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EXTIRPATION OF TUMORS LOCATED NEAR THE THORACIC CAGE

A Method for Increasing the Margin of Healthy Tissue on the Deep Side of the Tumor

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When an aggressive tumor develops in a flat muscle near the thoracic cage the question may arise as to how achieve an adequate margin on the deep side of the tumor. This is especially the case if the tumor has recurred after a previous non-radical operation. A method is described by which the external thoracic fascia, the external intercostal musculature, and the periosteum on the external surface of the ribs can be included in the specimen as a continuous wall of healthy tissue on the deep side of the tumor. This technique has been used in 11 patients, 9 of whom had undergone one or more inadequate operations earlier. Eight patients had a malignant tumor, three an extra-abdominal desmoid. In one of the latter patients, in whom a recurrent tumor was adherent to rib periosteum, the method was unsuitable. In the other patients the method appears to have been adequate for local control of the tumor.

Key words: chest wall; four-quarter amputation; operative technique; soft tissue neoplasm; surgical treatment; thoracic neoplasms

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Malignant soft tissue tumors must be removed with a margin of healthy tissue on all sides. The quality of the margin decides how wide it must be. A tumor originating in a muscle tends to get an elongated shape growing as it does preferentially in the direction of the muscle fibers. Therefore, in the longitudinal planes of the muscle, the margin must be very wide, which often means removal of the whole muscle. In the transverse planes the margin need not be as wide providing the preformed fascial confinement of the tumor-bearing region is included in the specimen (Stener 1971). Even malignant soft tissue tumors tend to respect preformed fibrous walls for a long time (Simon & Enneking 1976).

Tumors located near the thoracic cage present special problems. For radical removal of a tumor developed for instance in one of the broad muscles originating on ribs and inserting on the upper limb it may not be sufficient to excise the implicated muscle, including its fascia. There is often a need for increasing the margin of healthy tissue being removed on the deep side of the tumor. This is especially the case if the tumor has recurred after a non-radical earlier operation.

The purpose of this paper is to describe

a method by which the external thoracic fascia, the external intercostal musculature, and the periosteum on the external surface of the ribs can be included in the specimen as a continuous wall of healthy tissue on the deep side of the tumor.

ANATOMY

The following description of relevant anatomical details is based mainly on Grant's Atlas of Anatomy (1962).

The thoracic cage is covered by the external thoracic fascia which extends from one rib to the next. The intercostal musculature can be divided into three layers (Figure 1). The *most superficial* consists of the external intercostal muscle (1) which extends from the costotransverse joints in the back to the costochondral junction in the front, where it is replaced by the external intercostal membrane (2). The fibers of this muscle and membrane are directed obliquely downwards-forwards. The *middle* layer consists of the internal intercostal muscle (3) which extends from the sternum in the front to the junction of the middle and posterior thirds of the ribs in the back, where it is replaced by the internal intercostal membrane (4). The fibers of this muscle and membrane are directed obliquely downwards-backwards. The *deepest* layer consists of the innermost intercostal muscle (5) which extends from the junction of the anterior and middle thirds of the ribs in the front to the angle of the ribs in the back. The fibers of the innermost intercostal muscle are directed obliquely downwards-backwards. The intercostal nerves and vessels run between the middle and the deepest layers; where the latter is lacking they run close to the pleural membrane.

