An Integrated Approach for Treating the OB Patient: Treating the Five Diaphrams of the Body, Part I

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Introduction

Pregnant women are a joy to treat. They seem to be tied directly into the primary life force of the universe. Pregnancy is a time of change; anatomically, physically, mentally and emotionally. Part 1 of this paper will discuss the physiological as well as anatomical changes that occur during pregnancy. Part 2 will discuss diagnosis and use treating the five diaphragms of the body (the foot arches, the pelvis, the respiratory diaphragm, Sibson's fascia covering the thoracic inlet and the tentorium cerebelli) as a model for treatment.

PHYSIOLOGY

Cardiovascular System

The blood volume increases by approximately 40-55%. There are increases in stroke volume by 30%, heart rate by 10-20% and possibly an increase in the cardiac volume by 10%. The changes in the cardiovascular system indicate that there is more blood for the cardiovascular system to circulate.

There are numerous vascular changes that occur as well. The uterine blood flow changes from approximately 30-50 ml up to 500-1000 ml per minute. There is also an increase in the breast blood flow.

Respiratory System

It has been proposed that the respiratory rate is unchanged. The tidal volume increases by 40% and the residual volume (which is the volume after maximum exhalation) decreases by 20%. The expiratory reserve volume (the amount that can be expired at the end of normal exhalation) increases by 20% and the functional residual capacity decreases. The thoracic cage also flares, increasing the subcostal angle from 68° to 103°. The diaphragm, due to the changes of pregnancy, must increase in its excursion to oxygenate the increased blood volume.

A common complaint of pregnancy is a subjective feeling of dyspnea. Dyspnea is possibly due to the increase in blood volume to be oxygenated, and the anatomic changes which lead to altered respiratory function.

Renal System

Because there is more blood to be circulated by the cardiovascular system, there is more blood to purify. Therefore, the glomerular filtration rate increases by approximately 50% with a corresponding increase in sodium retention.

Endocrine System

The corpus luteum of pregnancy produces a polypeptide hormone called "relaxin". Also, there is an increase in the production of estrogen. These hormonal changes cause relaxation of the pelvic ligaments and also a general relaxation of many ligaments throughout the body.

These endocrine changes are helpful and detrimental from a structural point of view. Women who have pre-existing somatic dysfunction before pregnancy may be helped greatly during pregnancy. The relaxation of the ligaments allows for a greater, as well as easier, mobilization of a restricted joint. There is also a negative effect in that the relaxation of the ligaments can promote somatic dysfunction occurring at a joint; a common example is an acute pubic symphysis shear. This can be an excruciatingly painful somatic dysfunction.

ANATOMY

There are many anatomical changes that occur during pregnancy. The growing fetus within the uterus causes an overall anterior shift in the center of gravity of the pregnant woman with a compensatory posterior shift in the shoulders - the so-called "pride of pregnancy stance". There is an increase in the lumbar lordosis. These shifts cause changes in the thoracoabdominal pelvic cavities which impede function and will be discussed in the following sections.

First Diaphragm - Arches of the Feet

The navicular bone is like the keystone of the medial arch. With the postural changes that occur during pregnancy, it is common to find a functional pes planus or "flatfoot". The arch, especially the navicular bone, drops inferiorly. There is a change in the relationship of the talus to the tibia and fibula, which will change the orientation of the knee joint and, in return, will be reflected into the pelvis.

The tibialis anterior attaches to the medial cuneiform and base of the first metatarsal. The tibialis posterior attaches to the navicular, cuneiforms, cuboids and bases of 2-4 metatarsals. Together these muscles form a sling for the longitudinal arch. As the arch drops, there is an increased tone and tension noticed in the tibialis muscles.

The tibialis anterior attaches on the lateral anterior portion of the tibia and the approximate region where the iliotibial band attaches. When the arch drops, there is a change in the tensions of the tibialis anterior, reflecting into the iliotibial band which, in turn, will affect the pelvis. As the arch drops, the talus changes the relationship with the tibia and the fibula; the fibula being an attachment for the long and short head of the biceps. Therefore, the change in orientation of the fibula and tibia will have an effect on the long and short head of the biceps. The biceps femoris attaches from the fibula head to the ischial tuberosity as well as the sacrotuberous ligaments.

