HANDBOOK OF MUSCULOSKELETAL PAIN MANAGEMENT

*A Pocketbook **for** Physicians and Practitioners **by** Physicians and Practitioners*

Richard A. Gasalberti MD and Isaac J. Kreizman MD, Editors

Supported by an Educational Grant from
Acutis Diagnostics and Premiere Genetics
The New York State Pain Society – 1st Edition - March 2017

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ABOUT THE NEW YORK STATE PAIN SOCIETY:

Established in 2011, the New York State Pain Society's mission is to advance the art and science of pain medicine by promoting and maintaining the highest standards of professional practice through education and research; by aiding and encouraging the education of medical students, residents, fellows, practicing physicians, and other health care providers in pain management and by obtaining and publishing scientific information in pain medicine and management.

The concept of this Handbook was to provide a digital "pocket-sized" reference to be consulted by physicians and practitioners when considering treatment options to manage musculoskeletal pain. The goal is individualized, integrative management of common syndromes. The Editors ask that the reader recognize that the opinions contained in this Handbook are those of the authors and should be considered a resource: a place to begin the exploration of how to best treat your patient who suffers from musculoskeletal pain. This Handbook should not be the only resource consulted; it should be one of many from which the reader draws conclusions using his or her independent professional medical judgment.

The Editors wish to thank the authors, including the trainees who volunteered to complete editorial and research tasks to keep this endeavor on schedule. It was through many hours of collaboration by all the authors that this Handbook concept became reality.

The Editors wish to thank Acutis Diagnostics and Premiere Genetics for educational grant support. Each company evolved to deliver products and diagnostics that support quality pain care. Without educational support, this Handbook would still be just a concept.

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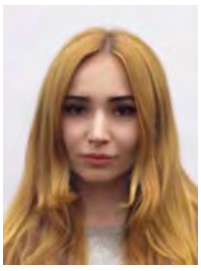

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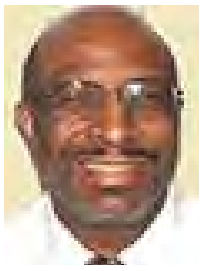

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CHAPTER 1.
ANATOMY, PHYSIOLOGY, PATHOPHYSIOLOGY

(including initial Patient examination)

Richard A. Gasalberti MD, Isaac J. Kreizman MD, Aziz Abdurakhimov MD.

UPPER LIMB

The upper extremity consists the shoulder girdle formed by the clavicle and scapulae, the arm formed by the humerus, the forearm composed of the ulna and radius, the wrist composed of the carpal bones, and the hand formed by the metacarpals and phalanges. The upper limb is supported and stabilized by muscles and ligaments. Table 2 describes muscles involved in a particular motion and nerves innervating these muscles (see Table 2). Blood supply occurs from brachiocephalic trunk and left subclavian artery.

Acromioclavicular Joint Injury

Anatomy. The acromioclavicular joint is a diarthrodial articulation between the articular surfaces of the acromial process and the clavicle, covered by the hyaline cartilage. The joint is safely stabilized by coracoclavicular ligament and acromioclavicular ligament, which covers the acromioclavicular joint capsule. (see Fig. 1)

Pathophysiology. AC joint injuries are due to direct force applied (fall directly) to the superior aspect of the acromion that may cause the acromioclavicular and coracoclavicular ligaments disruption, so called shoulder disruption. Overuse AC joint injury (aka wear and tear injury) is most common in individuals who are involved in sports. Anterior or posterior AC shear test, forced adduction test on hanging arm, Dugas test, AC distraction (bad cop) may be performed for diagnosing. [1]

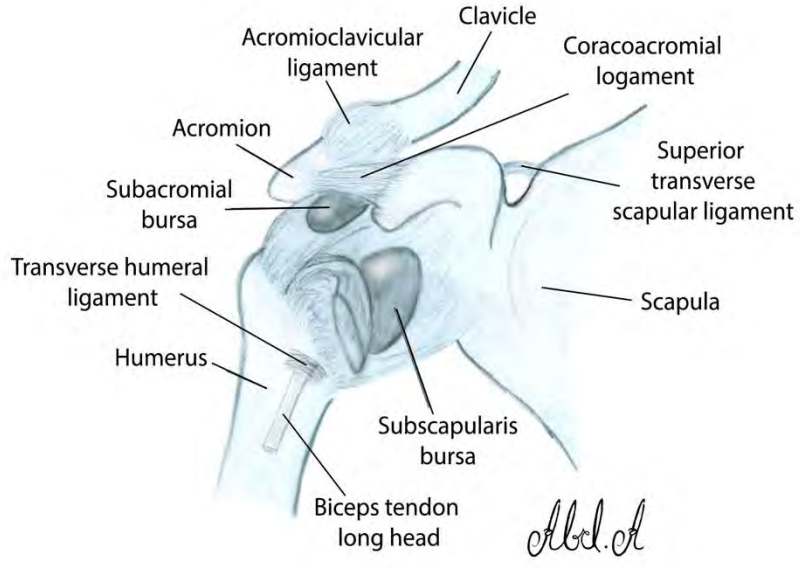

Fig. 1 Anterior aspect of the right shoulder. Subacromial bursa is located below the acromion and superiorly to the tendon of supraspinatus muscle separating it from acromion and deltoid. (by Aziz Abdurakhimov MD.)

Shoulder Dislocation

Anatomy. Shoulder stability is maintained by the glenohumeral ligaments, the joint capsule, the rotator cuff muscles (see Fig. 2), the negative intra-articular pressure, and the bony/cartilaginous anatomy.

Pathophysiology. Anterior dislocations are usually due to fall with a combination of abduction, extension of the arm and a force directed posteriorly. Also, anterior dislocations are associated with fractures (head of the humerus, greater tuberosity, clavicle or acromion can be involved). Posterior dislocation is generally caused by forceful contractions of the internal rotators with the shoulder internally rotated and adducted that may result from seizures, electrical shock, or lightning injury. Inferior dislocations arise from an axial force directed on an abducted shoulder.

Presentation. The patient with anterior dislocation holds the arm slightly abducted, in external rotation. Abduction and internal rotation are limited. The shoulder loses its usual round shape and the humeral head is palpable anteriorly, in the front of the shoulder. Posterior dislocation present with the arm internally rotated and adducted. External rotation and attempted abduction are painful. Inferior dislocation leads to a condition known as luxatio erecta. [2][3]

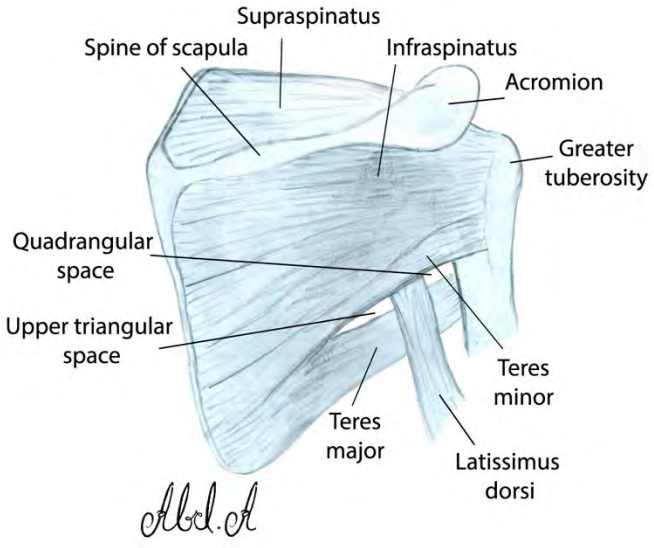

Fig. 2 The dorsal scapula muscles of the right side. (by Aziz Abdurakhimov MD.)

Rotator Cuff Disease

Anatomy. Shoulder muscles that form rotator cuff are innervated primary by C5-C6. Supraspinatus (subscapular nerve) abducts arm. Infraspinatus (suprascapular nerve) laterally rotates arm; pitching injury. Teres minor (axillary nerve) adducts and laterally rotates arm. Subscapular (subscapular nerve) medially rotates and adducts arm. (see Fig. 2)

Pathophysiology. Rotator cuff disease etiology is multifactorial. A combination of extrinsic, intrinsic, and biomechanical factors plays a major role in development of rotator cuff injury. The extrinsic factors include repeated impingement of the rotator cuff tendon against different structures of the glenohumeral joint. The conditions owing to these factors include the anterosuperior impingement syndrome, posterosuperior impingement syndrome and anterointernal impingement syndrome. Progressive age-related degeneration of the tendon may lead to “degenerative rotator cuff tear”.

Presentation. Pain and weakness of the upper extremity, decreased range of motions, clicking, catching, stiffness, crepitus. Rotator cuff tests include the impingement and topographic tests, combination of which allows determination of whether or not a patient’s symptoms are caused by rotator cuff disease [4][5]. Neer impingement test, Hawkins-Kennedy test, Yocum test and posterior impingement test are useful in confirmation of impingement syndromes. The topographic tests such as the Jobe test, full can test, Patte test, infraspinatus isolation test, Gerber lift-off test and speed palm up test are considered to be relatively sensitive but not specific.

Range of motion. Subacromial impingement syndrome (pain in elevation of the upper extremity between 45-120°); Acromioclavicular joint disorder (pain persists and worsens after 120° elevation); Frozen shoulder (when abduction is initiated by the scapulothoracic joint).

Adhesive Capsulitis

Adhesive capsulitis (aka frozen shoulder) is an idiopathic, benign, self-limiting condition characterized by pain, limited active and passive motions in the glenohumeral joint with capsular contracture.

Pathophysiology. Adhesive capsulitis is considered to be primary if its etiology is unknown. Secondary capsulitis develops in a set of a known disease such as systemic, extrinsic or intrinsic conditions. Affected capsule has no actual adhesions; rather it shows signs of synovitis. The pathologic process involves the anteriosuperior joint capsule, axillary recess, and the coracohumeral ligament. [4][6]

Presentation. Most frequently lost motions are shoulder abduction and external rotation. Progressively growing sharp pain at extremities. Also, pain at night with sleep interruption, which may last from 3-9 months.

Subacromial Bursitis (Subdeltoid Bursitis, Supraspinatus Tendinitis)

Pathophysiology. Most commonly occurs as a result of repetitive or prolonged activities placing strain on the subacromial bursa (see Fig. 1). Direct blow to the shoulder or due to a fall onto the shoulder, elbow or outstretched hand may also be a cause of this condition. Complication includes Frozen shoulder (also known as adhesive capsulitis).

Presentation. Patients complain of aching shoulder pain aggravated by using the arm above the horizontal level (painful abduction, internal rotation). Sleeping on the affected shoulder aggravates the pain. [7]

Bicipital Tendinitis

Anatomy. The biceps brachii has two heads located anterior to the humerus, with no attachment to the humerus itself. Tendon of the long head is exposed on the anterior shoulder as it passes through the humeral bicipital groove and inserts onto the superior aspect of the labrum of the glenohumeral joint. The bicipital tendinitis is an inflammatory process of the long head of the biceps tendon. (see Fig. 1)

Pathophysiology. Long standing repeated use or heavy strain on tendon are the primary causes. The transverse humeral ligament covers the intertubercular sulcus of the humerus, where the long head of the biceps tendon runs encased in its synovial sheath. If this ligament ruptures it may cause the tendon to slide back and forth, thus predisposing it to damage (wear and tear).

Presentation. Patients most often present with a specific history chronic overuse from repeated overhead activities. Main complaint is pain in anteromedial shoulder. Palpation over the bicipital groove usually provokes or exacerbates the pain. Biceps tendon instability may cause anterior shoulder “clicking” or “popping” sensation[8]

Medial Epicondylitis (Golfer’s Elbow)

Anatomy. The medial epicondyle is the common origin of the forearm flexor and pronator muscles (see Fig. 3). Golfer’s elbow is an overuse tedinopathy leading to microtearing, causing tendon degeneration. Pathology involves the flexor carpi radialis and pronator teres. Large diffuse tears can also occur in the palmaris longus, flexor digitorum superficialis and flexor carpi ulnaris.

Pathophysiology. Golfer’s elbow is the result of wear and tear injury leads to tissue degeneration. The pathology occurs as result of high-energy valgus stress on the medial elbow created by the overhead throw. Gradually the collagen fibers of the tendons lose strength and it becomes fragile and can break or be easily injured.

Presentation. Patients suffer from painful sensations in the elbow with the most sensitive region located near the origin of the wrist flexors on the medial epicondyle. Also, present with local tenderness over the medial epicondyle and the tendon of the flexor group, without swelling or erythema. [9][10]

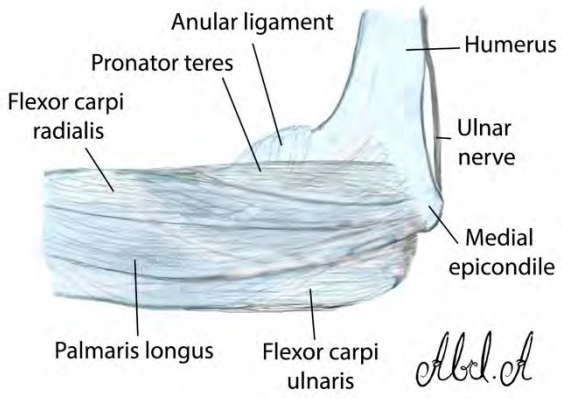

Fig. 3 Medial aspect of the right elbow showing flexor muscles and ulnar nerve.
(by Aziz Abdurakhimov MD.)

Lateral Epicondylitis

Is an overuse injury involving the extensor muscles of the forearm originating on the lateral epicondyle of the distal humerus. (see Fig. 4)

Pathophysiology. Commonly involves the extensor carpi radialis brevis muscle (macroscopic tearing) and less commonly the extensor carpi radialis longus, extensor digitorum, and extensor carpi ulnaris. Any activity involving wrist extension or supination can be associated with overuse of the muscles originating at the lateral epicondyle. The radial nerve is also in close proximity to this region, and divides into the superficial radial nerve and the posterior interosseous nerve.

