McCraw and Arnold's Atlas of Muscle and Musculocutaneous Flaps

John B. McCraw
Phillip G. Arnold

Interplast
Healing Bodies, Changing Lives

Global-HELP
Publication

HORIZONTAL RECTUS

ANATOMICAL CONSIDERATIONS

See VERTICAL RECTUS

Vascular pattern

Hartrampf and his associates have clearly defined the physiological limits of the lower horizontal rectus myocutaneous flap in humans. The recent experimental work of Ian Taylor has demonstrated the distribution of the cutaneous perforating vessels in a definitive cadaver study which depicts the vast majority of perforating vessels as residing in the area of the umbilicus and decreasing in numbers as one moves away from the umbilicus. This anatomical study helps explain why the upper horizontal rectus abdominis myocutaneous flap is less viable than a flap which is placed closer to the umbilicus. Similarly, the lower horizontal flap can be designed so low on the abdomen that it exceeds the viable limits of the rectus abdominis muscular perforators. It is surprising that the transverse rectus abdominis (TRAM) flap survives as well as it does when one considers the multiplicity of systems which are directly capable of supplying the same area of skin. These vascular systems include the inferior deep epigastric vessels, the eighth through the twelfth lateral intercostal vessels, and the superficial inferior epigastric (vertical groin flap) vessels. Since the deep inferior epigastric vessels are relatively dominant over the superior deep epigastric vessels, it is likely that the superior system partially supplies this lower abdominal skin in a retrograde fashion by way of a reversal of flow through the inferior system. The deep epigastric system is quite capable of carrying any portion of the skin which is "primarily" supplied by the superior epigastric system. The rectus abdominis muscle will also survive on the eighth through twelfth lateral intercostal system even after the superior and inferior deep systems have both been divided. Finally, the small superficial inferior epigastric vessels, which supply the vertical groin flap described by Shaw and Paine can also nourish a major segment of lower abdominal skin extending from the iliac crest to the rib cage and past the midline.

The superior deep epigastric artery is a continuation of the internal mammary artery. After passing beneath the costal cartilages, this vessel perforates the central portion of the rectus abdominis muscle, but it can enter the muscle in its lateral third. This anatomical variation necessitates a careful search for the superior vessel instead of a "blind" acceptance of its expected position. The vessel usually splits in the upper portion of the muscle into a costomarginal branch which supplies the lateral margin of the rectus abdominis muscle. The deep superior epigastric vessels are usually visible on the undersurface of the rectus abdominis muscle for a distance of five to eight centimeters from the costal margin. Occasionally, it is difficult to identify this vessel until the level of the costal margin is reached. The "watershed" between the superior and inferior systems lies near the level of the umbilicus at the visible termination of the inferior vessels. The inferior deep epigastric vessels are easily visualized on the undersurface of the rectus abdominis muscle from the level of the "watershed" inferiorly. These vessels arise from the common femoral vessels, pass above the inguinal ligament, and enter the posterior rectus sheath just below the arcuate line. The eighth through the twelfth lateral intercostal vessels enter the posterior rectus sheath before penetrating the undersurface of the rectus abdominis muscle. Although these vessels vary in size and number, they anastomose with the superior and inferior deep systems within the muscle and act as a hemodynamic "buffer" to abrupt changes in the other two major systems. The most important cutaneous perforating vessels pass from the rectus abdominis muscle to the skin in the periumbilical region. The individual location of these vessels is quite variable, but the highest density of large vessels is found in an area which extends from approximately three centimeters above the umbilicus to eight centimeters below the umbilicus. These cutaneous perforators are organized into vertical rows which are predictable in their location. The medial row of cutaneous perforators is located approximately 2.5 centimeters lateral to the medial border of the rectus abdominis muscle. The lateral row is located approximately six to seven centimeters lateral to the medial border of the muscle. The medial group of cutaneous perforators consists of larger vessels than the lateral group of cutaneous perforators. Occasionally, there may be a significant number of large perforators in the lateral group. Terminally, the cutaneous perforators reach the subdermal plexus level where they interconnect hemodynamically with the other surrounding vascular systems.

Motor Nerves

Intercostal nerves five to twelve.

Sensory Nerves

Intercostal nerves five to twelve.

USES

The horizontal rectus abdominis myocutaneous (TRAM) flap is used primarily for reconstruction of the breast.

The standard Hartrampf flap, which carries the abdominal pannus, is usually chosen over the other varieties of rectus abdominis myocutaneous flaps because of its size and malleability. As one moves away from the major concentration of deep perforating vessels around the umbilicus, the reliability of the horizontal rectus abdominis flap diminishes. This is particularly true of the very high upper horizontal rectus abdominis flap. The survivability of the horizontal flap can be improved either by using a double rectus abdominis muscle pedicle or by reanastomosing the deep inferior epigastric vessels in their new location.

REGIONAL FLAP COMPARISONS

Although the reliable pectoralis major and latissimus dorsi flaps are usually chosen for chest wall defects, the horizontal rectus abdominis flap also has certain applications. The upper horizontal rectus flap donor site can be primarily closed, and it is in close proximity to the lower chest. Unfortunately, there is approximately a 20% incidence of flap necrosis in most hands. The reasons for this are unknown, but this is probably related to the variability of the deep muscular perforators in the upper abdomen. The superiorly based vertical rectus abdominis flap is usually a better choice in these situations since it is almost totally reliable. This is particularly true in the case of chest wall resections where any partial flap loss could contribute to a life-threatening event. The standard Hartrampf flap can provide a massive amount of tissue for the anterior chest wall, but its dissection is more time-consuming and tedious. It is a safe flap to use for major anterior chest wall defects if the superior vessels are intact and if a double rectus abdominis muscle pedicle is used.

The lower horizontal rectus abdominis (Hartrampf) flap is used almost exclusively for reconstruction of the breast. It is best compared to the latissimus dorsi myocutaneous flap breast reconstruction. The latissimus dorsi flap is obviously more reliable, but it usually requires an implant with the attendant problems of a known foreign body. In fact, 70% of our post-mastectomy (modified and radical) latissimus reconstructions have developed Baker Class III encapsulations with time. Sadly enough, most of these patients experienced a good early result only to be disappointed by the capsular problems after three to five years. There are several situations in which the TRAM flap breast reconstruction is superior to the latissimus dorsi reconstruction. These include a very *large defect* which would require a massive skin replacement, *combinations* of infraclavicular, axillary, and lower chest wall deformities which cannot be adequately repaired by the latissimus dorsi flap, and such *marked obesity* that an implant placed beneath either the pectoralis or latissimus muscles would not be expected to produce symmetry with the opposite breast. The flap is also useful in the pectoralis or latissimus breast reconstruction "*cripple*" with unacceptable contour, shape, or repeated scar capsule formations. Whenever there is adequate abdominal fat and skin available to reconstruct the breast without an implant, the results with the TRAM flap are clearly superior to the best results with the latissimus dorsi method of breast reconstruction.

Since symmetry is such a major consideration, both breasts should probably be treated similarly in regard to silicone implants. For instance, if an opposite total mastectomy is done and reconstructed with a silicone implant, it may be inconsistent to use autogenous abdominal tissue for the other breast. Whenever possible it seems more reasonable to reconstruct both breasts with either silicone implants or with bilateral horizontal rectus abdominis flaps since the eventual results of shape and softness are quite different with each of these types of procedures.

DISADVANTAGES

The upper horizontal rectus abdominis flap has an unexpectedly high incidence of flap necrosis of approximately 20%. The donor site skin can be closed primarily, but this limits the width of the flap to approximately ten centimeters in thin patients and fourteen centimeters in moderately obese patients. Since all of the anterior rectus fascia overlying the rectus abdominis muscle must remain in continuity with the skin, a Prolene® or Marlex® mesh end-to-end replacement is usually necessary for the structural repair of the abdominal wall.

The lower horizontal rectus abdominis flap may be associated with a significant amount of discomfort from the tight abdominal closure and the extensive subcostal dissection. Implants are seldom necessary, but when they are, capsule formation occurs in some thirty percent of these cases. This is surprising because one would think that this fatty flap would be "protective." Flap necrosis is very infrequent if the appropriate limits of flap dimensions are observed. Although an excellent contour is usually achieved, the flap is technically difficult to shape. Some secondary flap revision has been necessary in approximately half of our cases. The reasons for this are distributed fairly equally between problems of the inframammary fold and problems of either excessive or deficient upper fullness. At the first stage it is sometimes difficult to create a proper inframammary fold in the medial breast because the muscular pedicle crosses this area and cannot be constricted. Fat stiffness is related to fat necrosis of the "opposite" abdominal

skin of the flap, and it will usually require a secondary excision when it occurs.

The donor site complications are clearly the dominating negative aspect of the TRAM flap. Hernias should be rare if the anterior fascial defect is properly repaired and bolstered with Prolene® or Marlex® mesh. The abdominal contour is seldom as satisfactory as in the esthetic abdominal lipectomy, and it should not always be considered a "bonus." The donor site scar can also be poor if it is necessary to close the skin wound under significant tension. Prolonged abdominal drainage — over seven days — is common, but seroma formation is rare. These patients deserve the same diligent care which one would offer any patient undergoing a major intra-abdominal procedure.

ADVANTAGES

The upper horizontal flap can give an adequate breast reconstruction, but an implant is almost always required. It is still a good secondary choice for an opposite breast reconstruction. However, it is more difficult to shape, and the inset of the flap into a transverse mastectomy scar is awkward. The lower transverse rectus abdominis flap provides an excellent breast reconstruction in patients with very large defects or in obese patients. When one attempts to gain symmetry with a large opposite breast, this is more easily done with the lower transverse rectus abdominis flap than with the latissimus flap. In the latissimus reconstruction the mandated large implant produces a round and wide breast rather than the desired cone shape offered by the rectus abdominis flap. The latissimus flap cannot be expected to correct a combination of defects, including the loss of the anterior axillary fold and the entire pectoralis muscle, because the latissimus muscle is not sufficiently large enough to correct all of these defects. Even in the most favorable postmastectomy situations, the results with the latissimus reconstruction are surpassed by the results with the TRAM flap procedure.

COMPLICATIONS, PITFALLS, AND DONOR SITE

Most complications have been related to the inexperience of the surgeon and are avoidable. The question of how to "delay" the flap or whether "delay" is effective is unsettled. We have occasionally attempted this maneuver when a large amount of tissue has been required. We have not experienced any flap loss with a "delay," but flap loss is not very common in any case. The method of "delay," which we have used is to complete the lower incision, to elevate the ipsilateral skin flap, and to partially ligate the deep inferior epigastric vessels. In a combined (J.B. McCraw and P.G. Arnold) personal series of more than two hundred cases, total flap loss has occurred in one case and partial flap losses have occurred in six cases. All of these cases were *early* cases. There have been no flap losses in the later cases. The differences may be ascribed to luck, but they are more likely related to operative experience. Any portion of the flap with questionable viability should be discarded. If a large amount of tissue is required, it is safer to use a double muscle pedicle.

Certain technical points should be reemphasized. Since the flap is "cold sensitive," the dissection of the entire upper abdomen and the recipient site should be completed prior to the final flap elevation. Warm packs are used throughout the procedure to maintain the flap temperature. A heating blanket, leg and arm wraps, heated inspired air, and heated intravenous fluids are used to maintain the "core" temperature of the body. The large surface exposed during the operation easily allows the "core" temperature to drop to 95 degrees. This temperature is the level at which flap problems will be encountered.

A safe abdominal closure constitutes the most critical area of concern. Hartrampf's method of preserving the linea semilunaris ligaments and repairing the anterior rectus abdominis fascia should be followed religiously. Further, the pyramidalis muscle and the anterior rectus fascia below the arcuate line should be left undisturbed. If there is any question about a safe closure of the abdominal donor site, the use of the TRAM flap must be carefully weighed. This is certainly the case in some obese patients or patients who have had previous intra-abdominal operations.

Flap elevation can be carried out in a number of ways. Although it is important to preserve the semilunaris ligaments in the course of flap elevation, it does not seem critical either to leave or to take a lateral strip of the rectus abdominis muscle. Approximately 1.5 centimeters of anterior rectus fascia should be left adjacent to the midline, and it is seldom necessary to remove more than four centimeters of the fascia lateral to this point. The anterior rectus fascia is usually elevated with the upper part of the rectus abdominis muscle in order to speed the dissection and to provide a strengthening layer for the fragile muscle. Completion of the skin elevation and division of the lower muscle is done only when the flap is ready to be inset. Upward retraction of the flap facilitates the final dissection of the superior epigastric vessels. It is not necessary to elevate the rectus abdominis muscle away from the chest wall because the division of the anterior rectus fascia on either side of the muscle (on the chest wall) provides for adequate upward flap mobility. The rectus abdominis muscle should be transposed in a gentle "S" fashion, and there should

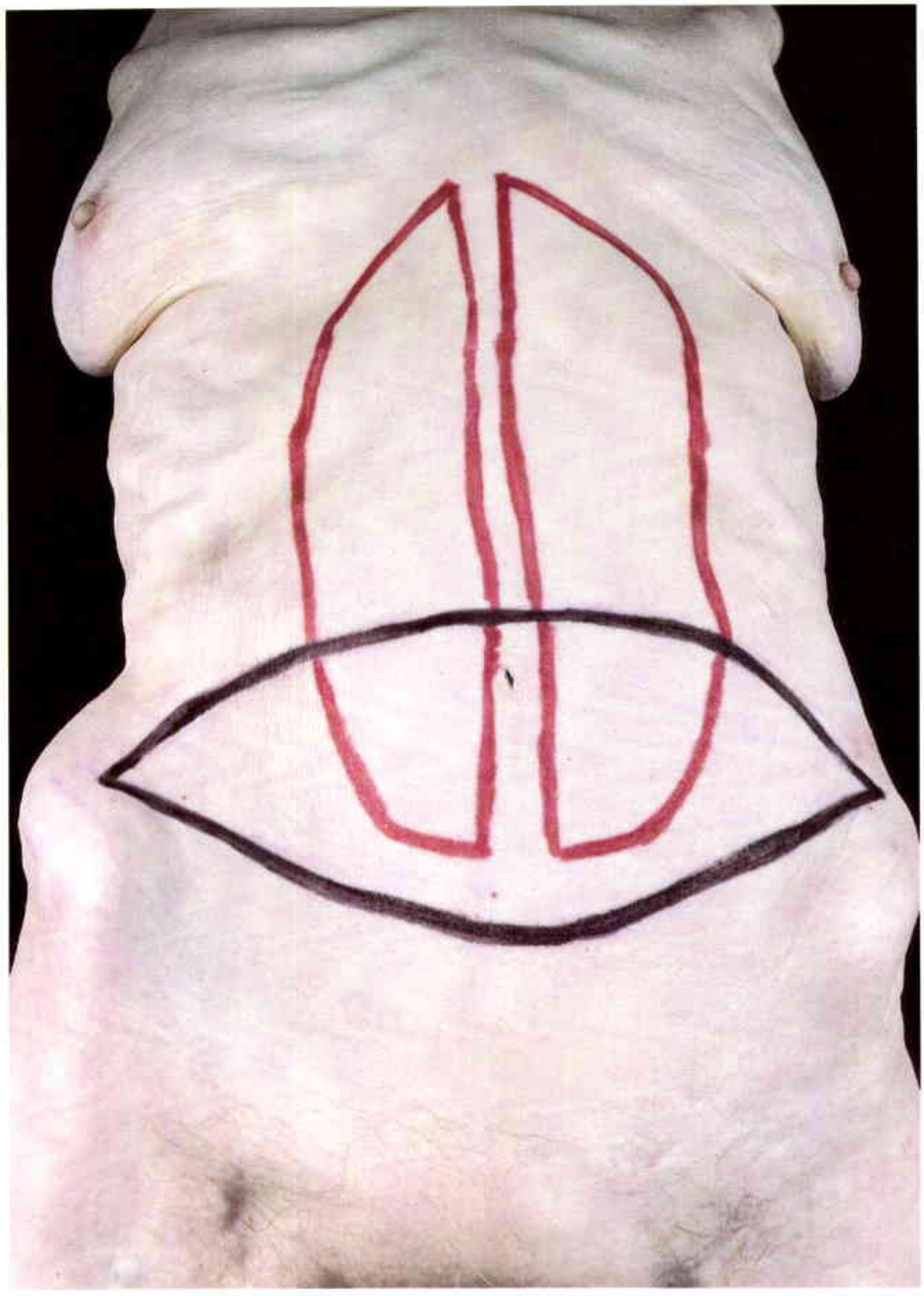
be no reason for torsion or tension on the transposed muscle pedicle. The value of fluorescein examination of the flap is debatable because many times a viable flap does not fluoresce well. This response is probably related to the cold sensitivity of the flap, but the nonfluorescence can be unnecessarily traumatic for the compulsive surgeon. Brisk red bleeding at the cut dermal edge is an equally good test of flap viability.

Postoperative care is similar to any other major abdominal wall reconstruction even though the abdominal cavity is not entered from a technical standpoint. Intense pulmonary care is necessary, and smoking is always interdicted. A Foley catheter is used for the first one to two days, and walking is encouraged the day following surgery.

Most of our concerns have been related to the donor site. If only four centimeters of anterior fascia are removed, it can routinely be directly reapproximated. Even in this favorable situation it is reasonable to use an overlay of artificial mesh to bolster the primary fascial repair. Very large anterior fascial defects usually do require an end-to-end or an overlapping mesh repair. Seromas can be troublesome, but their resolution is usually spontaneous. The contour of the abdomen can be a problem because of excessive fat in the epigastrium or flanks when compared to the lower abdominal contour. These have been treated by suction-assisted lipectomy or by direct fat excision. Although the horizontal scar may not be good and a vertical scar may be necessary, neither of these deficiencies has been a source of significant patient complaints.