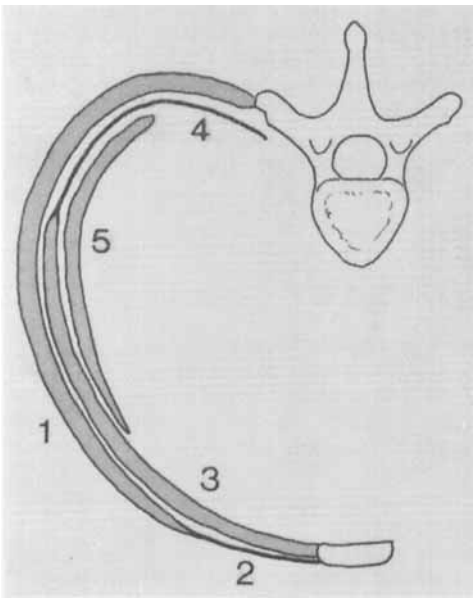

Figure 1. Schematic drawing representing the constituents of the three layers of intercostal structures. 1 = external intercostal muscle, 2 = external intercostal membrane, 3 = internal intercostal muscle, 4 = internal intercostal membrane, 5 = innermost intercostal muscle.

METHOD

When the thoracic cage has been exposed during the operation at a safe distance from the tumor the dissection is continued as illustrated in Figure 2. The periosteum of the rib chosen as the starting point for the dissection is incised along the border being most remote from the tumor site. It is then elevated as far as the insertion line of the external intercostal muscle and membrane on the opposite border. Once this muscle and membrane have been detached subperiosteally from the rib they are separated from the internal intercostal muscle and membrane as far as the next rib where they are again detached subperiosteally. The dissection is then carried on in this manner from rib to rib until the tumor region has been safely passed. In this way the external thoracic fascia, the external intercostal musculature, and the periosteum on the external surface of the ribs will be included in the specimen as a continuous wall of healthy tissue on the deep side of the tumor.

The separation of the external intercostal muscle and membrane from the internal ones is facilitated by the different fiber directions of these muscles and membranes. Because the fibers of the external intercostal muscle and membrane are directed obliquely downwards-forwards it is convenient when detaching this muscle and membrane from their rib insertions

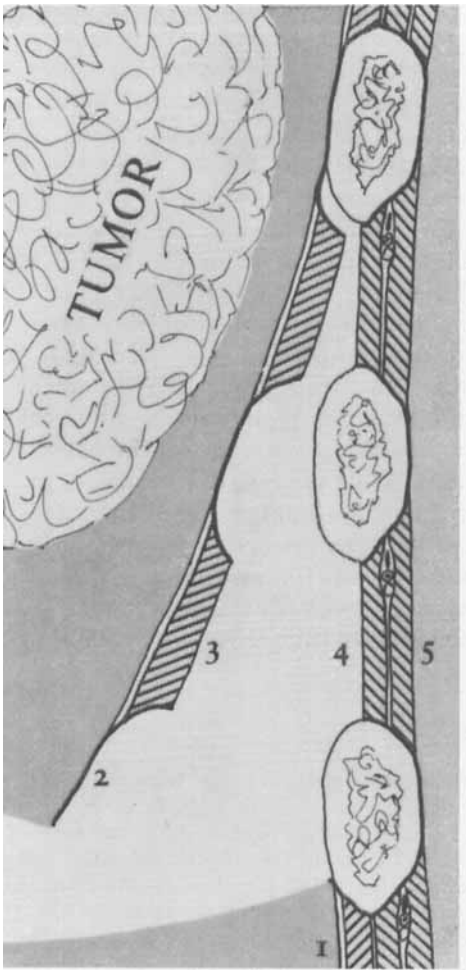

Figure 2. Schematic drawing demonstrating the method described for increasing the margin of healthy tissue being removed on the deep side of a tumor located near the thoracic cage. 1 = external thoracic fascia, 2 = periosteum of rib, 3 = external intercostal muscle, 4 = internal intercostal muscle, 5 = innermost intercostal muscle.

to proceed from behind forwards along the superior border of the rib and in the opposite direction along the inferior border. When making this dissection in the back it should be remembered that medial to the angle of the ribs, where the innermost intercostal muscle is lacking, the pleura comes next to the internal intercostal membrane.

CLINICAL MATERIAL

Since 1969 the technique described has been used for extirpation of a soft tissue tumor in 11 patients (Table 1). Their age ranged from 25 to 73 years. Eight patients had a malignant tumor, three a locally aggressive tumor (extra-abdominal desmoid). Nine patients had undergone one or more non-radical operations for the tumor before admission. Aspiration biopsy had indicated malignancy in the other two. None had signs of metastatic spread before operation.

