The Role of the Diaphragm: Understanding Dysfunctions and Effective Treatment with Manual Medicine and Neural Therapy

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Abstract

The Diaphragm: A Key Structure for Breathing and Overall Health

The diaphragm, as the central muscle of respiration, plays a vital role in breathing, trunk stability, and the regulation of intra-abdominal pressure. It is integral to numerous physiological processes and significantly impacts both respiratory and systemic health.

This article explores the clinical spectrum of diaphragmatic dysfunctions and analyzes their multifaceted causes, which range from neurological disorders to mechanical restrictions. Diaphragmatic dysfunctions represent a commonly overlooked medical issue that can manifest as symptoms such as dyspnea, sleep disturbances, chronic fatigue, gastroesophageal reflux, and even heart failure.

The etiology of such dysfunctions is diverse, including factors like chronic stress, myofascial trigger points, scar tissue, and mechanical trauma, all of which can irritate or impair the function of the phrenic nerve. Phrenic nerve impairment not only limits diaphragmatic movement but also disrupts the regulation of the autonomic nervous system and organ function.

The combination of neural therapy and manual medicine has proven to be a promising therapeutic approach. Targeted injections at myofascial trigger points and segmental therapies can effectively release adhesions and significantly enhance diaphragmatic function. In addition, manual diagnostics enable precise identification of segmental dysfunctions and fascial restrictions.

This integrative approach addresses not only localized biomechanical dysfunctions but also leverages the regulatory potential of the autonomic nervous system. The synergy between neural therapy and manual medicine offers new perspectives for treating these frequently misdiagnosed and undervalued medical conditions.

Keywords: Diaphragmatic dysfunction, Neural therapy, Manual medicine, Phrenic nerve, Myofascial therapy

Introduction

The scientific literature identifies five distinct types of diaphragms (Anraku M. et al., 2009): Sella diaphragm (Diaphragma sellae), oral diaphragm (Diaphragma oris), thoracoabdominal diaphragm (Diaphragma thoracoabdominalis), pelvic diaphragm (Diaphragma pelvis), and urogenital diaphragm (Diaphragma urogenitalis). This article focuses on the thoracoabdominal diaphragm (1).

The thoracoabdominal diaphragm is a dome-shaped structure composed of muscles and tendons, separating the

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thoracic cavity from the abdominal cavity. Its origin lies in the inferior thoracic aperture, the spine, the ribs, and the sternum (1,2). It is the most important respiratory muscle, innervated by the phrenic nerve, which arises from the cervical nerve roots C3 to C6 (3).

Dysfunction of the phrenic nerve, as well as movement restrictions caused by the mechanical attachment of the diaphragm to the chest wall during contraction, can lead to diaphragmatic dysfunction (1,4). Alterations in biomechanical properties due to excessive abdominal distension or irregularities in diaphragmatic fiber structure can contribute to the development of hypercapnic respiratory insufficiency, often necessitating mechanical ventilation (5).

Diaphragmatic dysfunction is associated with respiratory symptoms, including dyspnea, sleep disturbances, heart failure, exercise intolerance, hypersomnia, and, in severe cases, a negative impact on survival (1,6,7,8).

The primary goal of this article is to characterize diaphragmatic dysfunction as a clinical observation, define its causes, identify disease symptoms, and establish invasive diagnostic criteria for patients often misdiagnosed or overlooked in clinical practice. Furthermore, this article introduces a combination therapy approach involving Neural Therapy and Manual Medicine. In this context, this publication represents a novel contribution.

Structure and Function of the Diaphragm

During quiet, inactive inhalation, minimal changes occur in the diaphragm's dome shape. Muscle contraction results in a shortening of the apposition zone, causing the diaphragm to move caudally like a piston. This movement increases intra-abdominal pressure while reducing intrapleural pressure (10). These pressure changes are transmitted to the lungs, leading to lung expansion and compression of the chest wall. To balance this effect, intra-abdominal pressure increases, facilitating thoracic cavity expansion at the junction. Simultaneously, the diaphragm contracts at the lower ribs, contributing to the opening of the rib cage (3,10).

The diaphragm contains several openings through which thoracic structures pass into the abdominal cavity. A significant opening is located at the level of the eighth thoracic vertebra in the right hemidiaphragm, where the inferior vena cava passes from the abdomen to the thorax and connects to the right atrium. Between the crura of the diaphragm lies the aortic hiatus in the posterior midline, through which the descending thoracic aorta, thoracic duct, and azygos vein transition from the thoracic cavity to the abdominal cavity. The esophageal hiatus, situated within the fibers of the right diaphragmatic crus, allows the esophagus to traverse from the thoracic cavity into the abdominal cavity (2,8,9).

The diaphragm is innervated by two phrenic nerves, originating from the cervical roots C3 to C6. These nerves primarily control involuntary movements but also facilitate voluntary actions when needed (2,8). Each hemidiaphragm is supplied by its respective phrenic nerve, which manages both sensory and motor functions (7,8). The right phrenic nerve lies lateral to the caval hiatus, while the left nerve is situated lateral to the pericardium. Each phrenic nerve divides

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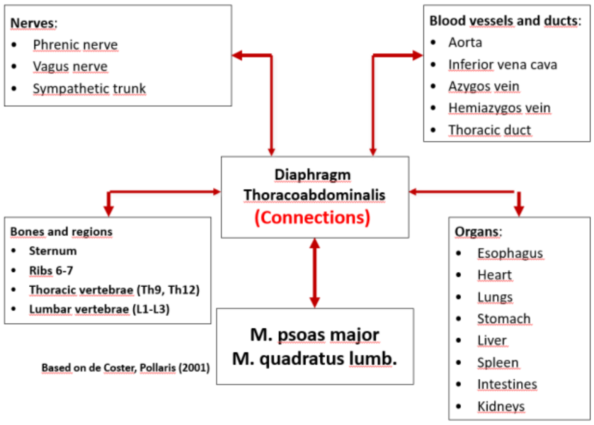
into four branches: the sternal, anterolateral, posterolateral, and crural trunks.

The diaphragm's primary blood supply comes from the bilateral phrenic arteries, which are direct branches of the thoracic aorta, and additional contributions from the internal mammary and pericardiophrenic arteries. Venous drainage is carried out via the phrenic veins, which empty into the inferior vena cava (4,10,11).



Marc de Coster, Annemie Pollaris: Viszerale Osteopathie , Hippokrates-Verlag, 2001

Schematic diagram 1: This figure illustrates the anatomical connections and relationships of the diaphragm (thoracoabdominal diaphragm) with various nerves, blood vessels, bony structures, and organs within the human body. It highlights the diaphragm's complex interactions with neighboring anatomical structures and serves as an educational tool in medicine and anatomy.

Diaphragmatic Openings	Location	Structures Passing Through
Foramen venae cavae	At the level of T8-T9	• Inferior vena cava
		• Right phrenic nerve
Hiatus oesophageus	At the level of T10	• Esophagus
		• Vagus nerve
		• Sympathetic nerves
		• Esophageal branches of the left gastric artery/vein
Hiatus aorticus	At the level of T12	• Abdominal aorta
		• Thoracic duct
		• Azygos vein
		• Hemiazygos vein

Table 1: This table details the openings in the diaphragm, their anatomical locations, and the structures passing through them. These openings represent critical anatomical passages for various structures, including blood vessels and nerves.

The presented table serves as a valuable tool for understanding the complex anatomy of the diaphragm and the associated structures. In the fields of medicine and surgery, anatomical knowledge is crucial for avoiding potential complications during interventions in the thoracic and abdominal cavities. Furthermore, understanding these anatomical relationships is essential for effectively applying manual medical and neural therapeutic techniques.

Knowledge of the anatomical connections and the structures traversing the diaphragm enables clinicians and therapists to plan and implement targeted and effective treatments, ultimately leading to improved therapeutic outcomes. The diaphragm, whose primary function is its involvement in respiration, facilitates the passage of numerous vessels, nerves, and organs. It serves as a conduit for the inferior vena cava, esophagus, aorta, azygos system, lymphatic vessels, and sympathetic nerves. Consequently, diaphragmatic dysfunction can result in impairments to these critical structures, potentially causing significant physiological disturbances (7,12).