Presentation. Patients typically present with pain just distal to the lateral epicondyle, elbow stiffness. Localized tenderness over the lateral epicondyle also commonly present. Patients will commonly have pain with palpation of the lateral epicondyle. Pain can be increased with resisted wrist, second or third finger extension (Cozen's sign, Mill's Test). [9][10]

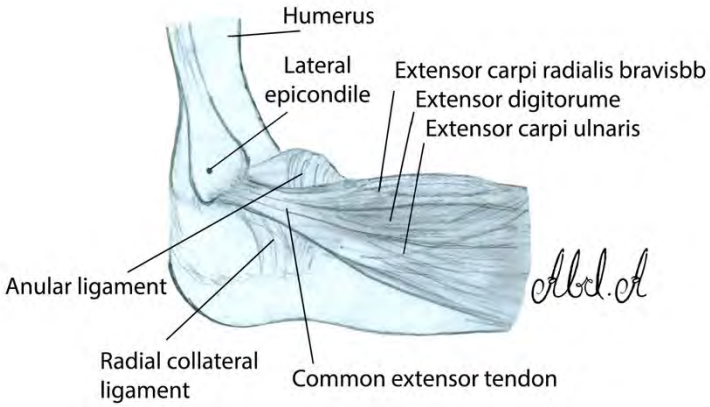

Fig. 4 Lateral aspect of the right elbow region showing extensor muscles.
(by Aziz Abdurakhimov MD.)

Ulnar Nerve Injury

Anatomy. Ulnar nerve is a terminal nerve of a brachial plexus that supplies innervation to muscles in the forearm and hand. Also, carries sensory innervation from skin of the hypothenar eminence and medial 1,5 digits. Muscles innervated by ulnar nerve at the forearm include flexor carpi ulnaris and ulnar half of the flexor digitorum profundus which function is to flex wrist and digits 4 and 5. In hand ulnar innervates muscles of hypothenar compartment, central compartment [11] (palmar and dorsal interossei muscles, lumbricals, and adductor pollicis). (see Fig. 4 and Fig. 5)

Pathophysiology. The ulnar nerve can be damaged at 3 most common sites. At the level of medial epicondyle of the humerus, at the level of the wrist (wrist lacerations; entrapment in Guyon canal or Cubital canal), and at the hand (fractured hook of hamate). Ulnar nerve entrapment may cause denervation and paralysis of the muscles supplied by the nerve, and most commonly occurs in Cubital canal and Guyon's canal.

De Quervain Tenosynovitis

Is a stenosing tenosynovitis of extensor pollicis brevis and abductor pollicis longus muscles contained within the first dorsal compartment at the wrist.

Pathophysiology. Non-inflammatory thickening of the tendons limits sliding of the tendons through the sheath. Histological specimens in De Quervain tenosynovitis shows a thickening and myxoid degeneration consistent with a chronic degenerative process. Repetitive motion or sustained a direct blow to the area of the first dorsal compartment usually leads to inflammatory lesion of tendon sheath.

Presentation. Severe aching and shooting pain resulting from thumb and wrist motion. Tenderness and thickening at the first dorsal compartment over the radial styloid. Usually, skin in thickened area forms a visible fusiform. Spasms, occasional burning sensation in the hand, difficulty gripping with the affected side of the hand is also present.

Finkelstein's sign test: the patient's thumb is folded into a clenched hand and then the wrist is deviated down to the ulnar side causes pain. [12]

Carpal Tunnel Syndrome

Anatomy. The carpal tunnel is a narrow fibro-osseous tunnel through which 9 tendons passes with the median nerve. Within the carpal tunnel median nerve runs between flexor digitorum superficialis and flexor digitorum profundus. Carpal tunnel syndrome is the most common of the median nerve entrapments with a collection of characteristic symptoms and signs. (see Fig. 5)

Pathophysiology. Anything that increases the volume of the tunnel contents such as the swelling of lubrication tissue around the flexor tendons or decreases the size of the tunnel can lead to compression of the median nerve. The median nerve entrapment undergoes demyelination followed by axonal degeneration.

Presentation. Patients with carpal tunnel syndrome have preserved flexion of the 2/3 digits and normal wrist sensation over the thenar eminence as the braches responsible for these functions arise more proximally. [11][13]

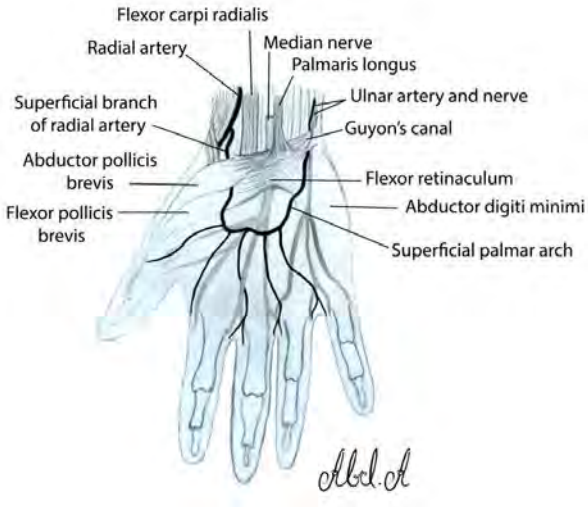

Fig. 5 Volar aspect of the right hand showing superficial palmar arch, median and ulnar nerves distribution. (by Aziz Abdurakhimov MD.)

LOWER LIMB

The lower extremity consists the hip bone which is formed by fusion of the ilium, ischium and pubis, the thigh formed by femur, the patella, the leg formed by tibia and fibula, and the foot composed of the tarsal bones, metatarsals and phalanges. The lower extremity is supported and stabilized by muscles and ligaments. Table 3 describes muscles involved in a particular motion and nerves innervating these muscles. Blood supply occurs from femoral artery continuation of external iliac artery.

Trochanter Bursitis

Pathophysiology. Certain preexisting conditions such as activities, possibility of falls, lateral hip surgeries are potentially associated with trochanteric bursitis. Pathology of hip abductor muscles can secondary inflame trochanteric bursa. Secondary inflammation of the bursa located between the gluteus medius and minimus (trochanter bursa) present specific clinical symptoms. As well iliotibial band, which is tight and runs over the bursa can irritate and inflame trochanteric bursa. (see Fig. 6)

Presentation. Primary symptom is pain at the trochanteric region of the lateral hip with or without radiation down the lateral thigh. Pain limits range of motions within affected lower extremity. Muscle weakness is also presented in-patient. Positive Patrick (FAbER) and Trendelenburg tests. [14][7]

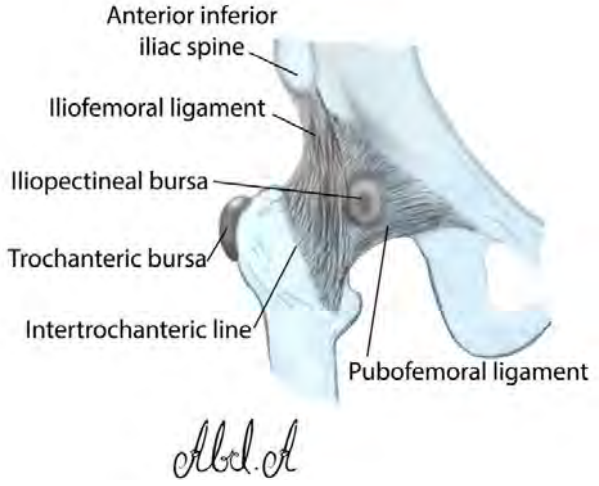

Fig. 6 Anterior aspect of the hip joint with bursae. (by Aziz Abdurakhimov MD.)

Sciatica

Pathophysiology. Sciatica is caused by the compression of L4-S3 nerves or sciatic nerve itself (herniated intervertebral disc, spondylolisthesis, degenerated discs) (see Fig. 7). Herniation causing inflammation, numbness, or excruciating pain. Inflammation in the spinal canal can also spread to adjacent facet joints and cause lower back pain and/or referred pain in the posterior thigh. [11][15]

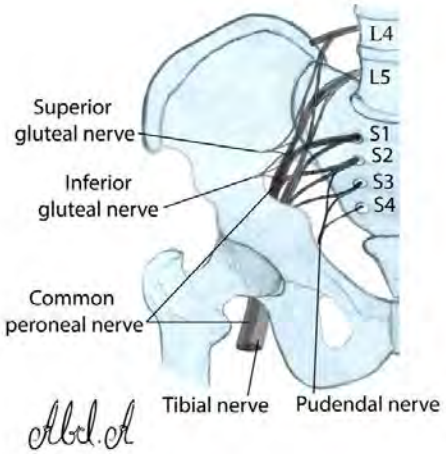

Fig. 7 Anterior aspect of the pelvis showing sacral plexus. (by Aziz Abdurakhimov MD.)

Medial Collateral And Lateral Collateral Ligament Injuries

Anatomy. Medial collateral ligament is located on the medial side of the knee join. Deep inner layer firmly attached to the medial meniscus and covers the inferior medial genicular vessels and nerve. Superficial layer of the MCL proximally attached to the medial epicondyle of the femur immediately below the adductor tubercle and distally attached to the medial condyle of the tibia. Main function of MCL is to resists forces that push the knee medially. Lateral collateral ligament also called fibular collateral ligament is located on the lateral side of the knee. (see Fig. 8)

Pathophysiology. Excessive valgus force across the knee joint is the primary cause of MCL injury. A common involved injury is called “Unhappy triad” where MCL, the medial meniscus, and the anterior cruciate ligament are involved. Lateral collateral ligament (LCL) injuries result from a varus force applied to the knee. Also during excessive lateral rotation to the knee pathophysiologic changes can occur to both MCL and LCL.

Presentation. Patients present with acute knee pain, stiffness and/or signs of joint instability. Erythema and swelling over the knee can appear after several days. Rapid-onset hemarthrosis and knee swelling indicates ACL tear. If the disease accompanied by peroneal nerve injury the clinical presentation will also include foot drop and paresthesia. [16](by Aziz Abdurakhimov MD.)

Fig. 8 Anterior aspect of the right knee joint in full flexion. (by Aziz Abdurakhimov MD.)

Anterior Cruciate Ligament Injury

Anatomy. ACL originates on lateral femoral condyle. It proceeds anteriorly and medially to insert on the anterior intercondylar area of the tibia. The primary function of the ACL is to prevent anterior motion of the tibia with respect to the femur, abnormal external rotation of the tibia and femur and knee hyperextension. The middle geniculate artery provides the primary blood supply to the ACL. (see Fig. 8)

Pathophysiology. The ACL is most commonly injured in noncontact injuries involving sudden decelerations and pivots on an extended knee. A popping heart or felt at the time of injury. Contact traumatic injuries often are associated with "terrible triad" (MCL, ACL, medial meniscus injuries).

Presentation. Physical examination shows swelling of the affected knee. Rapid-onset hemarthrosis also may be seen (middle geniculate artery). The knee will show laxity with the tibia able to be easily pulled forward relative to the femur (Lachman test, anterior drawer test). [16]

Prepatellar Bursitis

Anatomy. The subcutaneous prepatellar bursa is a fluid-filled synovial sac located between the overlying skin and the patella. It contains minimal amount of fluid and does not communicates with joint space. Main function of the bursa is to alleviate pressure and friction at bony prominences and ligamentous attachments, and allow maximum ROM.

Pathophysiology. Bursa is susceptible to injury from acute trauma or chronic repetitive pressure. Prepatellar bursitis is inflammation of prepatellar bursa most commonly due to repetitive anterior knee trauma from kneeling, called "housemaid's knee."

Presentation. Physical features of bursitis may include swelling over the lower pole of the patella and erythema of the knee. Crepitation and sharp localized pain on palpitation are present. Active ROM is often decreased or painful, but passive ROM is usually normal as it results in less pressure on the inflamed bursa. [7]

Knee Cysts

Related to chronic joint disease and are benign. There are several subtypes of cysts seen in and around the knee joint: synovial cysts, ganglion cysts, meniscal cysts and intraosseous cysts. The most common examples of synovial cysts in the knee are the popliteal cyst aka Baker's cyst (fluid collection of the gastrocnemius- semimembranosus bursa) and the proximal tibiofibular joint synovial cyst (believed to represent a joint capsule herniation, due to increased intra-articular pressure). Ganglion cysts are benign cystic mass that is surrounded by dense connective tissue, without a synovial lining and is filled with a gelatinous fluid, rich in hyaluronic acid and other mucopolysaccharides. Can have intra-, extra-articular and interosseous location. Meniscal cysts are associated with meniscal tears. [17]

Plantar Fasciitis

Anatomy. The plantar fascia is a thick fibrous band of connective tissue that originates from the medial tubercle and anterior aspect of the heel bone. From there, the fascia extends along the sole of the foot before inserting at the base of the toes, and supports the arch of the foot. (see Fig. 9)

Pathophysiology. The pathology is traditionally believed to be secondary to the development of microtrauma (microtears), with resulting damage at the calcaneal-fascial interface secondary to repetitive stressing of the arch with weight bearing.

Presentation. The pain caused by degenerative irritation at the insertion of the plantar fascia on the medial process of the calcaneal tuberosity. [18]

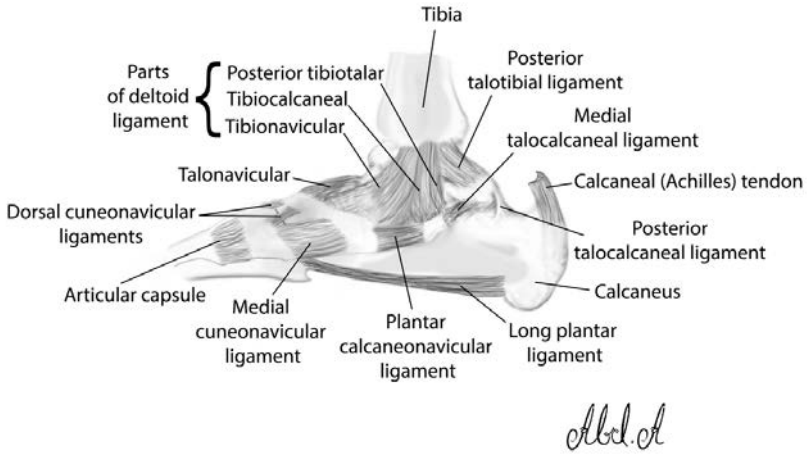

Fig. 9 Medial aspect of the right ankle with ligaments. (by Aziz Abdurakhimov MD.)

Ankle Impingement Syndrome

Pathophysiology. It may be congenital or occur as a result of synovial or capsular irritation secondary to traumatic injuries, infection, or rheumatologic or degenerative disease states. (see Fig. 10)

Anterior ankle impingement "footballer's ankle". Caused by repetitive forced dorsiflexion ankle injuries that leads to subsequent bone spur formation (anterior tibiotalar spurs). Present as anterior ankle pain with felling of stiffness usually after an ankle sprain. Dorsiflexion is limited and painful.