The follow-up time varied between 12 and 82 months in nine patients; the remaining two were operated upon recently.

One patient (Case 3), operated upon for a recurrent malignant fibroxanthoma in the left axilla (extended interthoracoscapular amputation), died after 15 months with pulmonary metastases, but the surgical field remained free from tumor.

One patient (Case 6), operated upon after a non-radical removal of a malignant giant-cell tumor of soft parts in the back (operation similar to that illustrated below in Case 8), was apparently free from tumor at follow-up but has later developed pulmonary metastases.

One patient (Case 4), operated upon for a recurrence of an extra-abdominal desmoid below the left axilla, adherent to ribs, developed a new local recurrence after 30 months. A resection of the thoracic wall including the implicated ribs was then carried out and at follow-up 27 months after this operation the patient showed no signs of recurrence.

The remaining six patients followed up were all well without any signs of recurrence or metastatic spread.

ILLUSTRATIVE CASES

Case 8. A 64-year-old man had noticed a rapidly growing mass below the right scapular angle at the level of the eleventh rib. Under local anesthesia a tumor measuring $6 \times 4 \times 3$ cm was enucleated from the latissimus dorsi muscle. As it proved to be a pleomorphic liposarcoma the patient was referred for radical excision of the tumor region.

A rectangular incision of the skin was made at a minimum distance of 2.5 cm from the scar of the previous operation and two semicircular auxilliary incisions were made for wide exposure of the tumor region and to permit, later on, primary suture of the wound without undue tension (Figure 3 A). The specimen, removed in one piece, comprised the excised skin with underlying and surrounding subcutaneous fat

Table 1. Summary of clinical data on eleven patients operated upon using the described technique.

Case no.	Age	Sex	Histologic type	Site	Period of follow-up (months)	Previous surgery	Aspiration biopsy	Local recurrence	Metastasis
1	60	Male	Extra-abdominal desmoid	Pectoralis minor	82	—	+	—	—
2	41	Male	Pleomorphic liposarcoma	Pectoralis major	82	+	—	—	—
3	33	Male	Malignant fibroxanthoma	Latissimus dorsi	15 (died)	+	—	—	+
4	53	Male	Extra-abdominal desmoid	Serratus anterior	57	+	—	+	—
5	25	Female	Extra-abdominal desmoid	Pectoralis major	31	+	—	—	—
6	33	Male	Malignant giant-cell tumor of soft parts	Latissimus dorsi	24	+	—	—	+
7	49	Male	Lipoma-like liposarcoma	Latissimus dorsi	13	+	—	—	—
8	64	Male	Pleomorphic liposarcoma	Latissimus dorsi	12	+	—	—	—
9	73	Female	Malignant mesenchymoma	Erector spinae	12	—	+	—	—
10	54	Male	Malignant Schwannoma	Plexus axillaris	1	+	—	—	—
11	59	Male	Myxoid and lipoma-like liposarcoma	Between latissimus dorsi and serratus anterior	1	+	—	—	—