Causes and Symptoms of Diaphragmatic Dysfunction

The causes of diaphragmatic dysfunction are diverse and range from neurological disorders to mechanical restrictions (7,8). Any damage or dysfunction of the phrenic nerve can impair diaphragmatic function. Excessive abdominal distension or irregularities in the fiber structure of the diaphragm can also alter its biomechanical properties, leading to dysfunction (7,8).

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The symptoms of diaphragmatic dysfunction are varied and may include dyspnea, sleep disturbances, heart failure, exercise intolerance, and, in severe cases, compromised survival. These symptoms are often nonspecific, making them easy to overlook or misdiagnose (6,11).

Diagnosis of Diaphragmatic Dysfunction

To effectively address dysfunctions of the thoracoabdominal diaphragm, it is essential to consider the complete innervation of the diaphragm to clinically assess the disrupted processes of inhalation and exhalation and to ensure targeted treatment. Approximately 75% of respiratory excursions are facilitated by the diaphragm, while 25% are attributed to thoracic respiratory movements. Additionally, the role of accessory respiratory muscles and bronchial muscle function must be taken into account, as bronchospasm can severely impact breathing even in the absence of detectable dysfunction of the respiratory musculature (4,13,14).

The diagnosis of diaphragmatic dysfunction requires a thorough clinical examination and specialized diagnostic techniques to determine the exact cause and extent of the dysfunction. Key diagnostic methods include imaging techniques such as X-rays, ultrasound, and MRI, which can reveal structural abnormalities and motion impairments of the diaphragm. Functional tests like spirometry and manometry are also valuable in evaluating respiratory function and identifying potential dysfunctions (11).

By combining structural and functional assessments, clinicians can obtain a comprehensive understanding of the underlying issues, facilitating the development of effective treatment strategies. This holistic approach is essential for accurately diagnosing and managing diaphragmatic dysfunction to improve patient outcomes.

Nerve and Vascular Supply of the Diaphragm

The diaphragm receives its sensory and motor innervation primarily from the phrenic nerve (C3, C4, C5, and C6) (15). However, recent studies suggest that the vagus nerve also provides motor and sensory innervation to the diaphragm (15). Specifically, research indicates that the crural region of the diaphragm receives motor efferents from the vagus nerve (15). This finding explains the presence of neuromuscular spindles, predominantly located in the crura of the diaphragm (15).

Some authors have described the diaphragmatic ganglia, situated on the underside of the diaphragm and connected to the phrenic nerves, as potential sympathetic ganglia, although this has not yet been definitively proven. A study aimed to clarify the true autonomic nature of these nerve cell clusters. For this purpose, the left and right diaphragmatic ganglia of eight freshly deceased adults were examined immunochemically. The findings revealed that all diaphragmatic ganglia were negative for vasoactive intestinal peptide but positive for tyrosine hydroxylase. This suggests that the phrenic ganglia may function as sympathetic ganglia with vasomotor functions (4,15,16).

The innervation of the diaphragm by the phrenic nerve can be explained anatomically by the fact that the diaphragm develops from the cervical myotomes and

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migrates caudally during embryogenesis, with its motor nerve following this migration (4,15,16). The right branch of the phrenic nerve extends into the peritoneal covering of the ventricle mesothelium (16). From there, it gives off branches to the inferior vena cava, liver, gallbladder, pyloric region of the stomach, and adrenal glands (4,13,14).

This anatomical and functional relationship highlights the diaphragm as the most important respiratory muscle, contributing approximately 75% to the mechanics of breathing. Pathological irritation of the afferent sensory portion of the phrenic nerve, however, does not only lead to diaphragm dysfunction but can also manifest as clinical symptoms associated with diseases of the liver, stomach, and pancreas. These conditions can result in symptoms radiating to the C3-C5 and T1-T5 spinal regions, manifesting as breathing restrictions, cervicobrachialgia, cervicocephalgia, dizziness, and functional movement disorders affecting the lower cervical and upper thoracic spine (4,7,8,13,14).

In cases of bilateral phrenic nerve paralysis, significant respiratory dysfunction occurs, particularly during physical exertion, as only the accessory respiratory muscles (e.g., intercostal muscles, scalene muscles, sternocleidomastoid muscles, serratus lateralis muscles, trapezius muscles, rhomboid muscles, and levator scapulae muscles) are available to facilitate thoracic movement.

The physiological movement of the diaphragm during respiration rhythmically influences the pulmonary circulation, the heart, and the abdominal organs due to volume shifts between the thoracic and abdominal cavities. This illustrates the significant impact of diaphragmatic dysfunction on the overall organism.

Arterial and Venous Supply of the Diaphragm

The arterial and venous supply of the diaphragm is essential for maintaining its function, ensuring oxygen and nutrient delivery while removing metabolic waste products.

Arterial Supply:

- **A. phrenica superior:** A branch of the thoracic aorta (1,5).
- **A. phrenica inferior:** Provides smaller branches that originate from the abdominal aorta or the celiac trunk.
- **A. thoracica interna:** Partially supplies the diaphragm directly.
- **A. musculophrenica:** A branch of the internal thoracic artery that supplies the lateral portions of the diaphragm.
- **A. pericardiacophrenica:** Accompanies the phrenic nerve, supplying both the diaphragm and the pericardium (1,5).
- **Aa. intercostales posteriores:** Contribute to the diaphragm's blood supply.

Venous Drainage:

- **Vv. phrenicae superiores:** Drain blood from the upper diaphragm.
- **Vv. phrenicae inferiores:** Handle venous drainage from the lower diaphragm.
- **V. suprarenalis sinistra:** Also participates in venous drainage (1,3,5).
- The **Azygos vein system** facilitates venous outflow from various parts of the diaphragm.

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The close relationship between arterial and venous supply and neural control ensures the diaphragm's vital functions, particularly in respiration and the regulation of intra-abdominal pressure (5).

Fascial and Diaphragmatic Connections and Their Clinical Implications

The fascial and connective structures linking the diaphragm to the pelvic floor and the rest of the body are of significant clinical importance. The abdominal musculature spans the ribs, lumbar, and pubic regions, involving muscles such as the **rectus abdominis, internal and external obliques, pyramidalis, cremaster, and transversus abdominis.** Other critical structures supporting the stability and function of the musculoskeletal system include the **psoas major, quadratus lumborum, erector spinae, and transversospinalis muscles.** These structures connect the ribs and lumbar regions to the pelvic floor, playing essential roles in stability and movement (2,11,17).

Fascial Interconnections:

Fascia is a continuous tissue layer that connects various parts of the body. Dysfunction within the fascia can negatively impact other internal body systems (18). Dysfunction of the diaphragm or its related structures can lead to disturbances in other areas of the body. A physiological change in one region can have cascading effects throughout the musculature covered by the same fascial plane (2,11,18). Symptoms can manifest locally or in distant regions that fail to adapt to the altered stress.

The fascia surrounding the diaphragm, particularly posteriorly (retroperitoneally), is divided into four segments and connects to the **aortic system, inferior vena cava, liver, psoas muscles, quadratus lumborum, cardiac region, diaphragmatic-esophageal ligaments, and kidneys.** This complex system is referred to as the **interface system** (2,19).
Fascia contains a high density of mechanoreceptors such as **Golgi, Pacini, and Ruffini corpuscles,** which possess proprioceptive properties and transmit crucial peripheral information. These corpuscles are also thought to have nociceptive functions (2,20,21).

Key Fascial Systems:

- **Fascia transversalis:** Closely associated with the transversus abdominis muscle and a continuation of the endothoracic fascia. It is connected to the pleura, pericardium, and diaphragm (2).
- **Thoracolumbar fascia:** Extends from the sacral region posteriorly through the thoracic region and up to the cervical spine. It envelops several muscles, including the **latissimus dorsi, trapezius, gluteus maximus, and external oblique,** and ligaments connecting the ilium to the sacrum. The sacrum, considered part of the pelvic floor system, is connected to the ilium through these ligaments (3,7,23,24).