Anterolateral ankle impingement caused by repetitive inversion ankle injuries, which may lead to synovitis, scarring, hypertrophy and finally impingement. Present as chronic unclear pain over the anterolateral ankle. Pivoting movement is painful. Commonly seen in basketball players.

Syndesmosis impingement caused by chronic instability and extrusion of the anterolateral talus secondary to tearing of the syndesmosis. Present as severe pain along the syndesmosis and interosseous membrane. External rotation is painful.

Posterior impingement caused by repetitive plantarflexion. Present as lasting pain, swelling, and catching of a synovial nodule. Plantarflexion is painful. [19]

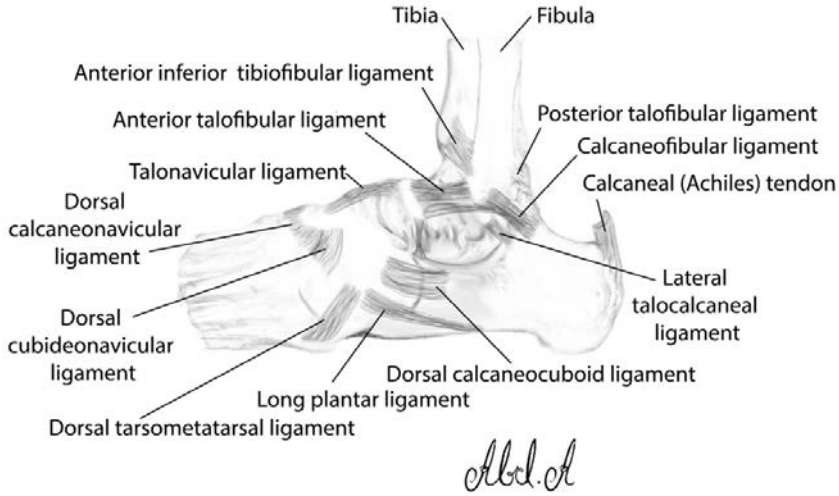

Fig. 10 Lateral aspect of the left ankle with ligaments. (by Aziz Abdurakhimov MD.)

Intermetatarsal Neuroma (Morton's Neuroma)

Anatomy. At the base of the toes, intermetatarsal nerve splits forming a "Y" and enters the toes. In this area the nerve gets pinched and swells, forming the neuroma. Intermetatarsal neuroma is the enlargement of the tissues surrounding sensory nerve that runs between the metatarsal bones (usually third and fourth). Despite the name, it is a benign condition.

Pathophysiology. Occurs as a result of a compression or trauma or surgery to the nerve or surrounding tissues. The most common cause is tight and high heeled shoes that press the metatarsal bones together exposing the nerve to excessive irritation during walking, producing pain. [20]

HEAD

Occipital Neuralgia

Anatomy. Occipital nerves take origin from the C1-C3 nerve root. The greater occipital nerve passes through the trapezius muscle and goes vertically to the scalp at the back and the top of the head, skin over the ear and the parotid glands. The lesser occipital nerve innervates the scalp in the lateral area of the head posterior to the ear. [11] (see Fig. 11)

Pathophysiology. Due to damage to the occipital nerves, repetitive neck contraction, osteochondroma, multiple sclerosis, spondylosis of the upper cervical spine. The nerve may be entrapped beneath the attachments of the trapezius and semispinalis capitis muscles to the occipital bone.

Presentation. Is characterized by chronic pain in the upper neck, back of the head and behind the ears. May cause typical migraine symptoms, dizziness.

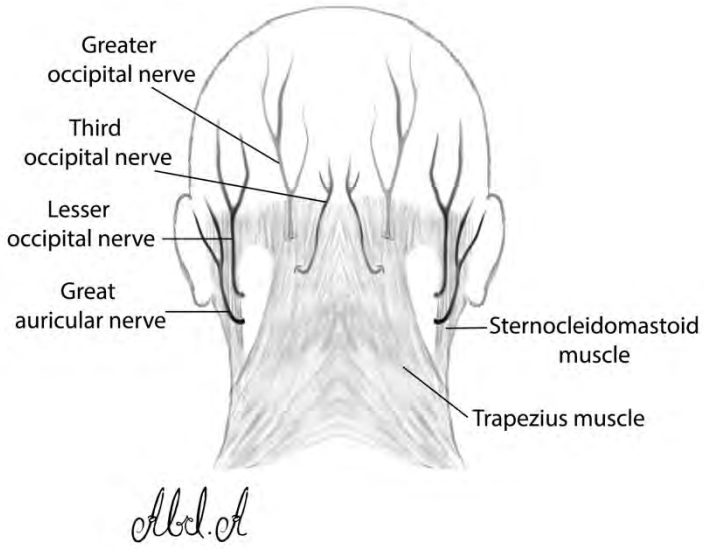

Fig. 11 Posterior view of the head showing occipital and auricular nerves distribution. Greater occipital nerve (dorsal ramus of C2); third occipital nerve (dorsal ramus C3); lesser occipital nerve (cervical plexus C2); greater auricular nerve (cervical plexus C2, C3). (by Aziz Abdurakhimov MD.)

Trigeminal Neuralgia

Anatomy. The trigeminal nerve is a mixed cranial nerve which carries general somatic afferent (GSA, sensory) and special visceral efferent (SVE, motor) fibers. Composed of ophthalmic (V1), maxillary (V2) and mandibular (V3) branches (see Fig. 12). Trigeminal neuralgia is a distinctive facial pain syndrome that may become chronic. [11]

Pathophysiology. No structural lesion is present. Vascular compression, typically at the trigeminal nerve entry into the pons, results in focal trigeminal nerve demyelination. The etiology of trigeminal neuralgia may be central or peripheral. [21]

Presentation. Characterized by unilateral sharp pain following the sensory distribution of cranial nerve V accompanied by a brief facial spasm or tic. Pain is aggravated by light touch, eating or talking. Suspect multiple sclerosis or posterior cranial fossa mass if bilateral.

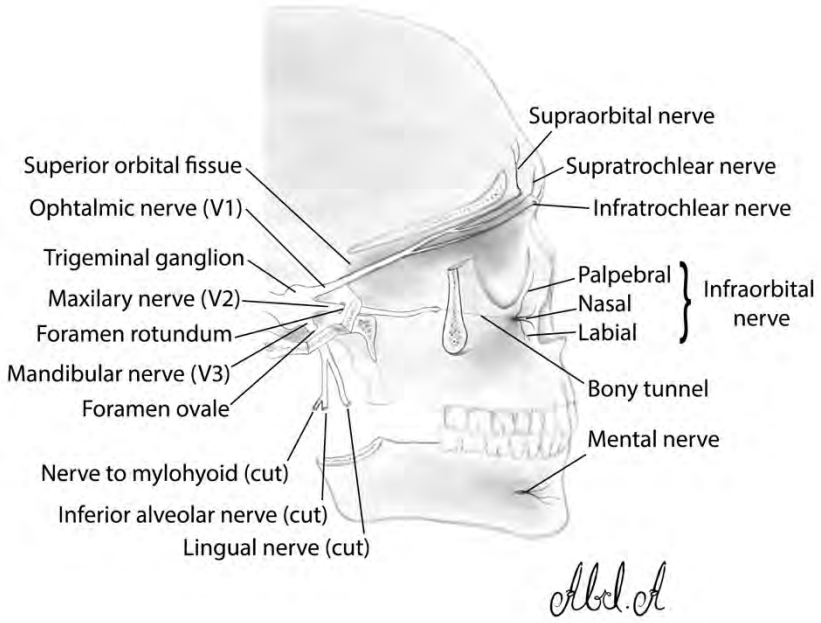

Fig. 12 The right ophthalmic, maxillary, and mandibular branches of trigeminal nerve. Lateral aspect. (by Aziz Abdurakhimov MD.)

AXIAL SKELETON

The axial skeleton includes the vertebral column, sacrum, coccyx, ribs, and sternum. The vertebral column usually consists of 33 vertebrae. 7 cervical C1 to C7, 12 thoracic T1 to T12 and 5 lumbar L1 to L5. Sacrum consists of 5 fused sacral vertebrae S1 to S5. Coccyx is composed of 4 frequently fused coccygeal vertebrae C1 to C4. Blood supply to the cervical spine occurs from vertebral arteries and ascending cervical arteries, to the thoracic spine from segmental arteries of the trunk and posterior intercostal arteries, to the lumbar spine from subcostal arteries and lumbar arteries, to the sacrum and coccyx from iliolumbar lateral and medial sacral arteries.

Cervical Radiculopathy

Anatomy. The nerve root is named from the lower segment that it runs between. C1 innervates the neck muscles. C2 carries sensation from the back of the head and scalp, along with motor innervation to several muscles in the neck. C3-C5 contribute to the formation of the phrenic nerve and innervate the diaphragm. The cervical enlargement C5-T1 gives the rise to the rootlets that form the brachial plexus, which innervates the upper limbs. [21]

Pathophysiology. Cervical radiculopathy is a dysfunction of a nerve root of the cervical spine. Most commonly radicular pain is attributable to disc herniation, degenerative conditions (rheumatoid arthritis, ankylosing spondylitis, Seronegative Spondylarthropathy), metabolic bone diseases (osteoporosis, hyperparathyroidism, Paget's disease of bone), neoplasm, cervical bone fracture, infections, congenital vertebral anomalies, diabetes can cause lack of blood flow to nerves.

Presentation see Table 1 on the next page.

LEVEL	SYMPTOMS
C5	Pain and/or weakness in the shoulders and upper arms; discomfort around the shoulder blades; rarely numbness or tingling.
C6	Pain and/or weakness along the length of the arm, including the biceps, wrists, and the thumb and index finger.
C7	Pain and/or weakness from the neck to the hand and can include the triceps and the middle finger.
C8	Pain from the neck to the hand; may cause weakness in handgrip, and pain and numbness can radiate along the inner side of the arm, ring, and little fingers.

Table 1. Clinical presentation of cervical radiculopathy regarding to nerve root disfunction of the cervical spine.

Cervical Facet Radiculopathy

Anatomy. Facet (zygapophysial) joint is a synovial joint with fibrous capsule, which located between articular processes of two adjacent vertebrae (see Fig. 13). Recurrent meningeal nerve innervates facet joint. Facet join is essential in stabilizing the cervical spine and prevention of excessive anterior translation. The mechanoreceptors from facet joint provide proprioception and pain sensation that can modulate protective muscular reflexes that can prevent joint instability and degeneration. [21]

Pathophysiology. Caused by trauma to the cervical spine, intervertebral disc injury or secondary to degenerative disc disease. When the intervertebral disc is damaged, more stress is placed onto the facet joints, as there is less space between their articulating surfaces. This in turn may result in degeneration.

Presentation. Neck and shoulder pain, stiffness with some degree of loss in the neck muscle flexibility, frequent headaches. It may also present with point tenderness overlying the inflamed facet joints. Pain radiates locally or into the shoulders or upper back.

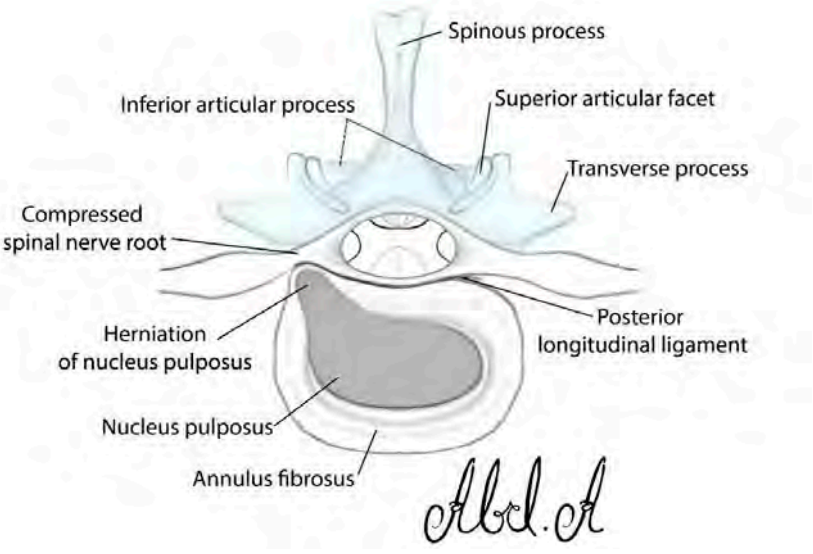

Fig. 13 Superior aspect of the seventh cervical vertebra showing herniation of nucleus pulposus. (by Aziz Abdurakhimov MD.)

Thoracic Radiculopathy

Anatomy. Thoracic spine consists of twelve vertebrae separated by intervertebral discs. The stability of the thoracic discs is specified by stabilizing effect of the rib articulations. Thoracic spine joints include fibrocartilaginous joint, zygapophysial (Facet) joint, costo-vertebral joint and costo-transverse joint (see Fig. 14). The thoracic spinal cord is composed of 12 thoracic segments and located inside the vertebral canal. The spinal nerve branches emerge below their corresponding vertebrae and go directly to the paravertebral ganglia of the autonomic nervous system. Ischemic injure of the thoracic spine is common due to fine blood supply at the watershed area (T4-T9). [21]

Pathophysiology. The pain arises as a result of chemical or mechanical irritation of the nerve root or arises as a result of excessive stresses caused by injury, deformity or other disease within the affected segment or adjacent segments. Annular tears, even in the absence of disc herniation, may contribute to thoracic pain. Thoracic intervertebral discs can herniate into the adjacent vertebral bodies and through the vertebral body endplate (Schmorl nodes or cartilaginous nodes). Central herniation may result in spinal cord compression, which presents with myelopathic symptoms, reduced sensation, tingling and burning. Centrolateral herniation may result in a presentation similar to Brown-Sequard syndrome. Lateral herniation may result in nerve root compression, which presents with a radiculopathy.

Presentation. Radicular pain due to herniated disc is described as electric, burning, or shooting pain. Numbness is commonly reported. Lesions at T9 and T10 can produce the Beevor's sign because lower abdominal muscles are paralyzed.