These changes in the anatomical relationships of the arches (first diaphragm) to the second diaphragm (the pelvic diaphragm) of the body can be enough to impede both the postural as well as respiratory motion of the pelvis and lower extremity.

Second Diaphragm - Pelvic Diaphragm

The pelvis is made up of the two innominates and the sacrum. It is heavily invested with muscle and neurovascular structures, as well as fascial structures. The endopelvic fascia attaches anterior to posterior, as well as medial lateral, forming what could be thought of as support bridges for the pelvic organs; namely the uterus, bladder and rectum. The bladder is suspended in the pelvis by the median umbilical ligament (embryonic remnant of the urachus) as well as its lateral and posterior attachments of endopelvic fascia. The cardinal ligaments containing the uterine artery forms a lateral suspension for the uterus. There is a direct connection between the bladder and the uterus, running anterior to posterior, forming the vesicouterine pouch. The bladder is also suspended by the lateral pubovesicular ligaments. The rectum is suspended by the presacral fascia as well as the vaginal rectal fascia.

The fascia of the pelvis and the endopelvic fascia basically suspends these three organs - the bladder, uterus and rectum within the pelvic cavity, allowing them to float within the content of the pelvic cavity. The names of the fascial ligaments are somewhat misleading, creating the idea that there are a number of separate ligaments within the pelvis. In reality, the ligaments are thickenings of fascia, which are continuous with each other and with the fascias of the rest of the body.

Any kind of twist in the pelvis, any restriction in the pubic symphysis or either sacroiliac joint can have a large effect on the endopelvic organs. A twist within the pelvis will impede the organs and the vessels leading to a stasis of fluid in the pelvic organs as well as the lower extremity. One proposed mechanism of swelling in the lower extremities is that the fetus will impinge on the inferior vena cava somewhat and cause a back pressure within the venous system, leading to venous stasis. Another possible mechanism is somatic dysfunction of the pelvis, impairing the ability of the pelvic diaphragm to move in conjunction with the respiratory diaphragm leading to stasis of lymphatic and venous fluid.

Third Diaphragm - Respiratory Diaphragm

The pelvic and the respiratory diaphragms are connected anteriorly, posteriorly, radially and laterally. Posteriorly, the quadratus lumborum is attached to the lumbar vertebrae and the iliac crest. Superiorly, the quadratus lumborum is attached to the twelfth rib. The quadratus lumborum could be viewed as a functional extension of the diaphragm. The quadratus lumborum has, as its action, both postural as well as respiratory motion. The quadratus lumborum acts as an anchor for the twelfth rib during respiration. Restriction in either hemidiaphragm can be seen reflected in the quadratus lumborum and through the tensor fascia lata into the iliotibial band all the way to the peroneal muscles of the lower extremity.

POSTERIOR

The diaphragm is attached to the twelfth rib posteriorly via the lateral and medial arcuate ligaments. The lateral arcuate ligament attaches from the twelfth rib to the transverse process of T12. The medial arcuate ligament attaches from the transverse process of T12 to the body and the anterior longitudinal ligament at T12. The medial and lateral arcuate ligaments form what could be thought of as caves for the quadratus lumborum and the psoas. These ligaments are basically thickenings of the fascia, covering the muscles in this region.

Medially, the crura of the diaphragm attaches to Ll, 2 and 3 on the right and Ll and 2 on the left. This is how it is described in most anatomy books. In reality the crura attaches to the anterior longitudinal ligament and blends to this ligament. It is impossible to separate the crura from the anterior longitudinal ligament at their attachments. Looking at specimens in the anatomy lab, the crura basically blend into the anterior longitudinal ligament and functionally become a portion of it. The anterior longitudinal ligament continues down through the lumbar vertebrae and can be shown to continue into the anterior sacral coccygeal ligaments and then directly into the pelvic musculature, thus forming the posterior connection between the pelvic and respiratory diaphragms. The lateral connection between the pelvic and respiratory diaphragm are through the muscles of the abdominal wall.

