

THE COSTAL MUSCULATURE. By THOMAS WALMSLEY, M.B.,  
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THE rib muscles are differentiated from the other muscles of the thoracic wall by a group of common characters, structural and functional. They represent the thoracic continuation of the abdominal muscular sheets, so that embryologically their derivation is alike; their mode of attachment to the skeleton is uniform, so that they are solely muscles of respiration; their innervation is through the anterior branches of the thoracic nerves; they have a marked tendency to a state of regression. The regression of these rib muscles is evident from their structure. The fleshy contracting part of each fibre is short, and completion is by a long tendinous part, indicating "the adaptation to a feeble amplitude of movement" (Cleland). In certain positions the sarcous part of the fibre may have undergone total regression, and the resulting representative structure is of a fascial nature. This is an emphasis of the fact that wherever fascia are well marked in the body, they represent, in major part, muscles (and their sheaths) which have not entirely lost their function. Possessing the enumerated features and constituting the costal musculature, there are recognised, in addition to the diaphragm, the

- M.m. serrati posteriores, superior et inferior.
- „ intercostales, externi et interni.
- „ levatores costarum.
- „ subcostalis et supracostalis.
- „ transversus thoracis.

As the abdominal cavity is held to possess, typically, a muscular wall of three strata, homologies have been founded for the costal muscles in an attempt to construct a uniform boundary for the pleuro-peritoneal cavity. But while many of the homologies are definitely established, others are still in dispute. For example, some authors consider the subcostalis as part of the "internal oblique sheet" (Cunningham, Le Double); by others it is placed as part of a deeper sheet and in series with the transversus abdominis (Henle, Testut). The following is a contribution towards the establishment of a fuller homology of the costal musculature, and is founded on the demonstration of the compound morphology of the "internal intercostal muscles."<sup>1</sup>

<sup>1</sup> The consideration of the endothoracic fascia will form the subject of a future article.

As described for the adult human subject, the relation of the completely costal members of the anterior thoracic nerves to the "internal intercostal muscles" is that, while posteriorly they are superficially placed, anteriorly they are deep to these muscles, the passage through the muscle being prolonged over some distance (fig. 1). The abdominal intercostal nerves seek a corresponding plane in their "perforation of the intercostalis internus" to run between the internal oblique and the transversalis abdominis muscles. The deep relation of the intercostal nerves in that part of their course deep to the "internal intercostal muscles" has been continuously described as the costal pleura. The branches of the lumbar

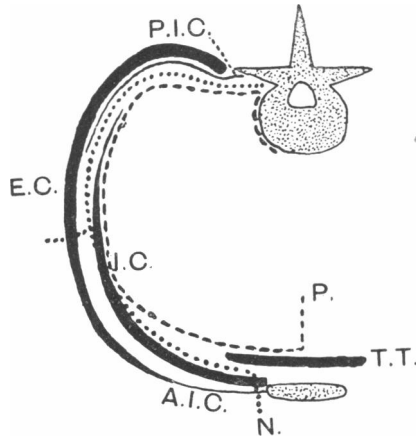


FIG. 1. — Diagrammatic representation of the thoracic wall as presently described.

E.C., external intercostal muscle; I.C., internal intercostal muscle; A.I.C., anterior intercostal membrane; P.I.C., posterior intercostal membrane; T.T., transversalis thoracis muscle; N., intercostal nerve; P., costal pleura.

plexus in series with the intercostal nerves, on the other hand, are not superficial to the internal oblique muscle till their final perforation of this layer, which is described as homologous with the "internal intercostal muscles." The double relationship of the nerve to the muscle, then, is peculiar to the thoracic region, and is such that the muscle may be considered, in relation to the nerve, as of two parts, a posterior portion and an anterior portion, the former being more deeply placed in the thoracic wall. Now, it is known that the origin of the "internal intercostal muscle" from the costal margin differs at different points throughout its length. Soulignoux has demonstrated that posteriorly the muscle arises from the inner lip of the costal groove, but anteriorly the origin is from both