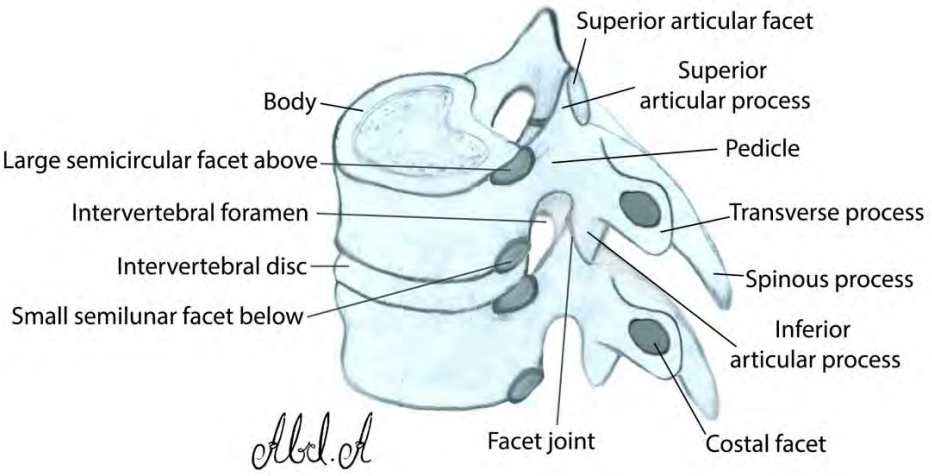

Fig. 14 Antero-lateral aspect of the eighth and ninth thoracic vertebrae. (by Aziz Abdurakhimov MD.)

Lower Back Pain

Anatomy. Spinal nerve fibers from L2-S2 provide motor control to lower extremities and related muscles (see Fig. 15). The conus medullaris is the termination of the spinal cord, which ends at vertebral levels L1-L2. The cauda equina is the collection of lumbar and sacral spinal nerve roots that run caudally and exit at their respective intervertebral foramina. The pia mater continues caudally as the filum terminale through the dural sac and attaches to the coccyx. The coccyx has only 1 spinal segment. Lesions affecting only the cauda equina cause polyradiculopathy in the lumbosacral area. Lesions affecting only the conus medullaris cause early disturbance of bowel and bladder functions. Lower back pain syndromes include lumbar discogenic pain syndrome, zygapophysial joint pain syndrome, sacroiliac joint pain syndrome, internal disc disruption, posterior sacrococcygeal joint pain syndrome, and etc.

Pathophysiology. Radiculopathy is a condition that results from nerve root impingement and/or inflammation that cause radicular pain, weakness, numbness in the areas that are supplied by the affected nerve root. LBP is most commonly associated with degeneration of the lumbar disc, degenerative facet arthritis, and spinal stenosis in the aging population. Patient may have worsening of their radicular pain when the symptomatic leg is extended at the knee and examiner passively flexes the hip. [22]

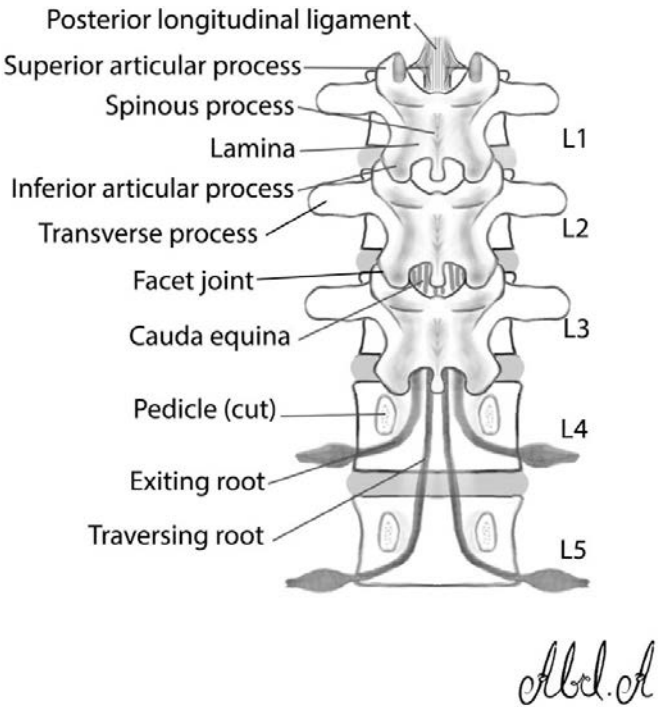

Fig. 15 Posterior aspect of the lumbar spine showing exiting and traversing roots (medial protrusion of intervertebral disc at level L4-L5 affects spinal nerve root at level L5). (by Aziz Abdurakhimov MD.)

Sacroiliac Joint Pain Syndrome.

Anatomy. Sacroiliac (SI) joint is a large diarthrodial synovial joint that joints the sacrum with the pelvis. SI joint supported and stabilized by ligamentous and muscle structures which surround and attach to the joint. Posterior SI joint is innervated from lateral branches of the L4-S3 dorsal rami, anterior joint from L2-S2. [23]

Pathophysiology. The mechanism of SI joint injury is due to abrupt rotation and high loading [24]. Etiology of joint pain varies. Inflammation, arthritis, fractures, ligamentous injury, pregnancy and myofascial pain are the main sources of pain.

ARM AND FOREARM			
Movement	**Muscle**	**Innervation**	**Root**
Elbow flexion	Biceps brachii	Musculocutaneous	C5, C6
	Brachialis	Musculocutaneous	C5, C6
	Brachioradialis	Radial	C5, C6
Elbow extention	Triceps brachii	Radial nerve	C6, C7, C8
Forearm supination	Supinator	Posterior interosseous	C5, C6, C7
		Musculocutaneous	
	Biceps brachii		C5, C6
Forearm pronation	Pronator teres	Median	C6, C7
	Pronator quadratus	Anterior interosseous	C8, T1

Table 2. Upper extremity muscle function and innervation.

SHOULDER			
Movement	**Muscle**	**Innervation**	**Root**
Shoulder abduction	Middle deltoid	Axillary	C5, C6
	Supraspinatus	Suprascapular	C5, C6
Shoulder adduction	Pectoralis major		
	Latissimus dorsi	Thoracodorsal	C6, C7, C8
Shoulder flexion	Anterior deloid	Axillary	C5
	Caracobrachialis	Musculocutaneous	C6
Shoulder extention	Latissimus dorsi	Thoracodorsal	C6, C7, C8
	Teres major	Inferior subscapular	C5, C6
		Axillary	
	Pectoralis deltoid		C5, C6
Shoulder external rotation	Infraspinatus	Suprascapular	C5, C6
	Teres major		
Shoulder internal rotation	Subscapularis	Superior/inferior subscapular	C5, C6
	Pectoralis major	Thoracodorsal	C5-T1
	Latissimus dorsi	Inferior subscapular	C6, C7, C8
	Teres major		C5, C6
Shoulder shrug (scapular elevation)	Trapezius	Spinal accessory	
	Levator scapulae	C3,C4,dorsal scapular C5	
Scapular protraction and rotation	Serratus anterior	Long thoracic n.	C5, C6, C7

Table 2. *cont.*

WRIST			
Movement	**Muscle**	**Innervation**	**Root**
Wrist flexion	Flexor carpi radialis Flexor carpi ulnaris	Median Ulnar	C6, C7, C8 C7, C8, C8
Wrist extension	Ext carpi rad longus Ext carpi rad brevis Ext carpi ulnaris	Radial Radil Posterior interosseous	C6, C7 C6, C7 C7, C8
MCP flexion	Lumbricals Dorsal and Palmal interossei	Median, ulnar Ulnar	C8, T1 C8, T1
PIP flexion	Flexor digitorum superficialis Flexor digitorum profundus	Median Median, ulnar	C7, C8, T1 C7, C8, T1
DIP flexion	Flexor digitorum profundus	Median, ulnar	C7, C8, T1
MCP, finger extension	Extensor digitorum Extensor inditis Extensor digiti minimi	Posterior interosseous	C7, C8
Finger abduction	Dorsal interossei Abductor digiti minimi	Ulnar	C8, T1
Finger adduction	Palmar interossei	Ulnar	C8, T1
Thumb abduction	Abductor pollicis longus Abductor pollicis brevis	Posterior interosseous Median	C7, C8 C8, T1
Thumb adduction	Adductor pollicis	Ulnar	C8, T1
Thumb flexion	Flexor pollicis brevis Flexor pollicis longus	Median, ulnar Anterior interosseus	C8, T1 C7, C7, T1
Thumb extension	Extensor pollicis brevis Extensor pollicis longus	Posterior interossei	C7, C8

Table 2. *cont.*

KNEE			
Movement	**Muscle**	**Innervation**	**Root**
Knee flexion	Semitendinosus	Sciatic (tibial division)	L5,S1,S2
	Semimembranosus		L4-S2
	Biceps femoris	Long head: Sciatic n. (tibial division) Short head: Sciatic n. (common fibular division)	L5,S1,S2
Knee extension	Quadriceps femoris	Femoral	L2, L3, L4
Ankle eversion	Peroneus longus Peroneus brevis	Superficial peroneal	L4, L5, S1
Toe extension	Extensor hallucis longus Extensor digitorum brevis	Deep peroneal	L4, L5, S1 L5, S1

FOOT			
Movement	**Muscle**	**Innervation**	**Root**
Ankle dorsiflexion	Tibialis anterior	Deep peroneal	L4, L5, S1
Ankle plantarflexion	Gastrocnemius Soleus	Tibial	L5, S1, S2
Ankle inversion	Tibialis posterior	Tibial	L4, L5, S1

Table 3. Lower extremity muscle functions and innervation.

HIP			
Movement	**Muscle**	**Innervation**	**Root**
Hip abduction	Gluteus medius Gluteus minimus	Superior gluteal	L4,L5,S1
Hip adduction	Adductor longus Adductor magnus	Obturator Obturator and sciatic	L2,L3,L4 L2-S1
Hip flexion	Iliopsoas	Femoral	L2,L3,L4
Hip extension	Gluteus maximus	Inferior gluteal	L5,S1,S2
Hip external rotation	Obturator internus	Nerve to obturator internus	L3-S2
	Obturator externus Quadratus femoris	Obturator Nerve to quadratus femoris	L2,L3,L4
	Piriformis	Ventral rami of L5, S1, S2	S1, S2
	Superior gamellus	Nerve to obturator internus	L4-S2
	Inferior gamellus	Nerve to quadratus femoris	
	Gluteus maximus	Inferior gluteal	L5, S1, S2
Hip internal rotation	Gluteus minimus Gluteus medius Tensor fascia latae	Superior gluteal	L4,L5,S1

Table 3. Cont.

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CHAPTER 2.
COMMON SYNDROMES

Frank Schirripa DO, Isaac J. Kreizman MD, Richard A. Gasalberti MD.

Plantar Fasciitis

Background. The plantar fascia attaching to the medial side of the calcaneal tuberosity is the main location of irritation causing pain in plantar fasciitis (see Fig. 9 on Chapter 1). It is worse during weight-bearing activities and in the morning but less when at rest. It is more common in females compared to males. [1]

Pathogenesis. The pain is generated due to chronic inflammation of the plantar fascia that has been under stressful tension for extended periods of time. Tight Achilles tendon, pes cavus, pes planus, bone spurs, improper footwear, high activity, and obesity are common risk factors.

Diagnosis. A physical exam, patient history, and risk factors are crucial for diagnosis. Plain X-ray films are ordered to rule out bone spurs or fracture.

Treatment. The patient is first advised to undergo conservative therapy. This includes weight loss, rest, ice massage, heel cups, orthotics, NSAIDS, Achilles and plantar fascia stretching, corticosteroid/anesthetic injection, extracorporeal shock wave therapy, and dorsiflexion night splints. Conservative treatment is mostly used and very effective in resolving plantar fasciitis. Plantar fascia release, a surgical procedure, is saved for failed conservative therapy. This form of treatment can be performed by a needle or an incision aiming to relieve tension that caused tissue damage. [2]

Carpal Tunnel

Background/Pathogenesis. The median nerve is compressed in the carpal tunnel causing a neuropathy. The carpal tunnel contains 4 flexor digitorum superficialis tendons, 4 flexor digitorum profundus tendons, 1 flexor pollicis longus tendon and 1 median nerve (see Fig. 5 on Chapter 1). The median nerve can be aggravated by increased carpal tunnel volume from CHF, renal disease, thyroid disease, pregnancy, mass or decreased tunnel volume from rheumatoid tenosynovitis, fracture, arthritis. The nerve can also be damaged from an idiopathic cause. The first 3 ½ fingers are affected with sensation except the base of the thumb. Muscle weakness occurs in the first two lumbricals, abductor pollicis brevis, opponens pollicis 4 heads of the flexor digitorum superficialis. [3]

Diagnosis. History and physical exam is a big part of the diagnosis. Complaints of numbness, paresthesias and pain to the first three and a half digits waking the patient up at night can be considered mild carpal tunnel syndrome. Continuous median nerve sensory complaints is considered moderate carpal tunnel syndrome. Severe sensation loss and atrophy is classified as severe carpal tunnel syndrome. Tinel's sign is when symptoms are elicited when the median nerve is tapped at the wrist. Phalen's test is positive when the wrist is held in 90 degrees of flexion for 1 minute and symptoms arise. Reverse Phalen's test is when symptoms ensure after the wrist is held in 90 degrees of extension for 1 minute. These helps further support the diagnosis. Electrodiagnostic testing helps further support the diagnosis of carpal tunnel syndrome.

Treatment. With no muscle atrophy, weakness, EMG abnormalities, a hand splint 0-30 degrees neutral to extension is indicated. Vitamin B6, thyroid, pregnancy, CHF may all contribute to carpal tunnel symptoms. All levels should be checked before proceeding with treatment. Levothyroxine, diuretics, and Vitamin B6 may help correct the symptoms if any abnormalities are found in the lab studies. NSAIDS or a steroid injection can help reduce inflammation and crowding in the carpal tunnel if related to an inflammatory process. Surgical intervention, transverse ligament release, is indicated with conservative therapy failure, muscle atrophy and persistent pain.