ANTERIOR

The organs and muscles of the pelvic cavity connect with the endopelvic fascia. The endopelvic fascia is connected to the median umbilical ligament and to the medial umbilical ligaments which go to the umbilicus and linea alba of the rectus sheath. Continuing superiorly from the umbilicus, the falciform ligament and ligamentum teres (round ligament) attach to the liver as well as the inferior surface of the diaphragm. Therefore, there is a direct anterior connection from the pelvic diaphragm to the respiratory diaphragm. The falciform ligament basically cuts the liver in half anterior to posterior.

The combination of the falciform ligament with the ligamentum teres (round ligament) embedded within it and the ligamentum venosum form an anterior to posterior fascial connection. So there is not only an inferior to superior connection from the pelvic diaphragm to the respiratory diaphragm, but there is also an anterior to posterior connection of the anterior abdominal wall to the posterior abdominal wall under the diaphragm.

The diaphragm interdigitates with the transversus abdominus at a 90° angle. This relationship with the transversus abdominus blending into the linea alba medially can be useful in treatment.

Reciprocal Function of the Respiratory and Pelvic Diaphragm

(There is a functional relationship between the pelvic diaphragm through the median umbilical ligament to the umbilicus and then the falciform ligament through to the diaphragm.) The pelvic diaphragm works in a reciprocal relationship with the respiratory diaphragm. As the respiratory diaphragm contracts, the pelvic diaphragm must relax to allow the abdominal and pelvic contents to shift inferiorly. If there is any restriction in the respiratory or pelvic diaphragms, this physiological phenomenon will not occur. It may be that there are neuronal pathways which reflexively relax the pelvic diaphragm when the respiratory diaphragm contracts and vice versa.

With each inspiration, the diaphragm acts on the lumbar vertebrae. There is a general flattening of all spinal A-P curves. The diaphragm, acting through the crura moves the anterior longitudinal ligament and has a far reaching effect throughout the cardiovascular system. Blood is pumped from the heart out to the extremities throughout the cardiovascular system. Blood is returned through the venous and lymphatic channels by the action of the pumping of the peripheral muscles. The return system (venous and lymphatic) is highly pressure-gradient dependent. When the return of blood enters the pelvic cavity and abdominal cavities, it is solely dependent on the pressure differentials between the thorax, abdominal and pelvic cavities. The lymphatic system returns 10% of the circulatory fluid from the periphery with each cycle. It has been estimated that in a 24-hour period, we turn over 100% of the circulating serum blood volume through the lymphatic system. The peripheral muscles act to pump the lymphatic fluid into the lymphatic channels and back centrally. Any disturbance in the thoracoabdominopelvic cylinder will impede the return of fluid centrally.

The growing fetus will displace the abdominal contents superiorly, pushing the diaphragm into the thoracic cavity. Affectively, there is a decrease in the superior to inferior length of the thoracic cavity. Therefore, the diaphragm must work at an increased rate of contraction against a stronger resistance to maintain oxygenation of the circulating blood volume.

Not only is there an effect on the superior to inferior length of the thoracic cavity, the growing fetus shifting the center of gravity anteriorly will increase the lumbar lordosis. This creates a larger tension on the crura of the diaphragm posteriorly, impeding diaphragmatic function. The pelvis is tilted anteriorly, greater tension is placed on the anterior abdominal wall and the thoraxes A-P diameter is decreased.

Fourth Diaphragm - Sibson's Fascia

The thoracic inlet, which is comprised of T1, the first ribs and manubrium, work as a functional unit. Any rotation of T1 will be reflected through the first ribs and the manubrium, changing the diameter of the superior thoracic aperture. Sibson's fascia is attached to the inferior border of the first ribs and the posterior border of the manubrium and going posteriorly to the region of the seventh cervical and the first thoracic vertebrae. It has imbedded within it the scalenus minimus which when contracted, tenses Sibson's fascia. This fascia acts as a diaphragm covering the cupula of the lung. Sibson's fascia is also responsible for maintaining a pressure gradient between the neck and the thorax. Without this gradient, the neck viscera would be sucked into the thorax with each inspiration.

The fascial connection of the pericardium to the sternum is called the "pericardial ligament".The pericardium is basically pretracheal fascia, which has extended down from the neck and embedded itself into the diaphragm. This pretracheal fascia continues from the diaphragm being the covering of the heart, connecting to the sternum and into the neck. The ribs are covered by the prevertebral fascia, which travels superiorly to the base of the skull.

