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CLINICAL COMMENTARY

PERTINENT DRY NEEDLING CONSIDERATIONS FOR MINIMIZING ADVERSE EFFECTS – PART ONE

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ABSTRACT

Background: Dry needling is an evidence-based treatment technique that is accepted and used by physical therapists in the United States. This treatment approach focuses on releasing or inactivating muscular trigger points to decrease pain, reduce muscle tension, and assist patients with an accelerated return to active rehabilitation.

Issue: While commonly used, the technique has some patient risk and value of the treatment should be based on benefit compared to the potential risk. Adverse effects (AEs) with dry needling can be mild or severe, with overall incidence rates varying from zero to rates of approximately 10 percent. While mild AEs are the rule, any procedure that involves a needle insertion has the potential for an AE, with select regions and the underlying anatomy increasing the risk. Known significant AEs from small diameter needle insertion include pneumothorax, cardiac tamponade, hematoma, infection, central nervous system injury, and other complications.

Purpose/Objective: Underlying anatomy across individuals has variability, requiring an in-depth knowledge of anatomy prior to any needle placement. This commentary is an overview of pertinent anatomy in the region of the thorax, with a 'part two' that addresses the abdomen, pelvis, back, vasovagal response, informed consent and other pertinent issues. The purpose of the commentary is to minimize the risk of a dry needling AE.

Conclusions/Implications: Dry needling is an effective adjunct treatment procedure that is within the recognized scope of physical therapy practice. Physical therapy education and training provides practitioners with the anatomy, basic sciences, and clinical foundation to use this intervention safely and effectively. A safe and evidenced-based implementation of the procedure is based on a thorough understanding of the underlying anatomy and the potential risks, with risks coordinated with patients via informed consent.

Levels of Evidence: Level 5

Key Words: Adverse effect, anatomy, dry needling, informed consent, pneumothorax

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INTRODUCTION

Dry needling is an adjunctive treatment procedure that is recognized as being within the physical therapy scope of practice by the 2014 version of the 'Guide to Physical Therapy Practice',[1] and is now recognized by state licensing boards in at least 33 states, including the District of Columbia.[2] While the first dry needling Medline citation by Karel Lewit occurred over 25 years ago,[3] this is a technique that, based on the number of articles in print, has gained significant popularity over the past five years. A review of the term 'dry needling' in the national PubMed database, by year, yielded one reference in 2000,[4] seven new references in 2009, and 51 new references in 2014. This technique has advanced from being taught in one physical therapy curriculum at Georgia State University in 2006,[5] to a technique that is introduced to entry level physical therapy students in many of the Physical Therapy programs in the United States. Dry needling may also be called 'Intramuscular Manual Therapy' (according to the Federation of State Boards of Physical Therapy),[6] and the two terms can be used synonymously. The typical needle for dry needling (DN) is a solid filament needle and since it does not inject anything, the technique is referred to as 'dry needling'.[7] The popularity is due to both patient acceptance and the demonstration that this technique has 'evidence based procedure' data for conditions like upper-quarter myofascial pain, where both immediate reduction of pain (grade A), and reduction of pain at four weeks (grade A), have been demonstrated.[8] As an evolving treatment modality, high-quality evidence remains to be clearly established for short or long-term pain and disability reduction for musculoskeletal pain syndrome for all regions of the body,[9] but there are studies that demonstrate a clinically significant reduction of pain for conditions that span osteoarthritis of the knee and hip,[10,11] shoulder pain,[4,12] neck pain,[13,14] and low-back pain.[15,16] Other factors, such as the optimal frequency (number of treatments), duration (length of time that a needle should remain inserted), intensity (the number of needles that should be used), and the use of electrical stimulation remains to be determined.[9,17] While the science behind the procedure continues to evolve, there is now widespread acceptance and use of this therapeutic intervention by physical therapists. The popularity of dry needling is due to the versatility of the technique for a variety of musculoskeletal conditions, combined with the many examples of clinical success.