Greater Trochanteric Bursitis

Background/Pathogenesis. This condition is caused by inflammation of the bursa that overlies the greater trochanter and deep to gluteus minimus, medius, and tensor fasciae lata. This phenomenon occurs more often in patients with obesity, hemiparesis, muscle asymmetry, osteoarthritis, leg length discrepancy, overuse, and trauma which ultimately alters gait. The altered gait will then cause the bursa to become aggravated. [4][5] (see Fig. 6 on Chapter 1)

Diagnosis. Physical and history is the mainstay of diagnosis. On exam, the patient is tender to palpation on the greater trochanter and during extension to flexion of the hip. There is pain often when patient walks up stairs or getting out of a car. The history explains that the patient has trouble sleeping on the affected side due to pain. X-ray of the hip is important to rule out fracture or any other bony pathology.

Treatment. Conservative therapy such as NSAIDS, iliotibial band stretching, and strengthening of the hip muscles are the first-line treatment. Corticosteroid injection into the trochanteric bursa is utilized for patients who failed conservative therapy.

Lateral Epicondylitis

Background/Pathogenesis. There is tearing at the extensor carpi radialis brevis from common overuse activities such as tennis, golf, and use of a screwdriver. The repetitive forearm supination and wrist extension aggravate the supinator and extensor tendons (see Fig. 4 on Chapter 1). Poor biomechanics in these activities also play a major role. The patient usually complains of weak grip strength coupled with pain distal to the lateral epicondyle at extensor tendon origin. [6]

Diagnosis. History and physical exam should be enough to diagnose lateral epicondylitis. Resisted flexion of the wrist and passive extension of the elbow can display pain at the lateral epicondyle. Also, when the elbow is stabilized, pain can be elicited in the lateral epicondyle when the patient pronates the forearm, extends, and radially deviates against force. X-rays can be performed to rule out bony pathology. [7]

Treatment. Conservative treatment includes ice, rest, NSAIDS for 2 weeks. Physical therapy is implemented to strengthen muscles supporting the elbow as well as teaching better biomechanics in elbow usage. A forearm brace can also reduce stress on the painful elbow. Corticosteroid injection, platelet-rich plasma injection, prolotherapy, and dry-needling can serve as treatment. Surgery can be performed if conservative treatment fails after 6-12 months. This includes extensor carpi radialis brevis debridement through a large incision or through multiple smaller incisions. Rehabilitation is important post-surgery to increase muscle strength and proper biomechanics.

De Quervain's Tenosynovitis

Background/Pathogenesis. Patient experiences radial sided wrist pain with movement. The mechanism of injury is due to repetitive trauma to the sheath holding the abductor pollicis longus and extensor pollicis brevis tendons. Repetitively picking up a baby or playing a specific sport using the wrist may facilitate this pain pattern. Scar tissue due to an old injury or rheumatoid arthritis can be possible causes of De Quervain's tenosynovitis. [8]

Diagnosis. History and physical is the mainstay for diagnosis. Finklestein's test is positive when the patient flexes the thumb into the hand and ulnar deviates the wrist and experiences pain. Imaging can be done to rule out fracture or bony pathology but is usually not needed

Treatment. Conservative measures such as NSAIDS to reduce inflammation and pain, a thumb spica splint to stabilize and reduce aggravation of the thumb. An occupational therapist may sometimes be consulted to teach the patient how to avoid stressful hand positions and also strengthen muscles in the area. Providers may offer corticosteroid injection into the tendon sheath if previous methods fail to help reduce inflammation. Surgery is performed when conservative methods fail and the surgeon cuts the sheath that holds the tendons. Rehabilitation with occupational therapy of the hand motions and muscles are important after surgery. [9]

Trigger Point

Background/Pathogenesis. A distinct location of irritable tissue that causes referred pain in a specific distribution. The trigger point can be palpated as a band of muscle or a nodule and when pressure applied, referred pain is felt. Chronic muscle contraction or overload, poor posture, trauma, and inconsistent exercise can cause trigger points. It is not only in myofascial structures but can also be found in ligamentous, cutaneous, and periosteal tissues. [10]

Diagnosis. History and physical exam easily diagnoses trigger points.

Treatment. Trigger points should be treated through a rehabilitation approach to try and resolve what is causing the trigger points. Massage therapy, stretching, cooling spray, range of motion exercises, pulsed ultrasound, electro stimulation can be among the conservative approaches. The more invasive tool would be the trigger point injection. The trigger point injection has many different approaches. Dry needling is one without anesthetic or irritant. Anesthetic can be administered combined with corticosteroid or alone. Botulinum can be injected which works quickly and used when other methods fail. Anesthetics can cause tissue necrosis while corticosteroids and botulinum can cause myositis and tissue damage. [11]

Sacroiliac Joint Pain

Background/Pathogenesis. The common thought for the mechanism of injury is hyper or hypomobility of the sacroiliac joint. Also, direct or repetitive trauma, overload to the joint, and capsular injury are common ways to induce SI dysfunction. The sacrum and the ilium share a syndesmosis posteriorly and a synovial joint anteriorly. Patient can present with leg, buttock, groin, and back pain. Positional changes and direct pressure on the joint can elicit pain. [12]

Diagnosis. Fabere, Gaenslen, Yeoman, Gillet's tests can further support the diagnosis of SI dysfunction. An X-ray is important to look for fracture, arthritis, and other types of bony pathology. CT will show greater bony detail and will be order if needed. MRI will look for soft tissue pathology such as labral tears or if there is still difficulty in coming up with a diagnosis. Blood tests may be ordered to rule out specific arthropathies. [13]

Treatment. Sacroiliac dysfunction is primarily treated with rest, NSAIDS, physical therapy, and a SI support belt. Physical therapists can help relax muscle spasms in the area, assess for ankylosing spondylitis, perform massages, and even use manual mobilization to the sacroiliac joint. They can even fix muscle asymmetries, strengthen the core, and stretch muscles of the hip which can provide some pain relief. Sacroiliac fluoroscopic-guided steroid injections are implemented when conservative therapy fails.

Facet Arthropathy

Background/Pathogenesis. The facet joints are significant weight-bearing joints that tend to bear more weight as time progresses and intervertebral discs reduce in size. They are synovial joints that are subject to capsular, meniscal, and synovial injury (see Fig. 15 on Chapter 1). Overloaded facets as well as pathologies previously listed can lead to osteoarthritis of the facet joint and ultimately induce pain.

Diagnosis. On physical examination, back pain is exacerbated with extension and rotation of the spine to the side of the facet pathology. This maneuver is called "facet loading." The back pain can also radiate down that same side. Facet arthropathy is typically diagnosed if there is pain reduction with a medial branch block or a facet joint injection. X-ray and CT of the spine may show degenerative changes but has low diagnostic capability. MRI can rule out disc pathology as well as interpreting facet changes. [14]

Treatment. Physical therapy rehabilitation is recommended after pain medication or an interventional procedure controlled the pain. Lumbar spine stabilization and correct biomechanics are the goals of rehabilitation. Fluoroscopic-guided steroid/local anesthetic facet joint injections or medial branch blocks are interventional procedures that precede radiofrequency ablation if the injections reduce pain.

Osteoarthritis

Background/Pathogenesis. Osteoarthritis is the most common form of arthritis which progresses with age. The population of people who experience repetitive overload or trauma to the joints will be at higher risk. It is more common in women greater than fifty-five years old but of equal prevalence from ages forty-five to fifty-five. This disorder is non-inflammatory compared to rheumatoid arthritis which is another common arthritis. Osteoarthritis can be described as the breakdown of articular cartilage in the joint space which normally serves as a cushion between bones. [15]

Diagnosis. History and physical help diagnose OA. Important historical statements include relief at rest and pain with activity, joint stiffness regresses throughout the day, crepitus on movement of joints and stiffness lasting less than 30 minutes. On physical exam, palpation of affected joints cause pain and are typically monoarticular. On X-ray, there is joint space narrowing due to loss of cartilage. Osteophytes and loose bodies are found in and around the joint space. Osseous cysts are another manisfestation of osteoarthritis which may break up into tiny pieces of bone. On X-ray, the most common sites displaying osteoarthritis include the hip, knee, distal interphalangeal joints, and joints of Luschka. New bone formation is often seen with a white appearance near joint space.

Treatment. It is crucial to educate patients that weight loss can slow the osteoarthritic process and reduce pain. Patients that are highly active may need to modify their lifestyle in order to reduce painful episodes associated with degenerative arthritis. Physical and occupational therapy introduce assistive devices such as canes and muscle strengthening to protect the joints from further damage. Medications are recommended depending on the patient. NSAIDS works well for relief of pain but is not appropriate for patients with renal insufficiency or gastrointestinal bleeds. Tylenol is another option but must not exceed the recommended dose. More invasive measures include hyaluronic acid injections, PRP, and corticosteroid injections into the joint space. This can be offered every 6 months for moderate knee arthritis if it decreases pain. [16][17]

Adhesive Capsulitis

Background/Pathogenesis. Adhesive capsulitis, also known as frozen shoulder, is characterized with pain and stiffness that gradually worsens over time but then resolves. It is more common in diabetics, thyroid disease, tuberculosis, Parkinson's disease, cardiovascular disease, depression, women over forty years old, and long periods of inactivity of the shoulder. The shoulder bursa and shoulder capsule synovial tissue stick together and becomes a thick connective tissue casing that constricts the shoulder. [18]

Diagnosis. A history and physical exam typically gives the physician the diagnosis. Adhesive capsulitis decreases active and passive range of motion which is displayed on physical exam. Abduction and external rotation of the shoulder is usually decreased first with adduction, flexion and extension following. An X-ray or MRI may be ordered to rule out other pathology. Contrast can be injected into the shoulder arthroscopically which will be of decreased amount further supporting the diagnosis of frozen shoulder.

Treatment. Initially, the goal of treatment is regain range of motion. Physical therapists can teach the patient specific exercises to improve range of motion. However, in order to regain range of motion and to perform effective rehabilitation, pain needs to managed appropriately. Corticosteroid injections into the shoulder and NSAIDS can control pain. The shoulder can be manually moved in different directions under general anesthesia to improve motion of the shoulder if conservative therapy fails. Patients who do not respond to the previous treatment may need an arthroscopic procedure to remove scar tissue.

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CHAPTER 3.
PHARMACOLOGICAL MANAGEMENT

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Acetaminophen (acetoacetic acid-p-phenetidide, APAP)

APAP has long been considered a first line oral agent for the management of the pain associated with osteoarthritis (OA). Notwithstanding, recent data supports that APAP has no advantages for OA compared to placebo [1]. The advantages of APAP include the overall safety profile, although it may elevate liver enzymes with usual doses when used regularly beyond 2 weeks. In general APAP is not associated with significant gastrointestinal risk, and renal toxicity is not generally problematic except for higher than recommended doses. Caution should be exercised as there is a clear risk for hepatic-toxicity with long term exposure at high doses. Previously acceptable dosing guidelines for APAP included doses of up to 4 grams per day. With newer data showing an increased risk for liver toxicity as doses increase, more recent suggestions to limit the total dose to no more than 3 grams per day for over-the-counter dosing and 4 grams per day under the direction of a prescribing clinician. Monitoring of liver function enzymes (LFT's) is appropriate for patients utilizing chronic APAP. When compared to nonsteroidal anti-inflammatories (NSAIDS), APAP offers advantages of avoiding adverse impact to platelet function. This can be of particular benefit in patient's status post-surgery, trauma, or in a neurosurgical ICU status-post intracranial bleed. More recently the use of intravenous (IV) APAP has become a popular mode of intervention for pain control for several reasons. The IV form offers advantages of rapid absorption, higher peak serum concentrations when compared to orals and does not undergo the classic hepatic first pass effect. Whereas oral APAP absorption will be slowed in patients on concomitant opioids due to delayed gastric emptying, this is bypassed with IV APAP. While all of the above would seem to make IV APAP an attractive option for pain control, its major utility when compared to oral (PO) APAP is more rapid onset of action and twice the maximum concentration with an equal area under the curve compared to equal doses by the oral route. Data does indicate better pain control within the first 30 minutes of dosing by IV but no difference between 1 to 6-hours post dose when PO and IV dosing are compared. Furthermore, the overall use of opioids was not different between the groups. A particular and somewhat unique issue associated with the use of IV APAP is the potential for symptomatic hypotension status post use. Clearly this limits the utility of the medication in a more mobile pain patient population where the risk for orthostatic hypotension may be compounded by the use of IV APAP. [2][3][4]

Nonsteroidal anti-inflammatory drugs (NSAIDs)

NSAIDs encompass a broad group of medications. Salicylates have a long history in the management of both Rheumatoid and OA. Propionic acid derivatives including but not limited to ibuprofen, flurbiprofen, naproxen, and ketoprofen have also been used for years. Acetic acid derivatives such as sulindac, indomethacin, and tolmetin can also be used. Failure to respond to one class of NSAID does not mean that they are ineffective. Changing class from an acetic acid derivative to a propionic acid derivative or visa versa, or even within the same class may at times prove effective.

Carboxylic Acids					Enoloic Acids	Non-Acidic Acids
Acetic Acids						
Salicylic Acids	Carbo- and Heterocylic Acids	Salicylic Acids	Propionic Acids	Fenamic Acid	Oxicams	
Aspirin Diflunisal	Ketorolac Etodolac Sulindac Indomethacin Tolmentin	Aspirin Diflunisal	Ibuprofen Ketoprofen Naproxen Flurbiprofen Fenoprofen Oxaprozin	Mefenamic Acid	Meloxicam Piroxicam	Nabumetone

Table 1. NSAID Chemical Classes

Traditional NSAIDs mechanistically block prostaglandin synthesis through the inhibition of cyclooxygenase-1 (COX-1) and cyclooxygenase-2 (COX-2). COX-1 is considered constitutional under normal circumstances and is in part responsible for platelet activity by activating thromboxane synthesis and produces protective prostaglandins within the gut. COX-2 activity is generally inducible and following an injury or illness is responsible for pain, inflammation, and fever. COX-2 is also readily present as a constitutional enzyme in the bowel and macula densa of the kidney.

Traditional NSAIDs block COX-1 and COX-2 and therefore, provide analgesia but also can cause GI distress and increased bleeding risk which is attributed to COX-1 activity. Selective COX-2 inhibitors, are associated with fewer GI side effects due to limited COX-1 inhibition. Additionally, through a negative feedback loop, COX-2 specific inhibitors stimulate prostacyclin which in turn results in more clotting therefore mitigating the increased bleeding risk associated with traditional NSAIDs. Notwithstanding, this pharmacological mechanism have the unfortunate outfall of increasing risk for thromboembolism.