Just as there is a relationship between the thoracic and pelvic diaphragms with respiration, Sibson's fascia acts as a diaphragm in a reciprocal relationship with the thoracic diaphragm. Any distortion of the thoracic inlet will lead to passive congestion of venous and lymphatic fluids throughout the whole body. The thoracic inlet is approximately 4-1/2" wide by about 2-1/2" long. Within this space is a great number of vital structures. The thoracic duct empties into the left subclavian vein in the region of the thoracic inlet as well as the right thoracic duct. The thoracic duct drains most of the lymphatic fluids of the body minus the right portion of the thorax, the right head and the right upper extremity. Any distortion of the thoracic inlet will lead to passive congestion of venous and lymphatic fluids throughout the whole body.

There are a great number of structures that traverse the thoracic inlet besides the thoracic duct. These structures include the trachea, the esophagus, the vagus nerve, the sympathetic chain ganglion, carotid arteries, subclavian arteries, and subclavian veins. The brachial plexus rests on the superior border of the first ribs. Based on these anatomical relationships, this becomes a very important area to examine.

Fifth Diaphragm - Tentorium Cerebelli

The tentorium cerebelli is connected to the Sibson's fascia through the prevertebral as well as pretrachael fascias. The pretracheal and prevertebral fascias as cylinders extending from the thorax into the neck region. The prevertebral fascia invests the ribs. It continues from 1st ribs superiorly to cover the bodies of the vertebrae as well as the anterior and posterior cervical vertebral muscles. This column of fascia is a direct connection between the first ribs, the manubrium and T1, to the base of the skull. The insertion of the muscles of the neck onto the skull, effectively connecting Sibson's fascia to the skull.

The tentorium cerebelli, being reflections of dura, is directly connected through the foramen magnum to the spinal dura to C2 and C3 and then to the second sacral segment, forming a continuous connection to the sacrum (cranial to pelvic diaphragm). There is evidence that the dura has firm attachments to most vertebrae throughout the column as well.

The tentorium cerebelli has embedded within it the venous sinuses. (The root of venous drainage from the skull is through the venous sinuses.) The tentorium cerebelli is attached to the petrous ridges of the temporal bone (enclosing the superior petrosal sinus) and the internal surface of the occiput. As the sphenobasilar junction goes into flexion, the tentorium is brought inferior and spreads out. In extension, the opposite occurs. The tentorium cerebelli aids in the circulation of venous as well as cerebrospinal fluid. The tentorium cerebelli is part of the dural structures that form the "core link" connecting the sphenobasilar junction to the sacrum. The reciprocal function of both areas is important in maintaining health.

Function of The Five Diaphragms Together

There is a synchronous motion of the five diaphragms of the body. As the respiratory diaphragm contracts, the pelvic diaphragm and Sibson's fascia work together to create pressure differentials which promote circulation of venous and lymphatic fluid. As the respiratory diaphragm contracts, the pelvic diaphragm relaxes, allowing the contents to drop into the pelvic cavity. A relative negative pressure is established in the thorax with positive pressure in the abdomen and pelvis. On exhalation, the respiratory diaphragm rises by elastic recoil and pressure gradients reverse.

The tentorium cerebelli and pelvic diaphragm work in synchrony as well. As the primary respiratory mechanism goes into its flexion phase, the tentorium moves inferiorly, the sacral base moves posterior with the apex moving anterior. The innominates move into external rotation. The reverse occurs in extension. There is a relationship of the primary respiratory mechanism (cranial rhythmic impulse) to the secondary respiratory mechanism (breathing) in which they tend to augment each other.

The arches have an effect on the other diaphragms through their role in posture. A functional pes planus (dropped arch) will restrict motion of the pelvis during respiratory and postural motion, thus affecting the four remaining diaphragms. How this is seen clinically will be discussed in Part 2.

The full functioning of the five diaphragms must be maintained to prevent symptoms of pain, passive congestion of fluid, dyspnea and others. As described, the five diaphragms are related to each other anatomically and therefore, functionally.

The diagnosis and treatment of the obstetrical patient using these principles will be discussed in Part 2 of this series, which will be published in the Spring issue of this journal, along with the complete reference list for both articles.