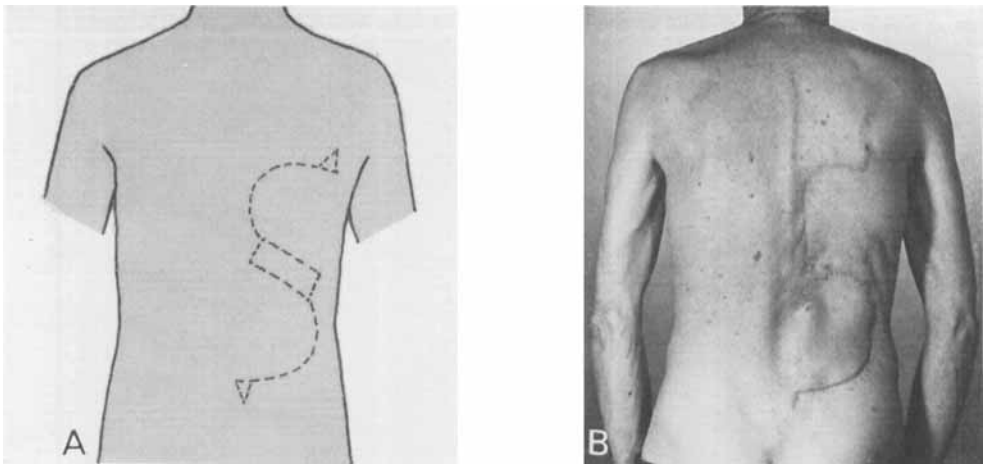

Figure 3. Case 8. A: *Skin incisions. See text.* B: *Patient 6 months after operation.*

(Figure 4 C), the latissimus dorsi, the serratus posterior inferior, the quadratus lumborum, most of the erector spinae and some of the abdominal muscles, and the periosteum of the four lowest ribs in continuity with the interlying external intercostal muscles (Figure 4 D). Figure 4 A shows the surgical field after removal of the specimen. Before the large S-formed wound (Figure 4 B) was sutured a small triangle of skin was excised at its upper and lower ends.

Histologic examination revealed that the specimen contained remnants of the tumor within the earlier operation field which, however, had been removed with an adequate margin of healthy tissue on all sides.

At follow-up 1 year after operation the patient was well without any signs of recurrence or metastases. The wound had healed nicely (Figure 3 B). He was not inconvenienced by the loss of musculature.

Comment

In this case, posteriorly, the external intercostal muscles were separated from the internal intercostal membranes (cf. Figure 1). Medial to the angle of the ribs care had to be taken not to damage the pleura underneath these membranes. An almost identical operation, in the same region, was done in Case 6.

Case 9. A 73-year-old woman had for a few weeks noticed a firm painless mass in her back. On examination an elongated tumor, whose size was estimated to be 13 × 9 × 5 cm, was found. It was located between the medial border of the left scapula and the spine. The long axis of the tumor had the same direction as the erector spinae muscle. Aspiration biopsy revealed a malignant mesenchymal tumor. A radical extirpation was planned.

The incision of the skin and the subcutaneous fat was made so that the biopsy track became included in the specimen with an ample margin. When the trapezius, the rhomboidei and the upper part of the latissimus dorsi muscles had been detached from the spinous processes it became clear that the tumor was free from the ribs; it appeared to have developed primarily in the erector spinae. This muscle was widely excised along with: on the posterior side, subcutaneous fat, parts of the trapezius, rhomboideus major and latissimus dorsi muscles; on the anterior side, the periosteum of four ribs in continuity with the interlying external intercostal muscles; and on the anteromedial side, vertebral periosteum including the posteriorly protruding part of the left transverse process of three vertebrae (Figure 5 C). Figure 5 A shows the surgical field after removal of the specimen, the deep side of which is shown in Figure 5 B. The tumor, which was never exposed during the operation, had been removed with an adequate margin of healthy tissue on all sides as revealed by serial sectioning of the specimen (Figure 5 D). The histopathologic diagnosis was malignant mesenchymoma.

At follow-up 1 year after operation the patient was well without any signs of recurrence or metastases.