The major drawbacks to NSAIDS, as a class of medications, include the well documented risks of both GI and renal toxicity. These risks increase with long term use and patient age. The risk for renal toxicity is further increased in patients with underlying diabetes and hypertension. COX -2 specific NSAIDs are associated with fewer GI risks compared to classic NSAIDs, but this has only been demonstrated in short term studies. The most COX-2 specific NSAIDs in order are: etodolac, then meloxicam, followed by celecoxib. There are no well controlled studies to show this holds for long term use. The risk for renal toxicity does not appear to be any different. COX-2 specific inhibitors carry the same black box warning as NSAIDs. As such caution should be the watch word with the long-term use of NSAIDs including cyclooxygenase inhibitors. [5][6][7]

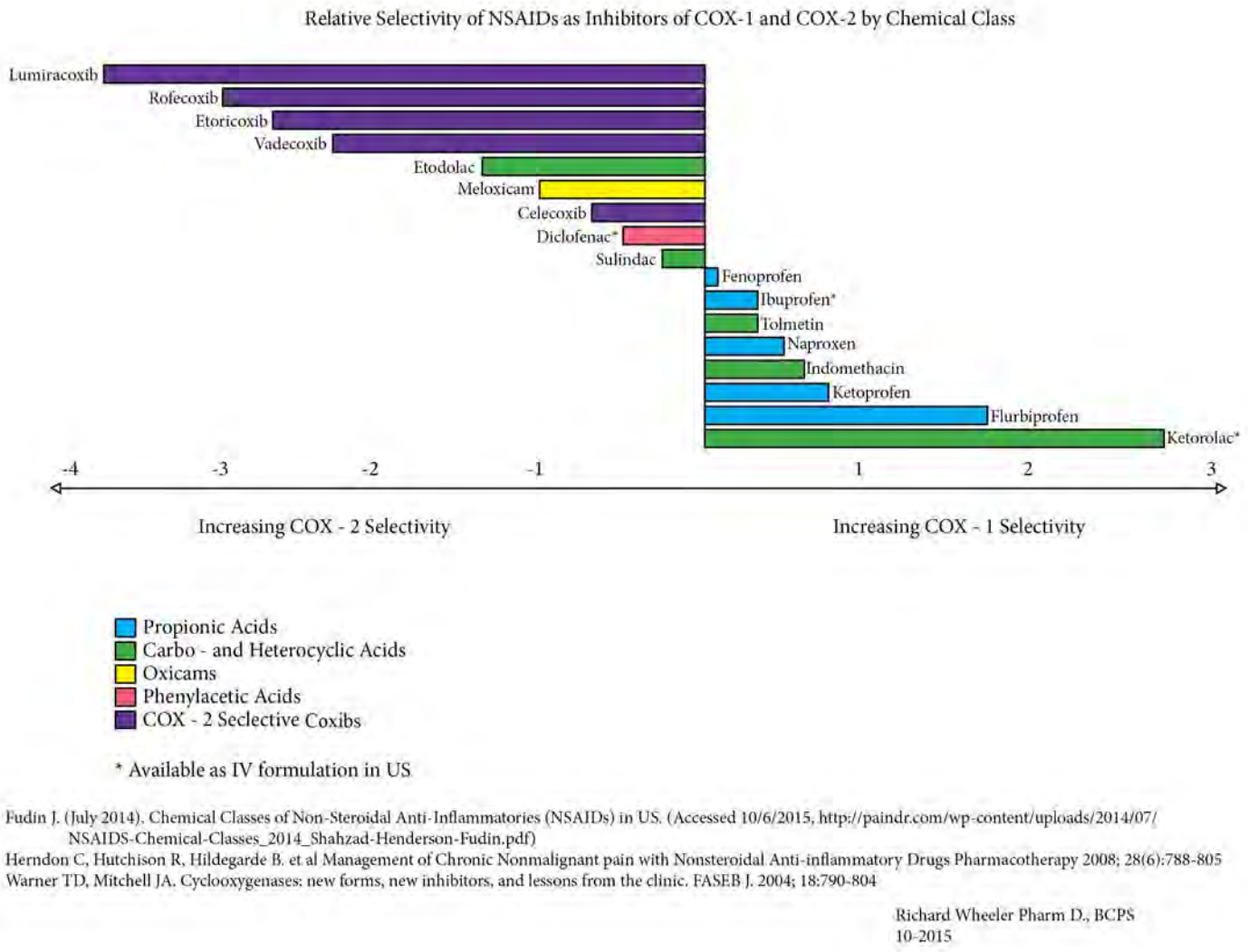

Figure 1. Reprinted with permission, Dr. Jeffrey Fudin. http://paindr.com/wp-content/uploads/2015/12/Relative-Selectivity-of-NSAIDs-as-Inhibitors_edit.pdf

Questions have been raised as to whether or not NSAIDS are independently associated with increasing blood pressures. Proposed mechanisms include possible impact on prostaglandin synthesis, cardiac output, or renal function. Other questions regarding NSAIDs and the potential impact on blood pressure in hypertensive patients is whether the impact, if there is one, is across all classes of antihypertensive or unique to specific classes of antihypertensive medications. Data from the literature indicates that NSAIDS as a broad class of medications is implicated in raising supine mean pressures on average 5mm of Hg. In general, NSAID use was associated with a more significant increase in BP in treated hypertensive patients who were on beta blockers and/or vasodilators. When diuretics were used the increase in BP was significantly blunted. [8][9]

	Studies Comparing NSAID Mortality		
	Singh, 1999(24)	**Cryer, 2005(26)**	**Tarone, 2004(25)**
Number of NSAID Deaths	16,500	3200	48/1,000 person-years
Data Source	Arthritis, Rheumatism, and Aging Medical Information System (ARAMIS)1	Based on US mortality data accumulated from 1990s	Medicare beneficiaries with a diagnosis of rheumatoid arthritis or osteoarthritis
Study Type	1999 observational study	2004 observational study	2010 observational study
Accuracy/Flaws	Questionable accuracy; based on small number; extrapolated inappropriately	Annual deaths of NSAID-induced GI bleeding Based on US mortality a decade earlier	Coxibs had elevated risk of cardiovascular disease, and less GI bleed c/t traditionals Coxibs did not raise the risk of all-cause mortality

Table 2. Represents studies comparing NSAID mortality.

NSAIDs are also associated with increased risk for adverse cardiovascular events and stroke. A systematic review of community based controlled observational studies by McGettigan and Henry out of the UK sheds light on potential risks of NSAIDs while also highlighting the uniqueness of each NSAID. While the propionic acid derivatives on a whole seem to be associated with lower risk, naproxen was consistently associated with significantly less cardiovascular risk, especially for stroke, than ibuprofen despite both being propionic acid derivatives. The risk for adverse outcome also appears to be dose dependent with ibuprofen, not with naproxen again another point of divergence within the same class of drug. [10][11]

More recently data suggests that chronic use of NSAIDs could be associated with an increased risk for second hip fracture after a primary hip fracture in both men and women. Data, however, is mixed and largely dependent on animal studies with randomized control studies in humans lacking. While fracture healing in animals has been examined, some studies may have examined healing early at only 21 days after fracture, and animal data does not necessarily predict a direct human correlation. Several explanations for a possible NSAID impact on bone health can be posited. It has been suggested that NSAIDs as a broad class may directly and negatively impact on bone remodeling. COX-2 is involved in cortical bone remodeling and by inhibiting the production of needed inflammatory prostaglandins to drive bone remodeling. In essence the balance between resorption and remodeling could be skewed. It is also possible that the population of patients who take NSAIDs chronically may be at higher risk to fall at baseline which in turn independently increases their risk for second hip fracture and other non-vertebral as well as vertebral fractures. [12][13]

Controversy also exists in the use of NSAIDs for post-operative orthopedic procedures with many providers avoiding use due to concerns for healing time. Presently, there are no randomized controlled trials in humans to support such an avoidance of NSAIDs post-operatively, with only limited short term studies completed in animal models. There is, however, evidence that poor pain control post-operatively is associated with an increased risk for the development of complex regional pain syndrome (CRPS). [13][14]

Another frequently asked questions regarding NSAIDs and surgery is when should an NSAID be discontinued pre-operatively. As previously discussed COX-2 specific NSAIDs are associated with lower bleeding risks compared to traditional NSAIDs and therefore the answer to this question is not generalizable to the NSAID class as a whole. As such, it is important for providers to consider bleed risk of the planned procedure, and COX-2 specificity of the NSAID as well as the half-life, as agents with increased COX-2 specificity and shorter half-lives may allow for discontinuation closer to surgery. [15]

Data from the UK makes note that out of 8 million people in the UK with OA, approximately half of that group takes NSAIDs on a regular basis, and that this contributes to an annual estimated 2000 deaths from NSAID side effects in the UK. An increased risk for adverse cardiac events led to the withdrawal of several COX-2 specific NSAIDs and broad class restrictions and precautions in patients with cardiovascular pathology. Given these concerns the role of NSAIDs in the long-term management of OA needs to be carefully considered and other alternatives need to be fully explored. [5][6][7]

Given the trepidation over using systemic anti-inflammatory medications as a long-term agent, other options have been considered in terms of delivery and ways to limit systemic load. Topical NSAIDs are an option that has gained traction.

Topical NSAIDs

Topical NSAIDs offer the potential advantage of the focal targeted application of an anti-inflammatory analgesic agent with the advantage of a decreased side effect profile. Other types of topical agents will be discussed later in this chapter. Topical NSAIDs may have utility in managing the pain of OA, both as an analgesic agent and an anti-inflammatory agent. Recent research has revealed that OA while not a classic inflammatory arthropathy does have a clear component of inflammation associated with it typically manifesting as a secondary synovitis in response to such factors as joint trauma, mal alignment, obesity etc. Topical NSAIDs have been shown in a meta-analysis to reduce joint pain and improve function, with loss of efficacy with use beyond 4-weeks duration. Given that the effectiveness of topical NSAIDs appears to wane after 4 weeks, they may have their greatest utility for management of flares of pain. A major benefit of topical NSAIDs when compared to oral agents is their side effect profile. [16][17][18]

While topical and oral preparations both carry the same black box warning, which is applied to the broad class of NSAIDS, the significantly lower plasma concentrations clearly decrease the risk for systemic toxicity. Data from Roth and Fuller indicates that the use of topical diclofenac preparations at a concentration of 1.5% applied QID was associated with a statistically significant lower incidence of gastrointestinal adverse events, as well as significantly lower incidence of adverse cardiovascular events, as well as laboratory abnormalities in terms of LFT elevation or changes in serum creatinine when compared to oral dosing. Work by Holt et al clearly demonstrates the marked differences between systemic loads seen with application of topical diclofenac both at 1.5% and 2 % compared with 75mg BID oral diclofenac. At steady state, peak exposure from oral diclofenac resulted in systemic exposure states that were approximately 60-80 fold greater than topical preparations. Moreover, and potentially very interesting was that topical preparations of diclofenac were noted to be eliminated 4-6 times slower when compared to oral diclofenac. In summary, the data is consistent with a systemic exposure utilizing the 2 % formulation at approximately 7 % of that noted with comparable dose of oral diclofenac at steady state. [18][19][20] Diclofenac patch (Flector), has been found to have similarly systemic peak serum concentrations. In fact, on day 4 of patch application, serum levels were found to be less than 1% of the serum levels compared to a single 50mg oral dose of diclofenac [21]. This provides support for the use of topical NSAIDs for localized pain in populations generally thought to be contraindicated for NSAID use, such as geriatric patients or those with decreased renal function.

In general, when one looks at topical NSAIDs as a class, the most common adverse events are associated with local site reaction to the topical preparation. The most common noted reaction was skin dryness and this was noted in approximately 25-40% of individuals.

Potential issues associated with topical NSAIDs and what in part may ultimately limit their utility include issues of tissue penetration. Various vehicles have been used to try and optimize skin penetration while at the same time limiting issues of skin sensitivity. [22]

Micronized NSAIDs

Recent developments are pairing nanotechnology and drug design. Micronized NSAIDs are allowing for increased efficacy with an improved safety profile, by reducing the drug's particle size and increasing surface are. This increases the rate of dissolution and absorption allowing for similar efficacy with much lower doses. Studies have found micronized NSAIDS to have similar Cmax levels, decreased time to Tmax and lower AUC. At the time of publication FDA approved micronized NSAID formulations include: indomethacin (Tivorbex), diclofenac (Zorvolex), and meloxicam (Vivlodex). [23]

Future of NSAIDs

Research is ongoing to further improve the safety profile and efficacy of NSAIDs, particularly, hydrogen sulfide releasing therapies in combination with an NSAID. Studies are currently examining Several H2S-releasing NSAIDs including diclofenac, naproxen indomethacin, ketorolac and aspirin.

Skeletal Muscle Relaxants

Skeletal muscle relaxants remain an ill-defined and confusing enigma to many since they produce a range of divers effects that remain poorly defined for clinicians [24]. Nevertheless, they are commonly prescribed for musculoskeletal pain. The class includes carisoprodol, chlorzoxazone, cyclobenzaprine, metaxalone, methocarbamol, and orphenadrine [28]. Each of these are FDA approved for the relief of discomfort associated with an acute, painful musculoskeletal conditions. Baclofen and tizanidine are FDA-approved for the treatment of spasticity due to multiple sclerosis, spinal cord disease or injury. Benzodiazepines, most notable diazepam, are also prescribed for adjunctive relief of skeletal muscle spasm.

Many of these medications are indicated for use during an episode of acute low back pain. Acute low back pain may include local pain and tenderness, muscle spasm, and limited range of motion, but what actually constitutes painful muscle spasm remains controversial [29]. Muscle spasm may be a variant of the myofascial pain presentation, and as such not really a spasm [30].

At the level of the peripheral muscle, tissues are comprised of intrafusal fibers that signal changes in muscle length. These lie in parallel with extrafusal muscle fibers that normally serve to contract or stabilize joints. When muscle tissue is stretched the intrafusal fibers stretch resulting is an increase in neural discharges carried by afferent nerve fibers. This signal is transmitted to the dorsal horn and synapses with alpha-motoneurons in the ventral horn, producing excitatory postsynaptic potentials. The result is a type of negative feedback, with muscle contraction of the intrafusal muscle fibers where the original stretch signal originated. These muscle fibers also maintain an efferent component, facilitated by small gamma-motoneurons that originate in the ventral horn of the spinal cord and travel together with the alpha-motoneurons that innervate extrafusal muscle fibers. The gamma-motoneurons adjust the sensitivity of the muscle fibers and regulate muscle tension over a wide range of muscle lengths. This complex system of afferent and efferent signaling through the motorneurons when at homeostasis leads to stabilization of muscle structures.