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the inner and outer lips of that gutter; further, that "the change in the position of the nerve" takes place at the doubling of the muscle. Careful dissection, however, of the "internal intercostal series" has shown that here we are really dealing with two distinct sets of muscles belonging to different tissue planes; that the fusion of these two sets into one as the "internal intercostal muscle" of each space is only an apparent fusion, for throughout their whole contiguous length they are separated by fascial tissue and by the intercostal nerve. The following dissections were carried

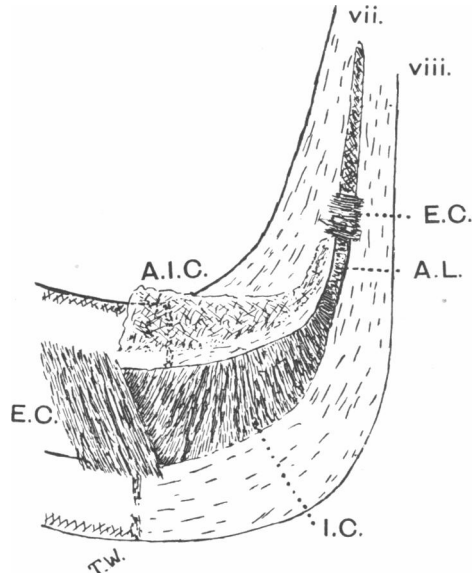


FIG. 2.—To show muscle fibres replacing the anterior intercostal membrane.

A.I.C., in proximity to the interchondral joints; E.C., external intercostal muscle; I.C., internal intercostal muscle; A.L., anterior capsular fibres of the interchondral articulation.

out on ordinary dissecting-room subjects. The sternum and vertebral column were sectioned longitudinally, and each half of the chest wall was treated separately.<sup>1</sup>

1. *Examination of the Superficial Surface of the Chest Wall.*—The external intercostal muscles were first exposed. They commence posteriorly in the region of the tubercles of the ribs and extend forwards to about the costal cartilages. Passing between successive ribs, the origin and the insertion of these muscles are on the lateral surfaces of the opposing

<sup>1</sup> It is proposed to leave for future consideration the relation of the disposition of contractile muscle fibre to function.

borders. In their anterior extension the muscle fibres gradually diminish in amount and the anterior intercostal membrane continues forwards the tissue plane. This membrane reaches the external margin in the upper spaces, but lower down it does not extend beyond the final fusion of the bounding cartilages, and in this region, 6th to 9th interspaces, muscle fibres are occasionally representative, especially in proximity to the interchondral articulations (fig. 2). While the membrane is loosely connected to the capsule of these joints, it does not form the anterior part of the capsule, nor is it in any way specifically interrupted at these positions. In the 10th and 11th interspaces the intercostal muscles extend forwards

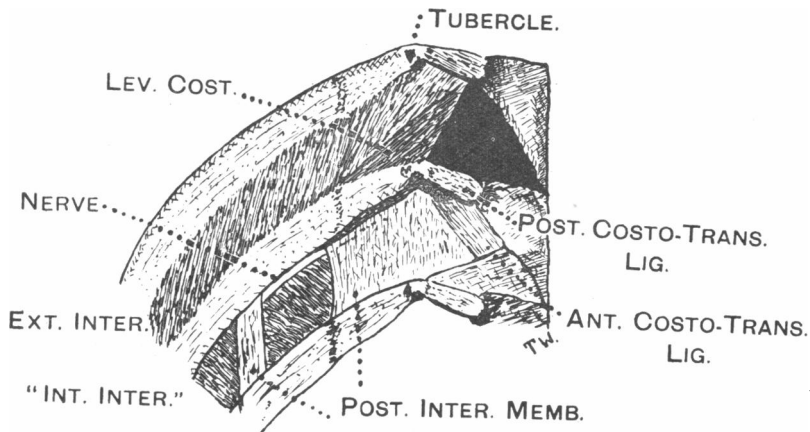


FIG. 3.—In the lower space the external sheet of the thoracic musculature has been reflected. The muscle called the "internal intercostal" will be noted as deep to the posterior intercostal membrane. (In the B.N.A. terminology the post. costo-trans. lig. is the lig. tuberculi costæ, and the ant. costo-trans. lig. is the anterior part of the costo-transverse lig.)

