McCraw and Arnold's Atlas of Muscle and Musculocutaneous Flaps

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VERTICAL RECTUS

ANATOMICAL CONSIDERATIONS

Surface Markings

The lateral margins of the two rectus abdominis muscles are easily palpated in a thin person. This is best done by having the patient simultaneously raise the legs and forcibly flex the neck while in a supine position. Only the portion of the muscle which extends onto the chest wall is difficult to palpate.

Origin and Insertion

The rectus abdominis muscle inserts into the pubic tubercle and the pubic crest. It originates over a broad area of the chest wall which encompasses the cartilages of the sixth, seventh, and eighth ribs. Laterally the muscle has an important relationship to the fascial confluence of the anterior and lateral abdominal wall musculature at the semilunaris ligament. Medially the muscle is loosely attached to the linea alba. The primary function of the rectus abdominis muscle is in assisting torso flexion. The loss of one muscle is seldom functionally detectable, but the loss of both muscles can result in some weakness of "pelvic tilt" in the supine position.

Adjacent muscles

The paired rectus abdominis muscles are the major vertically oriented muscles of the abdominal wall. They are partially fused to the origins of the pectoralis major and serratus anterior muscles superiorly. They share fascial attachments with the external and internal oblique muscles laterally and are contiguous with the puborectalis muscles inferiorly.

Vascular Pattern

The deep inferior epigastric artery arises from the common femoral artery and obliquely transverses the posterior undersurface of the rectus abdominis muscle. This is the dominant vessel of the rectus muscle and it will reliably supply the entire muscle. Although there is a vascular "watershed" between the superior and inferior epigastric systems, these vascular connections are seldom visible on the posterior surface of the muscle.

The superior epigastric artery branches from the internal mammary artery and passes between the xiphoid and the eighth rib cartilage on the undersurface of the rectus abdominis muscle. The superior vessels will reliably supply the upper two-thirds of the muscle, extending to a point approximately halfway between the pubis and umbilicus. The "watershed" between the superior and inferior deep epigastric systems occurs in the central portion of the muscle at a point near the umbil-

icus. The deep inferior epigastric vessels are easily visualized on the undersurface of the muscle throughout its course, while the smaller superior epigastric vessels are seen only for a distance of approximately five centimeters distal to the chest wall margin. Although the deep inferior epigastric artery is clearly the dominant vascular system, a significant secondary contribution is made by the posterior perforating vessels which accompany the eighth through the twelfth sensory and motor nerves to the rectus abdominis muscle. These deep perforating vessels penetrate the posterior fascial sheathe and enter the rectus abdominis muscle in its posterior midline. Even though these posterior perforating vessels are viewed as a minor system, they can maintain the viability of the entire muscle in the absence of both the superior epigastric and the deep inferior epigastric vessels. For this reason the muscle cannot necessarily be considered to have been "delayed" if only one or the other of these major systems has been interrupted. There is also a minor contribution made by perforating vessels which pass directly from the internal mammary artery into the proximal portion of the rectus abdominis muscle on the chest wall. The viability of the superiorly based flap is probably enhanced by leaving the rectus abdominis muscle attached to the chest wall because of these direct thoracic branches from the internal mammary vessels. For this reason it is safer simply to divide the medial and lateral fascial attachments of the muscle to the chest wall to improve upward mobility rather than to elevate the muscle totally away from the chest wall. The lower costal cartilages can also be removed for this same purpose, but this has been employed only on a few occasions.

Motor Nerve

Intercostal nerves five through twelve.

Sensory Nerves

Intercostal nerves five through twelve.

USES

The superiorly based vertical rectus abdominis myocutaneous flap is generally considered as a secondary option for lower chest wall and sternal defects and for reconstruction of the breast following mastectomy. Since its rotation point is near the midline, comparable coverage is provided for either the ipsilateral or the contralateral lower chest wall. The standard vertical myocutaneous flap will reach the jugular notch and a point approximately five centimeters from the apex of the axilla. The standard Hartrampf flap has a similar arc of

rotation, but it provides a significantly larger volume of tissue.

The inferiorly based rectus abdominis myocutaneous flap is most commonly used for large defects of the lateral abdomen, groin, and hip. It also has certain applications in massive surface defects of the perineum and in total vaginal defects. Ian Taylor has recently described a long inferiorly based "island" flap with a cutaneous segment which extends obliquely onto the chest wall. This radial extension further improves the arc of the inferior rectus abdominis flap and allows it to reach the midthigh.

REGIONAL FLAP COMPARISONS

Reconstruction of the upper two-thirds of the sternum and the central chest wall is usually accomplished by using the pectoralis major muscles either as "island" muscle flaps or as bilateral myocutaneous advancement flaps. The pectoralis major muscle is usually preferred over the vertical rectus abdominis flap for sternal defects because of its reliability, its ease of dissection, and its lesser donor site morbidity.

The lower one-third of the sternum and the adjacent chest wall is not always reached by either the pectoralis major or the latissimus dorsi muscles, even though both muscles may extend to the lower sternum. This is the usual reason for considering the vertical rectus abdominis flap for central chest defects. The transverse thoracoepigastric cutaneous flap can also be used in this situation, and its donor site can be primarily closed with wide undermining. The safety and the rotation point of the thoracoepigastric flap can be improved by including the upper portion of the rectus abdominis muscle with the thoracoepigastric skin as a compound flap. This particular upper horizontal configuration is applicable only to low chest wall defects because this "high" placement of skin limits the arc of rotation of the flap. The large anterior fascial donor defect is similar for both the vertical and the upper horizontal rectus abdominis myocutaneous flaps. It may be possible to close the fascial defect primarily, but it is preferable to use Prolene® mesh if the closure is at all tight.

For purposes of breast reconstruction the vertical rectus abdominis myocutaneous flap is compared to the lower transverse rectus abdominis (TRAM) flap. The TRAM flap is more malleable and easier to shape. The TRAM flap reconstruction seldom requires an implant. Because of the deficient horizontal projection, it is usually necessary to use an implant with the vertical rectus myocutaneous flap. In a markedly obese patient the vertical flap can provide a satisfactory breast reconstruction without an implant because the flap should have suffi-

cient bulk to give the desired projection. It is still difficult to obtain a result which is comparable to the Hartrampf procedure using the vertical rectus abdominis flap because shaping of the vertical "sandwich" of skin and rectus abdominis muscle is difficult. When either type of rectus abdominis myocutaneous flap is used to reconstruct the breast without an implant, the long-term result can be expected to be superior to the latissimus dorsi breast reconstruction.