Dry needling involves placing a solid filament needle into tissue for the management of pain and neuromusculoskeletal dysfunctions.[7] The diameter of the needle used is very small, just thick enough to allow the tissue to be pierced while maintaining needle integrity (for perspective, the typical needle is about five times the diameter of a single muscle fiber, with the needle gauge ranging from 32 to 36 equivalent to .25 mm to .20 mm).[18] Normally, the needle is usually placed in muscle trigger points (MTrPs) in the proximity of nerves, or placed in connective tissue.[9,19] Some position statements by State Boards of Physical Therapy have specifically defined dry needling as an 'intramuscular procedure involving the isolated treatment of myofascial (muscle) trigger points'.[19] A more expansive view of dry needling includes the target areas of muscles, ligaments, tendons, subcutaneous fascia, scar tissue, peripheral nerves, bones, and neurovascular bundles.[9] Dry needling can also be performed in tissues that vary in terms of the depth of needle penetration, with some dry needling performed at either a superficial or deep tissue level that may or may not include MTrPs. The many theories that are associated with dry needling suggest that the observed pain relief may be due to a variety of factors, to include: (1) peripheral and central pain modulation, such as that discussed with the 'gate control theory of pain modulation' by Melzak and Wall;[20] (2) central pain modulation that utilizes the endogenous opioid system;[21] (3) 'central sensitization', where conditions with enhanced nociception (hyperalgesia) and allodynia, are disrupted by the implementation of dry needling; (4) disruption of MTrPs, where there may be local ischemia and hypoxia due to excessive release of acetycholine at the motor endplate;[22] (5) 'distal to proximal' remote effects, where stimulation of a distal MTrP could result in reduced irritability of a proximally located MTrP;[23,24] and (6) placebo effects.[22] Dunning et al[9] in a review article, points out that research has demonstrated increases in blood flow and oxygen saturation levels following dry needling, increased fibroblastic activity and endocrinological and neurological effects that decrease the activation of the limbic system. Whatever the physiological mechanism or multiple neurophysiological mechanisms are that function to provide relief with dry needling turn out to be, the preponderance of the evidence suggests that the technique does offer relief for a variety of neuromusculoskeletal conditions.[9,12,13,25]

As referenced above, dry needling is now being introduced in many entry-level physical therapy programs as a therapeutic treatment option. In these entry level programs as well as phase 1 certification courses for DN, the gluteal region is a site that is commonly taught since the muscle is large and placement of a needle within this structure is relatively safe. During an introduction to dry needling, one of the authors had a chance observation that led to this topic of minimizing AEs. The issue that was evident during the orientation was that a site where dry needles are placed, can be the same site many health professionals are taught to avoid when injecting compounds or vaccines, due to the potential for damaging the sciatic nerve.[26] Specifically, several recommended sites where the gluteus maximus could be dry needled for MTrPs were demonstrated that placed the needle approximately midway between the ischial tuberosity and greater trochanter, over the sciatic and other smaller nerves. At least one of the dry needling sites was in a location where a different type of needle, one with a lumen that injects a drug, should be avoided.[27] The literature outlines cases of intramuscular needles damaging nerves in the gluteal region resulting in motor and/or sensory deficits. Villarejo et al annotated 370 injection injuries to nerves and Pandian et al described 36 additional cases, predominantly in young children with limited body mass.[27,28] In addition to the negative motor and/or sensory implications of a sciatic or posterior cutaneous nerve of the thigh injury, a key finding was that only 28 percent of the injuries ultimately had a good recovery.[27] While recognizing that there are differences between a hypodermic needle and a dry needle, the underlying anatomy suggested that there is some potential risk when placing a dry needle in the gluteal region along the approximate course of the sciatic nerve. The apparent disconnect between sites to avoid with differing needles used for different purposes led to consideration of potential of AEs associated with small gauge needle utilization. The small gauge (diameter) needle used is approximately similar when comparing acupuncture needles, dry needles, and the needles employed for diagnostic electromyography (EMG). Since they all will have the same impact on underlying anatomy, the literature associated with AEs from all of these procedures are referenced.

ADVERSE EFFECTS

One of the largest needling studies ever performed looked at the question of adverse effects (AEs) with acupuncture, and the study was designed to collect data to develop a medical information and consent form.[29] In this study by Witt et al, 229,230 patients self-reported any AEs following treatment for chronic osteoarthritis pain of the knee, hip, low back, neck, or for headache, allergic rhinitis, asthma, or dysmenorrhea.[29] The average patient received 10.2 $\pm$ 3.0 acupuncture treatments, for a total treatment session count of approximately 2.2 million sessions. Of these, 8.6% (19,726 patients) reported experiencing at least one adverse effect, and 2.2% (4,963 patients) reported an adverse effect that required further treatment.[29] The most common AEs were bleeding or pain, but two patient's experienced a pneumothorax, and one patient had a nerve lesion with side effects that lasted 180 days. While the collective findings cited above demonstrate that AEs do occur, the numbers reported in the Witt et al study, are probably lower than the actual incidence, since this study was based on patient's self-reporting rather than on actual incidence.[29]

