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THE MUSCLES OF RESPIRATION

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The muscles primarily concerned with respiration are the diaphragm, the scalene muscles and the intercostal muscles.

The most important muscle is the diaphragm, which is a surprisingly thin musculo-fibrous sheet separating the thorax and abdomen. Its origins are attached to the bony cartilaginous points of the thoracic outlet and the muscle fibres converge to an anteriorly placed central tendon. The origins are threefold: sternal, costal, lumbar.

1. **The sternal part:** this arises by two fleshy slips from the back to the xiphoid process.
2. **The costal part:** takes origin on each side of the thorax from the costal cartilages and adjacent parts of the lower six ribs.
3. **The lumbar part:** arises from two tendinous pillars or crura, one on each side of the anterior surface of the lumbar vertebrae and intervening discs. The right crus from the upper 3 vertebrae and the left crus from the upper 2. From the top of the crura, ligaments arch laterally on both sides, over psoas major to attach to the transverse process of the first lumbar vertebra — the right and left medial lumbo-costal arches and then again over quadratus lumborum to attach to the lower border of the twelfth rib, the right and left lateral lumbo-costal arches.

Muscle fibres take origin from all these points and converge towards the central tendon, the sternal fibres pass backwards, the costal fibres, which are longer, form marked domes on either side as they converge to their insertion. The posterior fibres are complicated, diverging from their origin to their insertion, and even crossing to the opposite side as in the case of the medial fibres of the right crus which ascend to the left of the oesophageal opening.

The Central Tendon

This is a strong aponeurosis which is centrally but more anteriorly placed, blending above with the pericardium. It is trilobar in shape, the middle leaf placed anteriorly and the right and left leaves curving away from the centre, backwards and laterally. The muscle fibres insert into the adjacent part of the central tendon, the lateral and posterior fibres doming up into the thorax and rising to a higher level than the actual central tendon — thus the fibres pass firstly upwards, curve and then pass down to their insertion.

This muscle is supplied by the phrenic nerves (3, 4, 5) and the lower 6 intercostal nerves.

The Scalene Muscles

There are six scalene muscles, three on either side of the cervical spine, joining the first two ribs with the cervical transverse processes.

1. **Scalenus anterior:** takes origin from the anterior tubercles of the transverse processes of C 3, 4, 5 and 6, it descends behind sternnocleidomastoid to insert into the scalene tubercle of the first rib.
2. **Scalenus medius:** takes origin from the transverse process of axis and the front of the posterior tubercles of the transverse processes of the lower 5 cervical vertebrae — it is the largest and longest of the scalenes and passes down to insert into the upper surface of the first rib, lateral to scalenus anterior.
3. **Scalenus posterior:** this is the smallest and most deeply seated of the scalenes passing from the posterior tubercles of the transverse processes of C 4, 5 and 6 to insert into the second rib, behind serratus anterior.

The nerve supply of these muscles is branches of the ventral rami of the appropriate cervical nerves.

The Intercostal Muscles

As their name implies these muscles fill the intercostal spaces, there are two sets: internal and external intercostals, and each set has eleven pairs of muscles taking origin from the lower border of one rib and inserting into the upper border of the rib below.

The external intercostals extend from the tubercle of the ribs posteriorly, the muscle fibres passing first down and laterally and downwards and medially, anteriorly at the junction of the rib and costal cartilage the muscles are replaced with aponeuroses — the external intercostal membranes connecting the muscles to the sternum.

The internal intercostals lie deep to the externals, they start at the sternum filling the intercartilaginous spaces and the fibres passing downwards and laterally, i.e. at right angles to the external muscles. They extend as far back as the posterior costal angles where they in turn are replaced by aponeuroses.

These muscles are all supplied by the adjacent intercostal nerves.

The mechanism of the thorax during respiration is controlled by muscles, but the manner in which it moves is dependant on the anatomy of the joints involved and the position and shape of the ribs.

The costo-vertebral and sternocostal joints of the first seven ribs are easily understood, all except the junction of the first rib and manubrium being synovial joints allowing varying amounts of gliding, angulation, and rotation at each articulation. When moving around an intero posterior axis[1] these ribs evert (buckethandle action increasing the lateral diameter of the upper and middle parts of the thorax. Simultaneously the antero-posterior diameter[1] is increased because the anterior ends of the ribs lie lower than their vertebral parts, and so therefore when they are lifted they will move upwards and forwards carrying the sternum with them.

The lower part of the thorax moves in a different manner owing to the shape and positioning of the costo-transverse joints, and also the fact that they are not firmly fixed anteriorly to the sternum but have an elongated synovial joint between the anterior ends of each costal cartilage, and the cartilage immediately above.

The articular surfaces of the upper costo-transverse joints are reciprocally[1] curved allowing the 'bucket-handle'[2] rotatory movement, while in the lower ribs these joints are flatter and more horizontally placed, allowing a posterior and upwards gliding movement of the respective rib on the transverse process. Therefore when the lower ribs are lifted an outward and back-

ward movement of the lower thorax[1] results, increasing its breadth, as also the breadth of the upper abdomen.