1

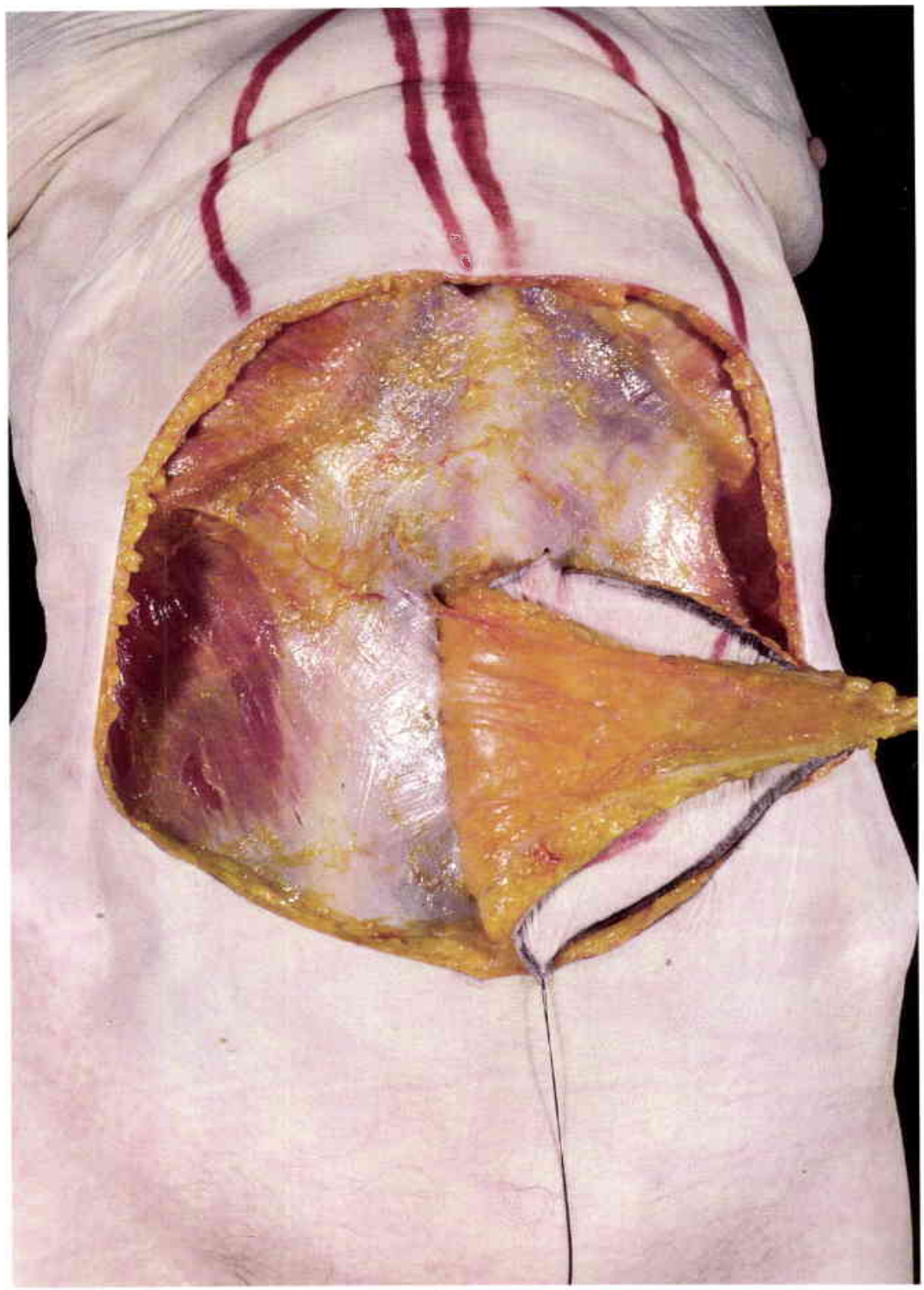
Intraoperative preparation. The legs, arms, and head are carefully padded and slightly flexed. The exposure to cold is limited by preoperative markings and skin preparation. The ''core'' temperature is maintained by a heating blanket, heated inspired air, and ''french fry'' lights. The legs are wrapped with ace bandages to promote vascular stability in the upright position.



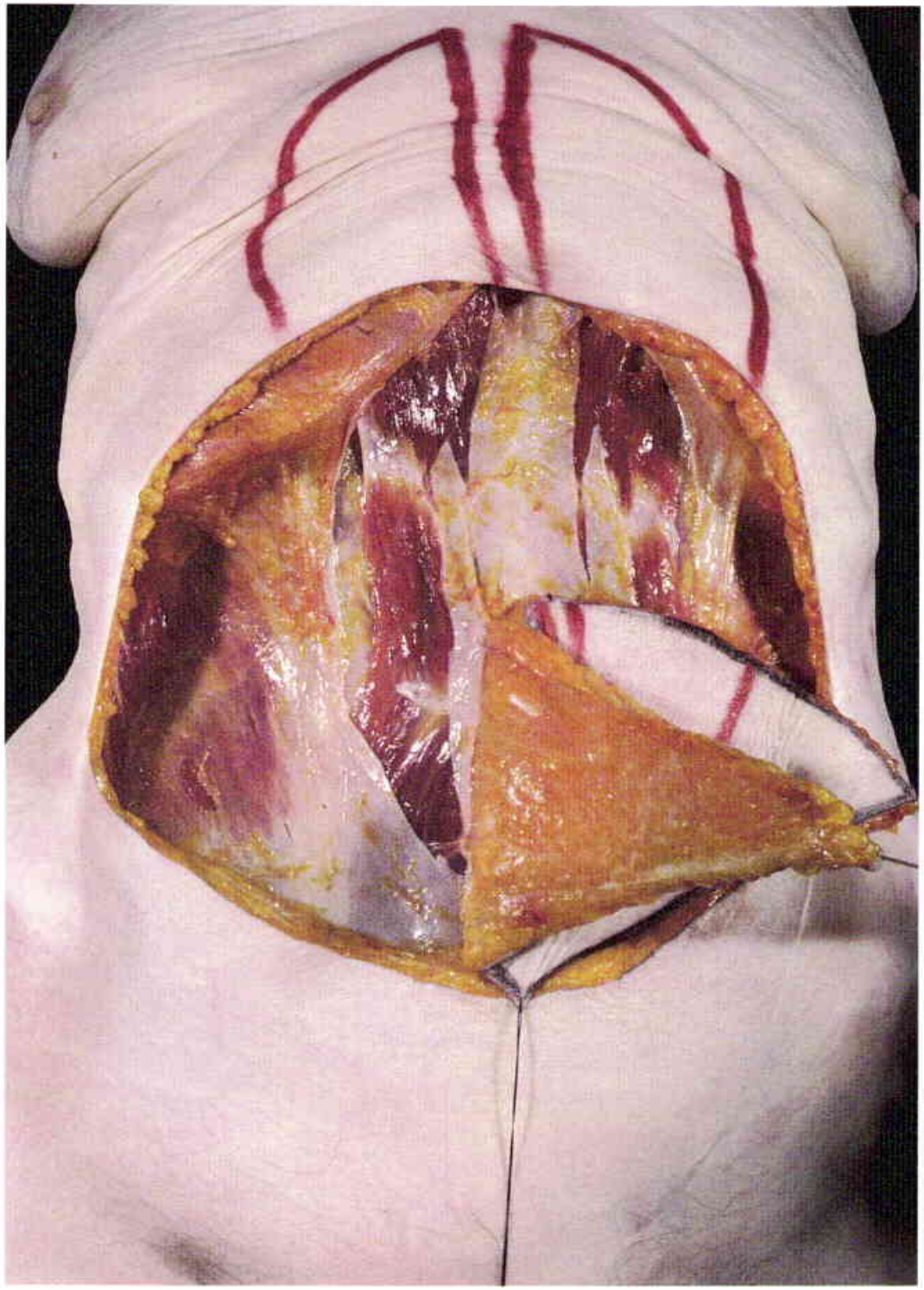
2
The TRAM flap is centered over the periumbilical perforators. A double muscle pedicle will be used to carry the entire skin ellipse.

3

Scissors are used to elevate the skin from the avascular midline fascia blindly. This dissection is carried 1.5 centimeters lateral to the medial border of each rectus muscle.

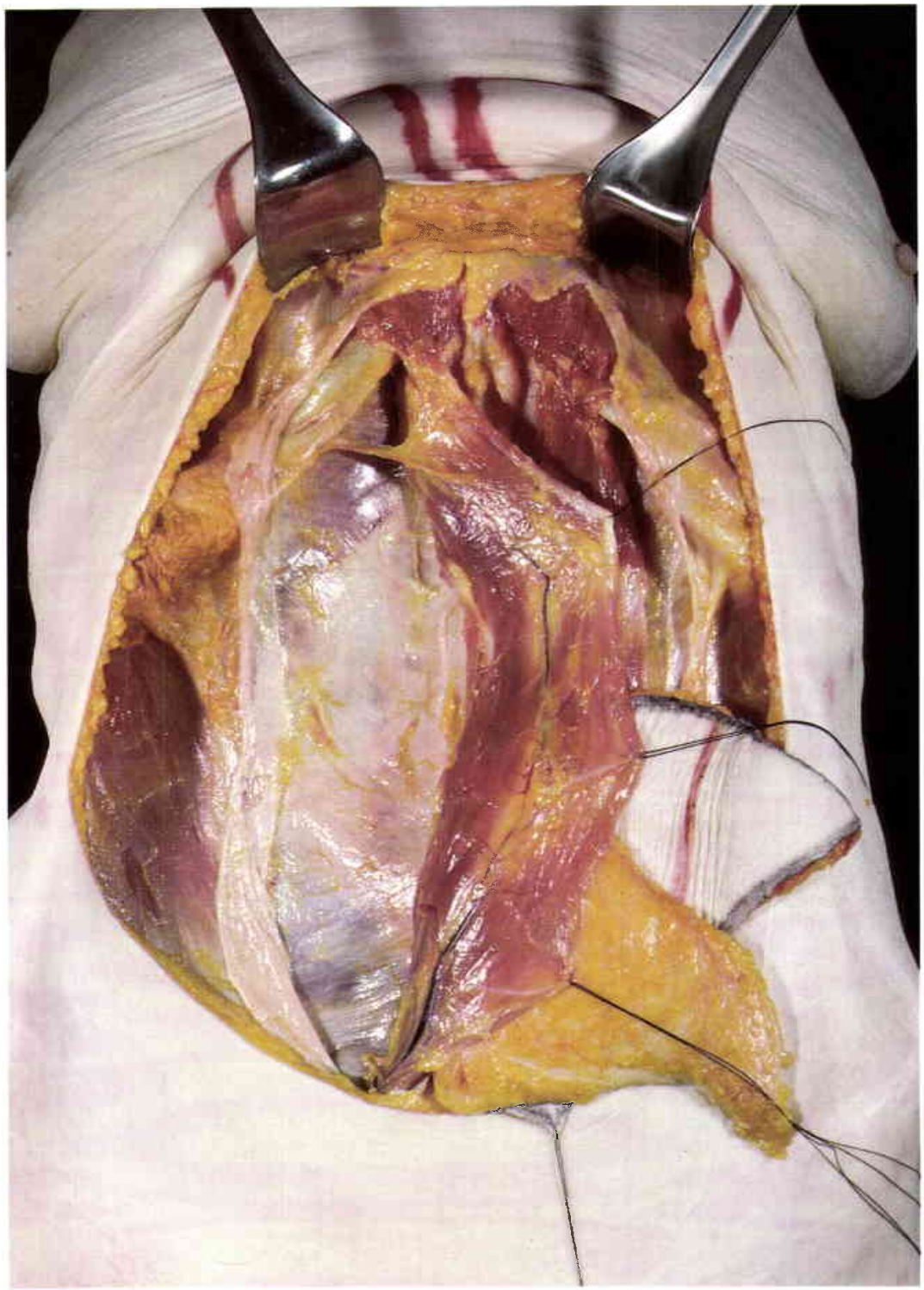


4
The lateral row of perforators is identified and ligated. The dissection is then carried medially until the more prominent medial row of perforators is encountered.

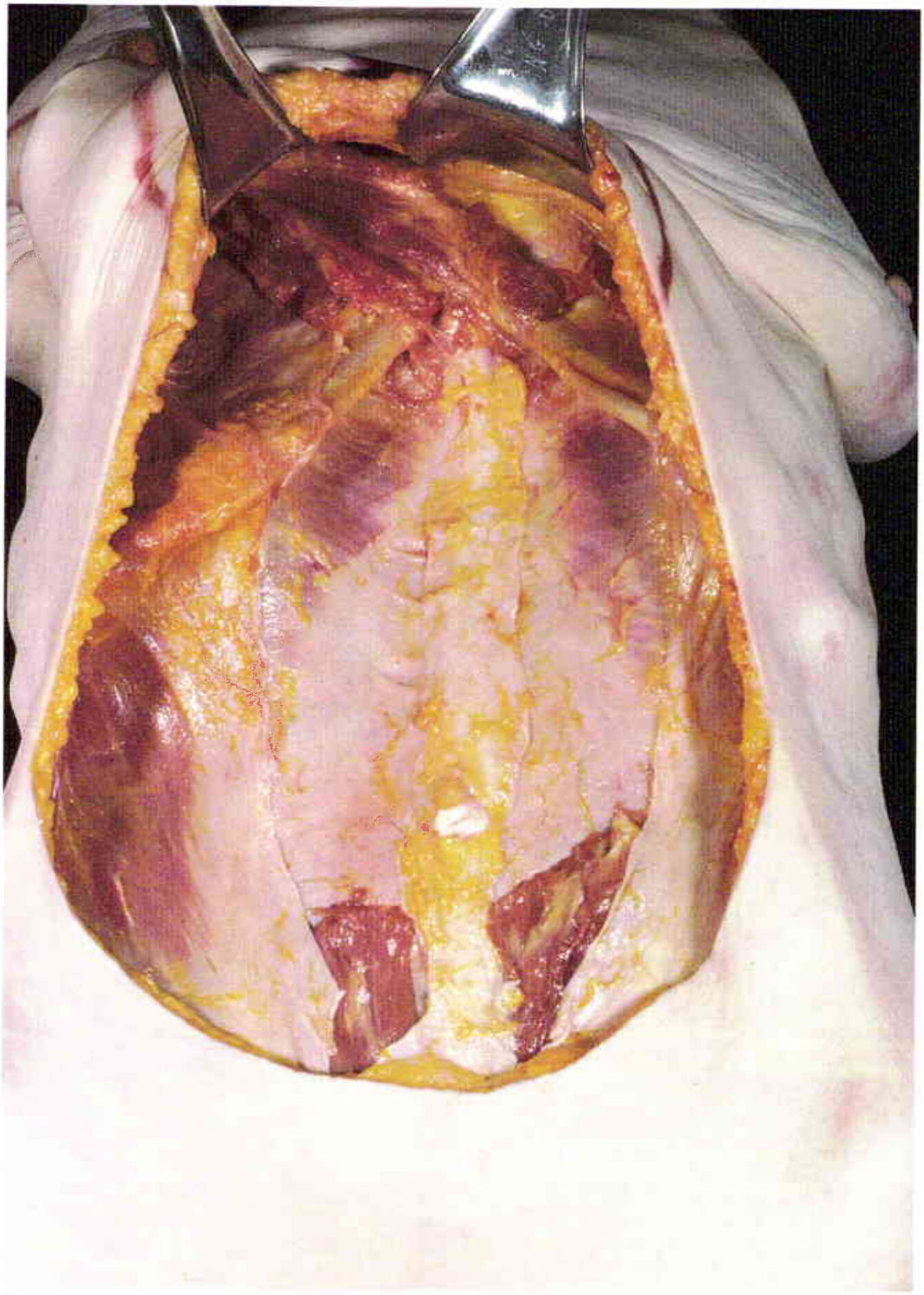


5

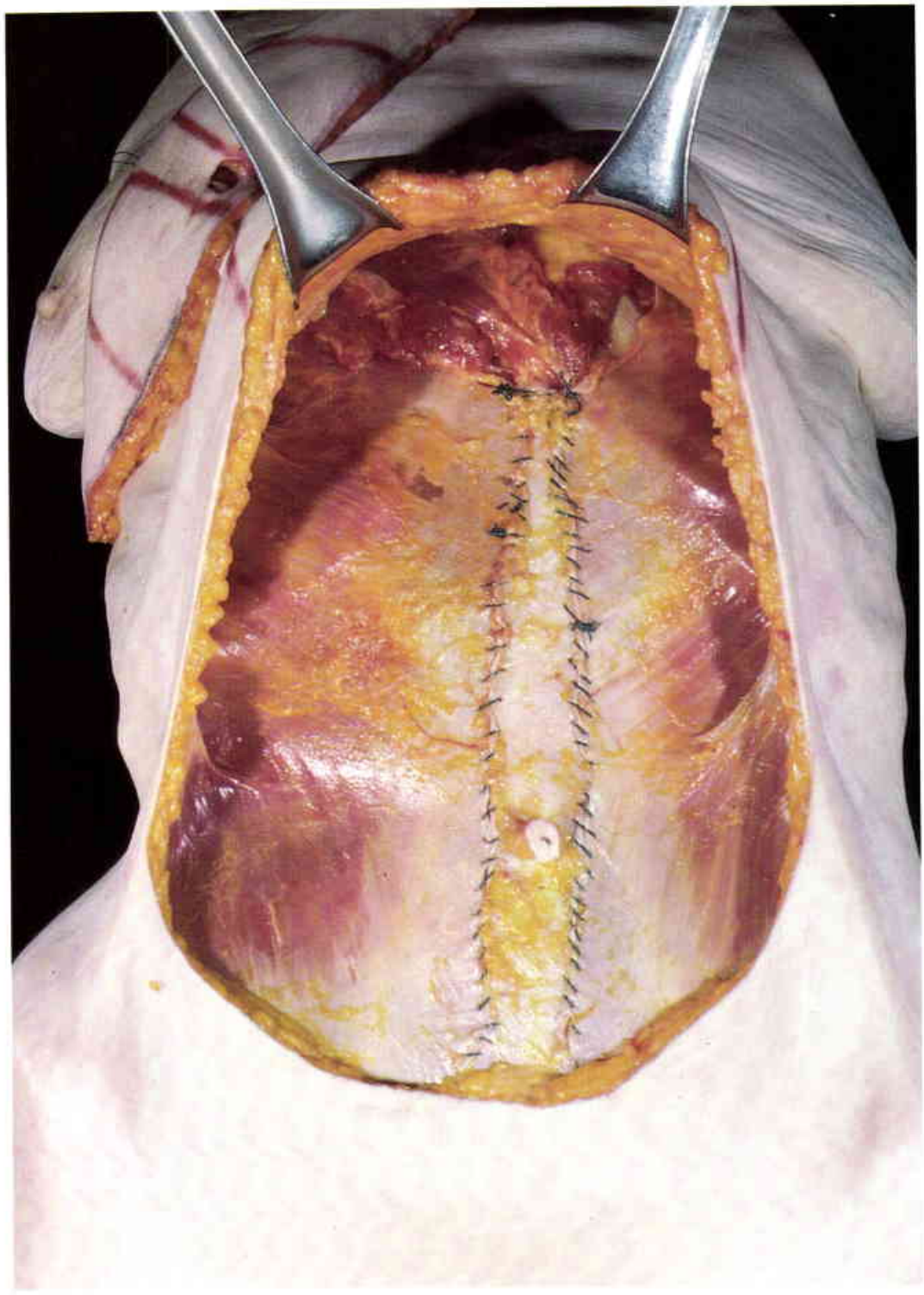
The upper abdominal skin and the two rectus muscles are completely dissected prior to the final elevation of the flap. A small strip of anterior rectus fascia is left on the surface of the rectus muscle to protect the muscle and to speed the dissection.