Adverse effects have also been documented with dry needling.[30-32] While most of the AEs are mild, any time that a needle is placed in a patient there is the potential for an AE. Regardless of the skill level of the practitioner, recognizing and documenting AEs may be enhanced if the health care provider is looking for them. This typically takes training and reflection. For example, past research with areas like 'plicae' causing knee pain or 'acetabular impingement syndrome' (AIS) as the etiology for hip pain, have demonstrated that conditions are not referenced until clinicians are aware and trained to look for those conditions. This is evident in a search using AIS as the search key within the National Library of Medicine's PubMed, with virtually no research articles on AIS in the year 2000, and by 2013 over 300 articles identified. Based on this realization, the purpose of this two-part clinical commentary is to examine three key topics related to DN and AEs. First, this Part 1 will deal with the thorax, examining the underlying anatomy that is at risk with specific dry needling sites, outlining cases reported in the literature and what might be done to minimize patient risk. A similar anatomical and clinical review will be performed for the abdomen, pelvis, and back in Part 2. The subsequent manuscript will also provide a description of a vasovagal response that can occur due to a variety of causes ranging from a needle stick to any strong emotional response. Lastly, the clinical commentary will outline one system that might be used to provide medical information and informed consent to a patient that is appropriate for dry needling intervention, along with several concluding observations.

Thorax and the risk of a pneumothorax

There are a number of DN sites in and around the thorax that treat conditions like adhesive capsulitis of the shoulder,[33] upper quarter myofascial pain,[8,34] neck pain,[35-41] and headaches.[42] Dry needling is often advocated for these areas based on generally favorable clinical outcomes, although effectiveness does vary between studies. To maximize the potential for safe needle placement in and around the thorax, clinicians often use a 'bracketing technique' where a bony backdrop is positioned to stop the needles progression, or the needle is placed in a way to be stopped by bone, such as the suprascapular fossa. When correctly done, this can be an effective way to minimize the chance of penetrating an unwanted region, such as the pleural cavity. Accidents can happen, however, when the needle slips along the side of a rib and penetrates further than anticipated, with the result being compromise of the pleural lining and a pneumothorax.[29,30,43] Several studies have demonstrated that needling of the serratus anterior, rhomboids, supraspinatus, iliocostalis, and the lower cervical paraspinals can result in pneumothorax.[29,30,44-46]

While the incidence of pneumothorax with small gauge needles has been reported in one study examining AEs to be less than one in 100,000 patient's treated,[29] when it occurs it can be a serious injury. Case reports suggest that the incidence may be higher than in the previously cited self-reported study that included acupuncture to all regions of the body, not just the thorax, but the incidence is low.[30,43,45-48] With larger bore needles, such as the 17 gauge coaxial needle used for a lung biopsy, the physician intentionally penetrates the pleural lining and lung to obtain a tissue sample.[49] In the case of this type of procedure with a larger gauge needle, the incidence of pneumothorax is about one-in-five patients (19.8% versus 23.1%), when needle penetration was performed in a conventional versus rapid-rollover group, respectively.[49] (Rapid-rollover has been defined as "the time between removal of the biopsy needle and placing the patient biopsy side down". The rapid time was 10 seconds or less.)[50] Regardless of the way this lung intervention is performed, these findings demonstrate that while not every needle that penetrates the pleural cavity will result in a pneumothorax, it is a concern. The advantage that a surgical team has with the tissue sample biopsy is that they are prepared for the emergency associated with a collapsed lung, with multiple physicians standing by and the ability to place a chest-tube or other device when indicated. In a clinical setting, there typically is not this team of professionals available and the occurrence of a pneumothorax can become a medical emergency. Additionally, while the needle used in dry needling is much smaller in diameter than the 17 gauge coaxial needle, it is large enough to result in a pneumothorax with a single misplaced needle stick.[30]

In addition to the potential for a pneumothorax, it should be emphasized that when this type of adverse event (AE) occurs, it is not consistently spontaneous at the time of the needle penetration and not consistently a complete pneumothorax. Three case reports demonstrate this fact.[30,43,48] Cummings et al,[30] describe a physician that was participating in a deep dry needling hands-on workshop. One of the participants described the following after a 0.3 x 50 mm Seirin needle was used to needle the iliocostalis muscle using a rib as a blocking site. In the case described the needle was advanced deeper than what was expected and the subject reported feeling pain. The subject described diffuse aching pain centered on the scapula, which began immediately and continued into the next day. The subject also had pain during inspiration, a dry cough, and a feeling of breathlessness, which worsened during physical activity to include walking. To provide a narrative picture of what he experienced, the subject provided the following description:

> "The needling was mid-morning and by mid-day I had a deep ache and stiffness in my left chest posteriorly. It was fairly diffuse, but was centered on the scapula. This continued the rest of the day and into the next day. By the morning I was also aware of a feeling of constriction on breathing and pain on taking or trying to take a deep breath, which I felt I couldn't actually perform fully. I also developed a dry cough, the breathlessness felt like an exacerbation of asthma symptoms (albeit more lateralized to the left) and was more noticeable on walking. I was also aware of a dull ache in the shoulder tip in the region of the acromioclavicular joint".[30,p.517]

A radiograph on the second day after the needling demonstrated a 20% left sided pneumothorax, with some breathlessness on exertion that was still present at two weeks, but was completely resolved by eight weeks. A second pneumothorax incident reported in the literature occurred during an acupuncture treatment for neck and right upper thoracic pain, with the patient experiencing shortness of breath and pain.[48] Four to five hours after treatment the pain became more intense, and after tolerating the pain and dyspnea for two days, the patient presented to the emergency room where the pneumothorax was verified.[48] In a case reported in the EMG literature with an attempted needle stick to the rhomboid major muscle, symptoms occurred within 40 minutes of the needle stick.[43] These three cases all demonstrate that the onset of pain and presentation of pneumothorax symptoms are not uniform, with one immediate presentation of symptoms and the others delayed minutes to hours. There are also reports where the symptoms have been delayed as long as three days.[43] When the pneumothorax is partial, it is often treated conservatively. When a large pneumothorax occurs, it may require a tube thoracostomy and the patient should be referred for emergency care.

The cases outlined previously demonstrate that the very small gauge needle used with DN can cause a pneumothorax, and that the presentation can be quite variable in terms of time of onset and the extent of lung involvement.[30,43,45] Clinicians performing DN should be well versed in the underlying anatomy and the potential for AEs and should notify the patient of foreseeable possible risks prior to performing the procedure with signed informed consent. In addition, an open line of communication should be developed with the patient when they are being treated. In the event that during a dry needling treatment the patient should need to cough, sneeze, or perform any other sudden movement, they should have been informed that it is imperative to notify the provider immediately so the needle can be withdrawn.

Anatomical Considerations

When performing dry needling in the region of the thorax, knowledge of the size and location of the pleural cavity is critical. The pleural cavity contains the right and left lungs, and these structures are intimately covered by parietal pleural (external) and visceral pleura (intimately associated with the lung tissue), which are housed within the thoracic cavity that is lined by endothoracic fascia.[26] The space between the visceral and parietal pleura is a potential space with a very small amount of lubricant that allows the two surfaces to move on one another with minimal resistance/friction. The layers that must be penetrated to create a situation where air could be introduced between these two layers are, from outside of the body to the pleural cavity: (1) skin, (2) superficial fascia (fat), (3) muscle with its surrounding deep investing fascia [in the case of the intercostals, this would be the external intercostals, the internal intercostals,the innermost intercostals, and the deep investing fascia or aponeurosis of each of those muscles], (4) endothoracic fascia, and then the (5) parietal and visceral pleura.[26] While it is intuitively apparent that the lungs are present in the thorax, the relatively thin thoracic wall and the vertical dimension of the lungs are not so clear. In a thin individual, a very short needle is able to penetrate all of the layers above and inadvertently enter the pleural cavity. Thus, while using a 'bracketing technique' with a thin muscle that lines the ribcage, like the serratus anterior muscle, a small misstep could result in an AE.[44] With a slightly longer needle, and not as intuitively obvious, the apex of the lung can be penetrated with a needle stick in the lower cervical paraspinals or the upper trapezius muscle. This was the case that Honet et al[46] described with a patient that developed a pneumothorax following a low paracervical EMG needle insertion. This unexpected event was followed-up by this professional with a cadaveric review of the region, with 23 cadavers examined for the location of the apex of the lung compared to the clavicle. The results of this investigation demonstrated that five of the 23 cadavers examined had lung tissue that extended above the clavicle, with a minimum distance from the skin to lung tissue of only 3.1 centimeters. This anatomical feature of the apex of the lung extending up into the lower cervical region was also described by McCutcheon and Yelland, who noted that the apex of the lung extends 2 – 3 cm above the clavicular line.[31] Thus, any needle penetration in the region of the upper trapezius, lower cervical paraspinals, rhomboids, supraspinatus, or other similarly placed muscle (e.g., levator scapulae, etc), is at a level where lung tissue needs to be considered.