The thoracolumbar fascia plays a pivotal role in spinal musculature. Dysfunction of the diaphragm can adversely affect this tissue, leading to both central and peripheral

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symptoms. The phrenic nerve and its related structures may also be impacted. For example, **cervical pain or dysfunctions** can originate from diaphragmatic issues and manifest via the thoracolumbar fascia, potentially leading to neck pain. This bidirectional relationship explains the occurrence of pain in the sacroiliac joint when dysfunctions exist between the diaphragm and pelvic floor (2,7,8,22,25).

Sympathetic Involvement in Pain and Fascial Dysfunctions

Studies have demonstrated that the **sympathetic nervous system** is closely involved in pain mechanisms (99). Wide-dynamic-range neurons establish connections with sympathetic basal neurons in the lateral horn of the thoracic and upper lumbar spinal cord. Nociceptive activation of these neurons induces efferent excitation of sympathetic origin neurons, leading to meaningful re-regulation in the affected region (99).

Effects of Nociceptive Activation Include:

- Vasodilation of blood vessels.
- Slowing of lymphatic drainage.
- Initiation of complex tissue processes, reducing the pain threshold of nociceptive fibers.

The high concentration of autonomous nerve fibers with free nerve endings in fascial tissues, especially in the thoracolumbar fascia, underscores its significant role in pain perception and regulation (2,8,23,24,28,29,30).

Clinical Consequences

Alterations in tissue behavior can lead to dysregulation and overactivation, resulting in complex syndromes such as **Complex Regional Pain Syndrome 1 (CRPS 1)** and **Complex Regional Pain Syndrome 2 (CRPS 2, formerly causalgia)** (31,32,33). These conditions highlight the importance of understanding the intricate relationships between the diaphragm, fascia, and sympathetic nervous system for effective diagnosis and treatment.

Diseases of the Mid-Cervical Spine Associated with the Phrenic Nerve

Studies indicate that the most common causes of cervical spine syndrome (CSS) are functional disorders such as poor posture, improper loading, or diseases of the thoracic (T-spine) and lumbar spine (L-spine), as well as degenerative changes in intervertebral discs, vertebral bodies, or joints. The location of the pain source determines the manifestation of corresponding accompanying symptoms (34,35).

Various neuroanatomical connections cause internal organs to react to nociceptive stimuli and generate projection symptoms that may cross apparent segmental boundaries (34,36). This results in segmental disorders. The segmental regulatory system defines and evaluates responses to pain stimuli, where the system's output is crucial. Stimuli from regulating tissues must align in their effector qualities; otherwise, the entire complex is affected, and output is altered if compensation is not possible (24).

Energetically open systems exhibit nonlinear behavior due to feedback mechanisms, which are essential for the self-organization of seemingly chaotic conditions (13,14,24). Repeated feedback of the output with the pain stimulus (input) can result in significant changes in organization, even from minor deviations (13,14,24,37).

The topographical position of the sympathetic origin nuclei in the thoracolumbar spinal cord is clinically

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significant, although often overlooked (6,13,14). These nuclei receive afferent impulses from internal organs, the musculoskeletal system, and the skin via interneurons converging in the dorsal horn (13,20,24,38,39).
After spinal and supraspinal modulation, sympathetic efferents from the original nuclei influence not only thoracolumbar segments but also extrasegmental body regions such as the extremities, neck, and head (20,21). Therefore, segmental definitions extend beyond the somatic system and must also include the autonomic nervous system (25,31,40–46).

Mid-Cervical Syndrome: Pseudoradicular Symptoms in Segments C3, C4, and C5

- Pronounced autonomic symptoms
- Palpitations
- Tachycardia
- Tachyarrhythmia
- Diaphragmatic motor dysfunction
- Esophageal and gastric disorders
- Liver and gallbladder dysfunctions
- Thyroid and tonsillar disorders
- All disorders linked to the phrenic nerve
- Roemheld syndrome

Differential Diagnosis

- Cerebral hemorrhage
- Cervical fracture
- Alveolar hypoventilation
- Disorders of anterior horn cells or neuromuscular junctions
- Fractures of the cervical spine
- Reduced lung compliance
- Myasthenia gravis
- Guillain-Barré syndrome
- Pleural adhesions
- Peripheral neuropathies

Diaphragmatic Dysfunction

Diaphragmatic dysfunction includes eventration, diaphragmatic weakness, and diaphragmatic paralysis. Eventration refers to a permanent elevation of all or part of the diaphragm caused by thinning of the diaphragmatic tissue, often of functional origin (3,4,5).
The diaphragm plays a critical role in respiration for mammals as the primary breathing muscle. Diaphragmatic paralysis can result from muscle weakness or damage to its neural supply. Depending on the severity and nature of the paralysis, a range of clinical symptoms may arise (7,8,9).
Dysfunction of the diaphragm can cause partial or complete impairment of the muscle's respiratory function. A combination of neural therapy and manual medicine has proven to be an effective treatment for alleviating clinical symptoms (9). Paralysis of the nerves controlling the diaphragm leads to total loss of its function. Diaphragmatic dysfunction can be unilateral or bilateral and may be temporary or permanent, depending on the cause. Mechanical hernias in the diaphragmatic area are characterized by the protrusion of abdominal organs or tissues through a defect in the diaphragm. Common congenital hernias include Bochdalek and Morgagni hernias, while hiatal hernia is an acquired condition. A hiatal hernia is identified by localized bulging of the diaphragm, which can be seen in a chest X-ray (3).

Risks of Diaphragmatic Dysfunction

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Dysfunction of the diaphragm can have significant health consequences. Common risks include:

- **Dyspnea (shortness of breath):** Leads to reduced intra-abdominal pressure and severely limits exercise tolerance.
- **Biomechanical changes:** Such as increased lumbar lordosis, elongation of the thighs and abdomen, and instability in the lumbosacral region. These can cause pain in the sacroiliac joint, hip, and lower back, often accompanied by increased activity of superficial back muscles.
- **Systemic complaints:** Such as thoracic outlet syndrome, sleep disturbances, headaches, and hypertension.

The diaphragm not only plays a central role in respiration but is also crucial for body stability and the function of the autonomic nervous system. Early diagnosis and treatment are essential to minimize these negative effects (3,7,8,9,60,69,82).

Etiology

Diaphragmatic dysfunction can result either from direct weakness and atrophy of the diaphragm muscle or from damage and irritation to the phrenic nerves (N. phrenicus). Unilateral diaphragm weakness is more common than bilateral weakness and may be temporary or permanent (47).

Any condition that impairs the innervation of the diaphragm, the function of its contractile muscles, or its mechanical attachment to the chest wall can lead to diaphragmatic dysfunction (7,8,48).

Typically, diaphragmatic dysfunction is associated with symptoms such as dyspnea, reduced mobility, sleep disturbances, cardiac issues, gastrointestinal disorders, and hypersomnia, all of which can impact patient survival. In cases of severe diaphragmatic paralysis or in patients with obesity or cardiopulmonary diseases, symptoms such as orthopnea, bending-induced dyspnea, coughing, chest pain, exercise-induced dyspnea, and sleep-related breathing disorders may occur (2,49).

The diagnosis and management of unilateral or bilateral diaphragmatic dysfunction can be challenging for clinicians, as it is relatively rare, its clinical manifestations are sometimes subtle, and obtaining a physiologically confirmed diagnosis can be difficult (9).

Diaphragmatic dysfunction is likely underdiagnosed but should not be overlooked, as it negatively impacts quality of life, serves as an indicator of disease severity, and in some cases, such as in intensive care settings, acts as a prognostic marker (17). Approximately one-third of patients report exertional dyspnea. In patients with concurrent debilitating cardiopulmonary diseases, dyspnea at rest may also be present (12,17).