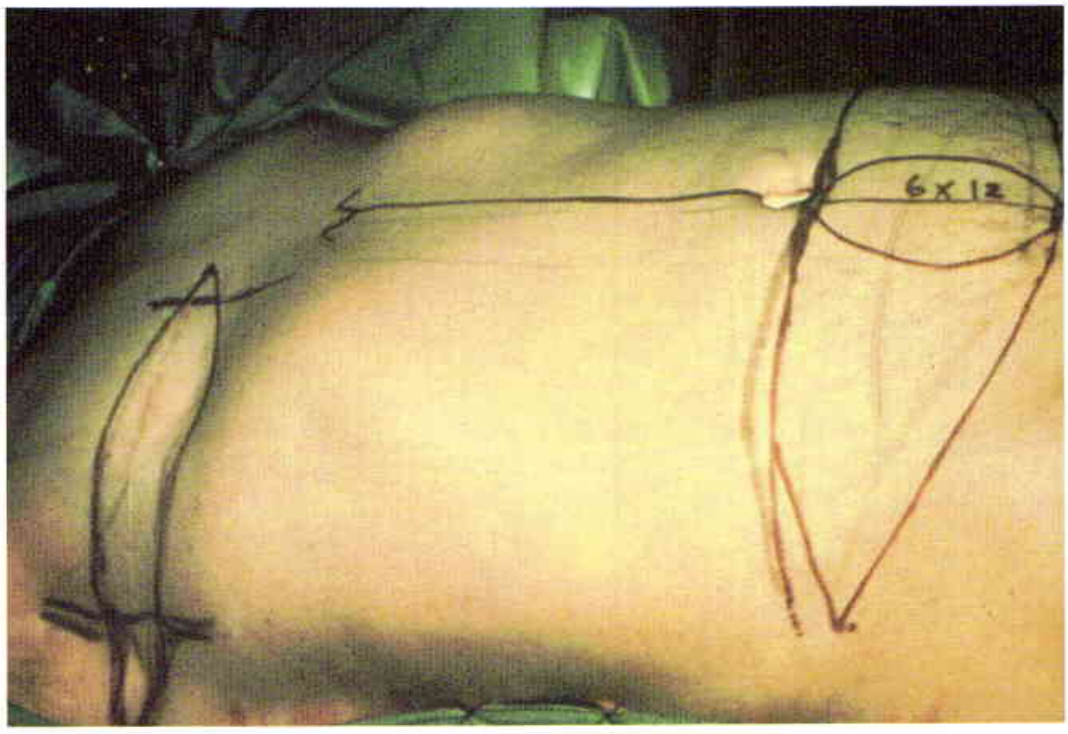
6
The right rectus abdominis muscle is rotated medially to expose the deep inferior epigastric vessels. This exposure is used to divide the anterior rectus fascia (from behind), approximately 1.5 centimeters lateral to the midline. This leaves a total anterior fascial defect of no more than four to five centimeters in width.



7
The flap is tunneled onto the chest without any torsion or tension on the vascular pedicles. The two muscular pedicles are visible in their course to the right breast area.

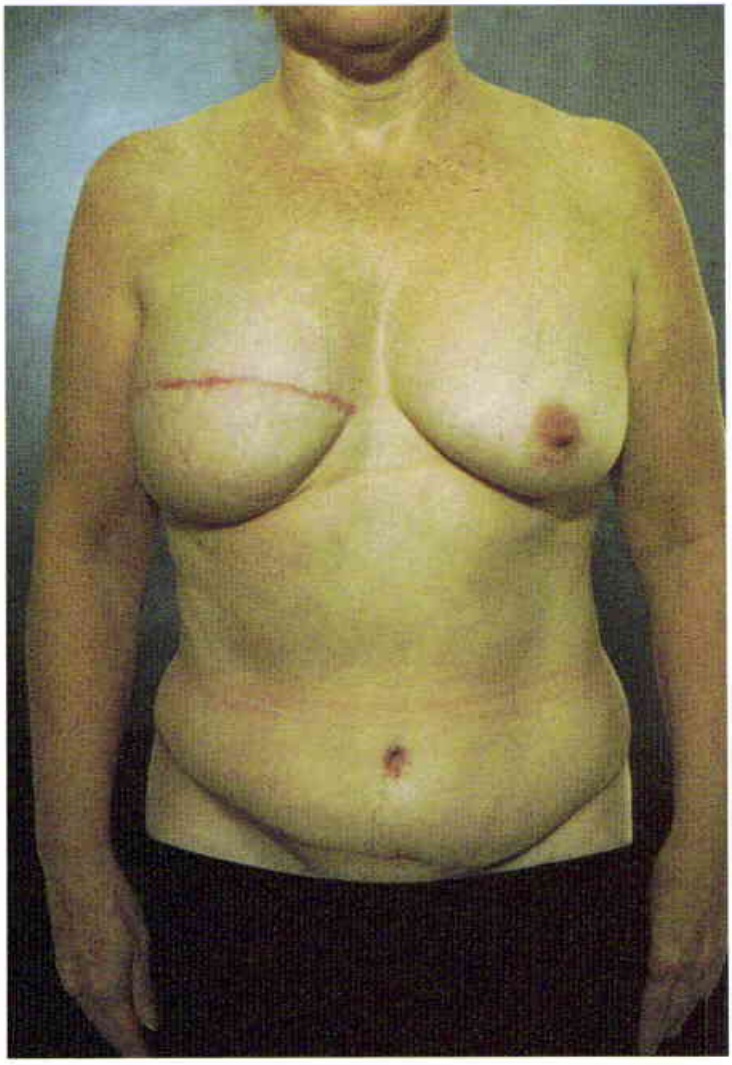


8
The bilateral anterior fascial defects are individually repaired and usually reinforced with an overlay of Prolene® mesh. The abdominal closure is equally as important as the shaping of the reconstructed breast.



9

Forty-five-year-old female two years following a modified radical mastectomy and irradiation. The mastectomy scar will be widely excised to remove the atrophic skin and the lateral "dog ear." A low TRAM flap is outlined. (Case of J.B. McCraw)

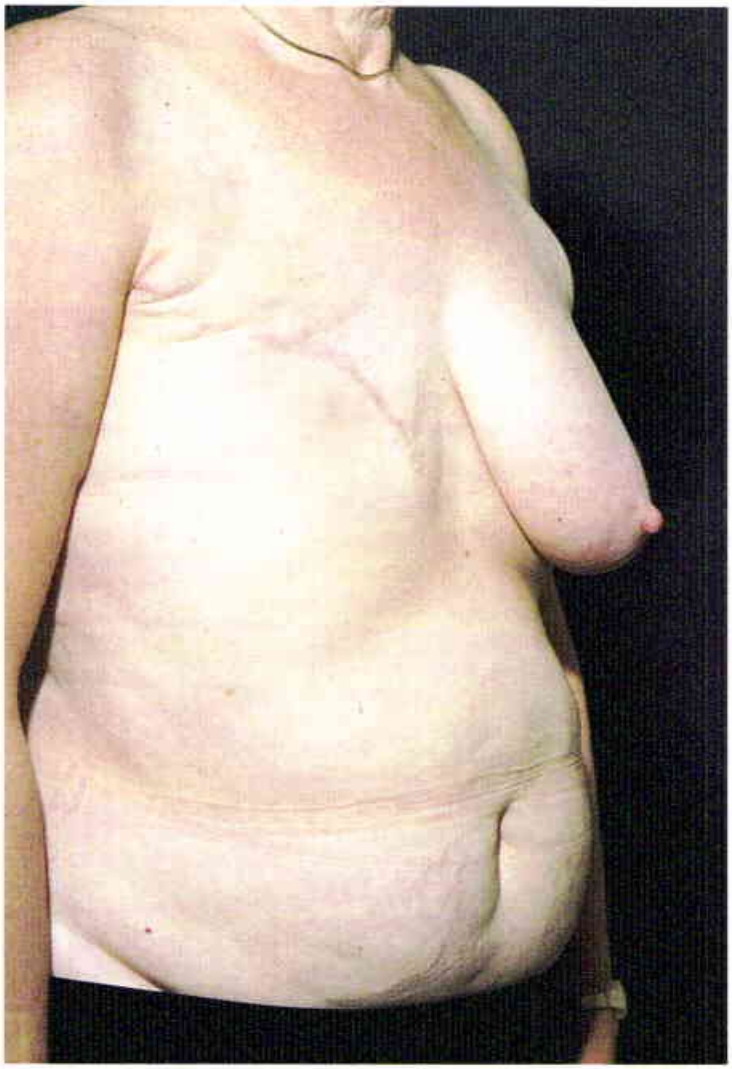


10

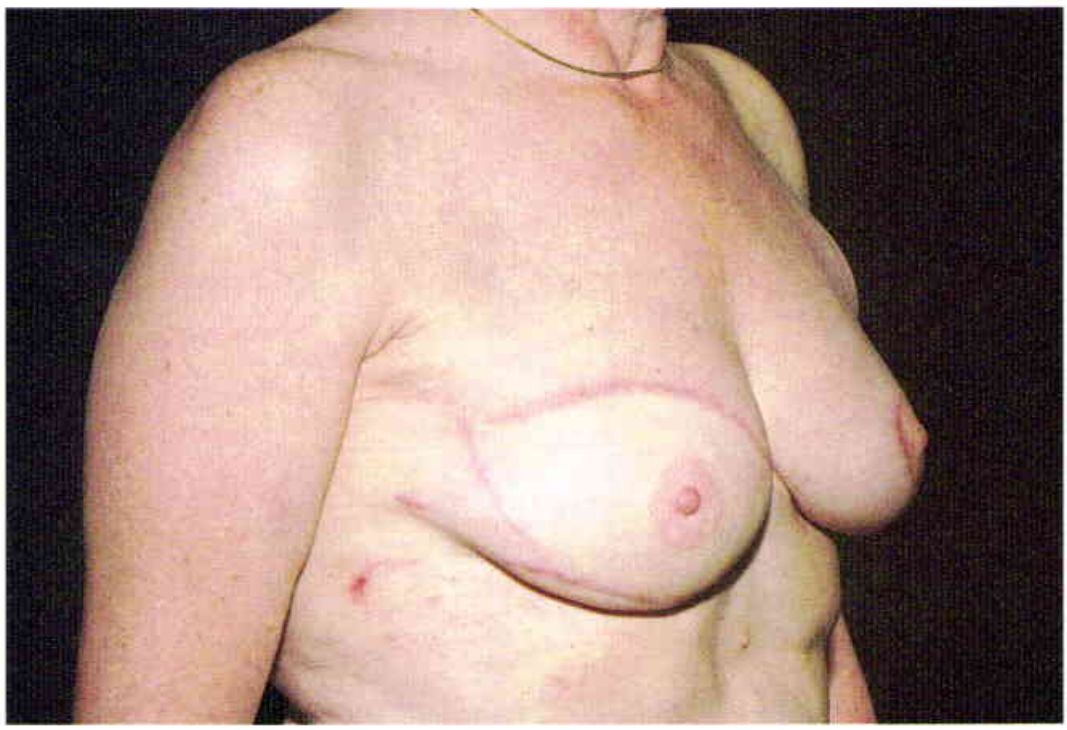
The flap was inset at the inframammary fold and contoured to match the opposite breast. The transverse mastectomy scar must be accepted as the upper line of closure.

11
A nipple-areola reconstruction was done at a second stage. A vertical wedge ''mastopexy'' was also performed on the reconstructed breast to improve the symmetry with the normal breast.

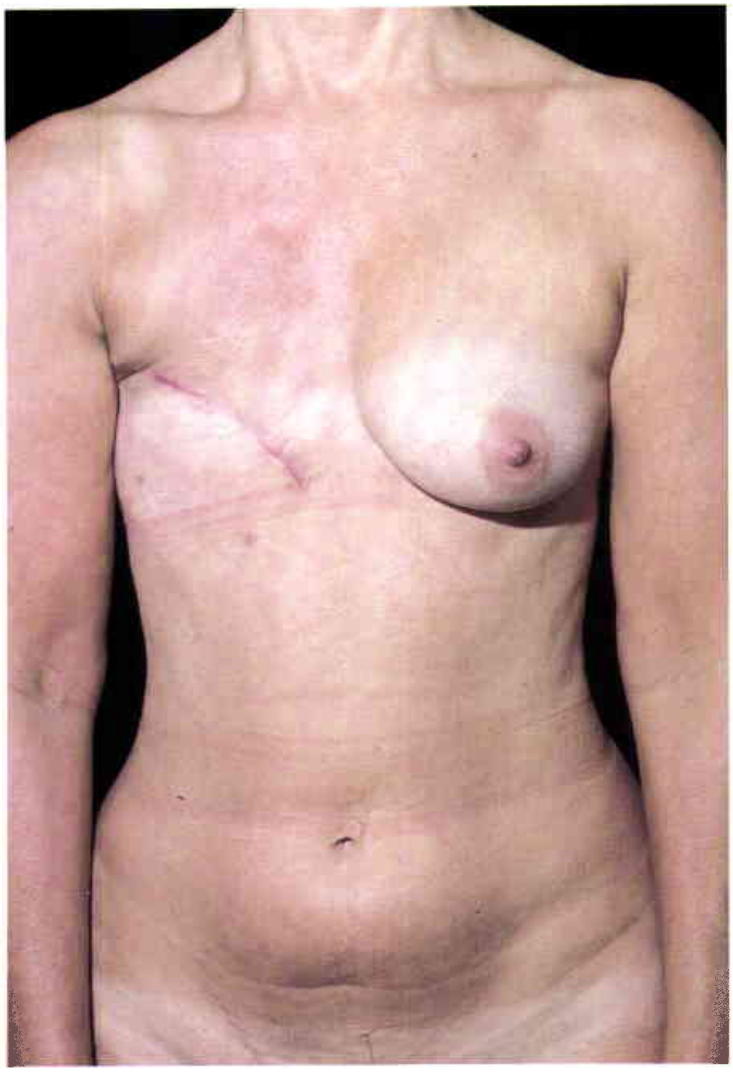
12
The ''upper fill'' provided by the buried TRAM flap is demonstrated.



13
Obese fifty-year-old female with a large and ptotic opposite breast. A TRAM flap was chosen as the best method to gain symmetry with the opposite breast. (Case of J.B. McCraw)

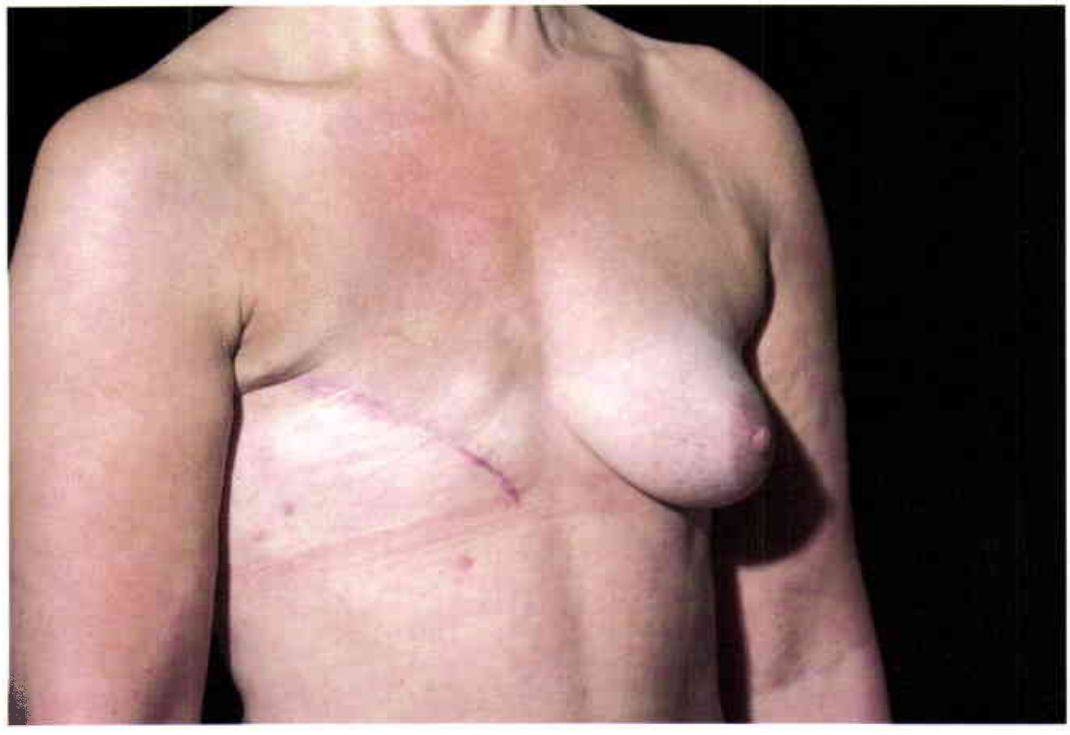


14
Even though a small reduction mammoplasty was performed on the opposite breast, it was necessary to emphasize the ptosis in the reconstructed breast.



15, 16

Youthful patient with a favorable mastectomy scar and a denervated pectoralis major muscle. The normal breast is only slightly ptotic. A double muscle pedicle will be used to carry the entire abdominal pannus in this thin patient. (Case of J.B. McCraw)



17, 18

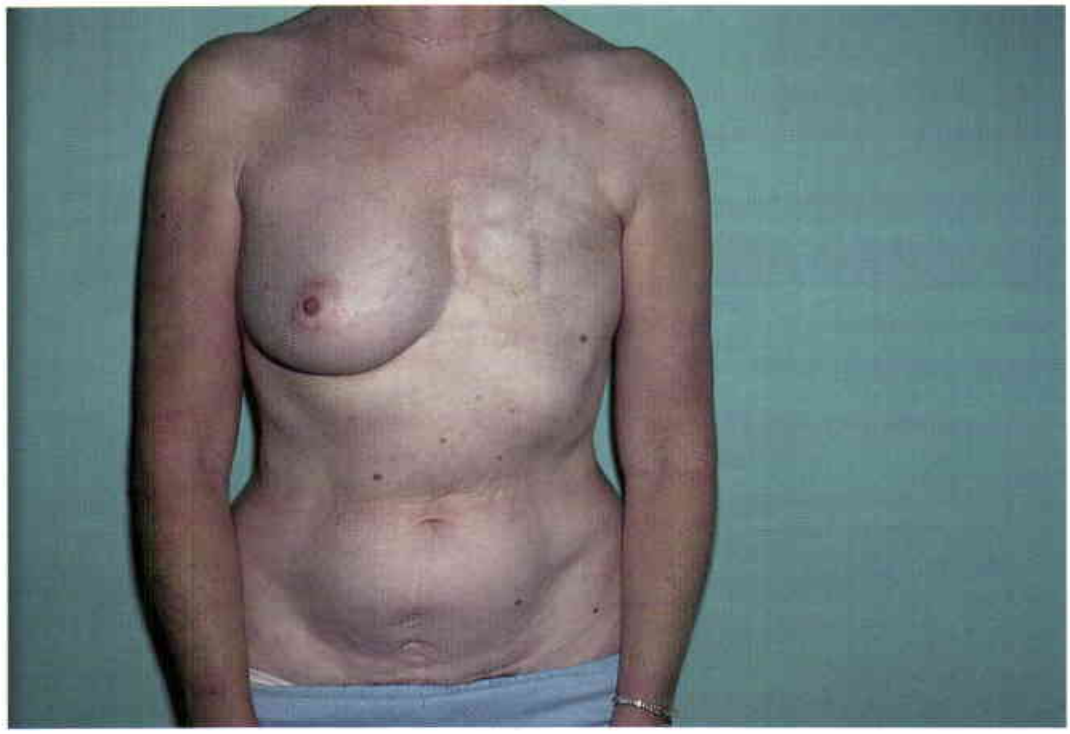
The upper mastectomy scar was converted from a straight line into a "C" shape to broaden the central portion of the reconstructed breast. A mastopexy was performed on the opposite breast at the time of the nipple reconstruction. The postoperative abdominal contour was improved by the use of the double muscle TRAM procedure.