In the dorsal horn a complex network of excitatory and inhibitory interneurons mediates motor reflexes in response to deep and cutaneous stimulation. Such reflexes mediate ipsilateral flexion and contralateral extension in response to noxious stimuli to coordinate a protective or escape response. Impulses from cutaneous afferents travel through the dorsal horn of the spinal cord and terminate on excitatory interneurons, which in turn terminate on presynaptic terminals of the intrafusal fibers further promoting excitation at the ventral horn alpha-motoneuron. Inhibitory centers in the bulbar reticular formation and facilitatory centers from several brain regions further regulate both corticospinal and reflex muscle activity. [31][32]

Excitatory neurotransmitters in the CNS play a major role in the modulation of movement in the spinal cord and include substances like glutamate, aspartate, and substance P. These neurotransmitters are released from the terminals of primary afferent fibers to mediate reflexes that enhance motor tone at the spinal level. Gamma-aminobutyric acid (GABA) is a major inhibitory CNS neurotransmitter, that emanates from supraspinal and interneuronal inputs. GABA is believed to play a major role in presynaptic inhibition of motor neurons in the dorsal horn. [33]

A reflex increase in muscle tone activates polysynaptic reflexes and produces hyperexcitability of alpha and/or gamma motorneurons [34]. In chronic muscle spasticity the processes is more complicated with pathology from supraspinal CNS descending pathways that produce excessive excitation or diminished inhibition of alpha-motoneurons in the dorsal horn. [35]

Mechanism of Action

The exact mechanism of action for these diverse agents is not clear although a variety of mechanisms have been proposed (see Figure 1). The substance mephenesin, an early muscle relaxants, in animal models affected monosynaptic and polysynaptic reflexes [36][37]. Subsequent animal data showed that mephenesin and methocarbamol prolonged the refractory period of skeletal muscle by a direct action on skeletal muscle fibers [38]. Frankly, surprisingly little has been described about the effects of commonly prescribed skeletal muscle relaxants such as cyclobenzaprine, methocarbamol, carisoprodol, and chlorzoxazone on neurotransmission.

The pharmacologic capacity of other commonly used drugs is less well characterized in specific relation to muscle spasm. Diazepam, a benzodiazepine, suppressed polysynaptic reflexes in cats, but required doses higher than would be used clinically [39]. Benzodiazepines in general, act by potentiating the postsynaptic effects of GABA within the CNS [35]. Baclofen (parachlorophenyl GABA) is a lipophilic derivative of GABA that binds to GABAB but not to GABAA receptors and may exert its effect, in part, by inhibiting certain excitatory neurotransmitters [33]. Tizanidine, is an a2-adrenergic receptor agonist that may also act by decreasing spinal excitatory amino acid release [40].

Centrally-acting Sedative-hypnotic Muscle Relaxants

Carisoprodol although not a controlled substance in the United States, is hepatically metabolized to meprobamate, a schedule IV controlled substance. Meprobamate produces physical and psychological dependence. [41-46] Substance abuse appears to be problematic with carisoprodol, probably due to meprobamate formation. In recent years, several states have begun treating carisoprodol as a controlled substance within their state formularies. Due to the dependence potential, carisoprodol should be cautiously tapered as opposed to immediately discontinued following long-term use. In 2007, the European Medicines Agency recommended the suspension of marketing authorization for carisoprodol-containing products for its 12 member states concluding that the risk of their use is greater than the benefits. [47]

Chlorzoxazone may be less effective than the other skeletal muscle relaxants [48]. Chlorzoxazone does not have any significant drug interactions, but does have a significant adverse effect profile that includes a rare idiosyncratic hepatocellular reaction. [49]50]

Metaxalone does not have any significant drug interactions and appears to have a fairly benign side effect profile. Hemolytic anemia and impaired liver function nay occur, but are uncommon. Nevertheless, fatalities attributed to the use of metaxalone have been reported. [51][52] Metaxalone is contraindicated in patients with severe renal or hepatic impairment. There are few published placebo-controlled studies of metaxalone for musculoskeletal pain. [53]

Methocarbamol is available in an oral form and a parenteral form for IV or IM use. Complications with the parenteral form include pain, skin sloughing, and thrombophlebitis. There are few published studies comparing it to placebo for the treatment of musculoskeletal pain. [54]

Antihistamine Muscle Relaxant

Orphenadrine Citrate is a derivative of diphenhydramine, (yes, the over the counter medication) and accordingly exhibits antihistaminic and anticholinergic properties. There have been reports of severe adverse reactions with parenteral use (e.g. anaphylactoid reaction). Orphenadrine's anticholinergic actions have been noted to produce significant adverse effects at high dosages, e.g. tachycardia, palpitations, urinary retention, blurred vision. [55]

TCA-Like Muscle Relaxant

Cyclobenzaprine is more structurally and pharmacologically similar to the tricyclic antidepressants, particularly amitriptyline, than it is to the centrally acting sedative-hypnotic skeletal muscle relaxants. As with the other skeletal muscle relaxants, cyclobenzaprine does not act directly on muscle tissue [56]. It is interesting to note that the 5 mg dose resultsin similar clinical efficacy with less sedation than the 10 mg dose. [57]

The value of muscle relaxant monotherapy remains uncertain. This appears to apply to cyclobenzaprine as well. In an open-label study of patients with acute neck or low back pain associated with muscle spasm who were randomized to be treated for seven days with either cyclobenzaprine 5 mg orally three times daily alone or with cyclobenzaprine 5 mg orally three times daily in combination with ibuprofen at doses of 400 mg orally three times daily or 800 mg three times daily, no significant treatment differences were found among these groups. [58]

Since cyclobenzaprine has a similar adverse event profile as the tricyclic antidepressants, one might want to avoid using cyclobenzaprine and a tricyclic antidepressant concurrently unless the combination is truly clinically indicated. Anticholinergic side effects including dry mouth, urinary retention, and constipation occur with cyclobenzaprine. Use of cyclobenzaprine is contraindicated in the setting of arrhythmias (with fatal consequences reported), congestive heart failure, hyperthyroidism, or during the acute recovery phase of a myocardial infarction. Concurrent use with pro-serotonergic agents such as selective serotonin reuptake inhibitors (SSRIs) may predispose patients to life-threatening serotonin syndrome. [59]

Concomitant use of cyclobenzaprine with tramadol may place patients at higher risk for developing seizures [56]. Concomitant use of cyclobenzaprine with monoamine oxidase inhibitors or use within 14 days after their discontinuation is contraindicated. Cyclobenzaprine can enhance the effects of all medications with CNS depressant activity. Older patients appear to have a higher risk for CNS related adverse reactions, e.g. hallucinations and confusion, when using cyclobenzaprine. Since withdrawal symptoms have been noted with the sudden discontinuation of chronic cyclobenzaprine, use of a medication taper is advised

GABA Agonist Muscle Relaxants

Diazepam is the most commonly prescribed and referenced benzodiazepine in the treatment of muscle spasms [60]. It has hypnotic, anxiolytic, antiepileptic, and antispasmodic properties. Sedation and abuse potential are the main concerns with this agent and class. It is important to slowly taper this agent after long-term use, as opposed to abrupt removal to avoid any withdrawal symptoms.

Baclofen. Studies have shown baclofen to have superior efficacy than diazepam. (25) Baclofen is unique in that it can be administered intrathecally in cases of severe spasticity and for patients who do not tolerate or have failed oral therapy. Baclofen should be tapered slowly after long-term use to avoid a withdrawal reaction and rebound phenomena. It should be used with caution in the elderly and for patients with renal impairment.

Central Alpha – 2 Agonist Muscle Relaxants

Tizanidine is related chemically to clonidine, but has significantly less antihypertensive effect [61]. The main adverse effect for most patients with this agent is sedation [62]. Currently tizanidine is FDA approved for the management of increased muscle tone associated with spasticity resulting from central nervous system disorders, such as multiple sclerosis or spinal cord injury. Two studies report use of tizanidine in of back pain or muscle spasm, either alone or in combination with ibuprofen, and another reports effectiveness in myofascial pain [63][64][65]. A multicenter, placebo-controlled study evaluated the efficacy and safety of tizanidine in the treatment of low back pain; tizanidine was found to provide more pain relief and less restriction of movement than placebo. Drowsiness was the most common side effect but acute low back pain patients, this effect may actually be desired, especially at night [63]. A study of 105 patients with acute low back pain who received tizanidine 4 mg orally three times daily with ibuprofen 400 mg orally three times daily or ibuprofen 400mg orally three times daily compared to placebo. The results suggested that the tizanidine/ibuprofen combination was more effective for moderate or severe acute low back pain than ibuprofen only. [64]

Acute Low Back Pain

Available data indicate that skeletal muscle relaxants are more effective than placebo to relieve acute low back pain [58]. Unfortunately, most of the data are dated, and are derived form studies for which the designs and analyses that would not be acceptable today. No data clearly show that any one agent as more efficacious than another. Some data suggest that chlorzoxazone may be less effective than other drugs, and as such, puts into question the use of this agent. [48][66]

Most clinical guidelines list skeletal muscle relaxants as optional agents for use individually or in combination with a non-steroidal antiinflammatory agent (NSAID). The federal clinical practice guideline published in 1995 specifically noted that skeletal muscle relaxants alone or in combination with an NSAID were no more effective than using an NSAID alone [67]. This conclusion has been supported in systematic reviews [48][66]. Skeletal muscle relaxants have been shown to more effective than placebo for patients with acute LBP with respect to outcomes such as short-term pain relief, global efficacy and improvement of physical outcomes [68-71]. A meta-analysis of cyclobenzaprine studies for acute low back pain concluded that, despite limitations in the available evidence, the combination of a NSAID with cyclobenzaprine may be appropriate [72]. It is probably best to consider the use of skeletal muscle relaxants as an adjunct or alternative to NSAIDs- this is especially important for patients for whom NSAID toxicity is a concern or when NSAID monotherapy proves suboptimal.

Systematic reviews have been published regarding the randomized controlled trials of muscle relaxants in the treatment of low back pain [48][66][73]. These concur that there is strong evidence that muscle relaxants are more effective than placebo for acute low back pain, but do not indicate superiority of a specific type of muscle relaxant. Muscle relaxants also appear to be useful in acute cervical pain presentations. [74][75][76]

Baclofen and tizanidine are well established for the treatment of spasticity secondary to upper motor neuron or spinal disorders [35][40][77]. Limited clinical evidence exists for the treatment of acute muscle spasm with baclofen. As noted previously, tizanidine has some evidence but can be extremely sedating especially at analgesic doses.

Chronic Low Back Pain

Despite the common use of skeletal muscle relaxants, relatively few data clarify their appropriateness in the treatment of chronic back pain [48][73]. No skeletal muscle relaxant has an indication for use in chronic back pain yet they are often prescribed on a long term basis [73]. When used in acute back pain, skeletal muscle relaxants are used to treat muscle spasms and associated pain during the normal recovery period of 1 to 3 weeks. Since this also correlates with the time course that most patients recover from their acute injury, it is difficult to discern the exact nature of the utility for these medications.

Skeletal muscle relaxants have CNS depressant effects and must be used with caution, particularly for patients with concomitant use of alcohol, anxiolytics, opioid analgesics, or other sedating medications. There is strong evidence that skeletal muscle relaxants are associated with increased risk for adverse effects related to the central nervous system [48][66][73]. Patients appear to benefit from less pharmacotherapy, especially avoiding substances that may cloud cognitive and functional capacities. [72]

Topical Analgesic Balms

Applying medicines topically is an ancient practice, that, while often perceived as pragmatic can become quite problematic. Many ancient cultures utilized a variety of natural substances (e.g. herbs and plants) for a variety of medicinal uses, including analgesia. Today a variety of topical remedies is available to patients with painful conditions, primarily as over-the-counter (OTC) analgesic balm, many of which have been available for decades. The majority of these preparations contain counter-irritants such as camphor, menthol, and salicylates either alone or in combination with each other or a variety of other medicinal ingredients. Capsaicin, a counter-irritant, and non-salicylate NSAIDs are also available in prescription and OTC topical formulations. Lidocaine and a variety of other substances used topically as well for musculoskeletal pain.

Topical drug administration would appear to maintain many potential benefits, especially in pain presentations that have a defined local and peripheral component. (80) The most obvious benefit is avoiding effects common with systemic administration of analgesics, e.g. adverse effects, drug interactions, need for an effective serum concentration. At the same time topical administration can be prone to a variety of limitations, often inversely related to the benefits of topical application. Benefits and limitations are summarized in Table 4. Direct topical drug application appears to avoid numerous problems that occur with systemic administration of medications. This is especially true for NSAIDs, where toxicity with systemic administration can be very difficult for many patients. As described below, topical NSAIDs appear to be useful for some acute pain presentations, (e.g. soft tissue injuries and postsurgical pain).

NSAIDs have the most evidence base among the topical analgesics. Moore and colleagues conducted a meta-analysis reviewing analgesic efficacy for acute pain related to soft tissue trauma, sprains, and strains [82]. They also analyzed pain relief for chronic pain conditions, such as osteoarthritis and tendonitis. The number needed to treat (NNT) was 3.9 for the acute pain conditions and 3.1 for the chronic pain conditions. The authors noted that local skin reactions were uncommon (3.6% of patients) in the studies. As could be expected, systemic adverse effects were extremely uncommon at less than 0.5% of patients exposed to this drug class. The evidence is not as compelling for the role of topical NSAIDs when compared to oral administration [82]. While topical administration does not appear to afford the same therapeutic profile, this route of administration is also better tolerated and may be of benefit in patients who would not otherwise be able to use an NSAID orally.

Topical Counterirritants

Topical counterirritants comprise a group of substances primarily for use by patients in a variety of OTC analgesic compounds. These include capsaicin, camphor, menthol, and salicylates which appear to provide analgesic benefit by desensitizing peripheral nociceptive receptors. Galeotti and colleagues suggested that menthol's analgesic properties may be mediated through selective activation of kappa-opioid receptors [83].