The inferiorly based rectus abdominis flap can be used to resurface the perineum completely and must be compared with the known results using the bilateral gracilis myocutaneous flaps and the posterior fasciocutaneous flaps of the thigh. The much larger inferior rectus abdominis flap should not be viewed as only a "back up" flap to these other reliable flaps. It now should be primarily considered as a single flap of choice for certain massive perineal and groin defects because of its size, reliability, and accessibility. For smaller problems in the groin or lower abdomen either the rectus femoris or TFL flaps are routinely chosen.

In the lateral abdomen very few flaps are available for resurfacing large defects. The proximally based latissimus flap will not reach this area at all. The groin flap and the thoracoepigastric flaps will not reach the most lateral aspects of the abdomen. The primary flap for comparison to the inferiorly based rectus abdominis flap is the distally based latissimus dorsi flap which is much less reliable and provides a much smaller area of coverage.

The inferior rectus abdominis myocutaneous flap is also a convenient and reliable source of tissue for total vaginal reconstructions. It is logical to use this anatomically convenient flap for "high" pelvic defects, but a laparotomy is required for the inset of the flap. If a laparotomy is already planned, this disadvantage is not relevant. The reliability and bulk of an inferior rectus abdominis flap cannot be matched by the smaller and more fragile gracilis myocutaneous flaps.

DISADVANTAGES

The primary disadvantage of any rectus abdominis myocutaneous flap is related to the abdominal wall donor site because the inclusion of fascia with this composite flap is obligatory. The anterior fascia should not be closed primarily unless it is a relatively tension-free closure. Even then it is a reasonable consideration to reinforce the fascial closure with an "onlay" patch of Prolene® mesh. If the actual fascial defect is more than seven to eight centimeters in width it should probably be repaired with an end-to-end patch of Prolene® mesh.

The superiorly based vertical rectus flap is more easily elevated than the TRAM flap, but it is harder to

shape and usually requires a Silastic® implant for breast reconstruction. It is a reasonable method of breast reconstruction in the markedly obese patient, but the result will not be comparable to the TRAM flap reconstruction.

The inferiorly based rectus abdominis flap is quite reliable and will carry all of the skin overlying the muscle. One cannot depend on carrying the cutaneous portion of the superiorly based flap to the level of the pubis without a prior "delay." When the common femoral vessels are injured it can be presumed that the deep inferior epigastric vessels will also be injured. In this situation a contralateral rather than an ipsilateral flap should be chosen.

ADVANTAGES

The very reliable inferiorly based rectus abdominis flap provides massive amounts of coverage for the difficult areas of the lower quadrants of the abdomen, the groin, and the perineum. The superiorly based flap provides excellent lower chest wall and lower sternal coverage. Its generous size allows it to be used to resurface the entire sternum. The midline abdominal skin incision can usually be closed without any undermining whether the vertically oriented flap is superiorly or inferiorly based. For some reason there seems to be less abdominal morbidity with the vertical rectus abdominis flap than there is with the lower horizontal rectus flap. This difference in morbidity is probably related to the extensive undermining of the skin over the rib cage which is necessary for the closure of the horizontal skin defect.

COMPLICATIONS, PITFALLS, AND DONOR SITE

Flap loss has been rare and the vertical rectus abdominis flap does not seem to be particularly "cold sensitive." The mechanics of elevating either the superior or the inferior vertical rectus abdominis flap are straightforward until one enters the region of the dominant vasculature. The superior vessels can be injured as they pass beneath the muscle at the margin of the costal cartilage because they are sometimes difficult to identify. It is possible to injure the inferior vessels, but they are easily visualized on the undersurface of the rectus abdominis muscle. If there is a question of vascular patency because of previous trauma or irradiation to the flap vessels, a selective angiogram is in order. Although massive irradiation of the dominant flap vessels can lead to the total loss of the flap this has not been observed. It is still prudent to choose the opposite, nonirradiated flap electively in order to avoid this eventuality.