Comment

This case illustrates how the described method of including rib, periosteum and external intercostal muscles in a tumor specimen can be combined with inclusion of vertebral periosteum and

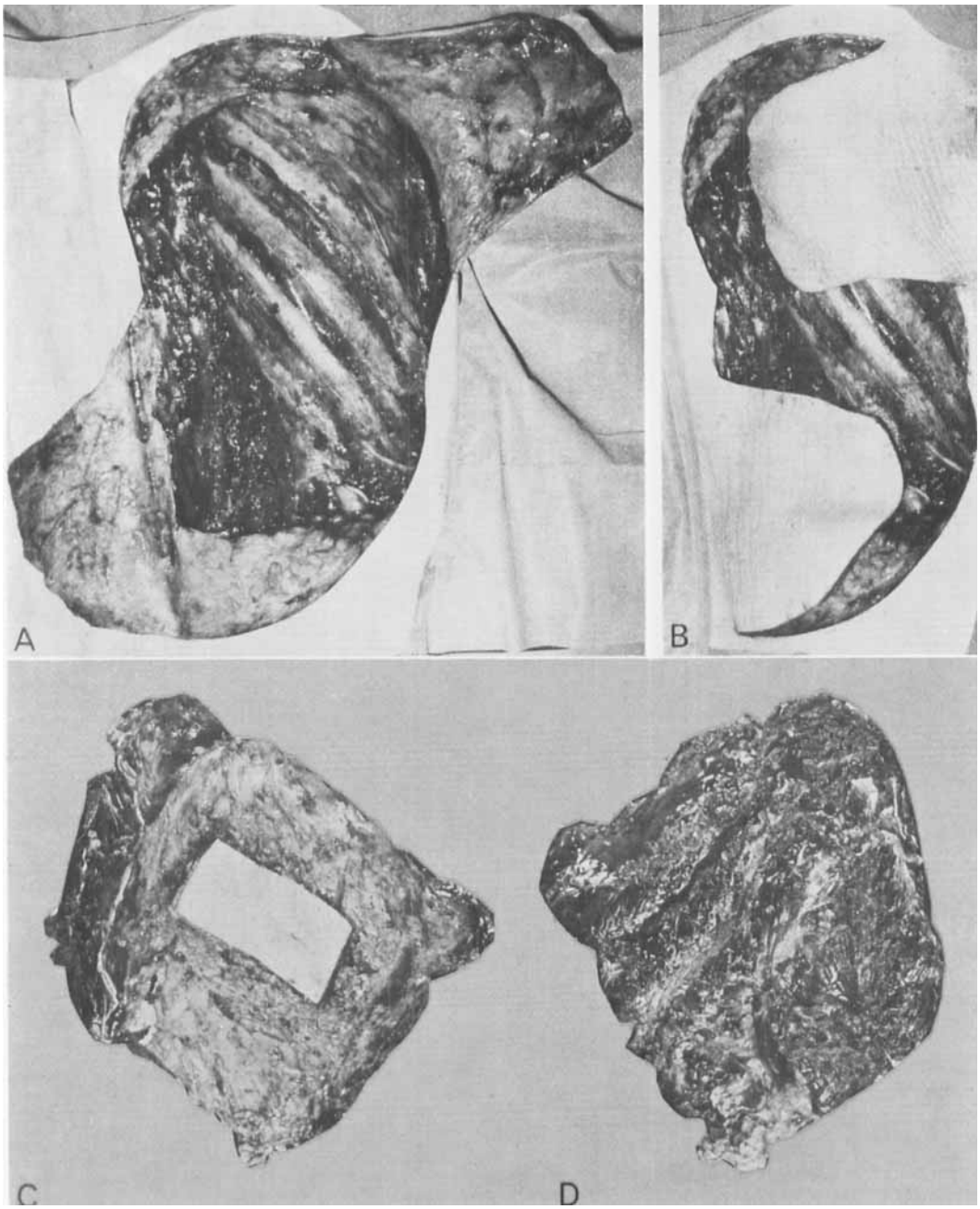

Figure 4. Case 8. Surgical field after removal of specimen (A) and before closure of wound (B). The specimen included a rectangular area of skin containing the scar and suture tracks after previous surgery (C) and, on the deep side, the periosteum of the four lowest ribs in continuity with the interlying external intercostal muscles (D).