deep to the posterior border of the corresponding digitation of the external oblique muscle of the abdominal wall, and a membrane of delicate structure continues the muscle anteriorly between the external and internal oblique muscles, and finally fuses with the aponeurosis of the latter muscle. Posteriorly the levatores costarum (long. et brev.) are in series with the external intercostals. The supracostalis, extending from the first rib over two or three spaces, may or may not be present, but is also a derivative of this sheet. This layer of the costal musculature, then, comprising the levatores costarum, the external intercostals, and the anterior intercostal membranes and the supracostalis, forms a complete external sheet from the vertebral column to the sternum, and is homologous with the external oblique muscle of the abdominal wall.

2. *Reflection of the External Sheet in the Whole of its Extent and Definition of the Anterior Parts of the Costo-transverse Ligaments.*—Nowhere are the intercostal nerves yet exposed. At the vertebral extremity of each space the posterior intercostal membrane is shown as a strong fascial layer which, towards the median plane, fuses with the anterior part of the costo-transverse ligament (fig. 3). Passing forwards in each space, this membrane becomes continuous with a layer of muscle tissue which, like the membrane, has its origin from the lateral lip of the costal groove. This muscle sheet, commencing as a thin layer about the mid length of each space, gradually increases in volume and, retaining throughout the original superficial relationship to the intercostal nerve, reaches, in the upper spaces, the sternal margin (fig. 4). In the lower intercostal spaces the anterior ex-

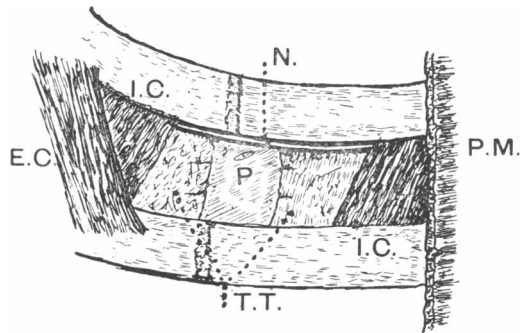


FIG. 4.—Dissection of the sternal end of the 3rd intercostal space.

N., intercostal nerve; E.C., external intercostal muscle; T.T., intra-costal membrane; P., pleura; P.M., pectoralis major.

tension of the muscular tissue is interrupted at the interchondral articulations, and the anterior fibres of the capsules of those joints have the same direction as the fibres of the muscle (fig. 2). In the 10th and 11th spaces the internal oblique muscle of the abdominal wall is directly continuous with the anterior portions of these intercostal muscles. The second layer, then, of the thoracic wall musculature is composed of the posterior intercostal membranes and the anterior parts of the "intercostales interni" muscles, and it arises throughout its whole length from the lateral lip of the subcostal groove and is entirely superficial to the intercostal nerves.

3. *Examination of the Deep Surface of the Chest Wall.*—The costal pleura and the extra-pleural fat were removed; it was noted that the fat is accumulated on the rib surfaces and is absent over the muscular tissue. The transversus thoracis muscle is seen to conceal the terminal portions of the upper intercostal nerves. When traced laterally this muscle becomes

continuous with a fascial layer of varying density, *through which* the intercostal nerves are visible (fig. 5). In all cases, however, the fascia is strong enough to allow of reflection, and will be found attached to the inner surfaces of contiguous ribs. At its commencement the fascia is striated in series with the parent muscle, and in a few cases a similar disposition of actual fleshy fibres will be found (Camper, Tarin). Continued laterally, the fascial fibres give place to muscular fibres, which also have their attachments on the medial surfaces of the bounding ribs. Commencing about mid-way in each space, this muscle sheet increases in volume and extends backwards deep to the posterior intercostal membrane, where it forms the subcostalis by passing over one or more ribs, and is continued as fascia or as muscle (Macalister) from about the angles of the ribs to the vertebral