The functional loss of one rectus abdominis muscle is usually not significant in the nonathletic person because the external and internal oblique muscles are so much stronger than the rectus abdominis muscles. This difference in muscular strength is also suggested as the reason why incisional hernias are more common with vertical incisions than with horizontal incisions. The remaining lateral abdominal wall muscles exert a stronger muscular "pull" on the incision than the rectus abdominis muscles. The development of a postoperative hernia should be a rare complication following the use of this flap if the anterior fascia is carefully repaired.
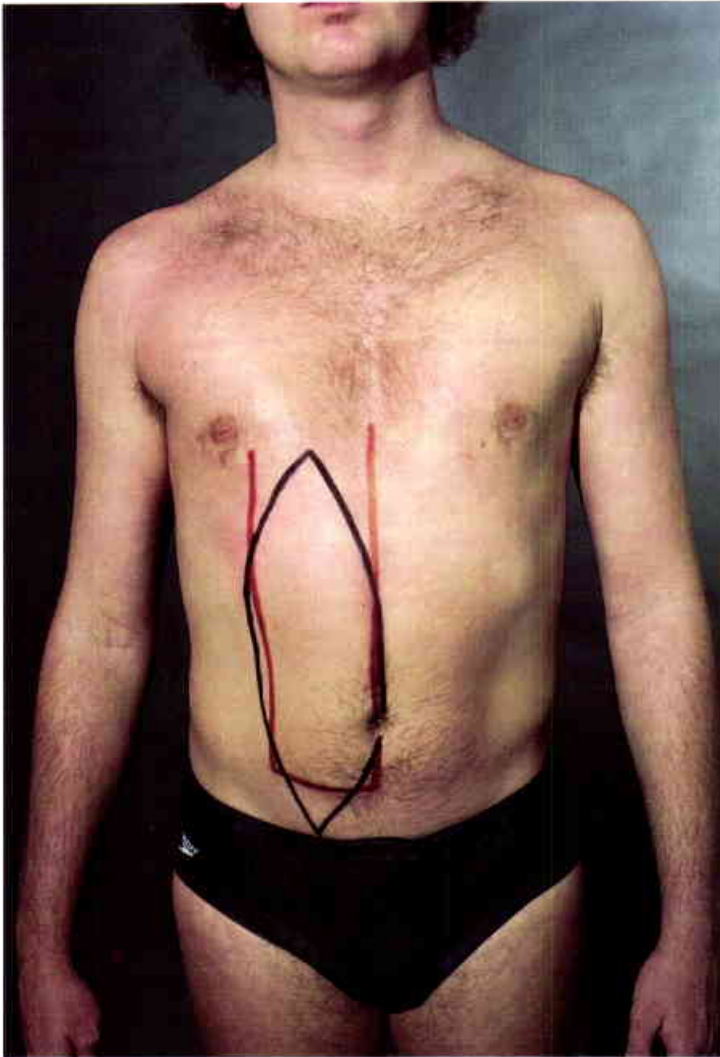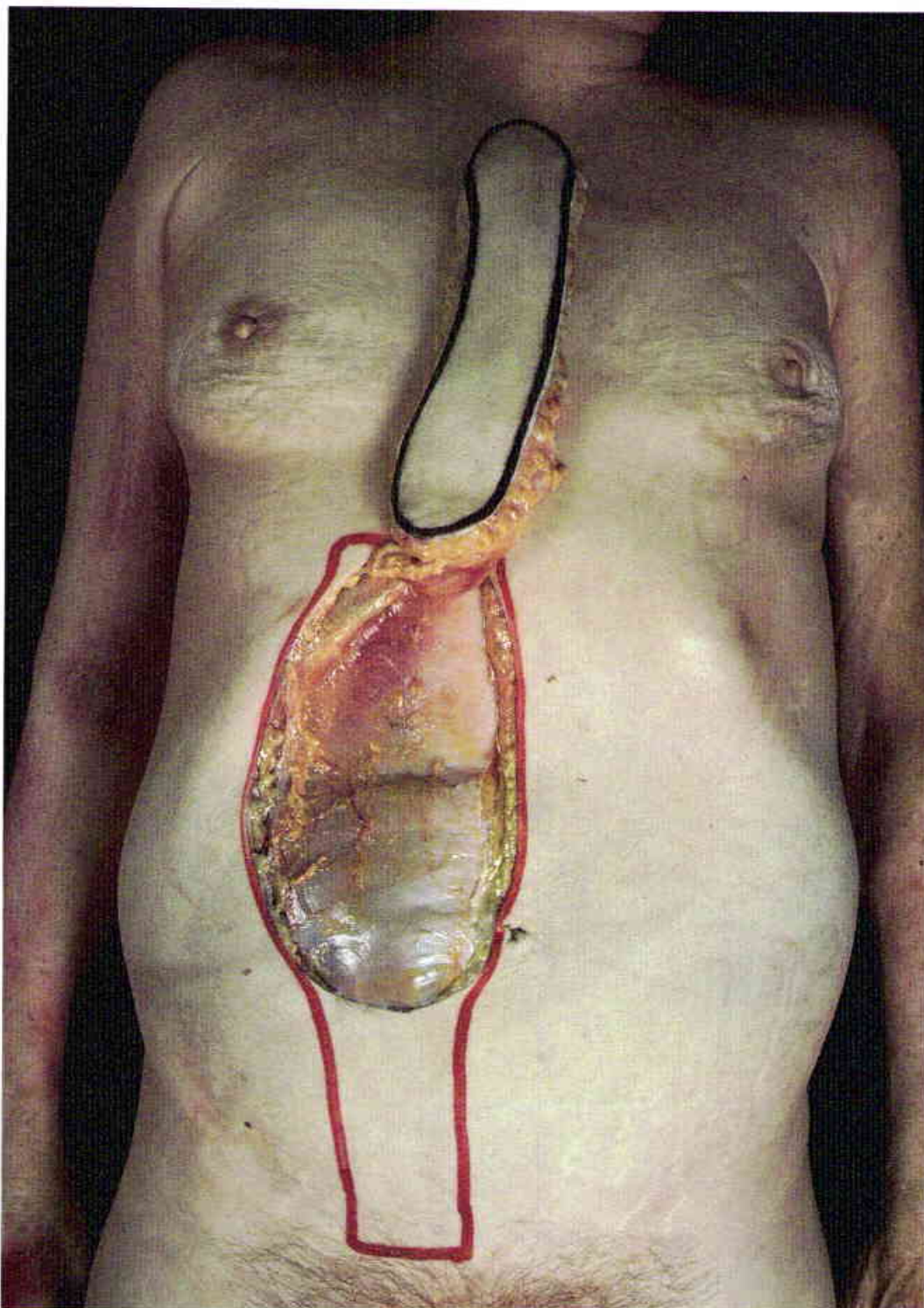
1

The primary territory of the vertical rectus abdominis myocutaneous flap is outlined. The superior vessels will reliably supply the upper two-thirds of the muscle.
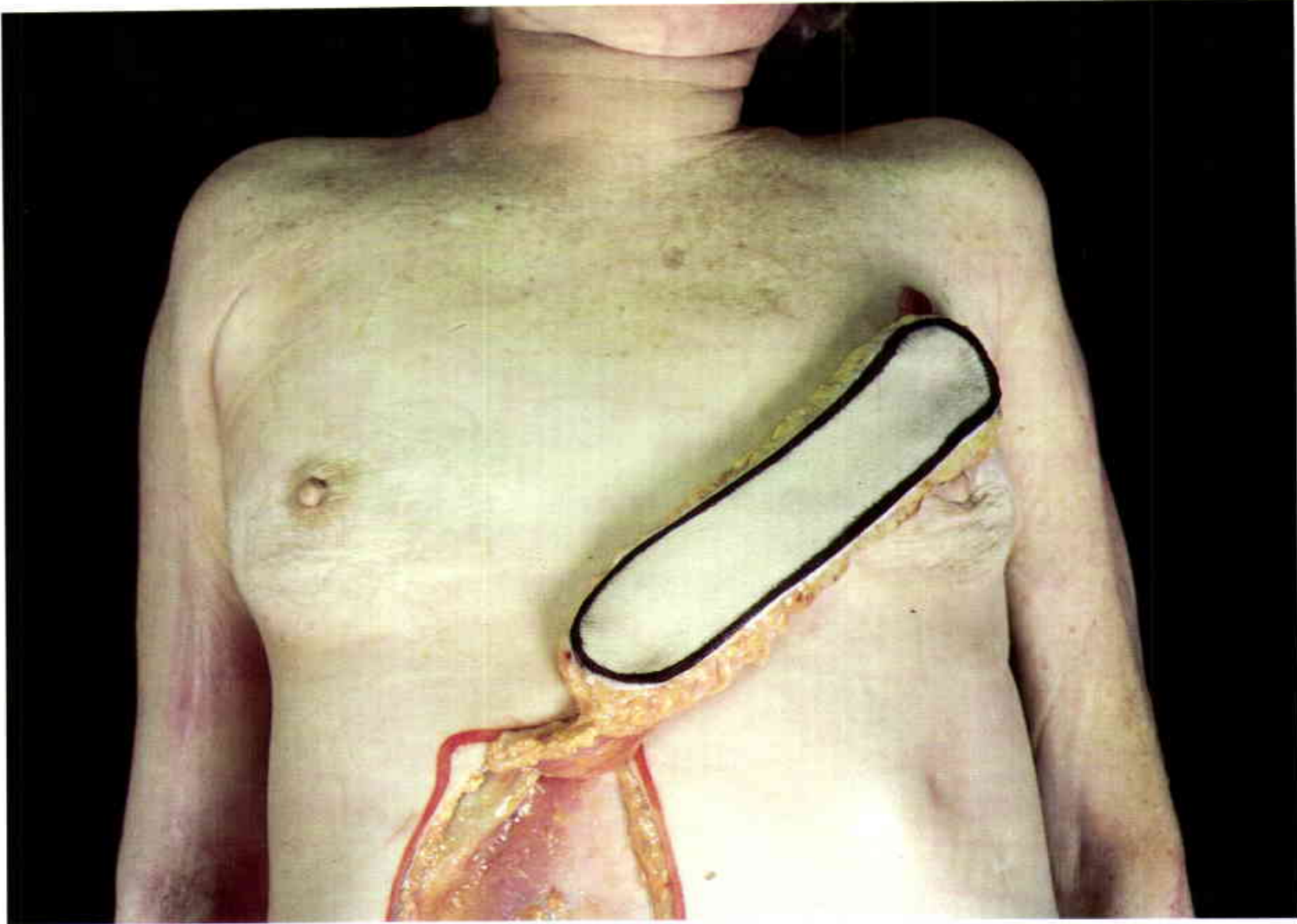