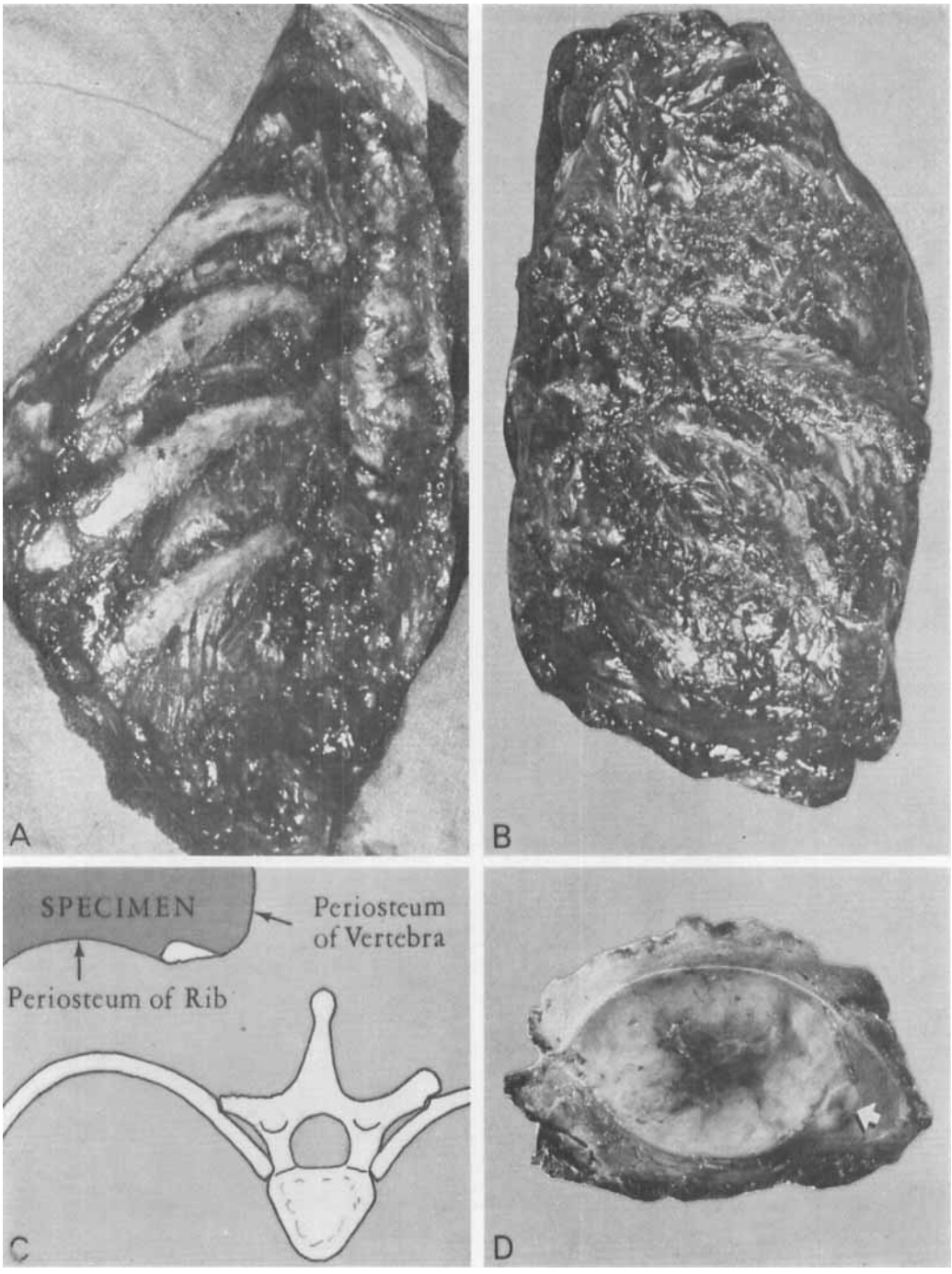

Figure 5. Case 9. A: *Surgical field after removal of specimen.* B: *Deep side of specimen.* C: *Schematic drawing showing that the specimen included costal and vertebral periosteum and the posteriorly protruding part of the left transverse vertebral processes.* D: *Transection of specimen. Deep margin: bottom, medial margin: right. Arrow indicates border between tumor and erector spinae.*