19

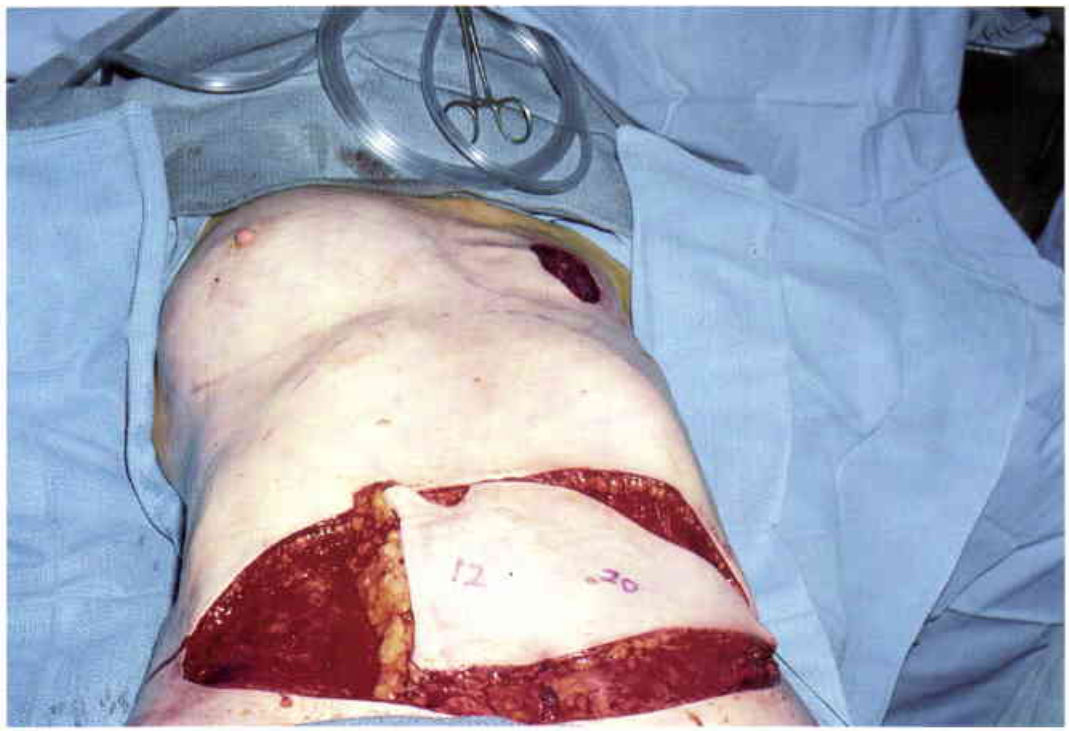
Fifty-one-year-old female who had undergone a radical mastectomy and irradiation. The left breast reconstruction was made complicated by the vertical mastectomy closure and the thin mastectomy flaps. (Case of P.G. Arnold)

20

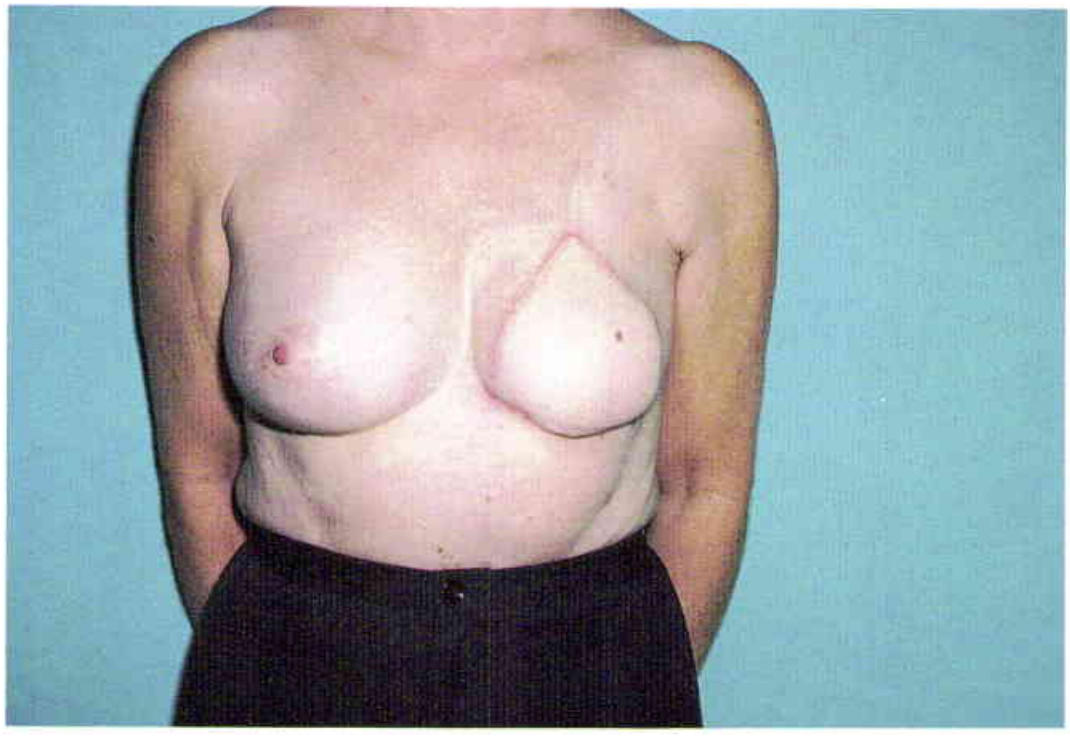
The volume of the single pedicled TRAM flap was not adequate to reconstruct the anterior axillary fold, to recreate the upper "fill," and to replace the lost skin.



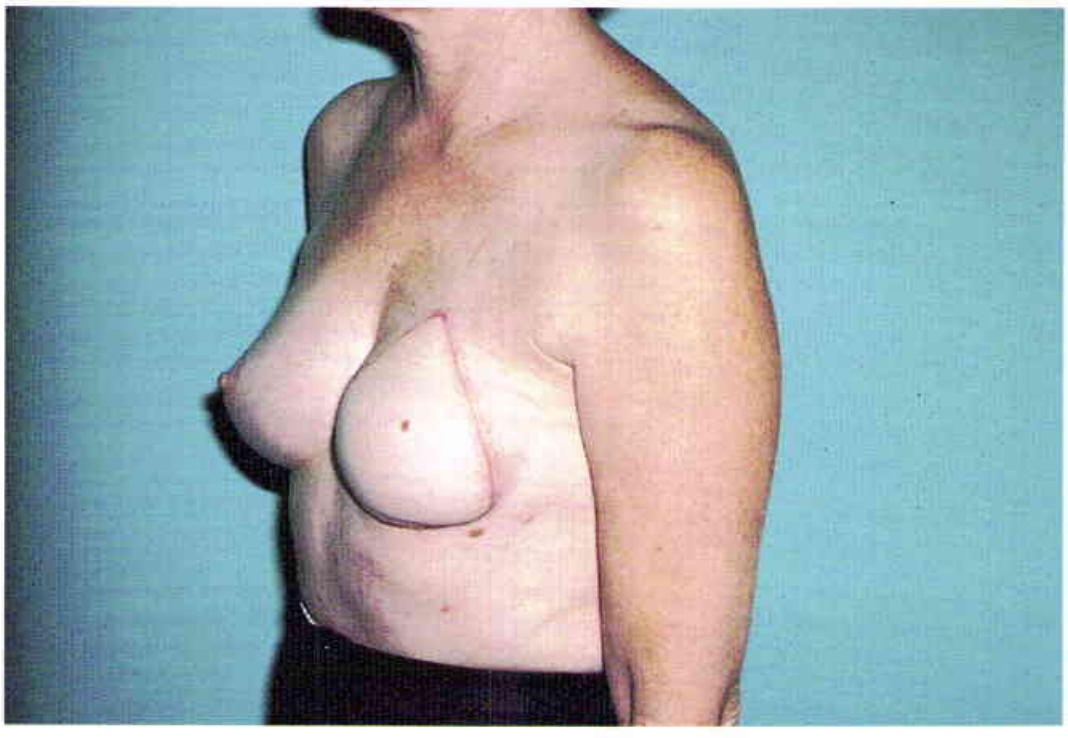
21
Fifty-one-year-old female who had undergone a modified mastectomy with a very medial vertical closure. A right lower paramedian scar limits the amount of abdominal tissue which can be transposed. (Case of P.G. Arnold)



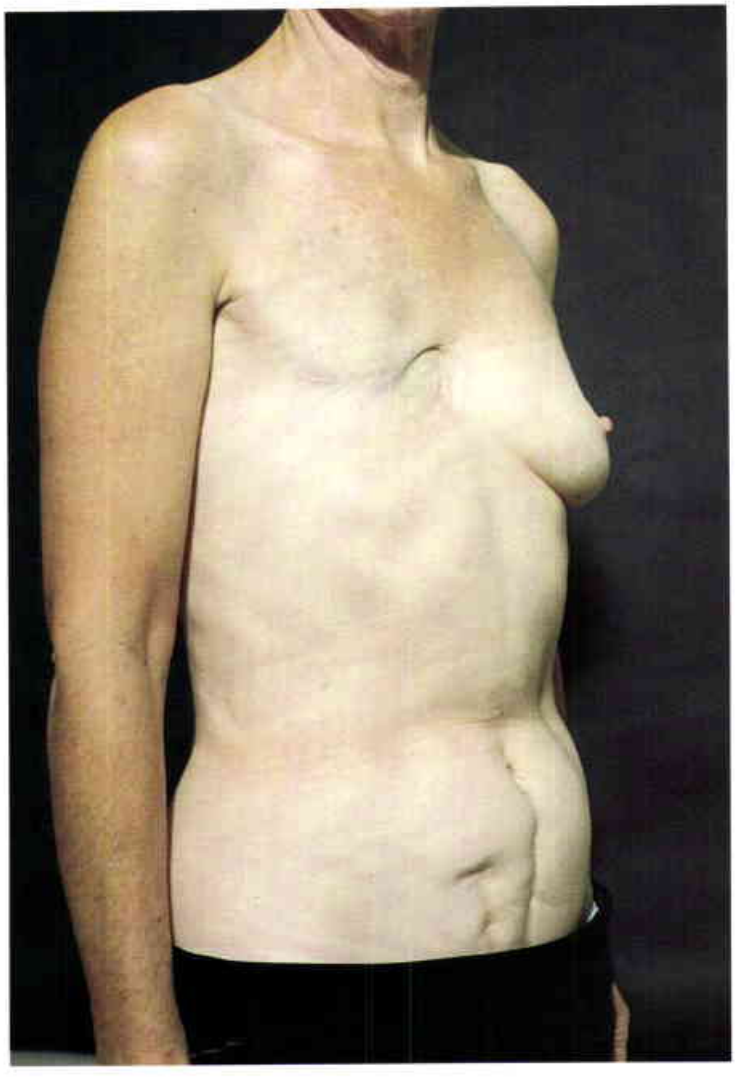
22
An ipsilateral TRAM flap was used because of the previous lower abdominal scar. Note the thinness of the mastectomy flaps.



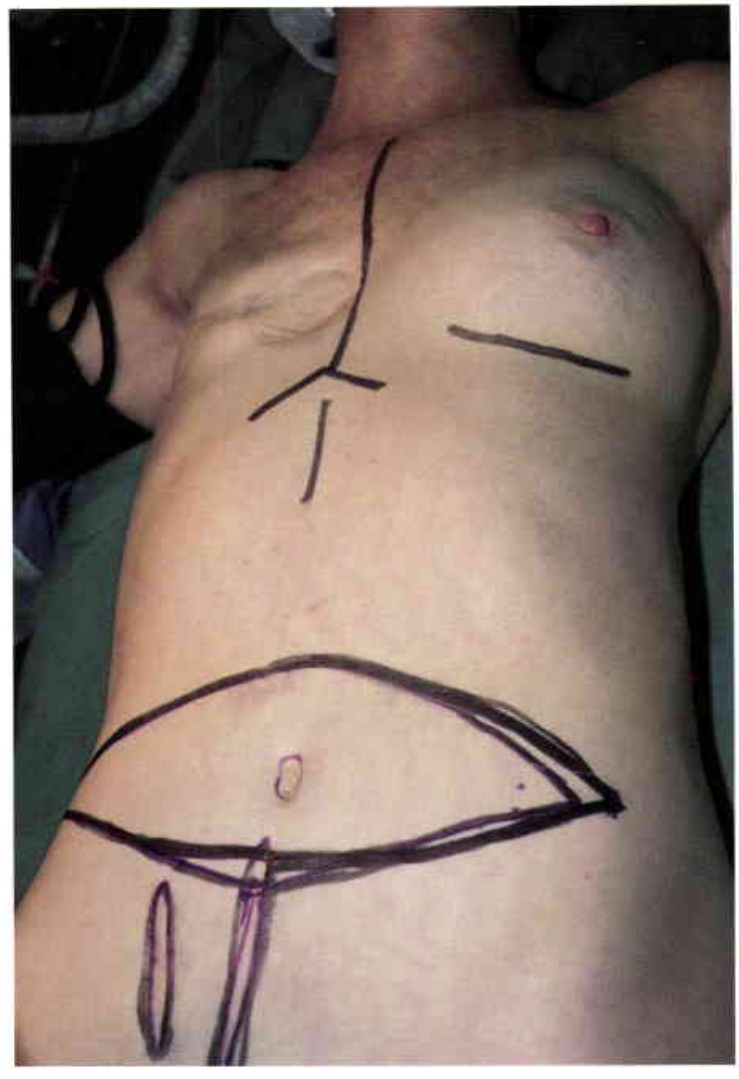
23
The TRAM flap was vertically oriented to accommodate the mastectomy closure. The midline margin of the abdominal flap was inset at the inframammary fold.



24
The TRAM flap produced good symmetry with the opposite breast and satisfactorily reconstructed the inframammary fold.



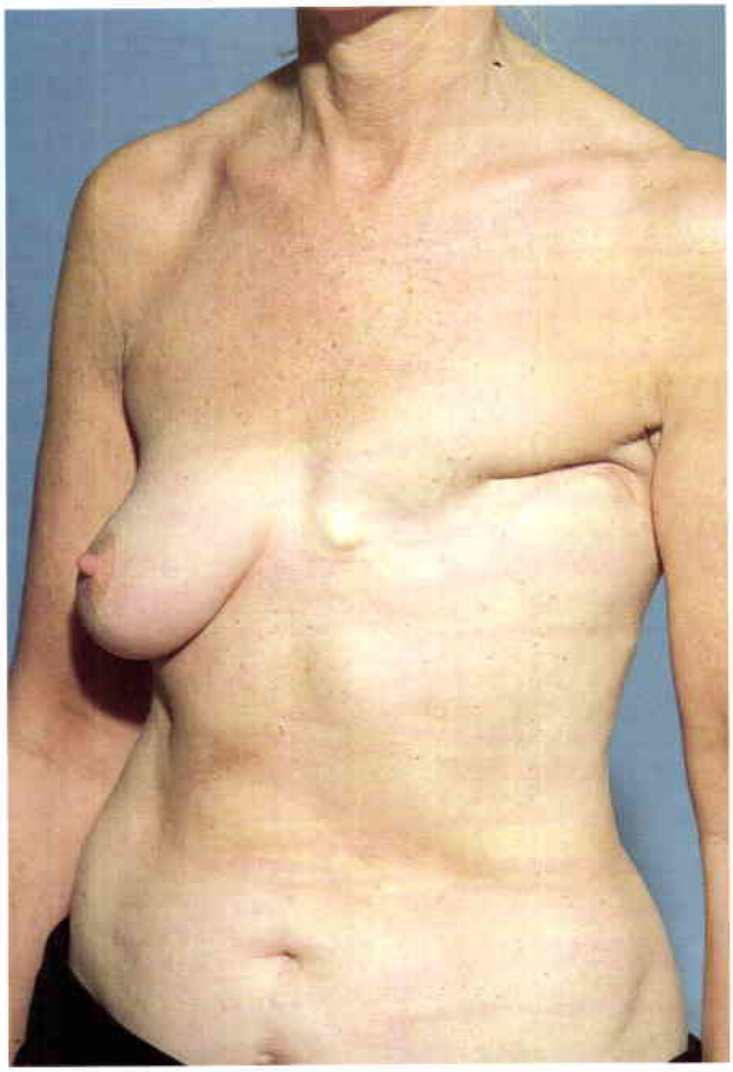
25
Forty-seven-year-old female with a heavily scarred abdomen and a mastectomy skin graft which extended onto the sternum. The youthful contour of the opposite breast presents an additional challenge. (Case of J.B. McCraw)



26
A high TRAM flap is outlined because this case predates the double muscle pedicle. Under no circumstances will the vasculature of the TRAM flap traverse a vertical abdominal scar.