Spanning inferiorly, the lower limits of lung tissue and the associated pleura are also not intuitively clear. Conceptually, the lungs proceed inferiorly to the level of the diaphragm that is the structural boundary that divides the thorax from the abdomen. The two lungs are separated by the thoracic contents standing in the middle (the mediastinum), that contain principally the heart, great vessels, and are surrounded by the pericardial sac that is tethered to the top of the diaphragm. Since the diaphragm is a domed structure, it proceeds further inferiorly where it is affixed to the spine and lower ribs, extending down to the 12th rib posteriorly.[31] Anteriorly, the mediastinal pleura covers the structures of the mediastinum, including the pericardial sac. This pushes the pleura laterally from the mid-line, (there is a portion of the right and left sternal lines of reflection that can be immediately contiguous, but they occur under the body of the sternum), so that the sternal line of pleural reflection on the right side turns laterally at the level of the 6th costal cartilage. On the left side, the equivalent sternal line of pleural reflection laterally occurs at the 4th intercostal space, but this line of reflection starts at the mid-clavicular line sagittally, due to the presence of the pericardial sac. From these positions, the sternal lines of pleural reflection continue laterally and are now termed costal lines of pleural reflection that then become continuous with the diaphragmatic pleura inferiorly.[26] The costal lines continue laterally and inferiorly passing across the mid-clavicular line at the 8th rib, and the mid-axillary region at the level of the 10th rib, and descend posteriorly and inferiorly to the level of the 12th ribs. It should be noted that while the inferior aspect of the lung has the ability to expand and fill the space down to the level of the 12th rib, it is not consistently at this inferior level, due to inspiration and expiration. During expiration, the lungs do not fully occupy the pulmonary cavities and potential spaces named the costodiaphragmatic recesses are created. The key point from a practitioner's perspective when placing a needle in the lower thorax, is to be aware that the pleural cavity does proceed inferiorly to the level of the necks of the 12th ribs.[26] Thus, when placing a needle in a muscle such as the iliocostalis, as was demonstrated in the Cummings article,[30] there is the potential to create a pathway for air and an AE such as a pneumothorax.

The thin layers of muscles that fill the intercostal spaces are also a consideration, since they are well designed to allow for the combined movement of the thoracic cavity that is needed for inspiration and expiration, provide protection along with the ribs, and are a light but strong muscular support. The three intercostal muscles, from superficial to deep, are the external intercostals, the internal intercostals, and the innermost intercostals. Structurally, the orientation of these fibers are conceptually similar to 'plywood', with the muscle fibers aligned in different orientations to provide strength in very thin muscles. The external intercostals span from superior to inferior with a lateral to medial orientation (hands in pockets configuration). The internal and innermost intercostals, span from superior to inferior with a medial to lateral orientation (hands positioned up in the axilla orientation). Neither of these muscle groups span the entire anterior to posterior dimension of the intercostal space. The external intercostals arise from the tubercles of the ribs posteriorly and span anteriorly to the costochondral junction anteriorly, and then have a membrane (external intercostal membrane) that spans the rest of the way anteriorly to the sternum. The internal and innermost intercostals arise from the sternum and span posteriorly to the angle of the ribs, with an internal and innermost intercostal membrane that continues posteriorly to the vertebrae.[26] Running between the layers of the internal intercostals and the innermost intercostals is the neurovascular bundle of vein, artery and nerve. This design allows expiration and inspiration, a passageway for nerves and blood vessels, and strength without a great deal of associated muscular weight. The combined intercostal muscles are too thin to reasonably attempt a dry needle insertion.

The brief overview of the anatomy of the lungs within the thorax provides a foundation from which specific needle placements can be considered. The pleural cavities in many individuals span above the clavicle, and they can be inadvertently accessed by a needle if that relationship is not appreciated. It should also be recognized that the anatomy discussed in textbooks and atlases is simply the most common variant and not necessarily what will be present within any given subject or patient. Honet et al[46] noted this variability when stating that "patients with long necks (more vertebrae above the clavicle) appear most susceptible. A Valsalva maneuver may also cause the lung apex to rise. Lung tissue is more vulnerable with the neck in flexion than in extension". [46,p.603] Extending this overview to the thoracic wall, the relatively thin wall created by the ribs and the combined intercostal muscles suggests that significant caution should be used when placing a needle in any structure that is near or adjacent to the thoracic wall. Similarly, with the recognition that the pleural lining extends inferiorly as far as T12, any needle placement in muscles such as the iliocostalis needling site needs to take into account the location on the thoracic wall and the potential depth of needle penetration. The descriptions that follow are designed to minimize the likelihood of an AE like a pneumothorax when needling in the region of the thorax, based on the underlying anatomy. While dry needling education varies, instructors do discuss anatomy when teaching dry needling techniques.