Muscle Action

Traditionally the intercostals with the diaphragm have been accepted as primary muscles of inspiration. However, with electro-myographic research, this theory is being questioned. The diaphragm and scalenes are now stated to be primary muscles of inspiration replacing the former theory, the function of the intercostals still being warmly debated. Galen originally described the external intercostals as inspiratory and the internal intercostals as expiratory; others have since stated that the function of the intercostals is postural. The 'postural' explanation is that the intercostals working together maintain[3] the rigidity of the chest and the correct relationship of one rib to another at any given time. This allows the primary muscles of respiration to work without the interference of pressure changes which could occur if the intercostal spaces were sucked in and blown out during each respiratory cycle. However, there is evidence[4] of increased activity in certain intercostals at different times, the upper 3 pairs in quiet inspiration and the lower intercostals in deep breathing.

As no fully accepted theory has been devised, a combination of the above opinion leads to an acceptable statement to the effect that during breathing the intercostals will contract, when required, either for pressure maintenance or to move a particular rib up or down. These functions although not of primary importance, are essential to normal respiration.

Quiet Breathing

During inspiration, scalenus anterior contracts fixing the first rib thus acting as a fixator of the upper part of the chest. The abdominal muscles fix the lower ribs and the diaphragm contracts pulling its domes and central tendon downwards on to the abdomen viscera and thus increasing the vertical diameter of the thorax.

Quiet expiration is a purely passive movement, the inspiratory muscles relax and return to their resting position, which together with the elastic recoil of the lungs cause air to be expired.

Deep Breathing

The upper part of the chest, ribs 1 and 2, is lifted and fixed by the scalenes, the bucket-handle action of the following ribs occur with the intercostals lifting them — maintaining their relationship with the first two ribs, thus both antero-posterior and lateral diameters are increased. Simultaneously the diaphragm contracts strongly, descends until the central tendon becomes fixed on the abdominal viscera, the muscle fibres continue to contract flattening the domes and lifting and spreading the lower ribs laterally and backwards. This considerably increases the lateral diameter of the thorax and upper abdomen, the upper abdominal viscera being flattened and spread sideways.

The extensors of the spine also contract in deep inspiration, flattening the thoracic curvature and opening the thorax, and so at this stage all diameters have been increased.

Forceful expiration is initiated by relaxation of all the muscles of inspiration followed by strong contraction of the abdominal muscles pulling the ribs down and increasing the intra-abdominal pressure, which forces the diaphragm up into the thorax and air is expired.

The accessory muscles of respiration, those joining the pectoral girdle to the thorax, latissimus dorsi and sternocleidomastoid are involved in forced breathing which is not a part of the normal pattern of respiration and is therefore not discussed here.

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I should like to thank Professor Keen of the Anatomy Department at the University of Cape Town for his help and advice in preparing this article.

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AN APPRECIATION

MISS MARJORY CATT, C.S.P.

It is with deep regret that we record the passing of Marjory Catt, one of the founder members of the South African Society of Physiotherapy. She, along with a small band of dedicated qualified physiotherapists fought for the official recognition of the profession and despite the scattered areas where physiotherapists were situated, formed what has become a substantial society with compulsory registration.

Miss Catt was born in Scarborough, England, and trained at the London Orthopaedic Hospital qualifying under the Chartered Society of Physiotherapy then known as the Chartered Society of Massage and Medical Gymnastics.

While training Miss Catt met Miss Winnie Evans from South Africa and together they formed a partnership, opening a practice in 1923. Miss Evans worked in Germiston and Miss Catt in Harley Chambers, Johannesburg. On the death of Miss Evans, Miss Catt took over the Germiston branch where she had the contract for the work of the Germiston Hospital before a Department was opened there.

Besides being an admirable and tireless practitioner, Miss Catt devoted a great deal of her spare time and energies to the administration and development of the society. She was several times President of the Central Executive Committee — later to be the National Executive Committee of the S.A.S.P.

In recognition of her loyalty and dedication Miss Catt was made an Honorary Life Member of the S.A.S.P. on her retirement from general practice. She however, always maintained her interest in the Society and the Branch.

She attended Branch meetings and functions until her health prevented her from travelling at night. She always kept in touch with current developments.

The last official function of the Society at which Miss Catt was able to attend was the opening ceremony of the Jubilee Congress in Johannesburg in July 1975. It was a proud moment for her as she was the only one present who had been a member for fifty years and able to look back to the real beginnings of the Society.

To her sister Mrs. J. Sewell from England, her cousin Mr. Hughes of Bedford View and other relatives and close friends we convey the sincere sympathy of the Society. We also say a very real "thank you" to Marjory Catt for her dedication and devotion to the profession and the South African Society of Physiotherapy.