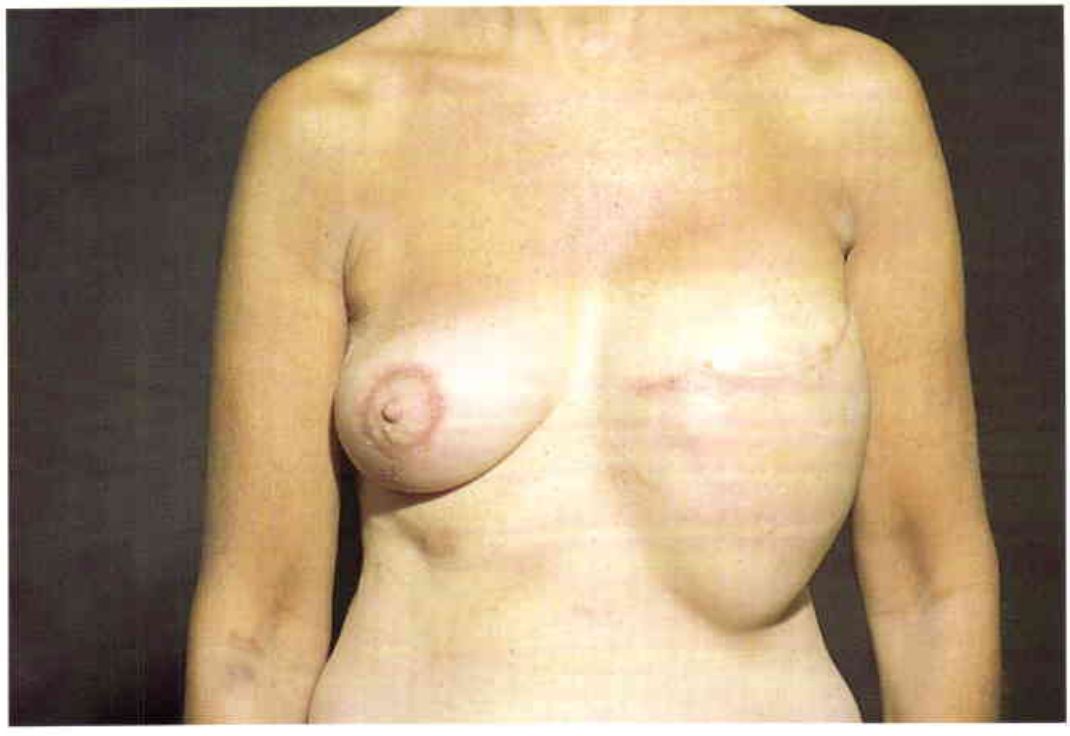
27, 28

The high abdominal closure through the umbilicus gives a predictably poor scar. The volume of the TRAM flap was insufficient to obtain symmetry with the normal breast. A double muscle pedicle would have provided the desired volume and allowed a lower abdominal closure.

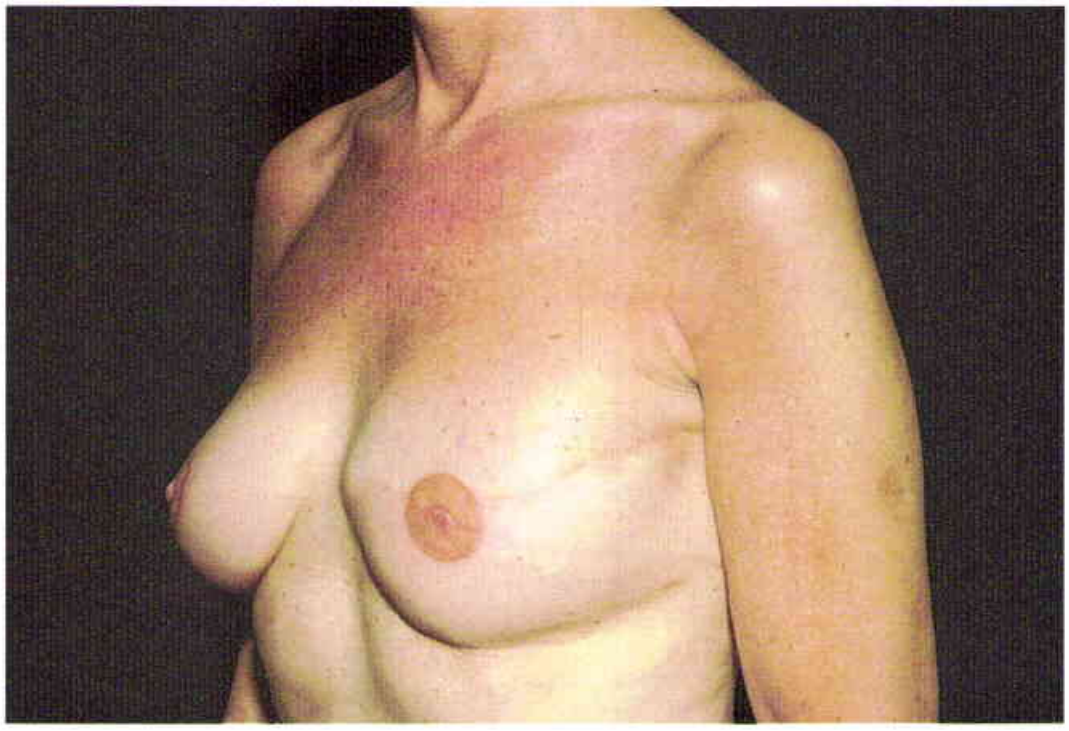


29, 30

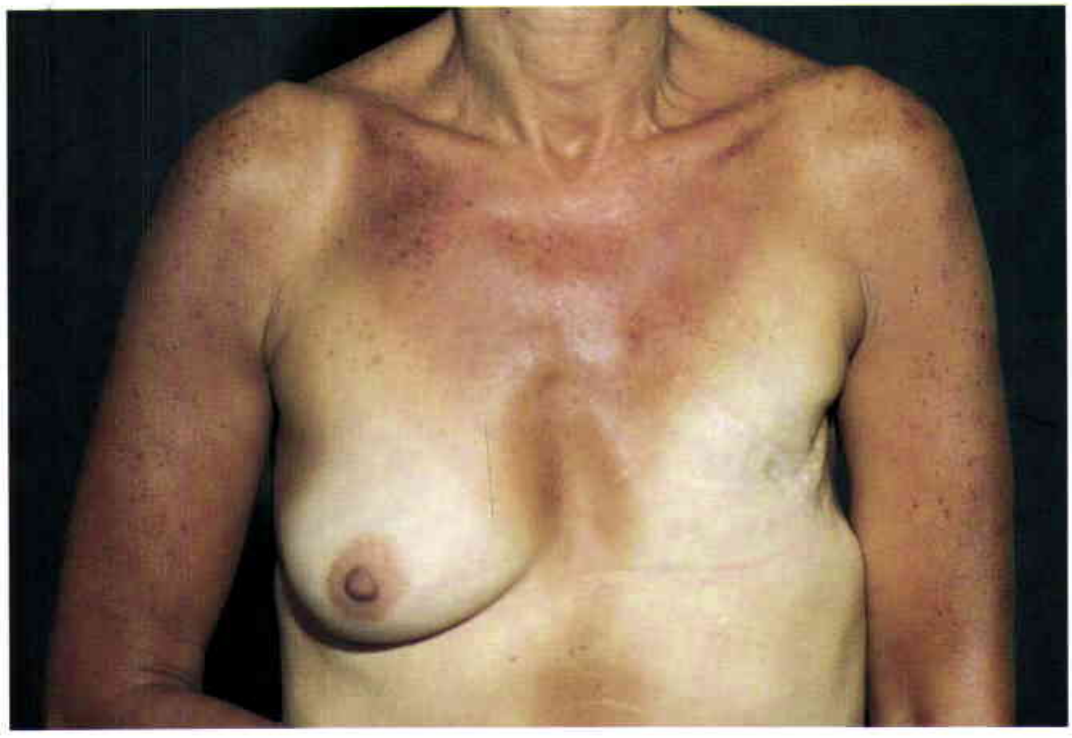
Forty-six-year-old female with an extensive mastectomy and a lower midline abdominal scar. The small abdominal pannus was not adequate both to replace the deficient breast skin and to produce an acceptable volume. A tissue expander was used to stretch the existing chest wall skin. (Case of J.B. McCraw)



31
The 1000 cc tissue expander corrected the skin deficiency and helped to recreate the inframammary fold.



32
The TRAM flap was completely deepithelialized and buried for volume replacement. The symmetry with the ptotic breast is acceptable.



33, 34

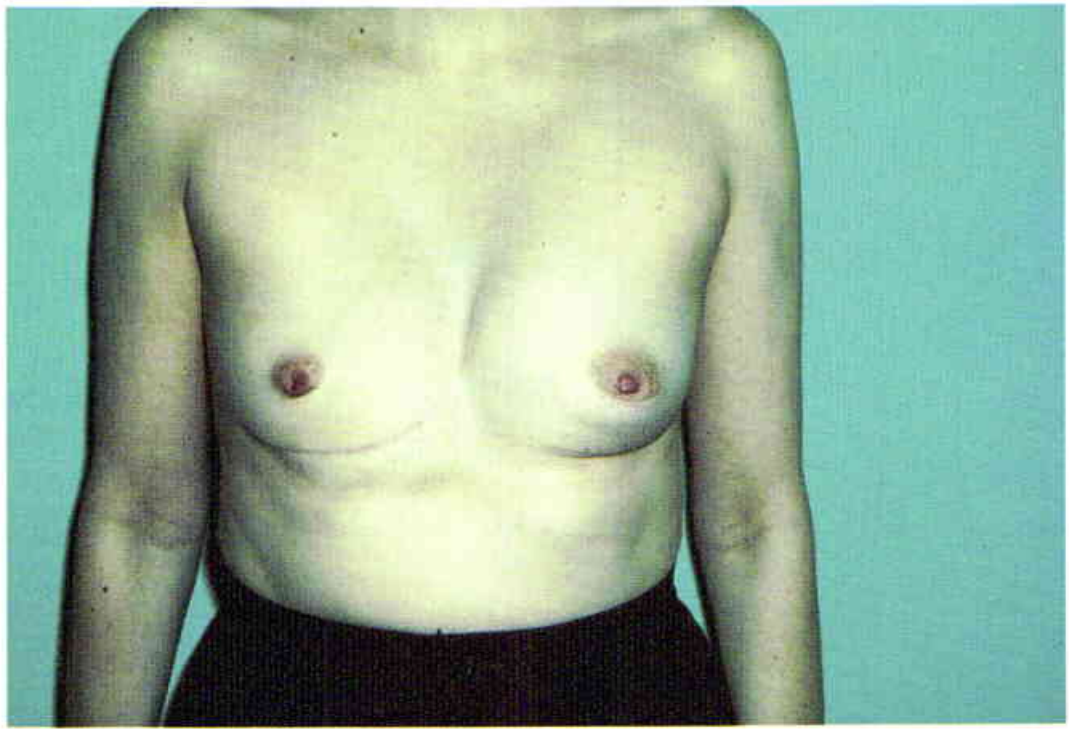
Fifty-four-year-old female following an extensive modified radical mastectomy with a "T" closure and "pie crusting" of the mastectomy flaps. (Case of J.B. McCraw)

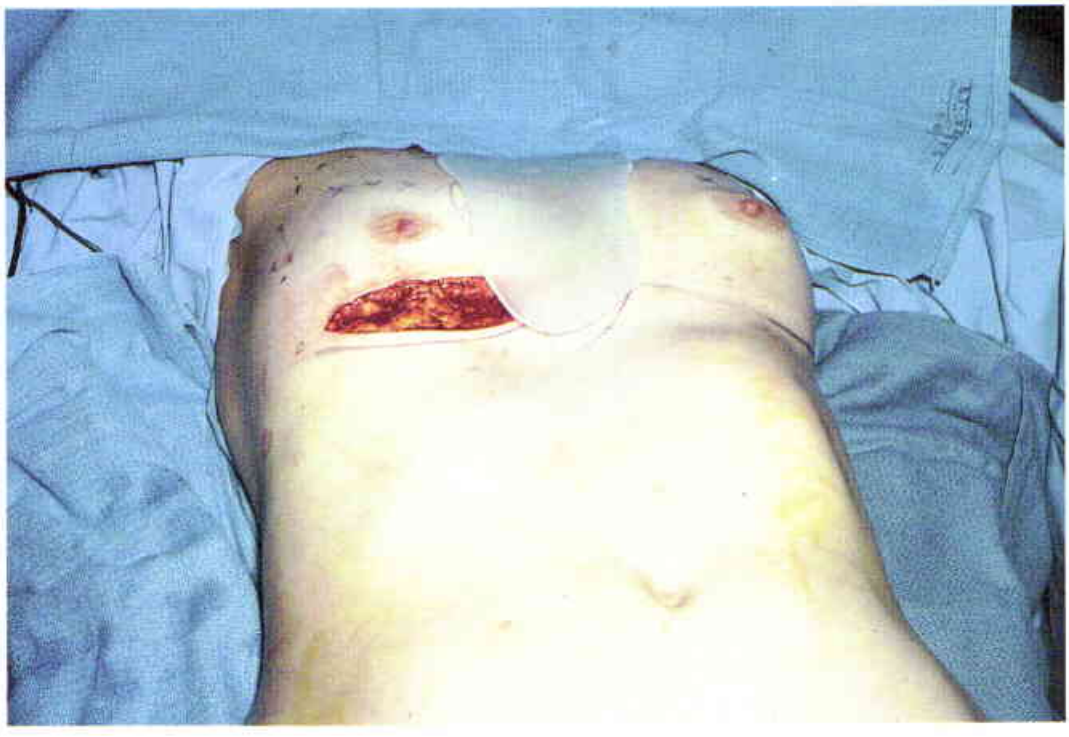
35, 36

A 1000 cc tissue expander partially replaced the deficient skin. It was still necessary to use a portion of the TRAM flap for skin replacement.

37, 38

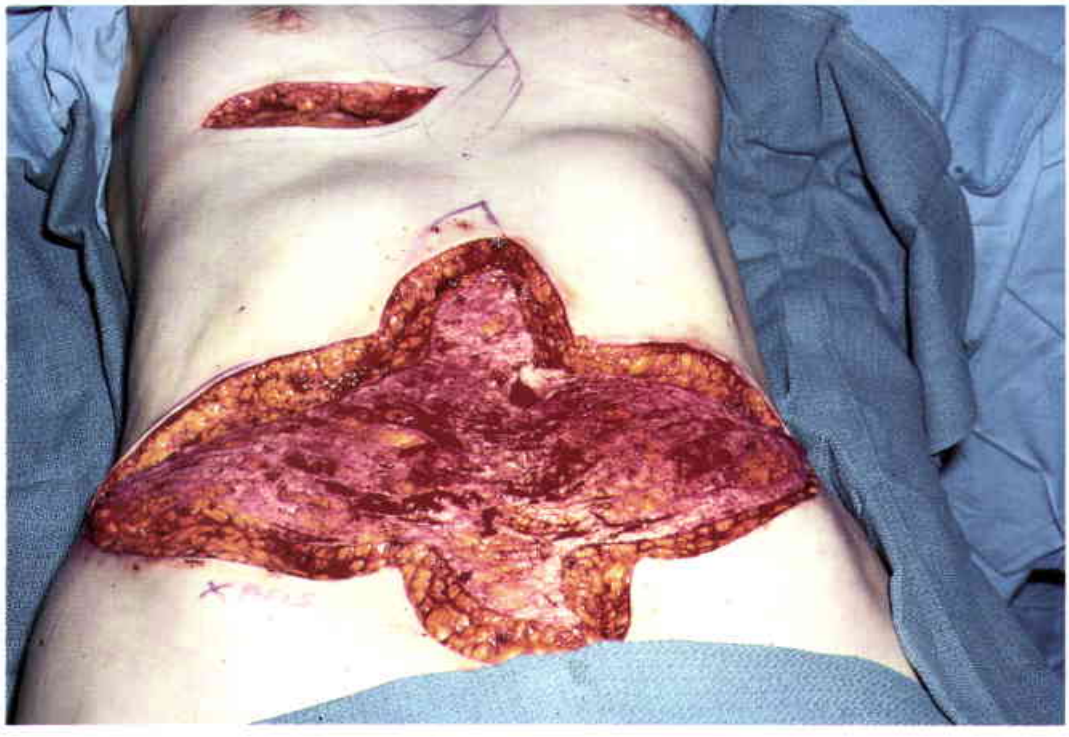
Two years postoperative. The abdominal contour and closure are good. A double muscle pedicle would have eliminated the need for the tissue expander.

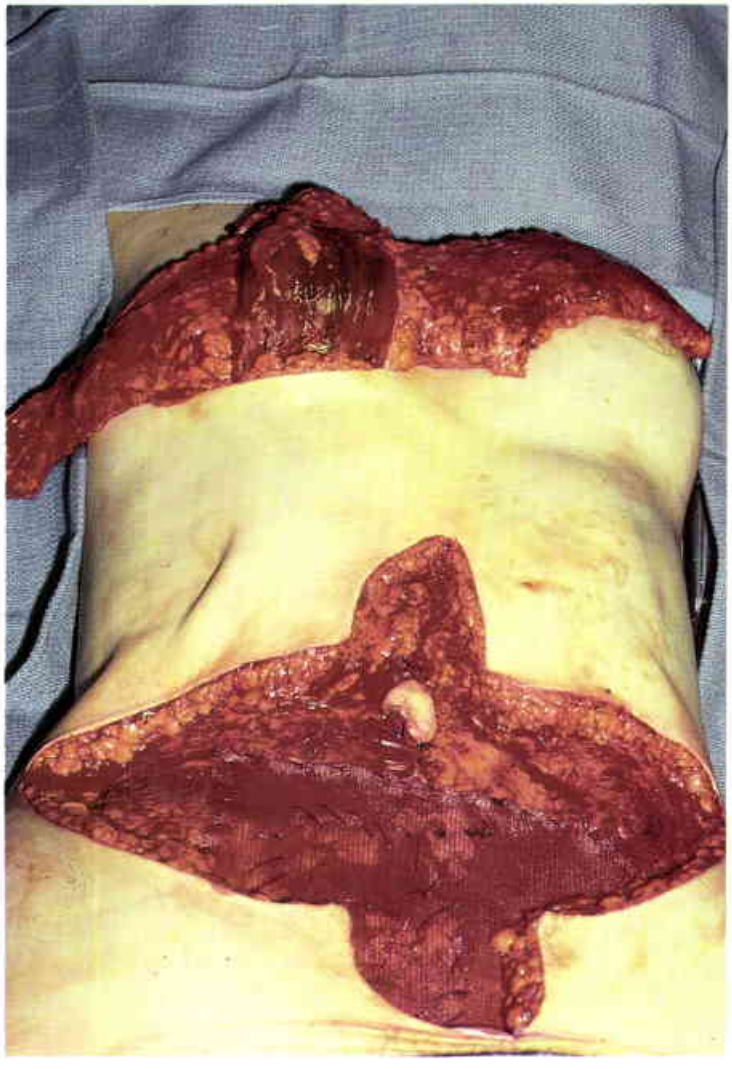




39, 40

Thirty-five-year-old female with pectus excavatum and a congenitally small right breast. This was previously treated with a disproportionate augmentation mammoplasty and a custom Silastic® sternal implant. Unfortunately, all three pockets communicated. (Case of P.G. Arnold)





41, 42

The entire TRAM flap was deepithelialized. The vertical component of the flap was used to correct the pectus deformity, and the remaining flap was used to augment the right breast. The left breast implant was removed.