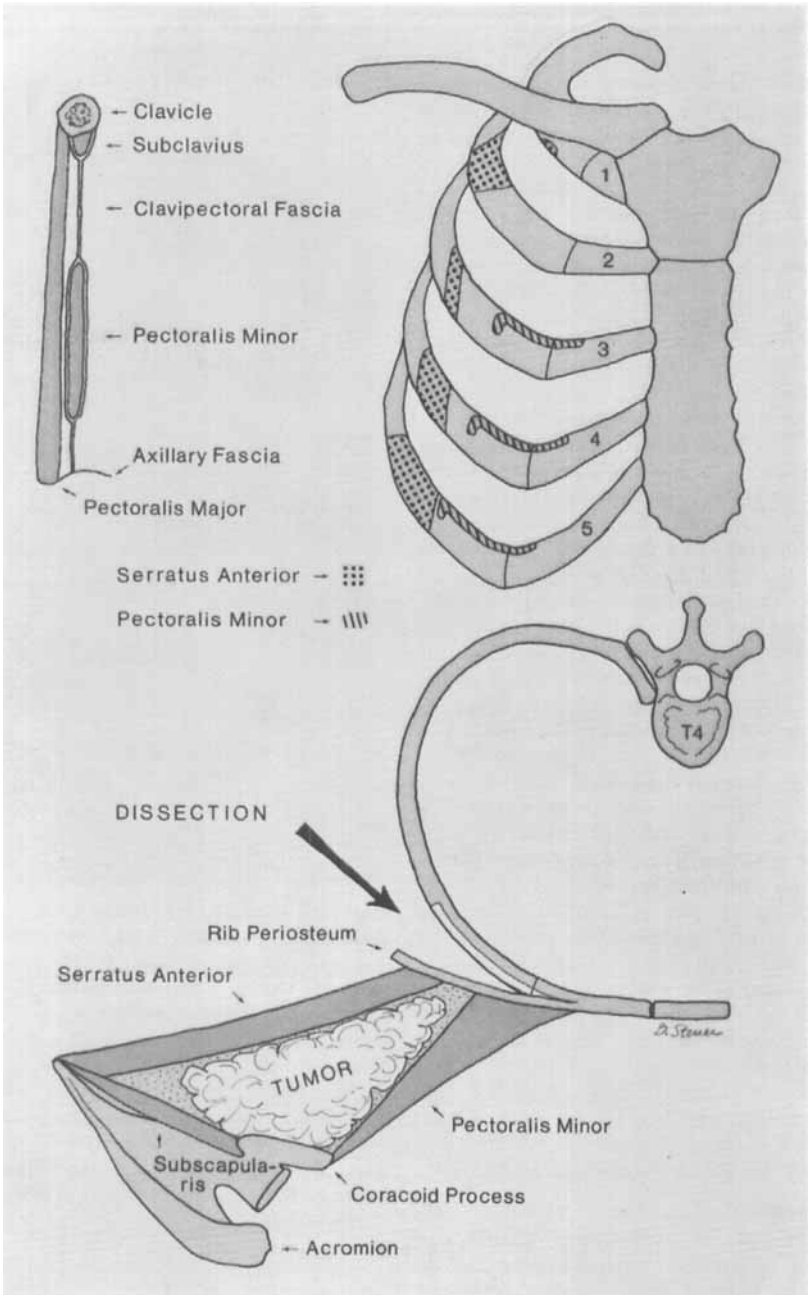

Figure 6. Case 10. Schematic drawings illustrating principle behind extended interthoracoscapular amputation (almost completed in bottom figure). Rib periosteum, in continuity with the external thoracic fascia and external intercostal muscles, is being included in the specimen within the field where the serratus anterior and the clavipectoral fascia (top left), including the subclavicus and pectoralis minor, are attached to the thoracic wall (top right). The room, in which the tumor grows, will thereby be removed unopened (cf. rib 4 in top right and bottom figures).

parts of the spine when the location of the tumor calls for this to be done.