Lower cervical spine

The safest way to place a needle in this region is to place it close to the midline, staying medial to the lateral dimension of the transverse process.[51,52] Honet[46] points out that if lateral to the transverse process, needle penetration of lung tissue is possible when placing a needle in the lower cervical paraspinal muscles. The author further suggests that in individuals with long and thin necks, that if a needle placement in this region is desired, it would be prudent to auscultate the neck with a stethoscope to determine if lung tissue is in the region of the needle placement. The length of the needle should be considered, since it has been demonstrated that a needle as short as 3.1 cm can reach lung tissue, and in the cadaver study performed, the average distance from the skin to the lung field was 3.3 cm.46 If the needle being placed is an EMG needle, he further suggests that the audio be turned on so that muscle electrical activity can be monitored during the procedure.

Trapezius

The trapezius is a thin muscle that spans the neck and thorax, with the lateral aspects inserting on the lateral half of the clavicle and on the spine of the scapula.[26] It is the most superficial muscle of the neck and upper thorax, being covered only by the skin and superficial fascia (fat). It is very thin, and it is technically challenging to place a needle in this muscle layer unless the clinician has feedback when inserting the needle, as is the case with a clinician performing an electrophysiological examination. In a small number of individuals, the superficial location of the trapezius can be complicated by the presence of a soft tissue lipoma since these are often found in the upper back and neck, with an estimated prevalence of 2.1 per 100 persons.[53] Medially along the midline, there are a number of muscles that would also have to be penetrated, before the thoracic cage would be compromised. These include as an abridged list, the rhomboid major and minor (at the level of the scapula), thin structures such as the serratus posterior superior, various portions of the erector spinae muscle mass, and the intercostal muscles. In the region of the upper trapezius and lower cervical spine, however, lateral to the spinous processes, there are fewer muscle layers between the trapezius muscle and the lungs. As noted in the paragraph above, needles in the range of 3 cm can reach lung tissue.[46] From a safety perspective, placing a dry needle medially presents less risk than more lateral needle placements, especially if attempting to needle the middle or lower portions of the trapezius.

Supraspinatus

This is typically a very safe muscle to place a needle into, since superior to the spine of the scapulae the supraspinatus fossa provides a bony 'shelf' that normally functions to protect the thoracic cage and it provides a bony backstop. Reinstein et al[45] have provided a case report where the expected protection provided by the supraspinatus fossa did not occur. In this case, a 37 mm, 27-gauge needle was inserted into the supraspinatus muscle just above the midline of the spine of scapulae, and the needle advanced until the scapula was encountered. Due to the placement of the needle, the scapula did not serve as a backstop and the patient experienced sudden, severe pain and difficulty breathing. Subsequent chest x-rays revealed a 10% pneumothorax. In response to this incident, the authors reviewed the anatomy and recommended that if a needle is placed in the supraspinatus muscle, then it should be placed three-quarters of the distance from the acromion to the vertebral border of the scapula, closer to the vertebral border. The reason for this is that the supraspinous fossa is narrowest at the midpoint, and in this region there is also the suprascapular notch that houses the suprascapular nerve. In this narrow, mid-point region along the spine of the scapula, there is the potential to miss the bony backstop and penetrate the thorax.

Infraspinatus

As is the case with supraspinatus, placing a needle into the infraspinatus is considered safe as long as the needle stays within the confines of the scapula. Structurally, the infraspinatus fossa provides a bony backstop and protects the underlying ribcage and lungs. McCutcheon and Yelland note that congenital foramina have been reported in the infraspinatus fossa with an incidence of 0.8 to 5.4%.[31] These foramina have presented with diameters up to 2 to 5 mm in size, clearly large enough that they could be penetrated by a small gauge needle. While rare, this finding again demonstrates that the anatomy atlases provide the most common variant when describing a region, and not necessarily the underlying anatomy of any individual patient.[54,56] A clinician needs to be aware of the depth of penetration and not rely solely on bone to stop the progression of the needle.