2

The rectus abdominis vascular territory provides the largest single myocutaneous flap in the body.

3

The primary territory of the vertical "island" rectus abdominis flap will easily cover the sternum. An anterior rectus fascial defect of this size will require reinforcement.
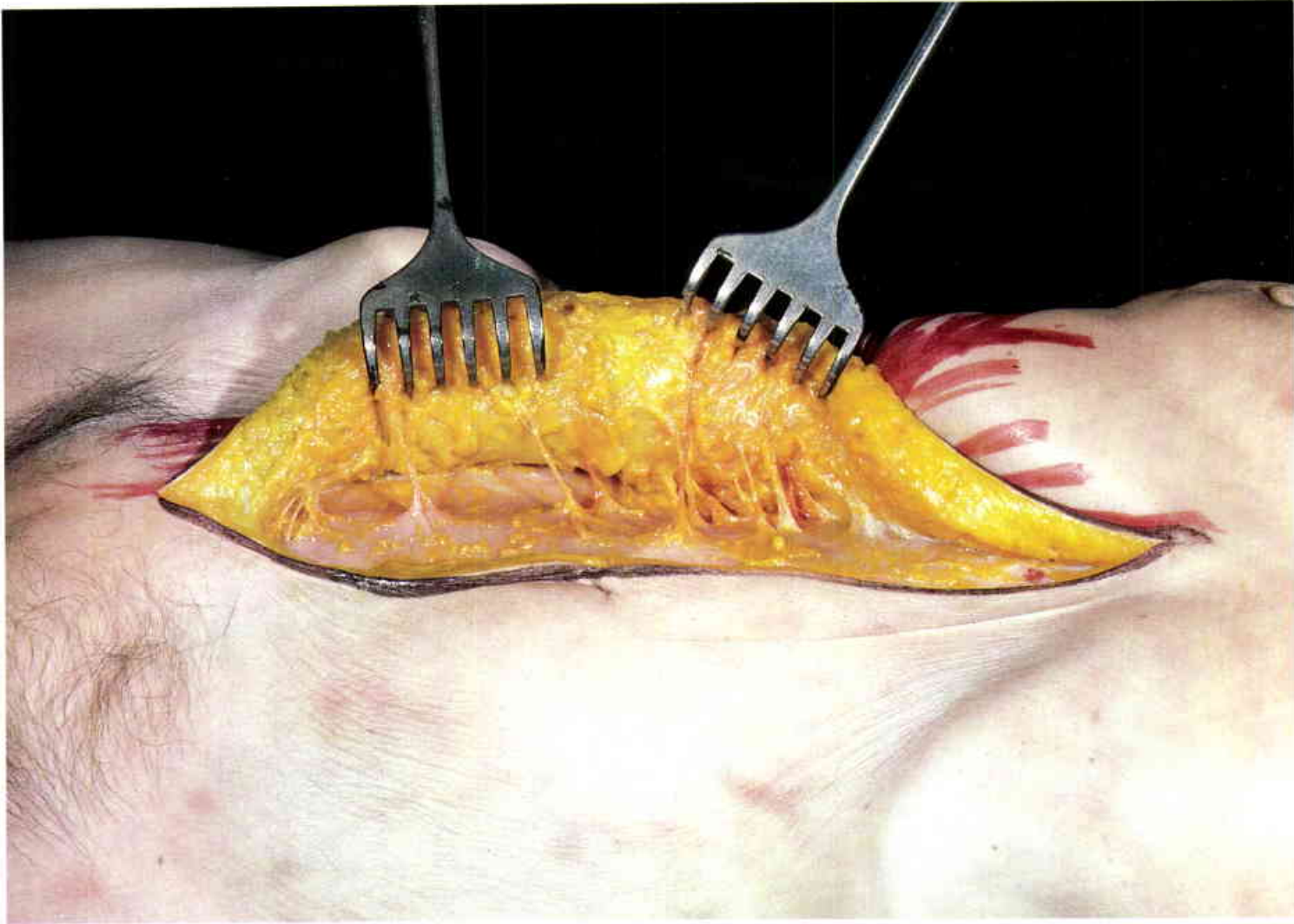
4

The vertical rectus flap will provide comparable coverage to either an ipsilateral or a contralateral lower chest wall defect.

5

The right rectus abdominis muscle is out-
lined in red. A midline abdominal inci-
sion will be used to retrieve an inferiorly
based muscle flap.

6

Exposure of the anterior rectus fascia.
Note that the rectus abdominis cutaneous
perforators are concentrated in the area
just above the umbilicus.