Most patients with unilateral diaphragmatic dysfunction exhibit some degree of physical performance limitation and have lower resting oxygen saturation levels. In patients with bilateral dysfunction, dyspnea may range in severity from mild exertional breathlessness to significant dyspnea at rest (9).

A majority of critically ill patients admitted to intensive care units show involvement of the diaphragm musculature. In recent years, the changes in diaphragmatic musculature previously categorized under this dysfunction have been further differentiated, revealing that patients undergoing mechanical ventilation often develop a specific type of diaphragmatic muscle dysfunction (50).

Mechanical ventilation is one of the primary causes of diaphragmatic dysfunction in

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these patients. Optimizing mechanical ventilation to prevent diaphragmatic injury can therefore play a crucial role in avoiding diaphragmatic dysfunction. This approach is referred to as diaphragm-protective ventilation (51).

Diaphragmatic Dysfunction

Causes of Diaphragmatic Disorders

The etiology of diaphragmatic disorders is diverse and can result in dysfunction or disease of the diaphragm. Below are some of the more common causes:

- **Diaphragmatic Hernia:** Symptoms include heartburn, regurgitation, and gastric reflux.
- **Trauma or Injury:** Injuries to the diaphragm from accidents, impacts, or surgical procedures can lead to dysfunction.
- **Obesity:** Increased intra-abdominal pressure in overweight individuals raises the risk of diaphragmatic hernias.
- **Pregnancy:** The growing uterus can exert pressure on the diaphragm, causing temporary breathing difficulties.
- **Connective Tissue Diseases:** Conditions like scleroderma may also affect the diaphragm.
- **Neurological Disorders:** These can impair nerve control of the diaphragm, leading to breathing difficulties.
- **Chronic Obstructive Pulmonary Diseases (COPD):** These may affect the diaphragm's function.
- **Diaphragmatic Contractures:** Stiffening or contraction of the diaphragm that limits its normal mobility (67,68).

Categories of Diaphragmatic Insufficiency

1. **Traumatic Causes:**
   Trauma is the most common cause of diaphragmatic insufficiency recognized in conventional medicine. Surgical procedures or trauma may injure the phrenic nerve, leading to diaphragmatic weakness. For instance, cardiac bypass surgery is the most frequent operation associated with trauma, with a risk of diaphragmatic insufficiency of up to 20%. During cold cardioplegia, the phrenic nerve can be frostbitten, resulting in temporary loss of diaphragmatic function (7,8,52).
   Due to the extended course of the left phrenic nerve in the thorax, left-sided diaphragmatic weakness is more common than right-sided. Mediastinal surgeries, esophageal procedures, or lung transplants also pose risks for diaphragmatic weakness. Additionally, penetrating injuries or gunshot wounds to the chest can damage the phrenic nerve (4,13,14).
   Examples include:
   - Cervical spine surgeries
   - Cardiac surgeries
   - Nerve blockages
   - Esophageal surgeries
   - Lung/heart/liver transplants
   - Central venous cannulation
2. **False Diaphragmatic Dysfunction:**
   - Bochdalek hernia
   - Eventration

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- Hiatal hernia
- Lipomas
- Morgagni hernia
- Lung resection (53)
- Traumatic rupture

3. **Extra-Diaphragmatic Diseases:**
    - Asymmetric emphysema (53)
    - Ascites
    - Atelectasis
    - Pulmonary embolism
    - Pulmonary or mediastinal masses
    - Subphrenic abscess
4. **Compressing or Infiltrative Processes:**
    - Cervical spine osteoarthritis and spondylosis
    - Goiter
    - Mediastinal or pulmonary malignancy
    - Pathological lymph nodes
5. **Inflammatory Diseases:**
    - Chronic inflammatory demyelinating polyneuropathy
    - Post-COVID syndrome
    - Herpes zoster
    - Mononeuritis
    - Parsonage-Turner syndrome
    - Post-viral inflammation
6. **Central Neurological Diseases:**
    - Amyotrophic lateral sclerosis
    - Chronic inflammatory demyelinating polyneuropathy
    - Guillain-Barré syndrome
    - Idiopathic neurological disorders
    - Spinal cord transection
    - Multiple sclerosis
    - Poliomyelitis
    - Rhizotomy
    - Stroke
    - Severe cervical spondylolysis
7. **Myopathies:**
    - Amyloidosis
    - Atrophy due to disuse/inactivity
    - Thyroid dysfunction
    - Critical illness or ventilation-induced diaphragmatic dysfunction
    - Muscular dystrophies
    - Post-viral illnesses
    - Malnutrition
    - Use of corticosteroids
8. **Connective Tissue Diseases:**
    - Systemic lupus erythematosus (SLE)/shrinking lung syndrome
    - Dermatomyositis
    - Mixed connective tissue diseases (9)

Functional Avascular Necrosis of the Femoral Head

Functional avascular necrosis of the femoral head is a condition with both orthopedic and functional causes. It is often triggered by dysfunction of the iliopsoas muscle, which may be associated with diaphragmatic dysfunction. Hip pain, typically the first symptom, radiates to the groin and initially manifests after prolonged activity. As the condition progresses, everyday activities such as standing and walking become increasingly difficult and painful. The disease may develop over months to one or two years (7,8,24).

The iliopsoas syndrome not only affects the hip joint but also impacts the lumbar spine, posture, and mobility of intervertebral joints. Shortening of the iliopsoas muscle can cause severe dysfunction in the lumbar spine and contribute to the development of avascular necrosis of the femoral head (7,8,54).

In orthopedic practice, the diagnosis of hip complex problems often relies on

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radiological findings, neglecting functional causes (7,8,36,55,56). However, a thorough functional examination following the principles of manual medicine is essential. This approach identifies musculoskeletal dysfunctions, such as iliopsoas muscle shortening or diaphragmatic dysfunction, which can then be specifically treated. A purely radiological approach is insufficient and risks overlooking critical functional connections and the true cause of symptoms.

Diaphragm and Spinal Stability

The tone of the diaphragm and the local stabilizing muscle system of the spine significantly influence spinal stability. Numerous studies have demonstrated the diaphragm's crucial role within the local spinal stability muscle group for effective spinal stabilization (57,58,59).

Radiological Differentiation

Radiological assessment distinguishes between:

- **Diaphragmatic elevation (high position)**
- **Diaphragmatic depression (low position)**

In conventional medical diagnostics of diaphragmatic disorders, several investigative methods are utilized. The diagnostic process often begins with a physical examination and, in some cases, an arterial blood gas analysis to measure oxygen levels in the blood. Additional diagnostic methods include:

- **Electromyography (EMG):** This test measures the electrical potential of muscle fibers stimulated by electrical impulses.
- **Imaging techniques:** These include chest X-rays, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound to detect fractures, pneumonia, cancer, anomalies, obstructions, or fluid accumulation.
- **Phrenic nerve stimulation tests:** These involve electrical or magnetic stimulation of the neck to evaluate the response of the phrenic nerve.
- **Pulmonary function tests** may also be performed to assess respiratory performance.

Diagnosis Using Non-Invasive Methods

The diaphragmatic musculature plays a significant role in various diseases, especially neuromuscular disorders, chronic obstructive pulmonary disease (COPD), and diaphragmatic dysfunction in critically ill patients. Functional assessment of the diaphragm is challenging but essential, as diaphragmatic dysfunction typically has negative clinical consequences. A thorough evaluation is necessary to determine the underlying cause and address its impact on symptoms, sleep homeostasis, and physical performance.

An experienced practitioner in neural therapy and manual medicine can often diagnose such conditions quickly. The increasing availability of ultrasound devices facilitates routine assessment of diaphragmatic function, enabling physicians to direct patients toward appropriate treatment when necessary.

Ultrasound Assessment

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Ultrasound examination of the diaphragm is a non-invasive technique increasingly employed in both clinical and research settings. Key variables assessed using this method include:

- **Static measurement** of diaphragmatic thickness.
- **Dynamic evaluation** of inspiratory diaphragmatic thickening and displacement (60).

Ultrasound has demonstrated greater sensitivity compared to fluoroscopy in assessing diaphragmatic function. Consequently, it is positioned as a primary clinical tool for quantifying and monitoring diaphragmatic function (61).