43, 44

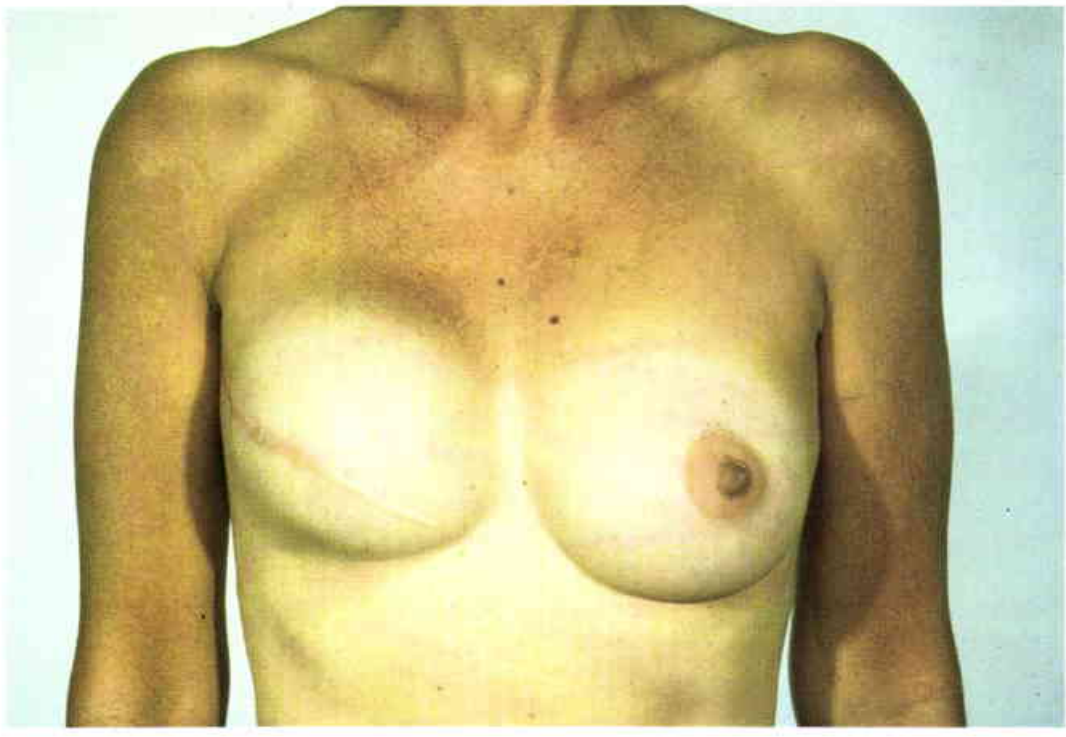
Reasonable breast symmetry was obtained, and the pectus deformity was corrected. The abdominal contour is acceptable, but the vertical closure is less than ideal.

45, 46

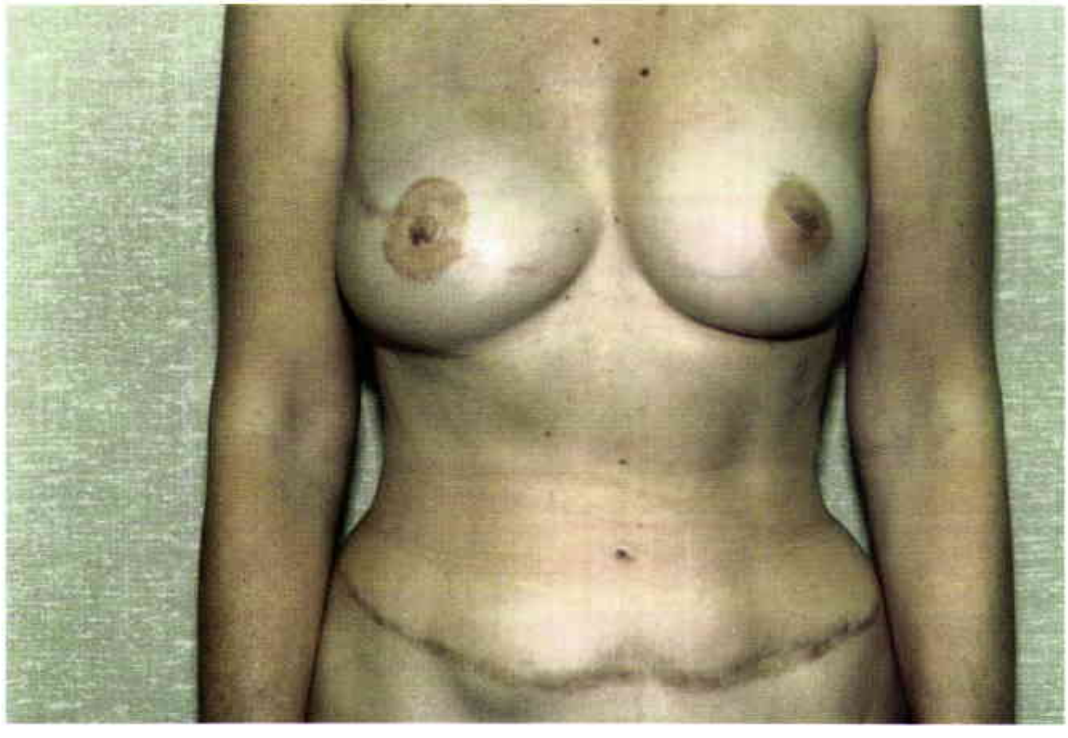
Forty-six-year-old female ten years following bilateral mastectomies and prepectoral implants. The very large abdominal pannus was adequate for a bilateral breast reconstruction without implants. (Case of J.B. McCraw)

47, 48

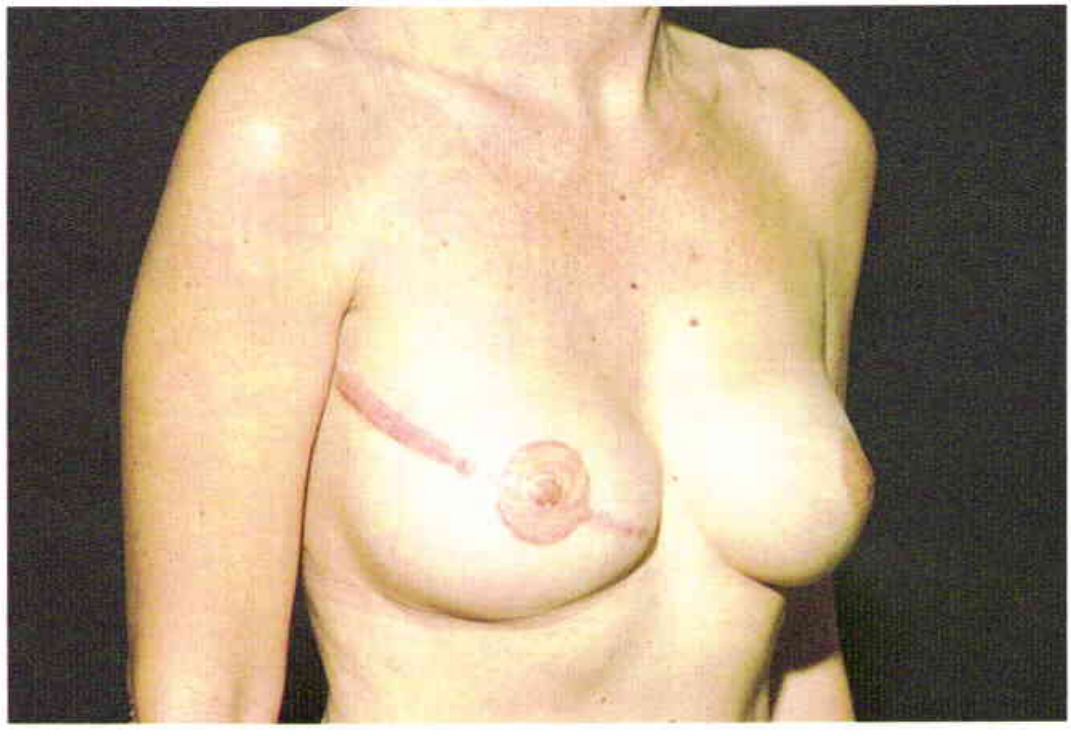
Only the bilateral TRAM procedure can be expected to provide such a large reconstructed breast with normal ptosis. The patient was happy to reach a definitive solution to her implant problems.



49
Forty-two-year-old female following a modified mastectomy and a subpectoral breast reconstruction. A capsular contracture persisted despite several open capsulotomies. (Case of J.B. McCraw)



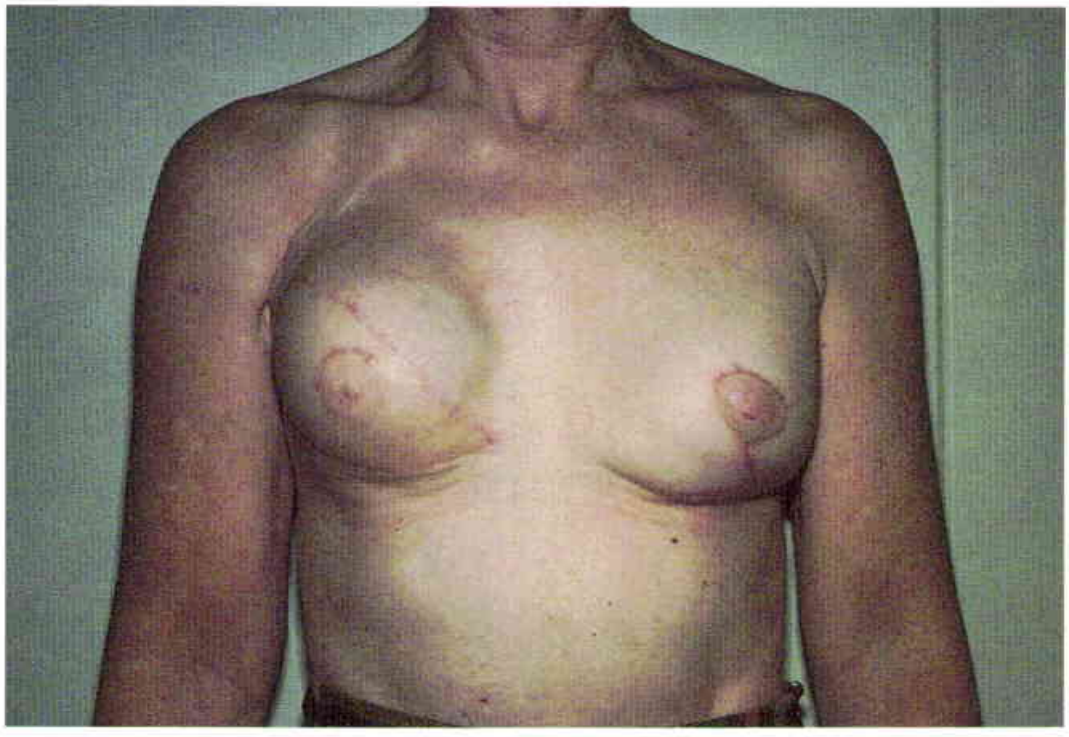
50
The right breast implant was replaced with a deepithelialized TRAM flap. The nipple was reconstructed in a second stage.



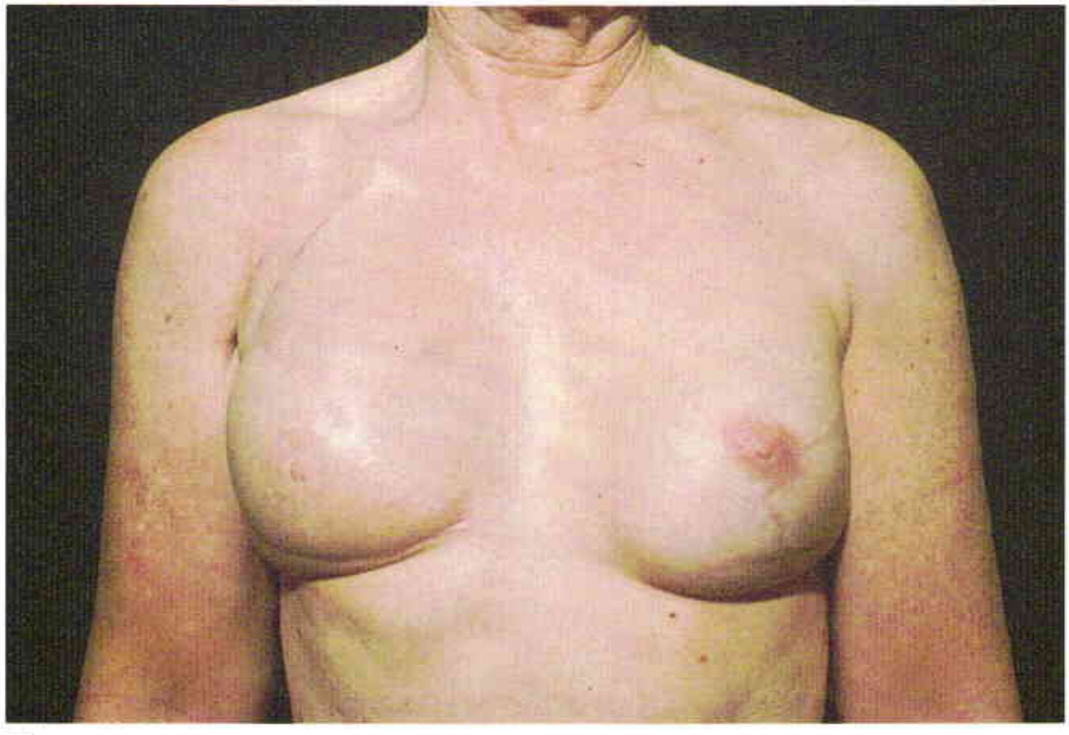
51, 52
Nearly ideal symmetry is achieved with the normal breast. The previous right subpectoral implant obviated the need for external skin replacement.

53

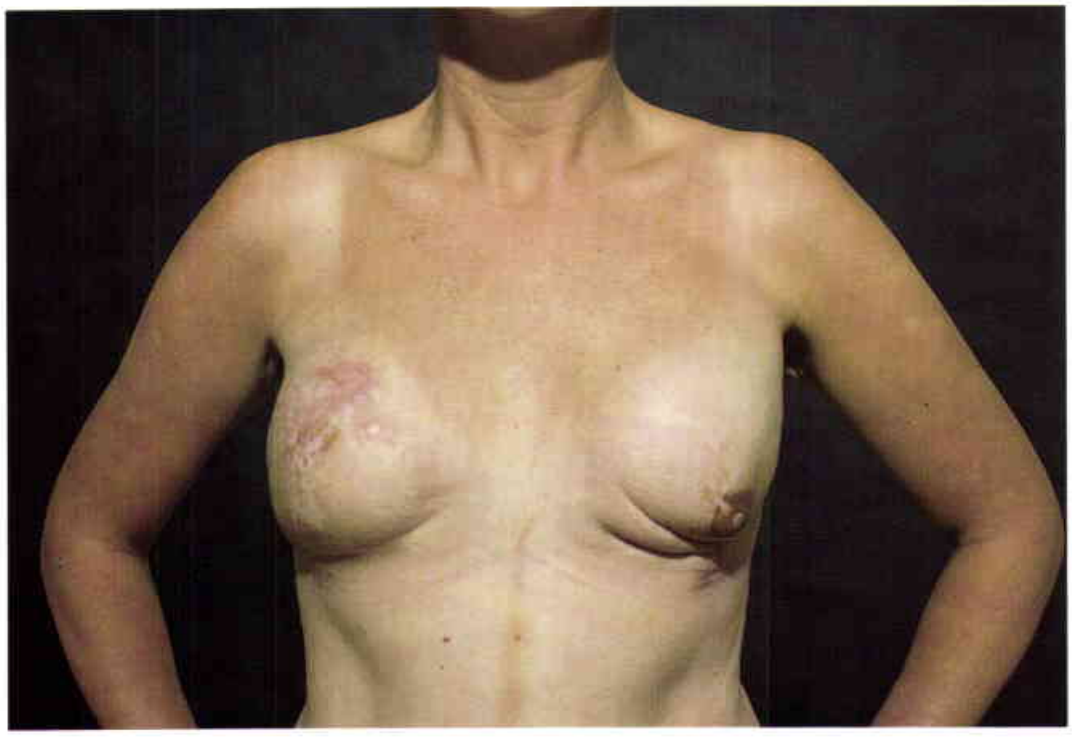
Fifty-four-year-old patient who had previously undergone a classical radical mastectomy with total removal of the pectoralis major and minor muscles. Both the mastectomy skin graft and the remaining chest wall skin were uncomfortable. It was not known in 1978 that the latissimus dorsi flap could not possibly correct all of the deformities extending from the clavicle to the inframammary fold. (Case of J.B. McCraw)

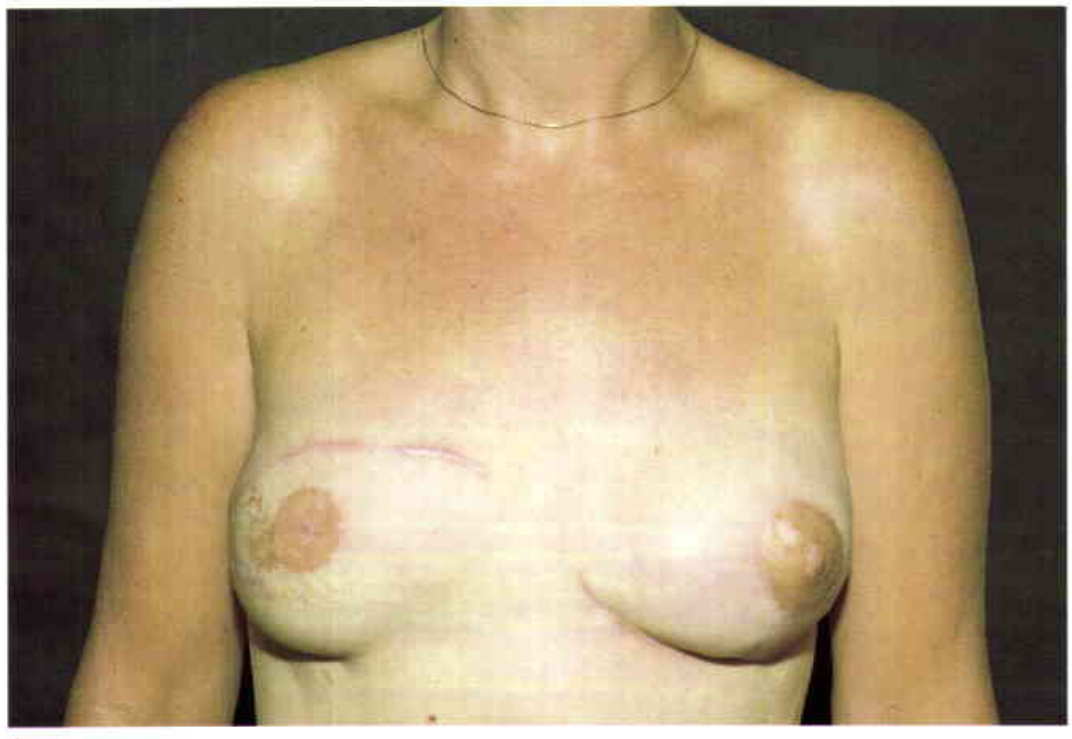


54
The latissimus breast reconstruction offered some improvement. Unfortunately the upper "fill" was deficient, and the anterior axillary fold remained uncorrected. Three open capsulotomies failed to relieve the capsular contracture.