7

The anterior rectus fascia is retracted with sutures. The lateral border of the rectus abdominis muscle has been separated from the linea semilunaris ligaments.
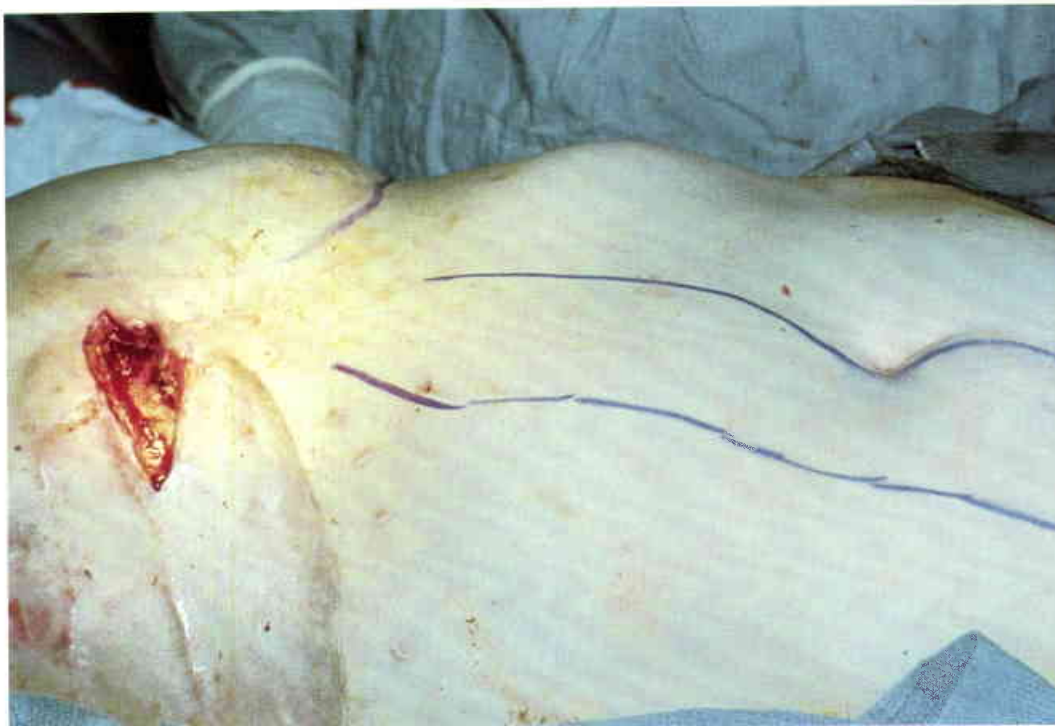
8

Rectus abdominis muscle flap rotated onto the thigh. The deep inferior epigastric vessels will reliably supply the entire rectus abdominis muscle.

9

The arc of the inferiorly based muscle flap includes the central perineum and the opposite groin. This anterior rectus fascial defect can be closed without any reinforcement.

10

Osteoradionecrosis of the sternum and costal cartilages in a fifty-six-year-old female who had undergone an extensive radical mastectomy and a skin graft. A vertical rectus abdominis flap is outlined because the latissimus dorsi muscle was devascularized. This case predates the description of the pectoralis "paddle." (Case of J.B. McCraw and L. Old)
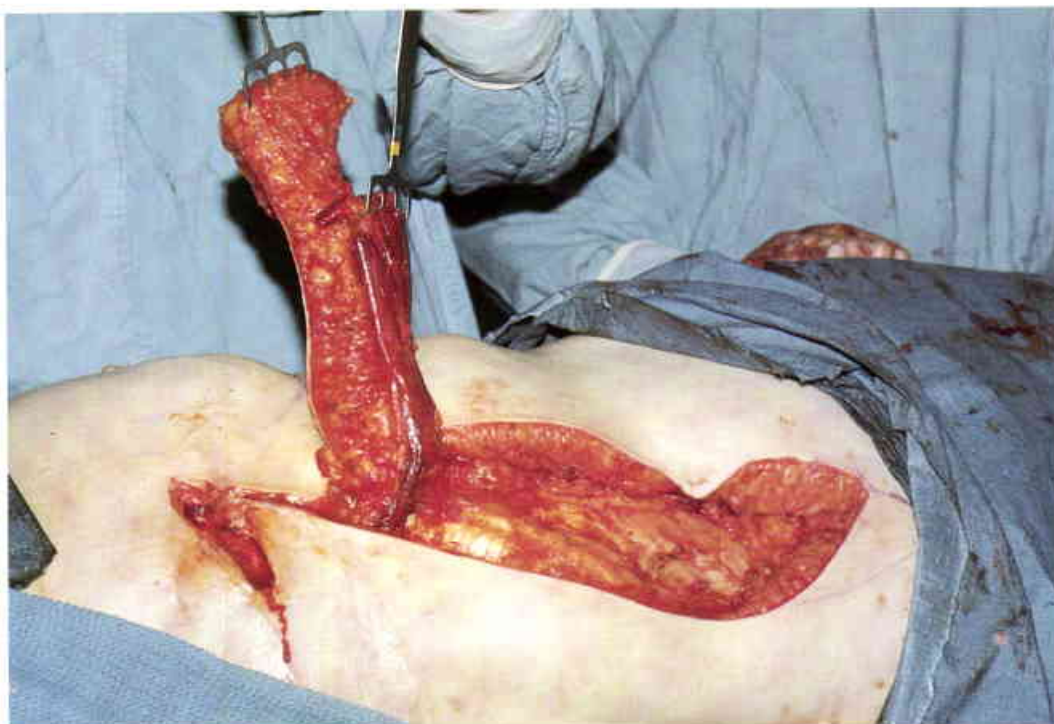
11

The ipsilateral rectus abdominis muscle was elevated to the level of the arcuate line. The flap was examined with fluorescein prior to the chest wall excision because of our concern about the effect of the irradiation on the internal mammary vessels. In some radiated cases we have obtained preoperative angiograms to determine the patency of the internal mammary vessels.

12

Once the viability of the flap was assured, the involved sternum and costal cartilages were excised. The flap has been converted into an "island" and rotated 180 degrees. The anterior fascial defect was primarily closed.

13

Healed flap and donor site at one year. The osteoradionecrosis has not recurred.

14

Infected median sternotomy six months following a coronary bypass procedure in a seventy-six-year-old female. The mediastinum had been irradiated thirty years earlier at the time of a right radical mastectomy. (Case of P.G. Arnold)

15

Forty-eight hours following the initial debridement and a "delay" of the rectus abdominis flap. The "delay" was done in an attempt to carry the distal tip of the flap, which was crossed by a lower transverse abdominal scar.
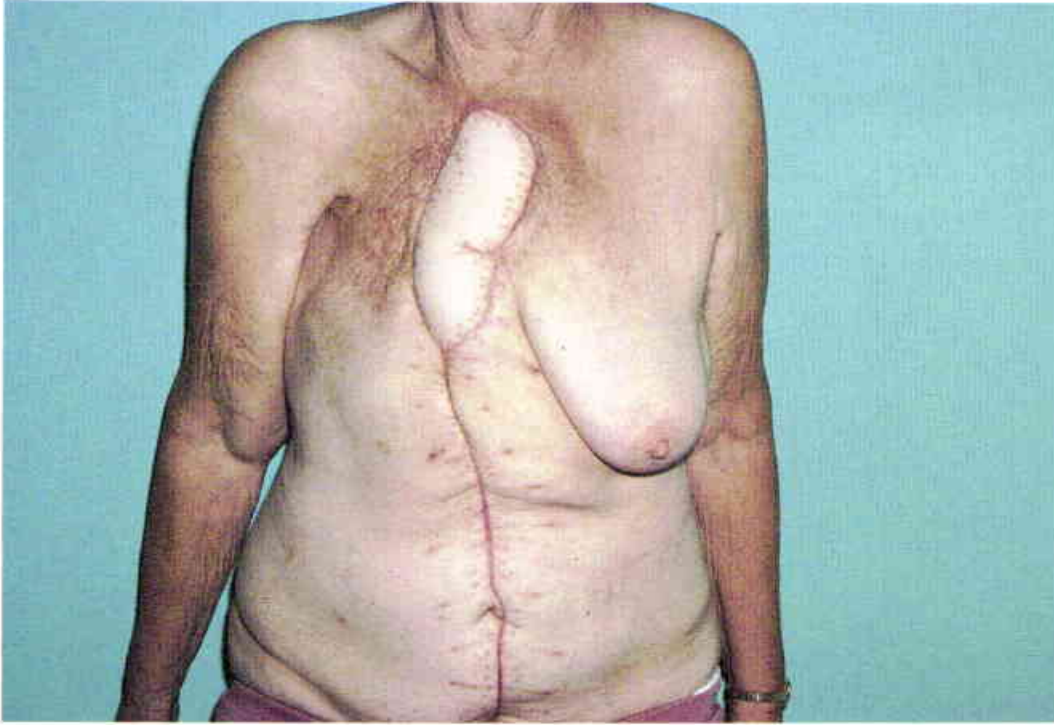
16