Diagnosis in the sense of manual medicine

Manual medicine is a specialized medical discipline focusing on the diagnosis and treatment of functional disorders of the musculoskeletal system, head, muscles, muscle chains, and visceral and connective tissue structures. Theoretical foundations, knowledge, and techniques from other medical fields are applied in this context (7,8,59,62,63). Treatment is performed exclusively manually and aims to achieve preventive, curative, and rehabilitative goals (7,8,59,62,63). Physicians are trained to diagnose health issues manually and to conduct therapy accordingly.

Unlike laboratory medicine, radiology, or histology, which are exclusively diagnostic disciplines, and physical medicine, which is exclusively therapeutic, manual medicine integrates both diagnostic and therapeutic approaches. However, the separation of diagnostic and therapeutic procedures in other disciplines necessitates collaboration among physicians. This division of labor, while based on differing expertise, may lead to delays in initiating treatment due to communication gaps and information loss (64,65).

Active Movement Examination

Active movement examination requires patient cooperation, where the patient follows examiner-directed movements to demonstrate joint functionality. Restricted mobility may result from deformities in passive joint elements—such as bones, cartilage, and the joint capsule—due to degenerative changes, leading to a loss of normal joint range. Additionally, active mobility can be affected by alterations in the active joint apparatus and the neuromuscular unit, including proprioceptive organs like muscle spindles and tendon organs (65,66,67,68,69).

Diaphragmatic Dysfunction Assessment

The patient is positioned comfortably on their back. The inspection of rib movement occurs during inspiration, where the ribs move caudally, and during expiration, where they move laterally in the opposite direction. In cases of diaphragmatic dysfunction, rib movement is typically restricted (see Fig. 1).

To assess diaphragmatic displacement, the examiner's hands are placed anteriorly along the rib margins, with thumbs positioned at the rib edges and fingers resting on the upper ribs. This hand positioning enables an accurate evaluation of diaphragmatic motion.

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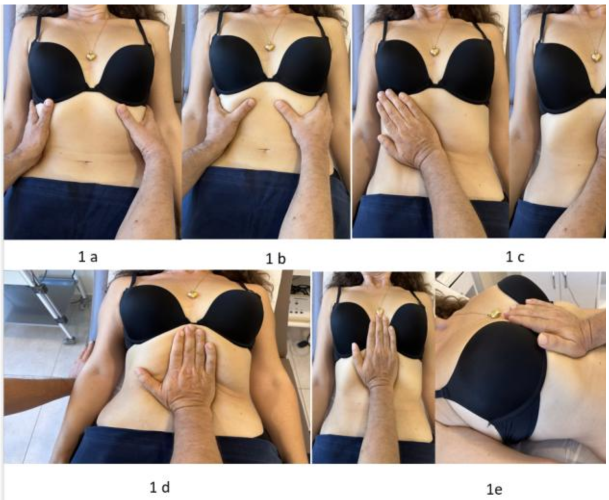

Fig. 1: The images depict various manual examination techniques of the diaphragm on a patient. The therapist uses both hands to apply pressure to the chest and abdominal areas to assess the diaphragm. **Fig. 1a and 1b:** Both hands of the therapist are placed laterally along the lower ribcage of the patient, applying gentle pressure to the diaphragm to test its mobility. **Fig. 1c:** The therapist's right hand is positioned laterally on the right ribcage, while the left hand stabilizes the lower abdominal area. **Fig. 1d:** In this image, pressure is applied centrally to the solar plexus area to examine the central portion of the diaphragm. **Fig. 1e:** In this position, the therapist applies lateral pressure, likely to test the mobility of the diaphragm while the patient is lying down. These images illustrate a manual examination of the diaphragm aimed at assessing its mobility and tension, possibly in the context of breathing issues or functional limitations.

During the following examination, the hands are positioned on the rib margins with consideration of the anatomical structures described above. The thumbs rest at the level of the rib margins, while the remaining fingers are placed on the upper ribs (Fig. 1b). As the diaphragmatic muscle descends during inspiration and ascends during expiration, this hand placement can be used to assess diaphragmatic excursion.

For the evaluation of different parts of the diaphragm, the following manual positions are recommended: domes, posterolateral region, xiphocostal region, medial ligament, and lateral ligament. To adequately assess the diaphragmatic domes, it is essential that the examiner's forearm remains parallel to the patient’s abdomen, with the thenar and hypothenar eminences of the hand aligned with the anterior margin of the ribcage. A gentle cranial pressure is applied to evaluate the elastic response of the tissue on both the right and left sides. It should be noted that tissue elasticity decreases as it responds to the applied stimulus (Fig. 1c), a common observation during manual examinations.

The assessment of the xiphoid region aims to determine whether the tissue exhibits uniform elasticity, which is necessary for normal breathing, during inspiration and expiration. In cases of abnormal diaphragmatic activity, this region is typically more rigid. The hand and forearm are positioned similarly to the assessment of the domes but located over the xiphoid process. A gentle cranial pressure is applied (Fig. 1d and 1e).

Fig. 2: 2a and 2b: The images depict a manual examination of the diaphragm in lateral and supine positions to assess potential dysfunctions. **Fig. 2a:** The patient is lying on their side. The therapist places one hand on the ribs and the other hand stabilizes the lower ribcage while applying pressure to the diaphragm in the lateral position. This technique allows for a precise evaluation of the diaphragm's

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lateral mobility and tension. **Fig. 2b:** The patient is again examined in the lateral position. One of the therapist's hands is positioned on the lower ribcage, while the other palpates the lower lateral abdominal region. This facilitates a detailed examination of the diaphragm's mobility in this position to identify any possible restrictions.

The examination shown in Fig. 2 serves to identify potential functional disorders of the diaphragm. To this end, the lateral and central mobility of the diaphragm and its response to pressure and movement are analysed.

Neural Therapy

In neural therapy, local anesthetics are used for both diagnostic and therapeutic purposes, leveraging the regulatory and plastic properties of the nervous system, particularly the autonomic nervous system (32, 33, 35, 70, 71). By applying targeted stimuli (via needles) and simultaneously erasing engrams selectively (using local anesthetics) in the sense of a "reset," neural therapy influences both the organization of the nervous system and tissue perfusion, especially microcirculation (36, 45, 46).

Following this "reset," the system has the opportunity to reorganize itself, potentially disrupting the vicious cycle of pain and inflammation. Pathological excitability of the sympathetic and nociceptive systems, stored as engrams in peripheral-spinal and (indirectly) supraspinal reflex arcs, is normalized. The therapeutic effect typically persists well beyond the pharmacological duration of the anesthetic (13, 14, 43, 44, 45, 46).

Correcting dysfunctions in the autonomic nervous system, particularly those affecting the balance between the sympathetic and parasympathetic systems, can have a beneficial impact on a wide range of diseases and pain conditions (14, 54, 56, 72, 73, 74).

Neural therapy involves injections into the skin (wheals), myofascial trigger points, fasciae, painful tendon attachments, joints, and other areas to alleviate pain and improve nerve function. In local therapy, injections are administered "loco dolendi" into the skin, while segmental therapy addresses polysegmental reflex interconnections between the skin, musculoskeletal system, and internal organs. A key component of segmental therapy includes infiltrations of nerves, peripheral arteries and their periarterial sympathetic plexuses, as well as sympathetic ganglia (32, 33, 75, 76).

Interference Field Therapy

In addition to the local and segmental therapies described above, the so-called "interference field therapy" is also employed (75). An interference field refers to a chronic irritative condition at any location in the body, where the irritation is so subtle that no direct symptoms manifest at the interference field itself. Instead, its effects, in the form of pain and inflammation, are observed outside the segmental structure (previous definition).

Modern neurophysiology no longer recognizes strict segmental boundaries in pathological processes due to cross-segmental sensitization, neuroplastic changes, immune processes, and neurogenic inflammation (13, 24, 32, 75). In contemporary research, the term "interference field" has been redefined as a "neuromodulatory trigger" (24, 75).