Rhomboid muscles

The rhomboids lie under the trapezius, so to reach them, a needle has to penetrate the skin, any underlying superficial fascia (fat), the trapezius, and then the rhomboids. Since these muscles are traditionally thin, the needle placement has to be precise to stay superficial to the lung field. An inadvertently deep needle stick can easily penetrate the pleural cavity, particularly if the needle is placed perpendicular to the plane of the skin. If performing a manual muscle test of the rhomboids with the patient prone, the arm on the involved side internally rotated and extended, it may be possible to detect the rhomboids where they insert on the medial border of the scapulae. This position can lift the muscle fibers off of the thoracic cage and permit an obliquely oriented needle to be positioned so that the elevated undersurface of the scapula (that is lifted off of the thoracic cage) can serve as a backstop should the needle penetrate too far. While possible, the key question for this muscle remains, 'is the benefit greater than the inherent risk'? A 1990 case report by Miller outlines the case of a patient who was being evaluated for a potential C5 radiculopathy and the left rhomboid major muscle was examined with an EMG needle since this is a C4-C5 innervated muscle.[43] Approximately 40 minutes after the procedure, the patient "became acutely anxious, restless, and short of breath. Chest x-ray revealed a large pneumothorax with rightward shift of the mediastinum".[43] This case report illustrates the reality that placing any type of a needle into the rhomboid muscles has some inherent risk. While the highlighted case study was associated with a small gauge needle used during an electrophysiologic examination, the implications are relevant for any needle placement in this area. Miller concludes his description by stating, "EMG of thorax is not a benign procedure and the risk of a pneumothorax must be weighed against its diagnostic benefits when selecting patients".[43, p.653]

Pectoralis Major

Trigger point dry needling of the pectoral muscles has been shown to be an effective treatment for chest wall pain and specific conditions like costochondritis.[57] The pectoralis major overlies the anterior aspect of the thorax, with a clavicular and sternal segment, and in many individuals, a slip from the abdomen.[26] The specific attachments to the thorax include the anterior half and medial aspect of the clavicle, anterior surface of the sternum, and fibers that arise from the aponeurosis of the external abdominal oblique muscle. Distally, the muscle inserts into the lateral lip of the intertubercular sulcus of the humerus. It is the most superficial muscle of the anterior thorax, lying directly under the skin and superficial fascia (fat) that in this region also includes specialized breast tissue in women. Under the pectoralis major, is the thin pectoralis minor that extends from ribs three to five to the coracoid process. The only other muscle layer deep to the pectoralis minor are the thin muscles represented by the intercostal muscles and/or their aponeurotic extensions. Internal to the ribs is endothoracic fascia and immediately internal to that layer is the parietal pleura of the lungs. The challenge with placing a dry needle in this area, apart from the most lateral portions of the muscle as it becomes aponeurotic prior to inserting into the humerus, is that in many individuals this muscle is relatively thin, and is covered by a significant amount of superficial fascia associated with the breast tissue of both genders. When inserting a needle into the pectoralis major, there is the potential of overshooting the muscle tissue itself and extending the needle into the thoracic cage. A technique to minimize this risk would be place the clinicians fingers along either side of an identified rib, and place the needle between the fingers, counting on a rib to serve as a 'backstop' for the needle. While this will often prove to be effective, it is relatively easy for the needle to pass along an edge of the rib and this not be realized until the pleural cavity has been breached, as was demonstrated in a previously referenced case report.[30] Due to the presence of breast tissue that overlies this muscle, there is gender sensitivity associated with a significant hands-on component, particularly with a female patient. Additionally, due to the general thickness of the superficial fascia layer (fat) overlying the muscle, specific knowledge regarding the depth of penetration is problematic. Should needling of the pectoralis major muscle be indicated clinically, it will be safest to do this in the lateral aspect of the muscle close to the humeral attachment. Safety would also be increased by orienting the needle obliquely so that should the needle extend through the thickness of the muscle, it would pass lateral to the ribs and avoid the lung fields.

Sternum

An alternate site to needle the pectoralis major is medially, since the axial skeleton attachment includes the anterior surface of the sternum and superior six costal cartilages.[26] This is also a site that some practitioners that provide acupuncture use.[58] Since the sternum is a flat bone that is easily palpated, placement of a needle in this region is typically very safe. As was the case with the infraspinatus fossa, however, the literature describes an incomplete ossification and fusion of the sternal plates, that most commonly occurs at the level of the fourth intercostal plate.[31,59] This type of incomplete fusion can occur with an incidence as high as 5 to 8%. Peuker and Cummings note that "a congenital sternal foramen is usually not able to be palpated due to overlying muscle tendon fibers and connective tissue".[59] The recommendation from this anatomical reality is that since an inadvertent needle placed through the sternum could penetrate the pericardial sac, dry needling in this region should be done superficially and in an oblique manner over the sternum. In the available literature, there are at least seven reported cases of cardiac tamponade associated with acupuncture.[58,60]

Serratus Anterior

The serratus anterior covers the lateral surface of the upper eight ribs, and then inserts into the medial border of scapula. Since it is a thin muscle in most individuals overlying the lateral ribs, if an individual performing dry needling or electrophysiological testing chooses to place a needle in this muscle overlying the lateral thorax, a 'bracketing technique' where a rib is positioned between two fingers is advocated.[31] Theoretically, if the needle stays within the fingers on either side of the rib, the rib will serve as a bony wall protecting the underlying thorax and pleural cavity. Caution is indicated, however, since it is easy for a needle to slide over the end of a rib, and with many patient's today with increased superficial fascia (fat) overlying the ribs and serratus, clear palpation of this muscle can be technically challenging.