Six months postoperatively. Predictably the tip of the flap did not survive the ''delay,'' but it was not needed.

17

Inflammatory carcinoma of the right breast in a fifty-five-year-old female. A vertical rectus abdominis myocutaneous flap was chosen instead of a skin graft to facilitate early wound healing and postoperative irradiation therapy. (Case of J.B. McCraw and G. Hoffman)
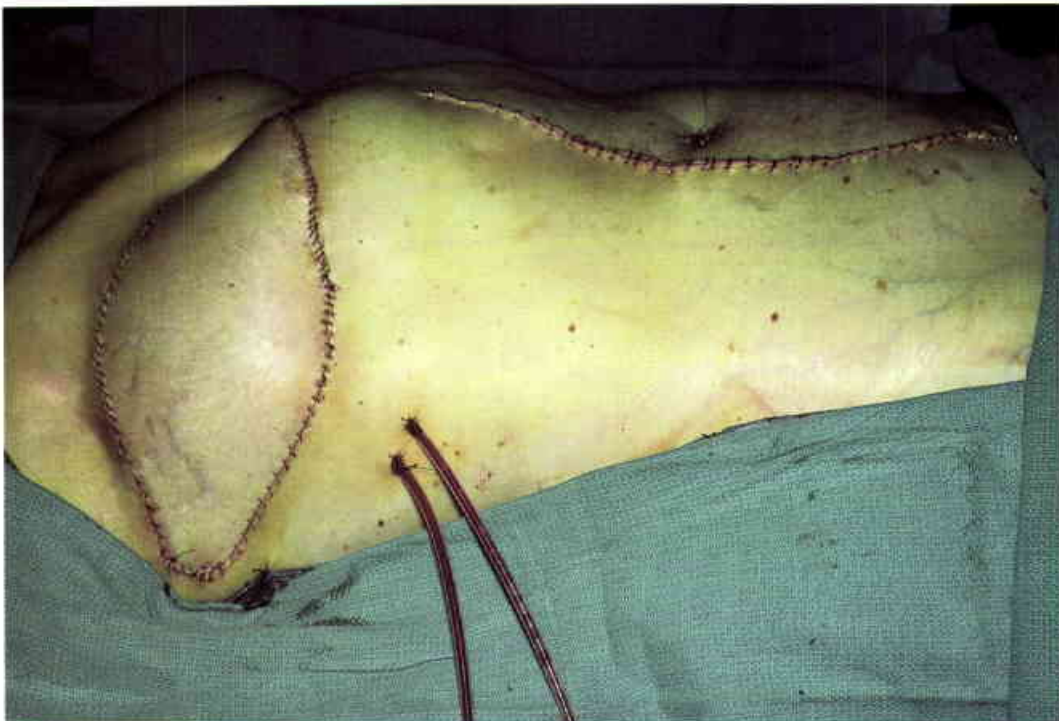
18

Inset of the vertical "island" rectus abdominis myocutaneous flap and primary closure of the abdominal defect. Note the visible fluorescence of the flap. Two operative teams were used to complete the mastectomy and reconstruction in less than two hours.

19

Irradiation therapy was begun in the second postoperative week. The quality of the skin replacement is much better than a skin graft. The patient has survived four years without a recurrence of the inflammatory carcinoma.

20
Twenty-three-year-old patient with prema-
lignant disease of the right breast. A ver-
tical rectus abdominis flap rather than a
horizontal rectus abdominis flap was cho-
sen for an immediate breast reconstruction
because of the lower abdominal scars.
(Case of J.B. McCraw and G. Hoffman)

21
Both breasts were extremely ptotic, and
the abdominal wall was flaccid.

22

A triangular skin flap was designed to replace the lost breast tissue. Both the skin and fascial defects of the abdomen were primarily closed.

23

One year following the immediate recon-
struction of the right breast and an oppo-
site breast augmentation and mastopexy.

24

Because of the extensive skin removal, a
small implant was also used in the right
breast reconstruction. The overall breast
contour and symmetry are better than the
preoperative condition.

25

The abdominal skin was closed by advancement with relocation of the umbilicus. The abdominal wall has remained stable without mesh reinforcement.
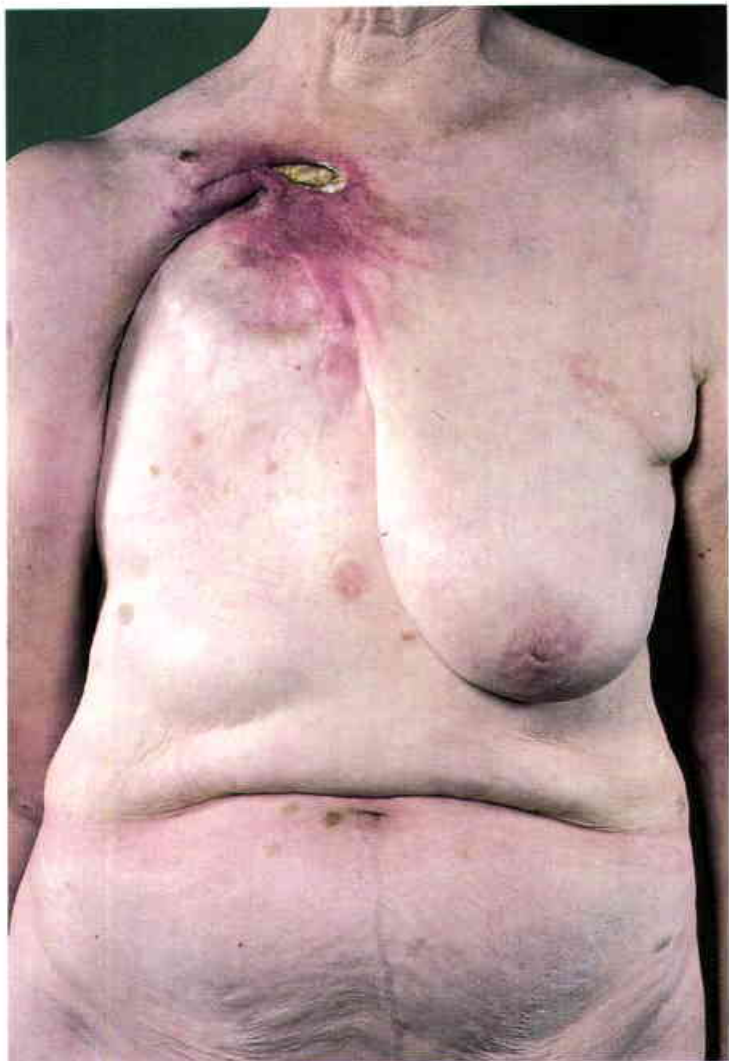
26