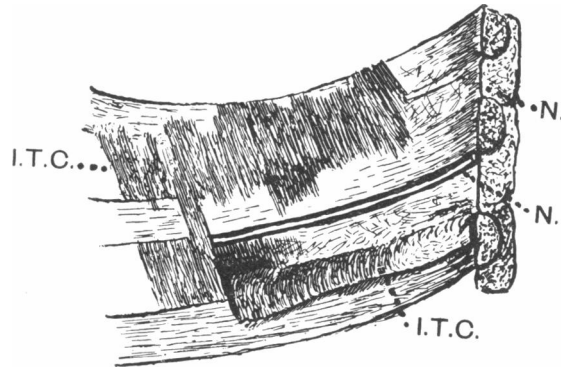


FIG. 5.—In the lower space the intracostal muscle and the fascia extending to the vertebral column has been reflected, thus exposing the intercostal nerve lying on the internal intercostal muscle and the posterior intercostal membrane.

column. In the 10th and 11th spaces it is possible to trace the transversalis abdominis as a fascial layer, in contact with the pleura, posteriorly to become muscular tissue disposed as in the upper spaces. Here we are dealing with the third layer of the thoracic musculature, throughout its whole length deep to the intercostal nerves. It comprises the transversus thoracis muscle, a layer of fascia in loose contact with the pleura derived from that muscle and from the transversus abdominis, the posterior parts of the "internal intercostal" muscles, and the subcostal muscle.

The "internal intercostal" muscle of each space, then, consists of two parts, morphologically distinct. The anterior portion is the more superficial, belongs to the internal oblique sheet, and is properly termed the internal intercostal muscle. It arises from the lateral lip of the costal groove, and is inserted into the upper border of the rib below, the striation being down-

wards and backwards. It is confined to the anterior two-thirds of each intercostal space. The posterior portion of the double muscle is in the plane of the transversalis sheet, and is hereinafter termed the intracostalis. It arises from the medial lip of the costal groove, and is inserted into the upper border and the medial surface of the succeeding rib, the striation again being downwards and backwards. The intracostal muscle is present in about the middle two-fourths of each space, and where it is contiguous with the internal intercostal muscle apposition has been described as fusion.

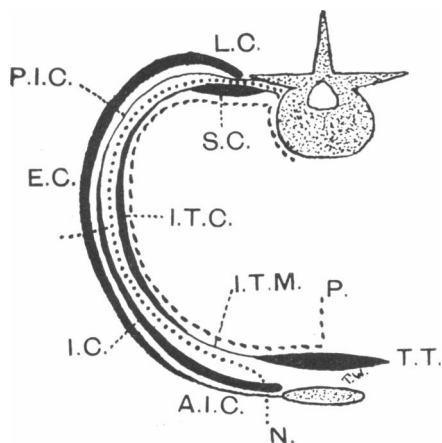


FIG. 6.—Diagram of the thoracic wall as reconstructed.

L.C., levator costae; I.T.C., intracostal muscle; S.C., subcostalis; I.T.M., intracostal membrane; N., nerve.

The thoracic wall musculature, therefore, consists of three distinct layers (fig. 6):

- A. External layer.—Levatores costarum, intercostales externi and the anterior intercostal membranes, supracostalis, and the serrati.
- B. Middle layer.—Intercostales interni and the posterior intercostal membranes.
- C. Internal layer.—Transversus thoracis, intracostalis, and the intracostal membrane, and the subcostalis.

These layers are each homologous with the corresponding layer of the abdominal wall, and the intercostal nerves preserve the typical relationship to the muscular strata.