Common interference fields with high prevalence include scars, chronic tonsillitis, displaced teeth, root remnants, osteitis in

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the root area, status post-pleuropneumonia or hepatitis, and mononucleosis (7, 75, 77, 78). Infiltrating a suspected interference field typically results in long-term relief of associated distant complaints. If favorable, repeated injections can desensitize the area concerning pain and inflammation (13, 14, 73, 75).

Function of the Autonomic Nervous System

The autonomic nervous system is primarily responsible for the motor innervation of smooth muscle in internal organs and blood vessels, as well as exocrine and endocrine glands (13,14). It also regulates vegetative parameters such as circulation, respiration, body temperature, water balance, digestion, metabolism, and reproduction (13, 14, 71, 75, 78). Together with the endocrine system, it maintains the "internal milieu" (homeostasis) while adapting organ functions to the body's needs and environmental demands. The autonomic nervous system operates largely unconsciously (13, 14, 79).

Functionally and structurally, the autonomic nervous system can be divided into two branches: the sympathetic and parasympathetic nervous systems. These two systems exert largely antagonistic effects on various structures (4, 13, 26, 27, 79, 80, 81). The maintenance of a stable internal milieu depends on the close collaboration of the sympathetic and parasympathetic components (13, 14).

The parasympathetic nervous system, originating in the brainstem and sacral spinal cord, is responsible for numerous bodily functions and is referred to as the craniosacral system (13, 14, 24, 83). The distribution of sympathetic nuclei is limited to the thoracolumbar segments (C8-L3) of the spinal cord but provides sympathetic fibers throughout the body. Consequently, there is no segmental correspondence between the somatic and sympathetic nervous systems, particularly in the head and extremities (4, 13, 14, 78, 79).

Role in Immunity and Inflammation

Recent research has highlighted the significant role of the autonomic nervous system in regulating immune and inflammatory processes (83, 84, 85). The two systems are intricately connected. In this context, neural therapy is a promising approach for modulating excessive inflammation in autoimmune diseases (85).

Segmental Anatomy

A spinal segment refers to a "slice" of the spinal cord containing the corresponding gray matter and spinal nerve roots, which merge to form a pair of spinal nerves. These spinal nerves, with their various fiber qualities, innervate specific body areas referred to as peripheral segments. A peripheral segment thus represents the projection of a spinal cord segment into a particular region of the body (37, 75, 86, 87).

The segmental (radicular) innervation of the skin (dermatome) represents the afferent connection, while the segmental (radicular) muscle innervation (myotome) reflects the efferent connection. Additionally, the segmental (radicular) periosteal/bone innervation (sclerotome) encompasses reflexive connections (37, 75, 86).

The segmental (radicular) innervation of visceral organs (viscerotome), dermatome, myotome, and sclerotome are reflexively interconnected within the horizontal

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segmental "slice" of the spinal cord. A key role is played by the sympathetic nervous system and its sympathetic trunk. Vertically, each spinal cord segment maintains feedback with the brainstem and higher autonomic centers (13, 14, 35, 75).

To diagnose segmental dysfunctions, palpation is crucial. During palpation, various tissue layers should be individually assessed, including skin, subcutaneous tissue, fascia, muscle, joint capsule, periosteum, bones, and internal organs (viscera) (62, 86, 87).

Materials Used in Neural Therapy

In neural therapy, local anesthetics such as procaine or lidocaine are used due to their short duration of action, which minimally disrupts physiological processes during a "reset." This minimizes the risk of side effects. Procaine is considered the first choice because it is metabolized in nearly all tissues by non-specific pseudocholinesterase. It has no known drug interactions or documented teratogenic effects. Since neural therapy does not utilize additives like preservatives or adrenaline, the side effects of procaine are minimal.

Over recent years, several alternative effects of procaine have been discovered, including membrane stabilization, antiarrhythmic, bronchospasmolytic, anti-inflammatory, perfusion-enhancing, microcirculation-promoting, anticancer, and other properties (76, 77, 88, 89, 90, 91, 92).

Indications

Neural therapy is applied to treat a variety of acute and chronic, reversible, and functional disorders and diseases (36, 43, 44). In clinical practice, it can be used for diagnostic or therapeutic purposes or as a complement to conventional medical treatments (44).

As a modern regulatory method, neural therapy addresses all regulatory systems of the body, including the nervous, hormonal, immune, circulatory, and lymphatic systems, as well as the musculoskeletal system and internal organs. Thus, its applications are broad and diverse (13, 14).

The autonomic nervous system, particularly the sympathetic branch, is involved in processes such as pain sensitization, immune and inflammatory responses, endothelial damage, and microcirculatory disturbances with potential neuroplastic changes (33). Following a temporary "reset" of the sympathetic nervous system through neural therapy, the system reorganizes into a physiological state, provided that its regulatory capacity remains intact.

Observations suggest improvements in pathological states related to immune function, inflammation, endothelial function, and microcirculation as outcomes of the interaction between the autonomic nervous system and neural therapy (13, 14, 74, 75, 93, 94, 95, 96, 97).

As a modern regulatory therapy affecting all major systems of the body, neural therapy offers a wide range of applications, making it a valuable tool in both the diagnostic and therapeutic management of various medical conditions (13, 14, 99).

Examples of Collaboration Between Neural Therapy and Manual/Osteopathic Medicine

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Restoring the physiological balance between the sympathetic and parasympathetic nervous systems is one of the fundamental principles of neural therapy. This improved homeostasis has positive effects on both the musculoskeletal system and internal organs. Disturbance fields, such as certain scars, can cause significant dysfunctions in the musculoskeletal system, including the diaphragm. In this context, the autonomic nervous system plays a critical role. Following neural therapy treatments targeting these changes, also referred to as neuromodulatory triggers (54, 55, 62, 75, 78, 100), the effects of manual or osteopathic therapies have been observed to last significantly longer.

Fascia as an Example

Fascia plays a vital role in the human body and functions as a sensory organ (101, 102, 103, 104). The innervation of fascia by sympathetic fibers and sensory elements implies that fascia can be influenced neuronally from any point in the body, even through psychological mechanisms, and can in turn affect other locations in the organism through neural connections (105). Fascia has active contractile properties (8, 24, 75, 105) that are dependent on sympathetic tone. Consequently, regulating sympathetic tone through neural therapy can favorably impact fascia tone. A direct neuronal "reset" with local anesthetics applied to the fascia itself can also reduce and regulate its tone. Since direct manipulation of the diaphragm is technically challenging, reflex mechanisms (via the dorsal horn and other pathways) are influenced through neural therapy measures (8, 75, 85).

The Lymphatic System

The regulation of the sympathetic nervous system appears to be significantly relevant to the lymphatic system's response (79, 81, 90, 98). It has been argued that this response plays a significant role in the development of pain, particularly in pain- or nociception-induced lymphatic stasis, which has gained increasing importance in understanding pain pathogenesis (79, 80, 81, 98).
Neural therapy measures, especially targeted injections and manipulation of lymphatic drainage, are closely linked to this process. Recently, lymph manipulation has also become a therapeutic focus. Studies in humans have shown that injections into costotransverse and costovertebral joints influence sympathetic activity. This finding may explain why neural therapy injections and manipulative or mobilizing treatment of the ribs often positively impact diaphragm dysfunction, which frequently stems from vasomotor dysregulation—highly dependent on the sympathetic nervous system (48).

Other Indications

The present study highlights results from laboratory and clinical studies, showing significant anticancer effects in both settings (88, 89, 92, 96).

Side Effects/Complications

Due to the ubiquitous presence of pseudocholinesterase, procaine exhibits almost complete safety with minimal side effects and no significant drug interactions (as mentioned above).
However, complications may arise if injection techniques are incorrect. It is crucial to ensure that local anesthetics are

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not administered into brain-feeding vessels or the cerebrospinal fluid, as this could lead to severe complications such as seizures or life-threatening conditions. Additionally, avoiding pneumothorax during the procedure is critical.