Seventy-year-old female who had undergone a right radical mastectomy and irradiation therapy twenty-five years earlier. An irradiation ulcer of the infraclavicular area was unresponsive to conservative therapy. A breakdown of the irradiated subclavian vessels was anticipated. (Case of P.G. Arnold)

27

Full-thickness excision of the upper chest wall and clavicle with preservation of the subclavian vessels.

28

A contralateral rectus abdominis myocutaneous flap is elevated. The patency of the left internal mammary vessel was determined by a preoperative angiogram.
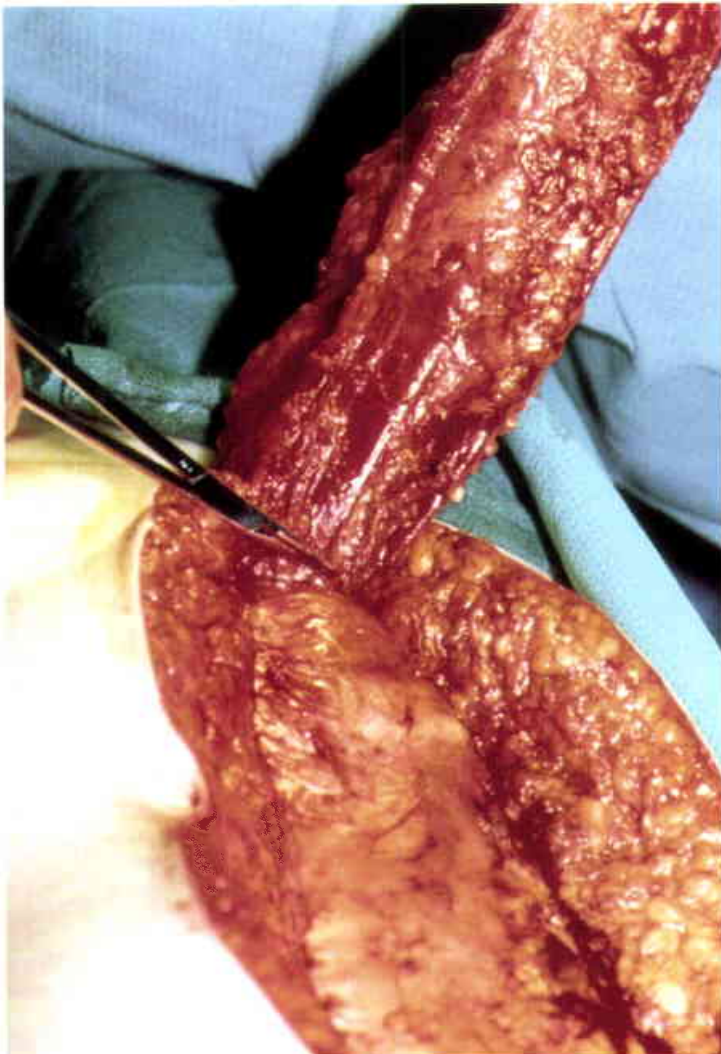

29

Appearance at four months. Note the extent of the supraclavicular coverage. The wound has remained healed for three years.
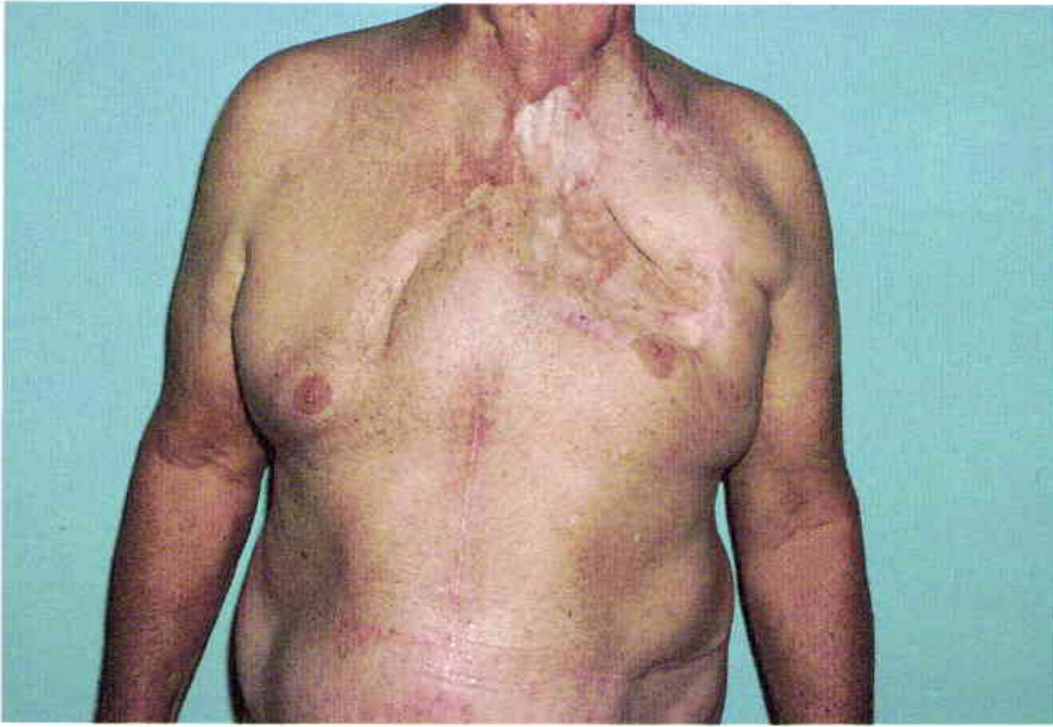
30

Fourth recurrence of a malignant histiocy-
toma which invaded the manubrium. Note
the skin graft on the left pectoralis major
muscle. (Case of P.G. Arnold)

31

The left rectus abdominis muscle was ele-
vated with the skin and subcutaneous fat,
but it was far too bulky. The skin was re-
moved from the flap and replaced as a
graft.