55
A completely deepithelialized and buried TRAM flap was used to replace the right breast implant and to correct the upper breast deformities. Acceptable breast symmetry was obtained.



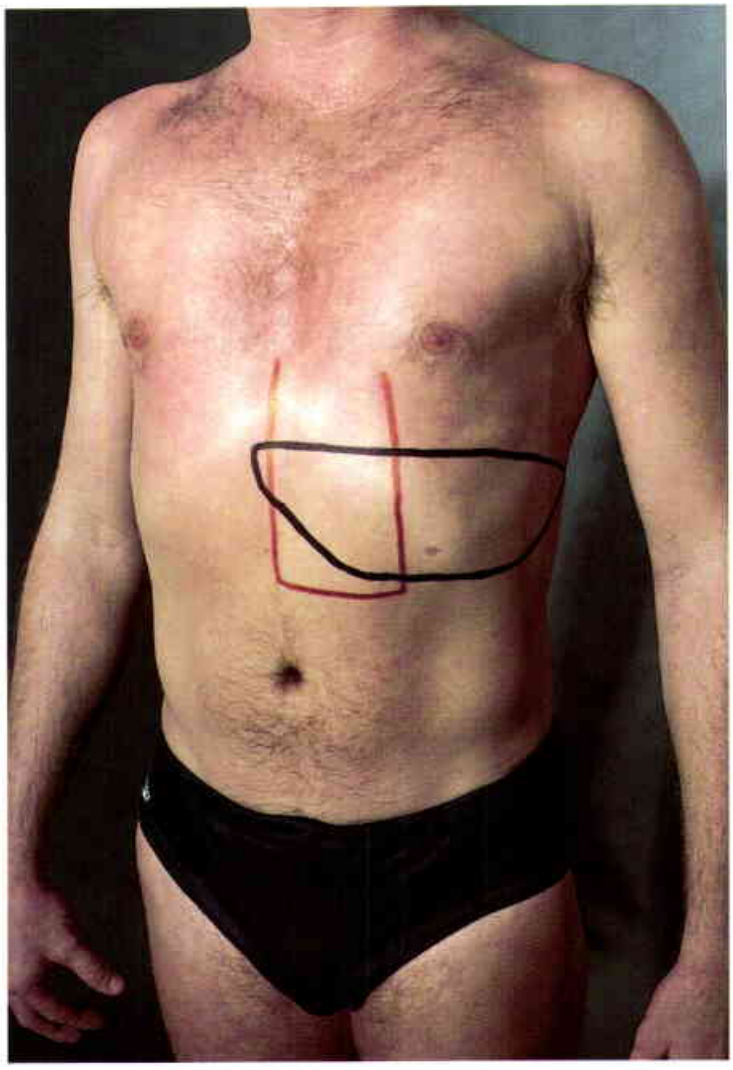


56, 57

Forty-one-year-old prophylactic mastectomy "cripple." There was extensive skin loss in both breasts, and the right nipple was also lost. The implants were painful and firm. Bilateral deepithelialized TRAM flaps were used to replace the breast volume in this difficult "salvage" situation. (Case of J.B. McCraw)

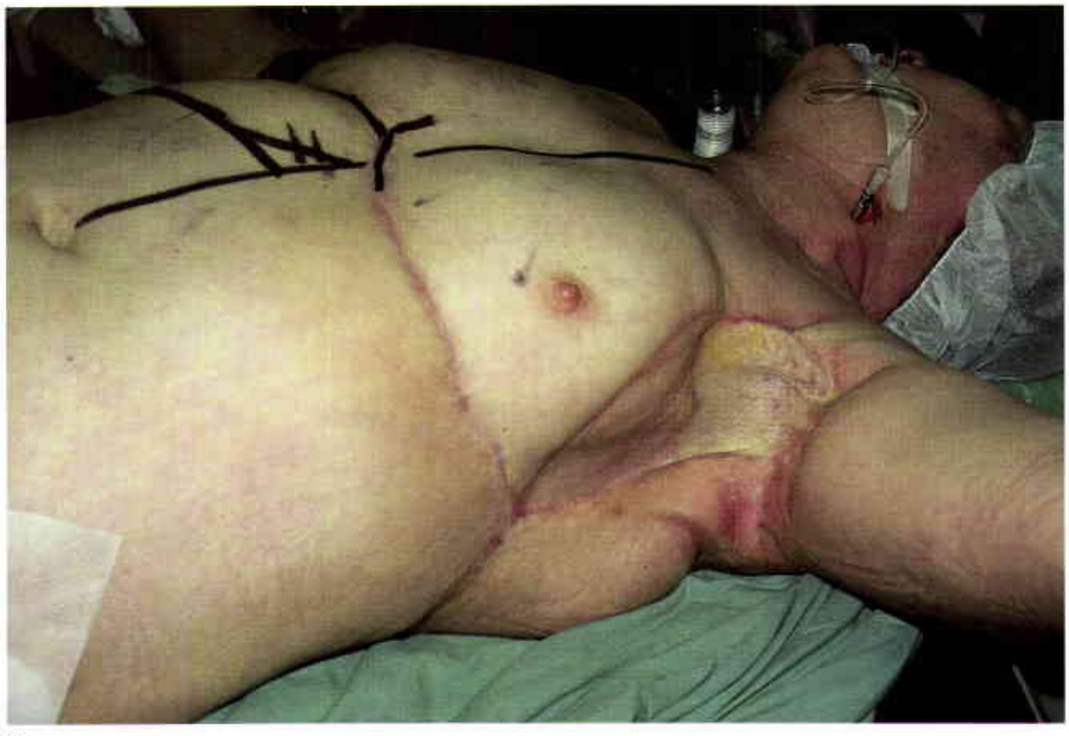
58
Fifty-six-year-old female following a left radical mastectomy and chest wall irradiation. The persistent ulceration contains adenocarcinoma. (Case of P.G. Arnold)

59
A full-thickness chest wall resection was carried out. Histologic "free" margins were obtained. A contralateral TRAM flap was used to reconstruct the chest wall defect since the latissimus muscle had been devascularized.



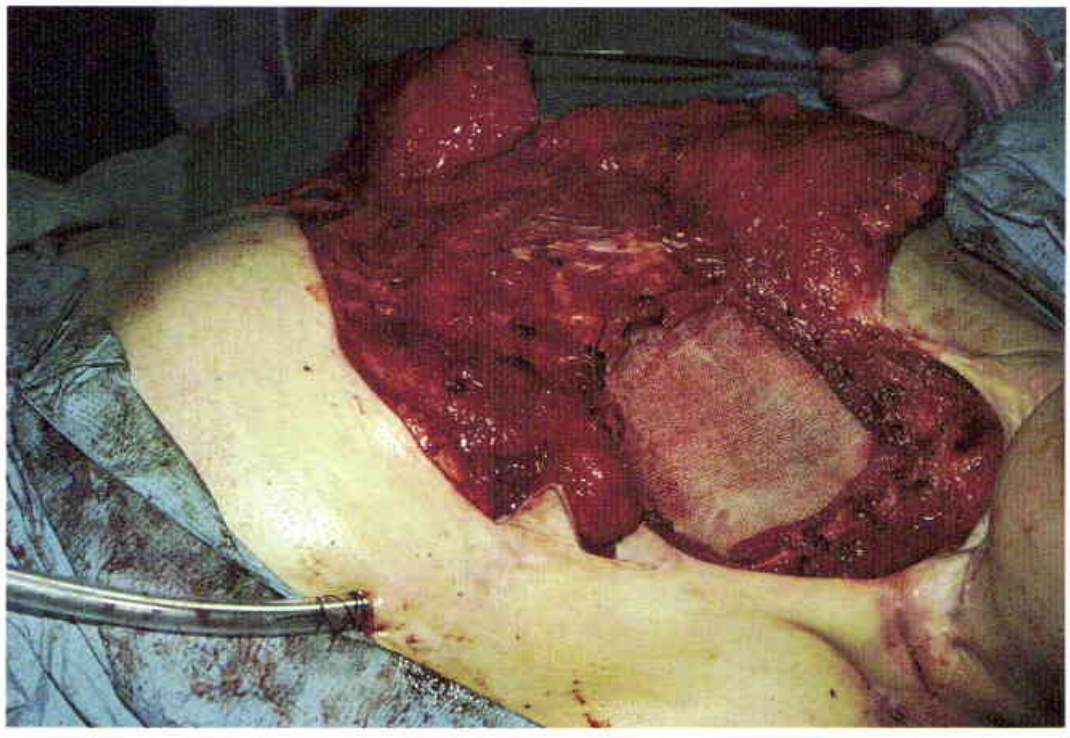
60

The standard upper horizontal rectus abdominis flap is demonstrated. The upper margin of the flap is placed near the inframammary fold. This becomes the line of closure after the abdominal skin is advanced superiorly.



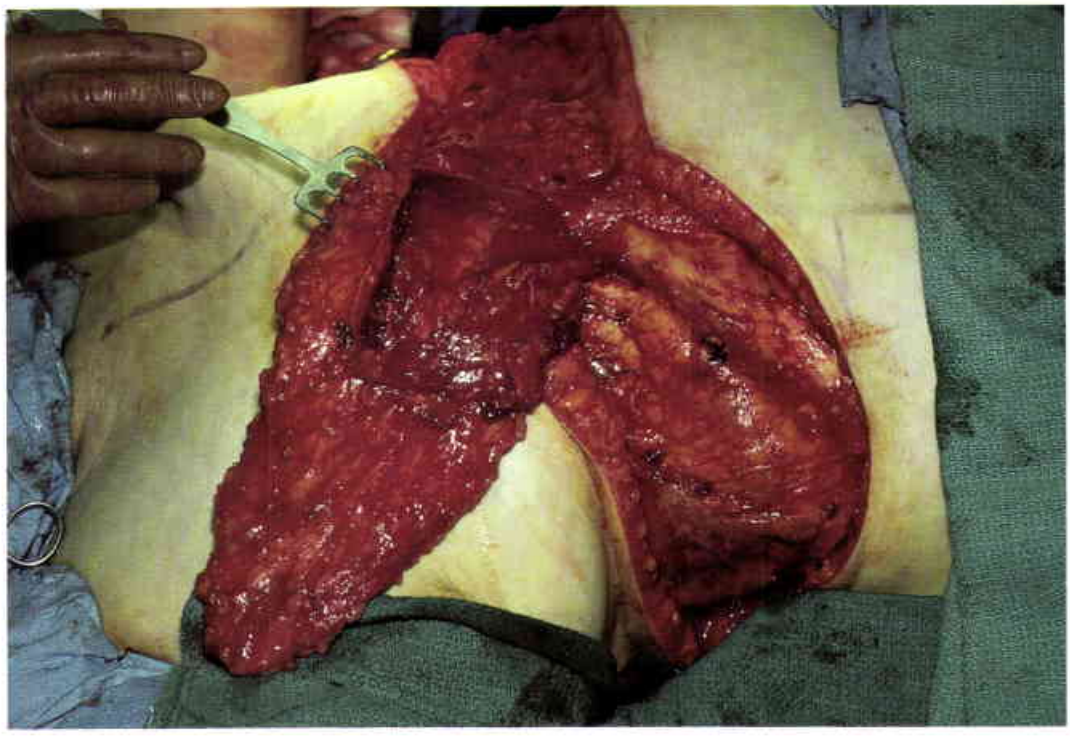
61

Fifty-eight-year-old female who had undergone a wide resection of a fibrosarcoma in the axilla four years earlier. The tumor is now recurrent in the chest wall at the level of the inframammary fold. An upper horizontal rectus abdominis flap is outlined on the opposite chest. (Case of J.B. McCraw and W. Hubbard)



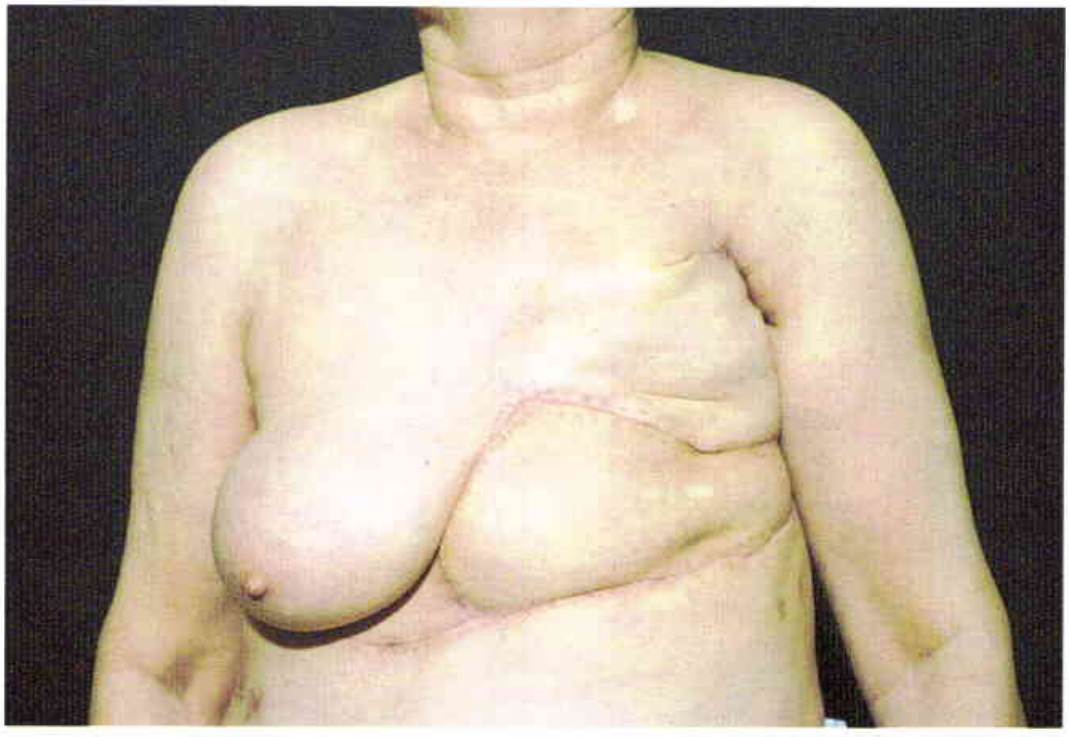
62
A full-thickness resection of the left lower chest wall was carried out. Marlex® mesh was used for stabilization.

63
An opposite horizontal rectus abdominis myocutaneous flap is outlined beneath the right breast since the left latissimus muscle had already been resected with the tumor.

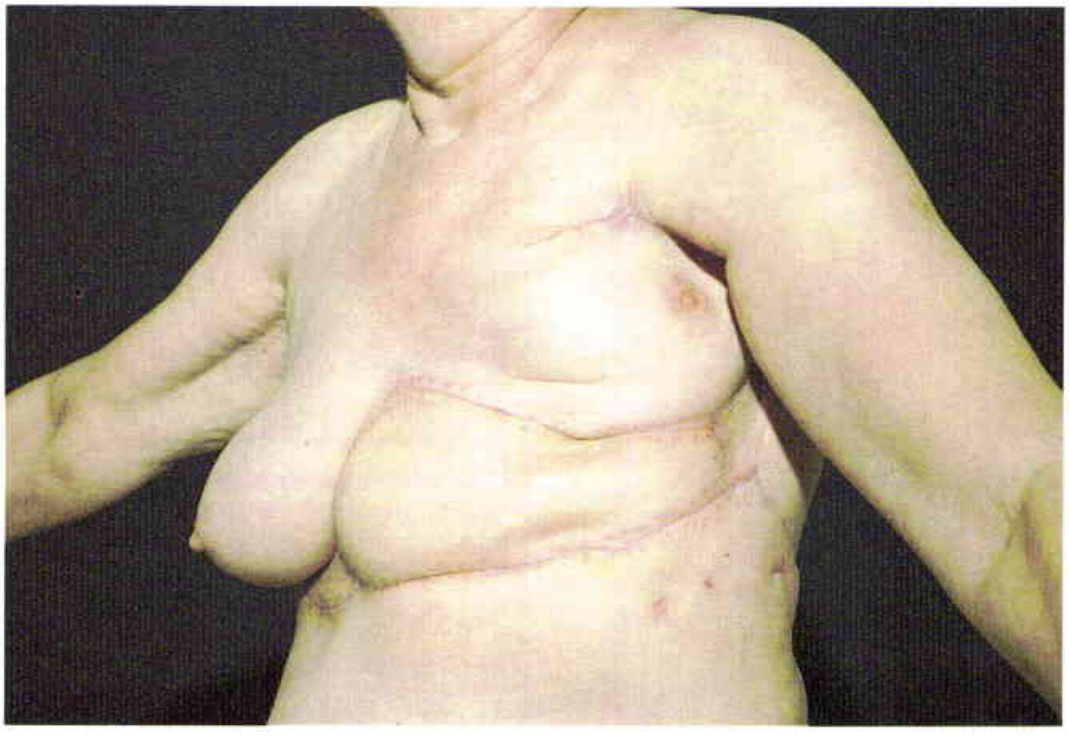


64

The rectus abdominis muscle is seen in the proximal portion of the flap near the face-lift retractor. The donor site will be primarily closed.