Mechanisms of Action

The following key mechanisms of action of neural therapy are summarized:

- **Interruption of Neural Reflex Loops**: Neural therapy temporarily interrupts pathological neural reflex loops, enabling the reorganization of pain-processing systems and inflammatory pathways.
- **Impact on Pathological Couplings**: It can reduce or eliminate pathological couplings such as "sympathetic afferent coupling" or "sympathetic sprouting."
- **Desensitization Effects**: Neural therapy has desensitizing effects on peripheral and/or central sensitization, which may include subsequent neuroplastic changes. This also applies to pathological neuroimmune interactions (90, 92, 93, 94).

Effectiveness, Practicality, and Cost-Effectiveness of Neural Therapy

Over the past few years, several large-scale studies have demonstrated the effectiveness, safety, and cost-efficiency of neural therapy. Notable works include Mermod's research (107), which explored its efficacy in treating chronic pain syndromes, and Egli's comprehensive analyses (108), which assessed the broad application of neural therapy for various functional disorders.

A recent study by Badwe (88) further highlighted significant improvements in quality of life and reduced treatment costs through the targeted use of neural therapeutic methods. Summaries of these and other studies can be found in works by Fischer (85), Nazlikul (29), and the systematic scoping review by Vinjes (98).

Clinical and Economic Benefits

These publications underscore that neural therapy is not only a safe and effective treatment for acute and chronic conditions but also a cost-effective alternative to conventional medical approaches. Studies indicate that the use of neural therapy significantly reduces overall healthcare costs by minimizing long-term medication dependence and invasive surgical interventions.

Neural therapy’s cost-effectiveness is complemented by its high level of patient safety. The use of local anesthetics such as procaine, which is rapidly metabolized by ubiquitous pseudocholinesterase, minimizes the risk of systemic side effects. This makes neural therapy an exceptionally reliable and well-tolerated treatment option that effectively addresses the regulatory and plastic capabilities of the autonomic nervous system.

Conclusion

The evidence base demonstrates that neural therapy can be an integral component of modern, patient-centered medicine. It is both clinically effective and economically sustainable, offering significant benefits in terms of safety, cost reduction, and clinical outcomes.

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Neural Therapy and Manual Therapy Protocol by Nazlikul

Segmental Therapy

- **Dermatom and Subcutis Treatment**: Targeting segments C2–Th9. Facet joint injections are performed depending on the degree of PS sensitivity using appropriate needles and local anesthetics.
    - Techniques include wheals (quaddles), fascia injections, trigger points, injections to the periosteum and joints, particularly facets (C1, C2, C3, C4, C5), tonsils, thyroid gland, and ear.
    - Specific treatment areas include C2–Th9 wheals and facet injections, as well as intercostal injections at Th4–Th7.

Ganglion Injection

- **Target Areas**:
    - Superior cervical ganglion
    - Inferior cervical ganglion
    - Injection at Punctum Nervosum
    - Injection at the celiac ganglion
    - Segments L1 and L2

- **Manual Therapy and the Diaphragm**
  Manual medicine, also known as manual therapy, encompasses a range of techniques where the practitioner uses their hands to examine, diagnose, and treat joints, muscles, and tissues. The focus is on the investigation, diagnosis, and treatment of joints, muscles, and connective tissues (24, 25, 37, 40, 42, 48, 109).

- **Key Focus of Manual Medicine**
  Manual medicine addresses reversible dysfunctions of the musculoskeletal system. It is noteworthy that these dysfunctions are not necessarily localized within the structural or postural organs themselves but may originate elsewhere in the body, manifesting in the musculoskeletal system.

  A fundamental prerequisite for manual medical interventions is the structural integrity of the individual components of the musculoskeletal system. Thus, the spatial and functional relationship between these elements may be disrupted, while the structure itself remains intact. Consequently, the objective of manual medical work is not the restoration of destroyed structures but rather the re-establishment of disrupted order within the system (37, 42, 54, 63, 64, 84, 109, 110, 111).

- **Manifestation of Dysfunction**
  Persistent dysfunctions often present as muscular tension or "hardening." Irritation of the spinal nerve root in the dermatome, myotome, and sclerotome typically leads to altered sensitivity and motor function. Any stimulus exceeding a specific threshold increases segmental muscle tension and raises sensitivity to further stimuli. The interaction of muscles within complex chain reactions subsequently influences motor

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function (38, 40, 54, 58, 62, 64, 65, 109).

- **Diagnostic Approach in Manual Medicine**
  Manual diagnostics integrate traditional medical diagnostic procedures with a variety of palpatory examination techniques based on anatomical, biomechanical, and neurophysiological principles (64, 65, 111).

  In addition to established treatment methods, manual therapy includes specific manipulation techniques aimed at reducing pain or creating therapeutic stimuli (see Nazlikul, H., 2010c). The findings from manual diagnostic procedures also promote active patient participation in preventive measures (62, 64, 65, 109).

  This approach underscores the value of manual medicine in addressing the complexities of musculoskeletal dysfunctions and highlights its relevance in both therapeutic and preventive healthcare.

- **Manual Manipulation**
  The diaphragm is attached to the lower ribs, the vertebrae, the xiphoid process, and numerous fascial structures. These attachments are of significant importance, as dysfunctions of the diaphragm can lead to biomechanical problems in other areas of the body due to the transmission of tension through the fascia.

  Several approaches exist for the manual medical treatment of the muscular diaphragm. The following section describes techniques for diaphragmatic doming and indirect diaphragm release, along with their applications.

- **Techniques for Diaphragm and Spinal Mobilization**
  Manipulation techniques aimed at improving the mobility of the spine, ribs, and diaphragm are explored. These techniques can help alleviate tension and restore normal function (62, 64, 65, 109).

- **Benefits of Integrated Approaches**
  The diaphragm performs a multitude of functions within the human body. In many cases, a combined application of neural therapy, manual medical mobilization, and manipulation following the injection of active trigger points has proven advantageous. The intricate connections of the diaphragm with the nervous system, the musculoskeletal system, and other structures offer a wide range of therapeutic benefits (7, 8).

  These integrated approaches aim to optimize function, alleviate symptoms, and address underlying dysfunctions, making them essential tools in the effective treatment of

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diaphragmatic and related systemic issues.

Mobilization

Targeted mobilization exercises (Figures 3 and 4) can effectively release muscle tension and improve diaphragm mobility (63, 64, 109).

Figure 3 illustrates the mobilization of the diaphragm in two different positions while the patient is lying in the supine position. **Figure 3A**: The therapist places their thumbs in a specific position below the rib cage to locate and prepare the diaphragm for mobilization. The therapist's hands are positioned to apply targeted pressure. **Figure 3B**: After the patient inhales (inspiration), the therapist applies pressure with their thumbs to stretch the diaphragm. This technique is performed during the exhalation phase to ensure effective diaphragm mobilization. (Photo: J.M. Werner, used with permission).

The method described is particularly important after a neural therapy intervention, as stretching the diaphragm helps to restore diaphragmatic function. This can improve breathing and increase the overall efficiency of the treatment.

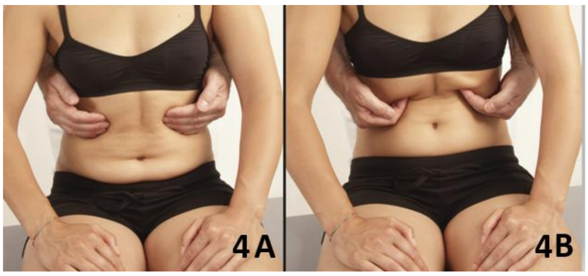

Figure 4. The image demonstrates the mobilization of the diaphragm from the back in two different phases: **Figure 4A (left):** The patient is seated on a treatment table while the therapist stands behind the patient. The therapist’s hands are positioned with the fingers placed directly below the rib cage to access the diaphragm. This position is intended as preparation for mobilization. **Figure 4B (right):** While the patient inhales, the therapist applies gentle, targeted traction outward on the diaphragm. This is done by the fingers, which gently stretch the diaphragm outward and upward. (Photo: J.M. Werner, used with permission).