Case 10. A 54-year-old man was admitted with a large recurrence of a malignant Schwannoma in the right axilla. He suffered severe pain and the arm, which was paralysed and edematous, was quite useless. Radiotherapy (6000 rad) had been given without much benefit. An extended interthoracoscapular amputation was performed. The extension beyond standard is illustrated in Figure 6. Instead of detaching the serratus anterior from the scapula and leaving it with the patient, this muscle was included in the specimen as it constituted the medial wall of the room occupied by the tumor. The anterolateral wall of this room was the clavipectoral fascia with the muscles it includes: the subclavius and pectoralis minor (top left in Figure 6), and the posterolateral wall was the subscapularis muscle. Between the lines along which the serratus anterior and the pectoralis minor are attached to the thorax (top right in Figure 6) the tumor-containing room was limited directly by the external thoracic fascia with underlying ribs and external intercostal muscles. So, in order to remove this room unopened and thereby increase the margin of healthy tissue being included in the specimen, the external thoracic fascia, the periosteum of the first, second, third and fourth ribs, and the external intercostal muscle and membrane of the first, second, third, and fourth intercostal spaces were removed within an area that included the rib attachments of the serratus anterior and pectoralis minor (Figure 7, cf. Figure 6 top right). The pectoralis major was also included in the specimen. The postoperative course was uneventful; the patient was able to leave the hospital after 4 days.

Macro- and microscopic study of the surgical specimen indicated that the tumor had been radically removed.

When last seen, 1 month after operation, the patient was apparently free from tumor. Being a Greek citizen, domiciled in Greece, he has not been available for later follow-up examination.

Comment

The same type of extended interthoracoscapular amputation was carried out in Case 3. In the standard type of "four-quarter" amputation (e.g. Moseley 1957) the serratus anterior is left with the patient on the thoracic wall. This is not adequate when the operation is done for a malignant tumor developing in the axilla, for instance, a leiomyosarcoma originating in the axillary vein or, as in Case 10, a malignant Schwannoma originating in the axillary nerve plexus. In such cases, the whole serratus anterior should be included in the surgical specimen, and an extra safety margin is obtained, without significant cost for the patient, by including rib periosteum and external intercostal muscles as described in Figure 6.

Figure 7. Case 10. Anterolateral aspect of thoracic wall after extended right interthoracoscapular amputation (cf. Figure 6). Horizontal arrows indicate the line anterior to which the external thoracic fascia, the periosteum of the four uppermost ribs, and the external intercostal muscle and membrane of the four uppermost intercostal spaces have been removed en bloc *with the specimen. The internal intercostal muscles have been exposed within this area. Notice the difference in fiber direction between the external and internal intercostals. Vertical arrow indicates the costochondral junction of the third rib (cf. Figure 6 top right).*

DISCUSSION

The described operative technique is indicated when an aggressive soft tissue tumor (malignant or only locally aggressive) develops within a flat muscle of the thoracic wall, especially if the tumor has

recurred or an extended excision is called for after a previous non-radical operation. The same technique can be used for increasing the margin when a four-quarter amputation is done (Cases 3 and 10). Nine of our eleven patients had previously been operated upon, only two underwent a primary operation.

The technique described should be used only when the tumor is mobile in relation to the ribs. The only local recurrence in our series occurred in a patient who underwent the operation for a recurrent extra-abdominal desmoid which was adherent to ribs (Case 4). In two patients, operated upon for recurrent tumors, pulmonary metastases occurred within 2 years, but no signs of local recurrence appeared. The fact that distant metastases develop does not indict the method used for local control of the tumor as long as the primary site remains free from recurrence (Bowden & Booher 1958).

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