Iliocostalis

As has been highlighted in the preceding case study of a physician that was involved in a dry needling workshop of the erector spinae muscles of the back, it is possible to penetrate the thoracic cavity and have a resulting pneumothorax.[30] While blocking the depth of needle penetration by bracketing a rib, the relatively thick muscles that are part of the erector spinae (spinalis, longissimus and iliocostalis), with overlying skin and fat, create a challenge for the clinician. In the case described, a 0.3 x 50 mm Seirin acupuncture needle was used, but when the needle was redirected following the first attempt when pain was experienced, a rib was touched at a depth of approximately 10 to 15 mm. Since there is not a clear oblique needle orientation that can be utilized in this case, in addition to the rib 'bracketing' that is typically utilized, it may be advantageous to seriously consider the length of the needle utilized. If a rib would be encountered at 10 to 15 mm depth, a short needle might be considered, and the clinician should be aware of the combined needle length extending from the skin as well as the approximate depth of the potential tissue layers penetrated.

Extremely rare but possible anatomical consideration in the thorax

While the above descriptions have focused on the remote possibility of a pneumothorax or penetration of the pericardial sac (in the case of needling in the vicinity of the sternum), other underlying anatomy can also be at risk. While extremely rare, there is a case of an acute cervical epidural hematoma as a complication of dry needling.[32] In this case, a 58 year old woman was treated with dry needling over the patient's neck and arm. Approximately one hour after treatment, she developed sudden weakness and numbness of her right arm and leg. This progressed to manual muscle test weakness that was 1/5 on the left and 4/5 on the right. Imaging showed an acute cervical epidural hematoma that at surgery was shown to be 9 x 1.2 x 0.5 cm in size, overlying the lower portion of the dura from C2 to T1. Etiology was attributed to dry needling performed six hours prior to the patient presenting to the emergency room, with depth of needle insertion not known. The patient did well following surgery to correct the hematoma. This is a rare case that demonstrates that bleeding is an additional potential concern when introducing a needle into tissue. The DN solid filament needle does not have a cutting edge, but has more of a rounded tip to push tissue aside rather that cut through it. Additionally, the high gauge of the needle (very small diameter needle), minimizes the likelihood of any significant bleeding. So, an AE associated with bleeding is small and the potential for a case like that described above is extremely rare. Having noted that, the literature does cite other cases with acupuncture needles where the spinal cord has been impacted, subarachnoid hemorrhage has occurred, and peripheral nerve tissue damaged.[61] These very rare cases all demonstrate, however, that the skilled clinician always needs to be cognizant of the structures at the tip of the needle and consider the way that a patient might react in response to the treatment provided.

While Part 1 of this clinical commentary provided an overview of the most significant AEs associated with the thorax, dry needling is performed at many other anatomical sites. Depending on the needs of a given patient, there may be a need to place a needle in the abdomen, pelvis, back, or other area such as the extremities. Part 2 of the clinical commentary will address some of these areas, as well as cover the potential for a vasovagal response, informed consent, the obese patient, the fearful patient, and DN as an adjunctive procedure.

CONCLUSION

Dry needling is an evidence based treatment modality that has broad application in the treatment of numerous neuromusculoskeletal complaints, when applied by a skilled and knowledgeable professional. The approach focuses on releasing or inactivating muscular trigger points to decrease pain, reduce muscle tension, and assist patients with accelerated return to active rehabilitation. To be performed effectively and safely, minimizing the chance that an adverse effect might occur, the clinician must have a clear understanding of the underlying anatomy of the region being dry needled. In the spirit of *primum non* nocere (first do no harm), the professional application of DN must be done with knowledge of and respect for the underlying anatomy. Part 1 of this clinical commentary outlined some areas of potential concern associated with the neck and thorax. In Part 2, the abdomen, pelvis, back, and other conditions such as a vasovagal response, informed consent, the obese patient, the fearful patient, and DN as an adjunctive procedure will be covered. Recognizing the need for a thorough understanding of anatomy and a systematic approach with the application of dry needling should work to minimize the incidence of adverse effects and increase the positive results obtained with this therapeutic approach.

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