32

Skin-grafted rectus abdominis muscle flap
covering the upper sternum. Removal of
the manubrium did not cause any chest
wall instability.

33
Forty-nine-year-old female with an extensive irradiation ulcer of the upper chest wall and sternum. (Case of P.G. Arnold)

34
The chest wall resection included a portion of the sternum and three ribs.

35
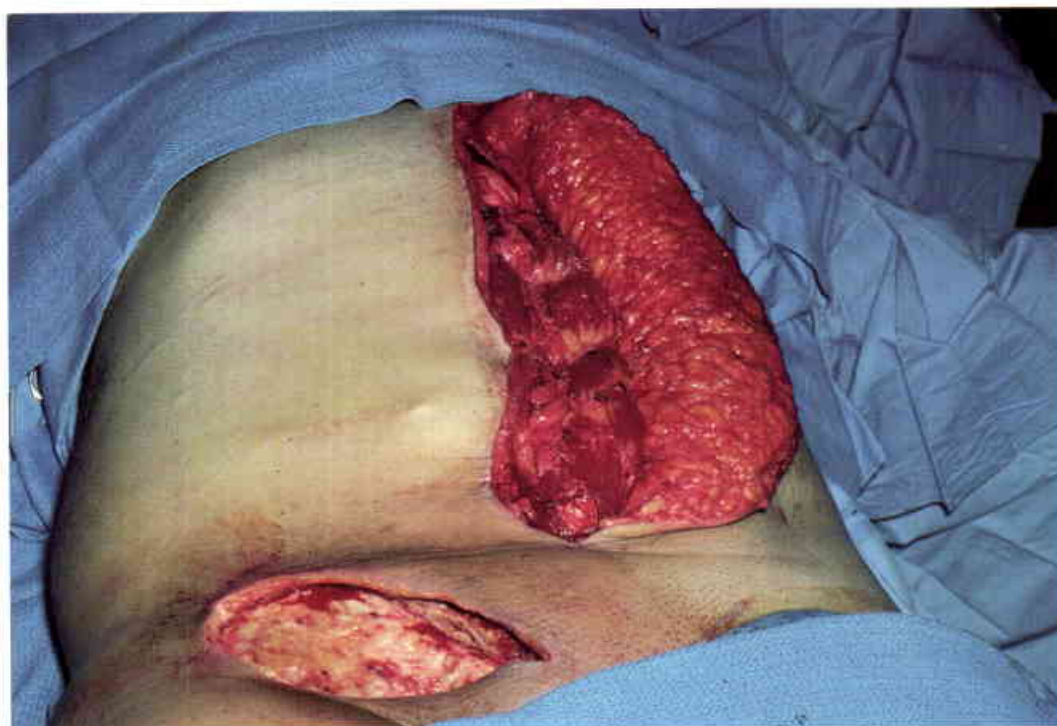The left rectus abdominis muscle was raised as an ''island'' muscle flap.

36
Appearance of the skin-grafted muscle flap closure of the chest wall at four months. The wound has remained healed for seven years.
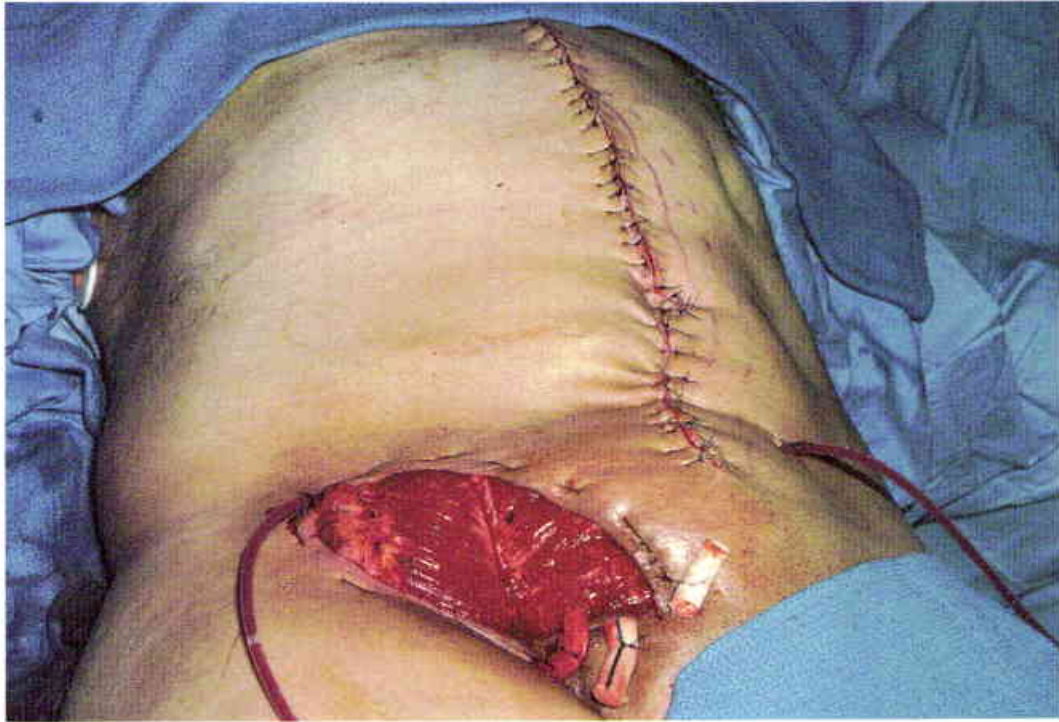
37

Fifty-one-year-old man with an extensive irradiation ulcer of the lower abdomen following a groin dissection. (Case of P.G. Arnold)

38

The contralateral rectus abdominis muscle was elevated on its inferior blood supply at the time of the debridement of the groin wound.

39

Inset of the left rectus abdominis muscle flap. Skin grafting was performed two days later.

40

Appearance at one year. The anterior rectus fascial defect was closed without reinforcement.

41

Shotgun wound of the left lower abdomen which destroyed the lower abdominal wall and the common femoral vessels. The right saphenous vein was used to reconstruct the left common femoral artery. Since the deep inferior epigastric vessels arise from the common femoral vessels, an ipsilateral rectus abdominis flap could not be used. (Case of J.B. McCraw and R. Russell)

42

A right inferiorly based rectus abdominis myocutaneous flap was used to provide muscle coverage for the femoral vessels and a fascial repair for the abdominal wall.

43

Healed flap at six weeks. The femoral
vessels have remained patent for four
years.

VERTICAL RECTUS

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