This technique is also suitable for self-mobilisation by the patient. The patient can place their own fingers below the costal arch (approx. 2-5 cm) and stretch the diaphragm outwards while inhaling. This promotes self-regulation and can effectively support diaphragmatic function.

The method shown is often used to restore diaphragmatic mobility and improve breathing after neural therapy or manual interventions.

Respiratory Therapy

Manual therapists are skilled in recommending breathing techniques and exercises aimed at strengthening the respiratory muscles and improving the coordination of breathing movements (63,64,65,109).

Myofascial Release Techniques

These techniques focus on resolving adhesions and tension in connective tissue (fascia), potentially improving mobility (29). Neuromuscular techniques are applied using muscular energy, joint positioning, myofascial, or post-isometric relaxation to address soft tissue, including visceral connective and lymphatic tissue (58,59,62,63,64). Myofascial techniques (58,62,63,64) specifically target the diaphragm and surrounding tissues, inducing relaxation.

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It is crucial that a thorough diagnostic evaluation by a physician or specialist precedes any manual therapy to identify the exact cause of diaphragm dysfunction. Possible therapeutic approaches that engage the diaphragm muscle include gentle myofascial release and therapeutic techniques targeting various areas of the diaphragm in the human body. The myofascial technique involves stretching the myofascial complex under low load and over an extended duration to restore the optimal length of the complex (69,109,111).

The therapist begins with a manual assessment of the myofascial complex to locate fascia restrictions. Pressure is then applied to the skin toward the restriction until a resistance (the tissue barrier) is manually perceived. Subsequently, the collagen barrier is engaged for several minutes without gliding over the skin or forcing the tissue until the fascia begins to yield, creating a sensation of softening (66,87). Several studies have explored the effectiveness of manual therapy in treating COPD (69).

Patient Access and Techniques

Patient management varies depending on the techniques employed and time management. Techniques include thoracic spine mobilization, lymphatic drainage or pumping, diaphragm decompression, and trigger point therapy. Additional methods include massage, rib articulation techniques, myofascial release for the thoracic outlet, suboccipital decompression, and muscle stretching (112).

The therapist's hands should be gently placed on the lateral rib margins to provide feedback on rib breathing. Hands can also be positioned in front of the rib margins, with thumbs at the rib margins and other fingers resting on the upper ribs. This manual position can be used to assess diaphragm displacement.

Diaphragm Mobilization

Ventral mobilization of the diaphragm should occur mid-inhalation following an injection. During the patient's breathing, two thumbs are placed underneath the dome-shaped area below the 12th ribs at the diaphragm's central part and stretched outward. This mobilization must be repeated with 5 to 8 movements per session.

Dorsal mobilization of the diaphragm should also occur mid-inhalation following an injection. For this technique, two to five fingers are placed behind the patient under the dome-shaped area of the diaphragm located beneath the 12th ribs and stretched outward.

Targeted Stretching and Tension Techniques

Stretching and applying tension to muscles, tendons, and ligaments is crucial for promoting the regeneration of cartilage, joints, and intervertebral discs. For joint-supporting ligaments and tendons, stimulating collagen fibers through longitudinal stretching is of significant importance (87).

Diaphragm Doming

The hand positioning and force vectors applied to the diaphragm are essential components of this method. A commonly utilized technique is known as "diaphragm doming," where the xiphoid process and the costal margin at the front of the chest are identified. Once located, the therapist places their thumbs and thenar eminences

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approximately 5 to 6 cm below the costal margin, emphasizing contact with the underside of the diaphragm during exhalation. The application of diaphragm doming resembles that of Position 3B, but with increased pressure. These exercises aim to enhance the mobility and strength of the diaphragm. They may include specific breathing techniques or physical exercises designed to stretch and strengthen the diaphragm while supporting its normal function (113).

Studies have demonstrated that this technique can contribute to reducing persistent cervical spine pain, attributed to the diaphragm's innervation by the phrenic nerve (C3–C5). A 2016 study investigated the effects of treating distal tissues neurologically connected to the original spinal segments (113).
In the study, pressure pain thresholds were measured in the paraspinal muscles at C4, the lateral end of the clavicle, and the upper third of the tibialis anterior muscle, both before and after the diaphragm release treatment. Results indicated a statistically significant hypoalgesia at the C4 spinal segment following the treatment (1, 86). This finding suggests that diaphragm treatment, due to its connection to the phrenic nerve, can exert a direct impact on C4 (7,8,86).

Additional Therapeutic Approaches

Depending on the type of diaphragmatic disorder, the following therapeutic approaches may be employed:

1. **Respiratory Therapy**: Specific breathing techniques can help improve diaphragmatic function and regulate breathing.
2. **Physical Therapy**: A physical therapist may recommend exercises designed to strengthen the muscles surrounding the diaphragm and enhance mobility.
3. **Nutritional Counseling**: Dietary modifications can be beneficial for conditions such as diaphragmatic hernias or other digestive disorders.
4. **Pharmacological Therapy**: In certain cases, medications may be prescribed to alleviate symptoms or address underlying causes.
5. **Surgical Intervention**: For severe diaphragmatic problems, such as hernias, surgical intervention may be necessary.

Conclusions

Breathing is a systemic activity involving multiple parts of the body. The health of the diaphragm is critical for many patients, not only those with respiratory conditions. The role of the autonomic nervous system is significant in diaphragmatic disorders, as any restriction in mobility during inhalation and exhalation or in the thoracic region can lead to discomfort.

Adequate training of the primary respiratory muscle can be beneficial in various clinical scenarios. However, only a few authors have addressed therapeutic techniques, neural therapy, and manual approaches, particularly the manual assessment of the diaphragm.

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Role of the Diaphragm: Understanding Dysfunctions and Effective Treatment with Manual Medicine and Neural Therapy

The combination therapy of neural therapy and manual medical treatment involves injections and various techniques aimed at improving the homeostatic function of the body as an integrated whole. The body has an inherent ability to initiate regeneration after a minor stimulus or impulse, with its regenerative potential considered remarkable under the right conditions. Compared to other medical procedures, neural therapy and manual medicine are more cost-effective and less invasive. The principle of viewing the body holistically as a functional unit is central to both neural therapy and manual medicine. Despite their positive aspects, the application of these methods remains limited, with patient consent being a critical factor.

The objective of this article is to present a hypothesis for diagnosing diaphragmatic disorders using invasive methods. Simultaneously, it describes a therapeutic approach utilizing neural therapy and manual diaphragm diagnostics, with particular emphasis on anatomical foundations and interconnections.

This article highlights the importance of the phrenic nerve alongside the diaphragm muscle and introduces a combination therapy of neural therapy and manual medicine for clinicians.

The diaphragm is an exceptionally complex structural organ that performs a multitude of functions essential to the health of the entire body. These include critical roles in respiration, posture, organ function, pelvic function, and the function of the oral floor. Additionally, the diaphragm plays a pivotal role in the cervical spine, the trigeminal system, and the mammary glands. It is also integral to the vascular and lymphatic systems.

In the diagnosis and treatment of diaphragmatic disorders, it is crucial to consider not only the diaphragm muscle itself but also the innervation and clinical significance of the phrenic nerve (N. phrenicus). The diaphragm should not be viewed in isolation but as part of a complex systemic network. In summary, dysfunction of the diaphragm can have substantial clinical consequences.

Regardless of its cause, diaphragmatic insufficiency can lead to significant clinical impacts, necessitating a thorough investigation to determine its underlying causes. Such investigations are critical to effectively addressing symptoms, maintaining sleep homeostasis, and improving physical performance. Evaluations should account for the diaphragm's effects on symptoms, sleep, and physical functionality.

Manual medical examinations, alongside the increasing accessibility of ultrasound technology, provide simple yet effective tools for the routine assessment of diaphragmatic function. The targeted modulation of the autonomic nervous system, particularly through neural therapy and manual therapy, has proven to be an effective approach in treating chronic syndromes caused by diaphragmatic dysfunction.

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