Werners LL. Dreise MM et al. Which breast is the best? Successful autologous or alloplastic breast reconstruction: patient-reported quality-of-life outcomes. *Plast Reconstr Surg* 2015; 135: 43–50.
3. Rozen WM, Rajkomar AK, Anavekar NS et al. Post-mastectomy breast reconstruction: a history in evolution. *Clin Breast Cancer* 2009; 9: 145–154.
4. Fujino T, Harashina T, Aoyagi F. Reconstruction for aplasia of the breast and pectoral region by microvascular transfer of a free flap from the buttock. *Plast Reconstr Surg* 1975; 56: 178–181.
5. Hammond DC. Latissimus dorsi flap breast reconstruction. *Plast Reconstr Surg* 2009; 124: 1055–1063.
6. Randolph LC, Barone J, Angelats J. Prediction of postoperative seroma after latissimus dorsi breast reconstruction. *Plast Reconstr Surg* 2005; 116: 1287–1290.
7. Yang JD, Huh YS, Min YS et al. Physical and functional ability recovery patterns and quality of life after immediate autologous latissimus dorsi

breast reconstruction: a 1-year prospective observational study. *Plast Reconstr Surg* 2015; 136: 1146–1154.
8. Hartrampf CR, Jr. Breast reconstruction with a transverse abdominal island flap – a retrospective evaluation of 335 patients. Semin *Plast Surg* 1987; 1: 123–135.
9. Knox AD, Ho AL, Leung L et al. Comparison of outcomes following autologous breast reconstruction using the DIEP and pedicled TRAM flap: a 12 year clinical retrospective study and literature review. *Plast Reconstr Surg* 2016; 138: 16–28.
10. Albornoz CR, Cordeiro PG, Farias-Eisner G et al. Diminishing relative contraindications for immediate breast reconstruction. *Plast Reconstr Surg* 2014;134: 363e–369e.
11. Teymouri H, Stergioula S, Eder M et al. Breast reconstruction with autologous tissue following mastectomy. *Hippokratia* 2006; 10: 153–162.
12. Kroll SS, Schusterman MA, Reece GP et al. Abdominal wall strength, bulging, and hernia after TRAM flap breast reconstruction. *Plast Reconstr Surg* 1995; 96: 616–619.
13. Spiegel AJ, Khan FN. An intraoperative algorithm for use of the SIEA flap for breast reconstruction. *Plast Reconstr Surg* 2007; 120: 1450–1459.
14. Chevray PM. Breast reconstruction with superficial inferior epigastric artery flaps: a prospective comparison with TRAM and DIEP flaps. *Plast Reconstr Surg* 2004; 114: 1077–1083.
15. Roostaeian J, Yoon AP, Sanchez IS et al. The effect of prior abdominal surgery on abdominally based free flaps in breast reconstruction. *Plast Reconstr Surg* 2014; 133: 247–255.
16. Guerra AB. Breast reconstruction with gluteal artery perforator (GAP) flap: a critical analysis of 142 cases. *Ann Plast Surg* 2004; 52: 118–125.
17. Allen RJ, Lo Tempio MM, Granzow JW. Inferior gluteal perforator flaps for breast reconstruction. *Semin Plast Surg* 2006; 20: 89–94.
18. Buntic RF, Horton KM, Brooks D et al. Transverse upper gracilis flap as an alternative to abdominal tissue breast reconstruction: technique and modifications. *Plast Reconstr Surg* 2011; 128: 607e–613e.
19. Allen RJ, Haddock NT, Ahn CY et al. Breast reconstruction with the profunda artery perforator flap. *Plast Reconstr Surg* 2012; 129: 16e–23e.
20. Raje R, Chepauk R, Shetty K et al. Breast reconstruction with free anterolateral thigh flap. *Indian J Plastic Surg* 2003; 36: 84–88.
21. Elliott LF, Beegle PH, Hartrampf CR Jr. The lateral transverse thigh free flap: an alternative for autogenous-tissue breast reconstruction. *Plast Reconstr Surg* 1990; 85: 169–178.
22. Hartrampf CR, Noel RT, Drazan L et al. Rubens's fat pad for breast reconstruction: a peri-iliac soft-tissue free flap. *Plast Reconstr Surg* 1994; 93: 402–407.
23. de Weerd L , Elvenes OP, Strandenes E et al. Autologous breast reconstruction with a free lumbar artery perforator flap. *Br J Plast Surg* 2003; 56: 180–183.
24. Hamdi M, de Frene B. Pedicled perforator flaps in breast reconstruction. *Semin Plast Surg* 2006; 20: 73–78.
25. Mallucci P, Branford OA. Concept is aesthetic breast dimensions: analysis of the ideal breast. *J Plast Reconstr Aesthet Surg* 2012; 65: 8–16.
26. Winocour S, Saksena AB, Oh C et al. A systematic review of comparison of autologous, allogeneic, and synthetic augmentation grafts in nipple reconstruction. *Plast Reconstr Surg* 2016; 137: 14e–23e.
27. Motakef S, Mountziaris PM, Ismail IK et al. Emerging paradigms in perioperative management for microsurgical free tissue transfer: review of the literature and evidence-based guidelines. *Plast Reconstr Surg* 2015; 135: 290–299.