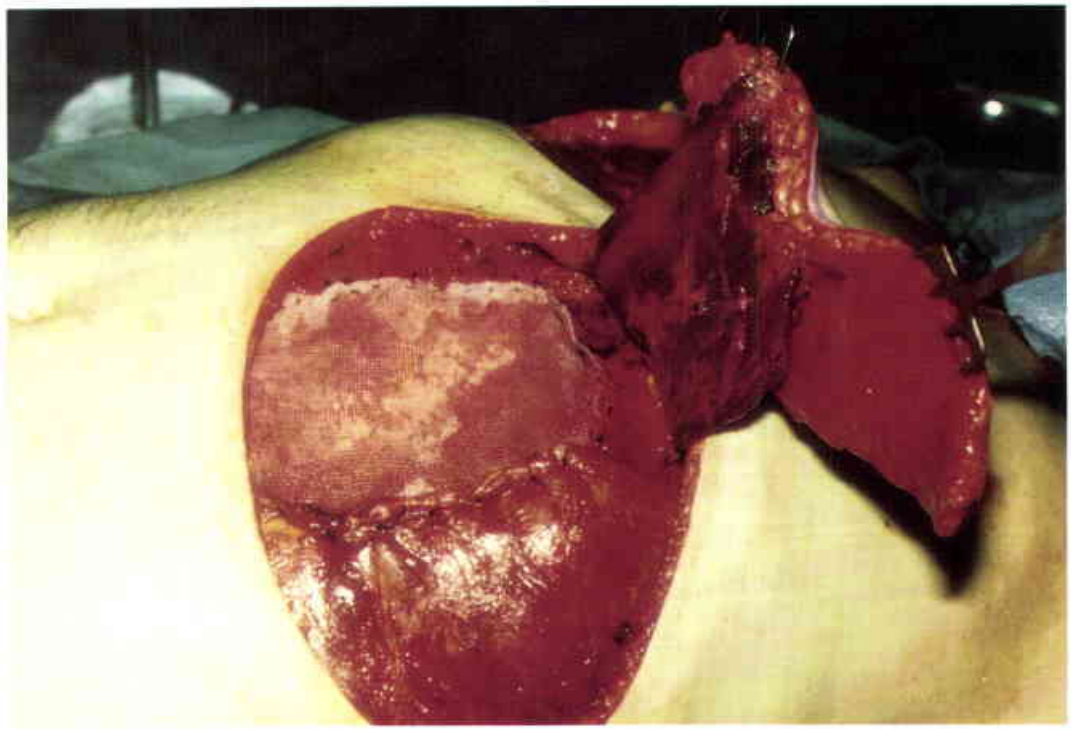


65
A vertical rectus abdominis flap would have been more reliable, but an upper horizontal flap was chosen because it more easily accommodated the unusual central and lateral chest wall defect.

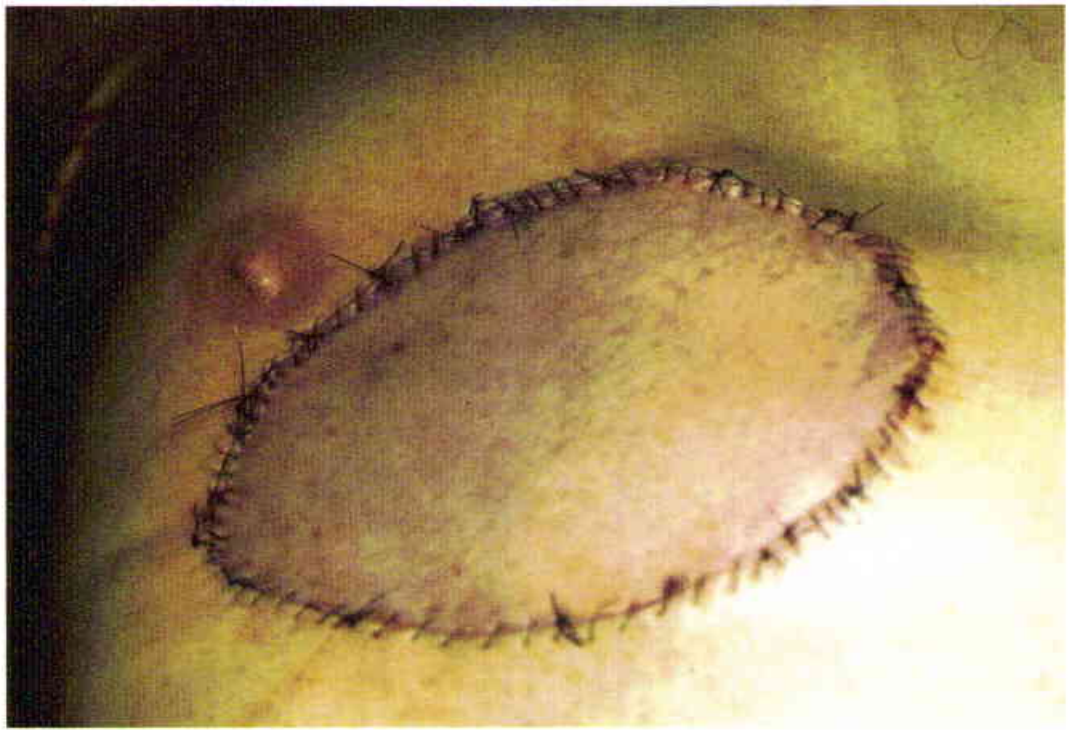


66
The entire upper horizontal rectus flap survived and provided good chest wall coverage. The left breast was moved superiorly to correct the axillary contracture.

67
Fifty-seven-year-old man with a Level III melanoma of the right lower chest wall. An upper horizontal rectus abdominis flap is outlined on the left rectus muscle. (Case of J.B. McCraw)



68
The rectus abdominis myocutaneous flap is elevated to the level of the xiphoid. The abdominal donor defect has been closed with Marlex® mesh. Note the broad attachment of the rectus abdominis muscle to the cutaneous segment.

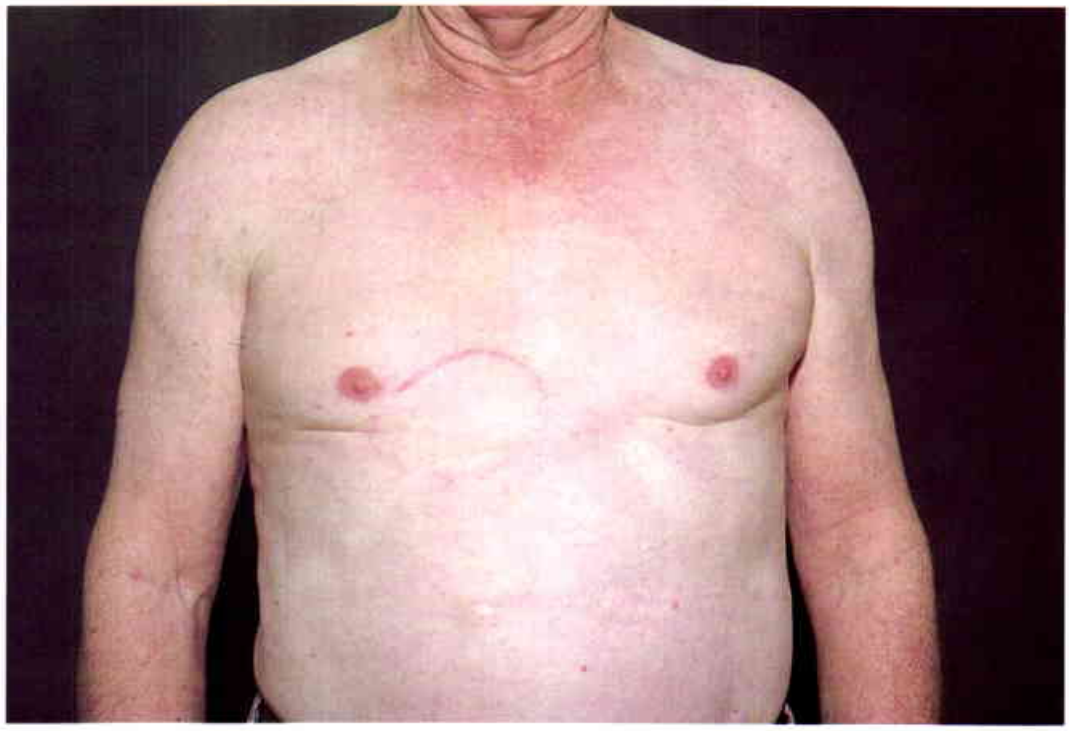


69, 70

The inset flap did not fluoresce well. Since this was not thought to be a mechanical problem, nitroglycerin paste was applied to the flap. Note the improved flap color and fluorescence within a two minute period.

71, 72

Primarily closed donor site and inset flap. The color match and contour restoration are excellent in this patient. The quality of the reconstruction and the faster healing time cannot be matched by a skin graft.



Arnold, M. "The surgical anatomy of sternal blood supply." *J. Thorac. Cardiovasc. Surg.* 64: 596, 1972.

Baroudi, R., Pinotti, J.A., Keppke, E.M. "A transverse thoraco-abdominal skin flap for closure after radical mastectomy." *Plast. Reconstr. Surg.* 61: 547, 1978.

Boyd, J.B., Taylor, G.I., and Corlett, R. "The vascular territories of the superior epigastric and the deep inferior epigastric systems." *Plast. Reconstr. Surg.* 73(1): 1, 1984.

Bricout, N. and Banzet, P. "The use of the lower rectus abdominis musculocutaneous flap in breast reconstruction." *Ann. Chir. Plast. Esth.* 30: 111, 1985.

Bunkis, J., Walton, R.L., and Mathes, S.J. "The rectus abdominis free flap for lower extremity reconstruction." *Ann. Plast. Surg.* 11(5): 373, 1983.

Bunkis, J., Walton, R.L., Mathes, S.J., Krizek, T.J., and Vasconez, L.O. "Experience with the transverse lower rectus abdominis operation for breast reconstruction." *Plast. Reconstr. Surg.* 72(6): 819, 1983.

Caix, M., Outrequin, G., Descottes, B., Kalfon, M., and Pouget, V. "The muscles of the abdominal wall: a new functional approach with anatomoclinical deductions." *Anat. Clin.* 6(2): 101, 1984.

Davis, W.M., McCraw, J.B., and Carraway, J.H. "Use of a direct transverse thoracoabdominal flap to close difficult wounds of the thorax and upper extremity." *Plast. Reconstr. Surg.* 60(4): 526, 1977.

De la Plaza, R., Arroyo, J.M., and Vasconez, L.O. "Upper transverse rectus abdominis flap: the flag flap." *Ann. Plast. Surg.* 12(5): 410, 1984.

Dinner, M.I. and Dowden, R.V. "Rectus abdominis flaps (letter)." *Plast. Reconstr. Surg.* 72(2): 268, 1983.

Dinner, M.I. and Dowden, R.V. "The value of the anterior rectus sheath in the transverse abdominal island flap." *Plast. Reconstr. Surg.* 72(5): 724, 1983.

Dinner, M.I. and Dowden, R.V. "The L-shaped combined vertical and transverse abdominal island flap for breast reconstruction." *Plast. Reconstr. Surg.* 72(6): 894, 1983.

Dinner, M.I., Dowden, R.V., and Scheflan, M. "Refinements in the use of the transverse abdominal island flap for postmastectomy reconstruction." *Ann. Plast. Surg.* 11(5): 362, 1983.

Dinner, M.I. and Hartrampf, C.R., Jr. "Re: Drever: lower abdominal transverse rectus abdominis myocutaneous flap for breast reconstruction (letter)." *Ann. Plast. Surg.* 11(5): 453, 1983.

Dinner, M.I., Labandter, H.P., and Dowden, R.V. "The role of the rectus abdominis myocutaneous flap in breast reconstruction." *Plast. Reconstr. Surg.* 69(2): 209, 1982.

Drever, J.M. "The epigastric island flap." *Plast. Reconstr. Surg.* 59: 343, 1977.

Drever, J.M. "Total breast reconstruction." *Ann. Plast. Surg.* 7: 54, 1981.

Drever, J.M. "The lower abdominal transverse rectus abdominis myocutaneous flap for breast reconstruction." *Ann. Plast. Surg.* 10(3): 179, 1983.

Drever, J.M. "Letter to the editor. Re: Dinner et al: refinements in use of transverse abdominal island flap." *Ann. Plast. Surg.* 11(5): 453, 1985.

Drever, J.M. and Hodson-Walker, N. "Immediate breast reconstruction after mastectomy using a rectus abdominis myodermal flap without an implant." *Can. J. Surg.* 25(4): 429, 1982.

Drever, J.M. and Hodson-Walker, N. "Closure of the donor defect for breast reconstruction with rectus abdominis myocutaneous flaps." *Plast. Reconstr. Surg.* 76(4): 558, 1985.

Elliot, L.F. and Hartrampf, C.R., Jr. "Tailoring of the new breast using the transverse abdominal island flap." *Plast. Reconstr. Surg.* 72(6): 887, 1983.

Gandolfo, E.A. "Breast reconstruction with a lower abdominal myocutaneous flap." *Br. J. Plast. Surg.* 25: 452, 1982.

Georgiade, G.S., Voci, V.E., Riefkohl, R., and Scheflan, M. "Potential problems with the transverse rectus abdominis myocutaneous flap in breast reconstruction and how to avoid them." *Br. J. Plast. Surg.* 37: 121, 1984.

Giampapa, V., Keller, A., Shaw, W.W., and Colen, S.R. "Pelvic floor reconstruction using the rectus abdominis muscle flap." *Ann. Plast. Surg.* 13(1): 56, 1984.

Hartrampf, C.R., Jr. *Transverse Abdominal Island Flap Technique for Breast Reconstruction after Mastectomy*. Baltimore: University Park Press, 1984.

Hartrampf, C.R., Jr. "Abdominal wall competence in transverse abdominal island flap operations." *Ann. Plast. Surg.* 12(2): 139, 1984.

Hartrampf, C.R., Jr., Scheflan, M., and Black, P.W. "Breast reconstruction with a transverse abdominal island flap." *Plast. Reconstr. Surg.* 69(2): 216, 1982.

Hester, T.R., Jr., Nahai, F., Beegle, P.E., and Bostwick, J., III. "Blood supply of the abdomen revisited, with emphasis on the superficial inferior epigastric artery." *Plast. Reconstr. Surg.* 74(5): 657, 1984.

Hueston, J.T. "The evolution of breast reconstruction after mastectomy for cancer." *Aust. N.Z. J. Surg.* 49(5): 527, 1979.

Lejour, M. and De May, A. "Experience with 33 epigastric rectus flaps in breast reconstruction." *Handchir. Mikrochir. Plast. Chir.* 15(4): 257, 1983.

Logan, S.E. and Mathes, S.J. "The use of a rectus abdominis myocutaneous flap to reconstruct a groin defect." *Br. J. Plast. Surg.* 37: 351, 1984.

Kaufman, T., Hurwitz, D.J., Boehnke, M., and Futrell, J.W. "The microcirculatory pattern of the transverse-abdominal flap: a cross-sectional xerographic and CAT scanning study." *Ann. Plast. Surg.* 14(4): 340, 1985.

McCraw, J.B. and Dibbell, D.G. "Experimental definition of independent myocutaneous vascular territories." *Plast. Reconstr. Surg.* 60: 212, 1977.

McCraw, J.B., Dibbell, D.G., and Carraway, J.H. "Clinical definition of independent myocutaneous vascular territories." *Plast. Reconstr. Surg.* 60: 341, 1977.

Milloy, F.J., Anson, B.J., and McAfee, D.K. "The rectus abdominis muscle and the epigastric arteries." *Surg. Gynecol. Obstet.* 122: 293, 1960.

Parkash, S. and Palepu, J. "Rectus abdominis myocutaneous flap: clinical experience with ipsilateral and contralateral flaps." *Br. J. Plast. Surg.* 70(2): 68, 1983.

Parkash, S. and Ramakrishnan, K. "A myocutaneous island flap in the treatment of a chronic radionecrotic ulcer of the abdominal wall." *Br. J. Plast. Surg.* 33: 138, 1980.

Pennington, D.G., Lai, M.F., and Pelly, A.D. "The rectus abdominis myocutaneous free flap." *Br. J. Plast. Surg.* 33: 277, 1980.

Psillakis, J.M., Woisky, R., and Saracut, G. "Rectus abdominis deepithelialized musculocutaneous island flap as a silicone substitute in breast reconstruction." *Ann. Plast. Surg.* 10(6): 492, 1983.

Robbins, T.H. "Rectus abdominis myocutaneous flap for breast reconstruction." *Aust. N.Z. J. Surg.* 49(5): 527, 1979.

Robbins, T.H. "Breast reconstruction using a rectus abdominis musculocutaneous flap: 5 yr. follow-up." *Aust. N.Z. J. Surg.* 34(2): 286, 1981.

Robbins, T.H. "Post-mastectomy breast reconstruction using a rectus abdominis musculocutaneous island flap." *Br. J. Plast. Surg.* 34(2): 286, 1981.

Scheflan, M. "Rectus abdominis myocutaneous flaps (letter)." *Plast. Reconstr. Surg.* 72(5): 737, 1983.

Scheflan, M. and Dinner, M.I. "The transverse abdominal island flap. Part I. Indications, contraindications, results, and complications." *Ann. Plast. Surg.* 10(1): 24, 1983.

Scheflan, M. and Dinner, M.I. "The transverse abdominal island flap. Part II. Surgical technique." *Ann. Plast. Surg.* 10(2): 120, 1983.

Shaw, W.W. "Breast reconstruction by superior gluteal microvascular free flaps without silicone implants." *Plast. Reconstr. Surg.* 72(4): 490, 1983.

Slavin, S.A. "The rectus abdominis myocutaneous flap: observation and refinements (letter)." *Plast. Reconstr. Surg.* 71(2): 280, 1983.

Smith, P.J., Foley, B., McGregor, I.A., and Jackson, I.T. "The anatomical basis of the groin flap." *Plast. Reconstr. Surg.* 49: 41, 1972.

Tai, Y. and Hasegawa, H. "A transverse abdominal flap for reconstruction after radical operations for recurrent breast cancer." *Plast. Reconstr. Surg.* 53(1): 52, 1974.

Taylor, G.I., Corlett, R.J., and Boyd, J.B. "The extended deep inferior epigastric flap: a clinical technique." *Plast. Reconstr. Surg.* 72(6): 751, 1983.

Taylor, G.I., Corlett, R.J., and Boyd, J.B. "The versatile deep inferior epigastric (inferior rectus abdominis) flap." *Br. J. Plast. Surg.* 37: 330, 1984.

Vasconez, L.O., Grotting, J.C., Calderon, W., and Mathes, S.J. "Reconstruction of the breast: where do we fall short? An evolution of ideas." *Am. J. Surg.* 148(1): 103, 1984.

Vasconez, L.O., Psillakis, J., and Johnson-Giebeik, R. "Breast reconstruction with contralateral rectus abdominis myocutaneous flap." *Plast. Reconstr. Surg.* 71(5): 668, 1983.

Webster, D.J. and Hughes, L.E. "The rectus abdominis myocutaneous island flap in breast cancer." *Br. J. Plast. Surg.* 70(2): 71, 1983.