28. Cordeiro PG, Santamaria E, Hu QY et al. Effects of vasoactive medications on the blood flow of island musculocutaneous flaps in swine. *Ann Plast Surg* 1997; 39: 524–531.
29. Chen C, Nguyen MD, Bar-Meir E et al. Effects of vasopressor administration on the outcomes of microsurgical breast reconstruction. *Ann Plast Surg* 2010; 65: 28–31.
30. Eley KA, Young JD, Watt-Smith SR. Epinephrine, norepinephrine, dobutamine, and dopexamine effects on free flap skin blood flow. *Plast Reconstr Surg* 2012; 130: 564–570.
31. Eley KA, Young JD, Watt-Smith SR. Power spectral analysis of the effects of epinephrine, norepinephrine, dobutamine and dopexamine on microcirculation following free tissue transfer. *Microsurgery* 2013; 33: 275–281.
32. Ashjian P, Chen CM, Pusic A et al. The effect of postoperative anticoagulation on microvascular thrombosis. *Ann Plast Surg* 2007; 59: 36–40.
33. Galanis C, Nguyen P, Koh J et al. Microvascular lifeboats: a stepwise approach to intraoperative venous congestion in DIEP flap breast reconstruction. *Plast Reconstr Surg* 2014; 134: 20–27.
34. Mehrara BJ, Santoro TD, Arcilla E et al. Complications after microvascular breast reconstruction: experience with 1195 flaps. *Plast Reconstr Surg* 2006; 118: 1100–1009; discussion 1110–1111.
35. Tran NV, Evans GR, Kroll SS et al. Postoperative adjuvant irradiation: effects on transverse rectus abdominis muscle flap breast reconstruction. *Plast Reconstr Surg* 2000; 106: 313–317; discussion 318–320.
36. Chang EI, Liu TS, Festekjian JH et al. Effects of radiation therapy for breast cancer based on type of free flap reconstruction. *Plast Reconstr Surg* 2013; 131: 1e–8e.
37. Becker C. Treatment of breast cancer-related lymphedema using combined autologous breast reconstruction and autologous lymph node transplantation. In: Spiegel A. *Breast reconstruction: current perspectives and state of the art techniques*. Croatia: *InTech* 2013; 13: 229–236.
38. Basta MN, Fischer JP, Kanchwala SK et al. A propensity-matched analysis of the influence of breast reconstruction on subsequent development of lymphedema. *Plast Reconstr Surg* 2015; 136: 134e–143e.
39. Yamamoto Y, Sugihara T. Microsurgical lymphaticovenous implantation for the treatment of chronic lymphedema. *Plast Reconstr Surg* 1998; 101: 157–161.
40. Becker C, Assouad J, Riquet M et al. Postmastectomy lymphedema: long-term results following microsurgical lymph node transplantation. *Ann Surg* 2006; 243: 313–315.
41. Classen DA, Irvine L. Free muscle flap transfer as a lymphatic bridge for upper extremity lymphedema. *J Reconstr Microsurg* 2005; 21: 93–99.
42. Kułakowski A. The first cases of breast reconstruction in the Institute of Oncology in Warsaw [in Polish]. *Nowotwory J Oncol* 2008; 58: 364–368.
43. Towpik E. Postmastectomy breast reconstruction: 15 years of experiences of the Warsaw Cancer Center [in Polish]. *Nowotwory J Oncol* 2000; 5: 529–535.
44. Towpik E. Breast reconstruction after mastectomy with latissimus dorsi island myocutaneous flap [in Polish] *Pol Tyg Lek* 1988; 42: 1060–1062.
45. Towpik E, Różycki-Gerlach W. Breast reconstruction using latissimus dorsi island flap without an endoprosthesis. *Eur J Surg Oncol* 1992; 18: 53–56.
46. Towpik E, Różycki-Gerlach W. Surgical delay of TRAM flaps for breast reconstruction. *Eur J Surg Oncol* 1991; 17: 595–597.
47. Towpik E, Mazur S, Witwicki T et al. Elevating the island: the simplest method of delaying the TRAM flap. *Ann Plast Surg* 2000; 45: 240–243.
48. Towpik E, Witwicki T, Mazur S. Immediate breast reconstruction using pedicled TRAM flap with microanastomoses of inferior epigastric and thoracodorsal vessels [in Polish]. *Nowotwory* 1998; 48: 57-62.
49. Witwicki T, Towpik E, Mazur S et al. Breast reconstruction using free TRAM flap with microvascular anastomoses to internal mammary vessels: report of 2 cases. *Nowotwory J Oncol* 2001; 5: 499–501.
50. Witwicki T, Towpik E, Mazur S et al. Early results of breast reconstruction using pedicled rectus abdominis myocutaneous island flap with additional microanastomoses of inferior epigastric vessels [in Polish]. *Pol Przeg Chir* 2000; 72: 799–805.
51. Ulatowski L, Kaniewska A. The use of the DIEP flap in modern reconstructive surgery. *Pol Przegl Chir* 2015; 87: 472–481.