Capsaicin appears to have the best evidence for use among the topical analgesics, primarily in osteoarthritis. Analgesic activity for capsaicin is attributed to depletion of substance P from peripheral nerve terminals. This requires both time and consistent dosing. A recent systematic review of topical capsaicin for musculoskeletal pain found an NNT of 8.1 for pain relief [84]. A variety of guidelines list capsaicin as a useful adjunct for use in patients with osteoarthritis. The European League Against Rheumatism (EULAR) and the American College of Rheumatology both recommend capsaicin for the treatment of pain in osteoarthritis [85][86]. The main issue related to capsaicin use is the adverse effect profile, which occurs to some extent with all patients, and is an expected consequence of the mechanism of action. In the aforementioned systematic review, side effects were problematic in approximately one-third of the patients [84]. Typical experiences include local adverse reactions such as pain upon application, burning, stinging, and redness at the site of application. This adverse effect profile is probably the biggest disadvantage for this medication, causing either early discontinuation or reduced patient compliance leading to absence of efficacy [87][88].

The other counter irritants can be classified as rubefacients, including salicylates. There are few good efficacy data for these medications, probably in part because these substances have been used for so long. The benefit of these agents may also be due to the actual administration process, i.e. rubbing, causing increased stimulation in the area.

While salicylates may also have activity similar to other NSAIDs, their topical mechanism remains poorly elucidated. Mason and colleagues reviewed the use of topical salicylates for acute musculoskeletal pain [89]. These authors noted that topical salicylates produced a significant reduction in pain compared to placebo, with a NNT of 2.1. The benefit of this medication class for chronic use is limited by both lack of efficacy data and the potential for adverse effects with continued administration.

The reader may be aware that there are various compounding pharmacies that sell mixtures of various medications to be applied topically- the role of these preparations in the management of musculoskeletal pain is difficult to assess. No such compounded preparation is FDA approved and while there are many anectdotal reports of good outcome, there are no high qualtiiy published studies.

Conclusion

Skeletal muscle relaxants and topical analgesic balms comprise a cadre of substances that are commonly used for a variety of pain conditions. Skeletal muscle relaxants have value for acute back pain, mainly as adjunctive agents with other forms of analgesia and physical therapy. The use of these agents in chronic pain conditions remains controversial. This is in part due to the lack of efficacy data available for the use of these substances in chronic back pain conditions. Moreover, these agents maintain a substantial adverse effect profile that often is counterproductive for patients with chronic pain.

Topical analgesic balms are commonly used for self-care in acute painful conditions. Capsaicin is the one substance within this group with potential value in osteoarthritis. The main challenge with this substance is managing expectations and adverse effects.

Table 3. Pharmacotherapies Commonly Used for Muscle Spasm.

Drug	Onset	Duration	Common Dosing	Side Effects	Important Drug Interactions
Sedative					
Carisoprodol (Soma)	30 min	4-6 hours	350 PO QID	ataxia, dizziness, drowsiness, N/V, withdrawal potential	Additive effects with alcohol and other CNS depressants
Chlorzoxazone (Parafon Forte)	~ 1 hour	3-4 hours	250–750 mg PO TID-QID.	dizziness, drowsiness, headache, N/V	
Metaxalone (Skelaxin)	1 hour	4-6 hours	400-800 mg PO TID	dizziness, drowsiness, headache, N/V, rash	
Methocarbamol (Robaxin)	30 min (PO)	N/A	750-1000 mg PO QID	blurred vision, dizziness, drowsiness	
TCA Like					
Cyclobenzaprine (Flexeril)	~ 1 hour	12-24 hours	5-10 mg PO TID	drowsiness, dizziness, dry mouth	Additive effects with alcohol and other CNS depressants; Seizures with tramadol and MAOIs; Additive effects with tricyclic antidepressants

Antihistamine					
Orphenadrine (Norflex)	1 hour (PO)	4-6 hours	100 mg PO BID	tachycardia, lightheadedness, N/V, dry mouth	Additive effects with alcohol and other CNS depressants; Coadministration with propoxyphene can lead to confusion, anxiety, and/or tremors
GABA Type					
Diazepam (Valium)	30 minutes (PO)	Variable, depending on elimination	2-10 mg PO TID	sedation, fatigue, hypotension, ataxia, respiratory depression	Potentiation of effects when taken with phenothiazines, opioids, barbiturates, MAOIs
Baclofen (Lioresal)	3-4 days (PO) 30 min (IT)	Variable (PO) 4-6 hours (IT)	5 mg PO TID titrated up to 40–80 mg/day	drowsiness, slurred speech, hypotension, constipation, urinary retention	Antidepressants (short-term memory loss); additive effects with imipramine
Central Alpha 2 Agonists					
Tizanidine (Tizanidine)	2 weeks	Variable	2-8 mg PO TID - QID	drowsiness, dry mouth, dizziness, hypotension, increased spasm/tone	Additive effects with alcohol and other CNS depressants; reduced clearance with oral contraceptives

Table 3 *cont.*

Table 4. Benefits and Limitations of Topical Analgesics [79]

Benefits	Limitations
• Avoid need for oral absorption • Avoid metabolic complications and systemic adverse effects • Ease of dose termination in the event of untoward side effects. • Direct access to the target site Convenient administration • Improved patient acceptance and adherence • Alternative route when oral not viable (e.g. patient with emesis)	• Absorption pharmacokinetic issues due to molecular size, lipophilicity, and skin permeability • Topical enzymatic activity may occur and reduce efficacy. • Localized skin irritation, such as erythema can occur.

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CHAPTER 4.
INTERVENTIONAL PAIN MANAGEMENT

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The Following is a brief description of the more commonly utilized pain management procedures encountered in a typical pain management practice.

TRIGGER POINT INJECTIONS

Trigger point injection therapy is indicated when physical examination has revealed the presence of one or more tender spots over the muscles, which produce a positive "jump sign" following application of digital pressure. The pain elicited corresponds with the site of the patient's complaint. The use of trigger point injections is contraindicated in the presence of

1. Systemic infection.
2. Bleeding disorders.
3. Local anesthetic allergies.
4. Localized infection.

The use of local anesthetics in performing trigger point injections is preferred to the use of dry needling since injection of local anesthetic solutions provides an immediate analgesic effect [11]. The local anesthetic is injected into the site of maximal tenderness and is infiltrated through the surrounding areas of muscle fibers. The success of trigger point injections is independent to the local anesthetic used. Commonly used local anesthetics include lidocaine, bupivacaine, and Procaine. The use of local anesthetics when compared to saline provides greater pain relief. Following the performance of trigger point injections, it is common to find that the analgesic effects usually exceed the known duration of the local anesthetic. It has been theorized that this is due to the depletion of histamine and substance P from the nerve dings along with the release of the endogenous opioids. The addition of small doses of steroid to the trigger point injection solution has been used to reduce the inflammation within the trigger point without the side effects associated with systemic steroid administration. It has been shown that the use of steroid during trigger point injections resulted in greater pain improvement than the use of lidocaine solely. The improvement was less than acupuncture and vapor coolant. The most common complication seen with the use of steroid injections includes hyperglycemia, atrophied muscle, skin depigmentation, and tendon atrophy. Although I am not a fan of dry needling, it has been used for direct mechanical disruption of trigger points [6][12]. The largest beneficial effect is achieved when the point of maximal tenderness within the trigger point is needled thereby producing immediate analgesia. There was a study that compared different techniques for the treatment of myofascial pain including

1. Lidocaine.
2. Lidocaine plus steroids.
3. Vapor coolant spray with acupressure.
4. Dry needling.

The study found that dry needling produces a 63% improvement rate while the use of local anesthetic produces a 42% improvement.

The study concluded that the use of dry needling appears to be at least as effective as the use of medication for the treatment of trigger point injections

In summary, myofascial pain associated with trigger points is very commonly found in a busy pain management practice. The use of trigger point injections play a vital role in long- term treatment of this disorder along with other conservative measures as noted above.

EPIDURAL STEROID INJECTIONS

Epidural steroid injections have been used as a modality for pain management since the 1960s. The indications include: [14]

1. Radicular symptoms involving the lower back (sciatica).
2. Neck pain radiating to the upper extremities.
3. Thoracic radiculopathy.

The patients meet the indications for this procedure after failing to respond to conservative therapy including physical therapy, chiropractic care, acupuncture, and oral analgesic medications. There is usually documented radiological evidence attributed to the pain including herniated discs, degenerative disc disease, and spinal stenosis. Of note, conservative therapy should be tried for at least three to four weeks before consideration of epidural steroid injections is made. As the name implies injectable steroid medications are utilized due to their anti-inflammatory effects and the fact that they are slowly released in the epidural space. Commonly used steroid medications include methylprednisolone acetate and triamcinolone acetate, which are two types of depot steroids. The pain relief achieved by epidural steroid is believed to occur due to an anti- inflammatory effect, which blocks the activity of the nociceptive C-fibers, which transmit pain signals. The technique used to perform an epidural steroid injection is similar for both the cervicothoracic and lumbar routes of injection. Since the lumbar epidural injection is the most commonly used by pain management practitioners I will limit the technical description to the lumbar route. After obtaining informed consent, the patient is placed in a prone position on a fluoroscopy table with a pillow under the abdomen. Of note, there are still some practitioners performing this injection using a blind technique, but the accuracy of the needle placement is lower as compared to using fluoroscopic guidance [13]. With the blind technique, the sitting or lateral decubitus position as well as the prone position are commonly used. With obese patients, the sitting position is more commonly used as the anatomical landmarks can be palpated more easily when the patient is sitting and flexed forward. The more commonly used position utilizing fluoroscopic guidance is the prone position with a pillow under the abdomen.

Following routine sterile prep and application of a sterile drape, local anesthesia is administered at the vertebral level that is appropriate as the site of injection based on the dermatomal distribution of the patient's pain. There are several commonly used epidural needles including a Tuohy, and Hustead needles, which have been developed to achieve a successful epidural injection while at the same time minimizing potential complications. The needle is placed between the two vertebrae of interest (most of the time below L2 to prevent any risk of trauma to the spinal cord. The needle is generally directed through a translaminar approach. The needle is directed midline through the skin, subcutaneous tissue, supraspinous ligament, interspinous ligament, and finally the ligamentum flavum before the needle enters the epidural space. The technique used to confirm passage of the epidural needle through the ligamentum flavum is called loss of resistance technique, which utilizes the anatomical phenomenon that the epidural space is the first open space from the skin inwar. Use of either air or fluid along with a low resistance syringe will result in either air or fluid to easily be injected into this first open space. Aspiration of the epidural needle helps to confirm that the cerebrospinal fluid has not been entered. In addition, there should be no blood flowing backwards through the hub of the epidural needle. When fluoroscopy is used proper needle placement can be confirmed by injecting a small dose of iodinated contrast (example Omnipaque). After the epidural space has been entered 3-5 cc of a solution including either saline or low dose local anesthetic mixed with 80 mg of methylprednisolone or 15 mg of triamcinolone is then injected. The needle is then withdrawn and a Band-Aid placed over the injection site.

Epidural injections are contraindicated in patients who have been diagnosed with a coagulopathy, systemic illness, and infection in the region of the epidural injection along with anatomical difficulties, which would prevent successful entrance into the epidural space. Using a blind technique (without fluoroscopy) is not recommended in patients having undergone spinal fusion, implantable morphine pumps, implantable dorsal column stimulators, and post laminectomy syndrome.

Headaches following a lumbar epidural steroid injection is the most common complication. This complication is generally thought to be the result of a dural puncture with subsequent leakage of cerebrospinal fluid. Other complications include epidural abscess, epidural hematoma, nerve damage, spinal

cord injury, as well as side effects of the steroids being used. Of note, injury to nerve roots has also been reported. Other complications included adhesive arachnoiditis. In addition, spread of the local anaesthetic to the subarachnoid space can cause weakness, numbness, respiratory difficulties, aseptic meningitis and infectious meningitis.

In summary, epidural steroid injections in the properly selected patient are generally successful due to the fact that the mechanism of pain involves inflammation of spinal nerve roots due to a mechanical and chemical cause of the inflammation. It generally requires between one and three injections given over an eight-week period of time to produce long-term pain relief.

Of note, in performing lumbar epidural injections it has been shown that using a blind technique the miss rate ranges between 17-30%.

TRANSFORAMINAL EPIDURAL STEROID INJECTION

Lumbar Transformational Epidural Steroid Injections

This technique is also known as selective spinal nerve root injections and are indicated to treat radicular pain due to foraminal stenosis. Performing this technique requires the use of fluoroscopy since a blind technique will not accurately localize the needle tip into the neural foramen of the selected lumbar vertebrae. The patient is placed in the prone position and a posterolateral approach is used. A sterile prep and drape is performed prior to the start of the procedure and after ascertaining proper trajectory for the needle 1% lidocaine is administered over the skin and subcutaneous tissue prior to the insertion of the spinal needle. A spinal needle is directed through the skin and subcutaneous tissue using fluoroscopic guidance and the needle tip is directed just inferior to the pedicle at the 6 o'clock location. The needle was then advanced into the foramen using anterior posterior and oblique views. The depth of the needle in the foramen is determined using a lateral view under fluoroscopy. This technique is performed with the patient awake and responsive, either with no sedation or mild sedation in order to ascertain the presence of any paresthesias, which would indicate that the needle tip is touching either a spinal root or the spinal cord itself. When the needle is correctly placed, the use of iodinated dye will reveal the outline of the intended nerve root.

The target for the needle placement is just lateral to the location of the superior articular process and at the 6 o'clock location of the pedicle. One can use a metal guide to locate where the skin wheal/local anaesthetic injection should be performed. The proper location of the needle insertion generally is about 12 cm from the midline of the spinous process.

Generally, a 22-gauge 3-1/2 spinal needle should be of adequate length to properly perform a transforaminal epidural injection. Of note, following the injection of dye, the spinal nerve root should be outlined by the dye and the practitioner needs to make sure that there is no vascular uptake of the dye and no uptake by the subarachnoid fluid indicating a malposition of the needle.

The contrast in addition may outline the dorsal root ganglion and may go retrograde into the epidural space. Again, safety measures involving performance of a transformational epidural injection include aspirating the syringe before injection to confirm that there is no blood or CSF being aspirated into the syringe, using a test dose of local anaesthetic along with the injection as well as the injection of contrast all of which help confirm proper needle placement. Complications of transformational epidural injections are similar to those listed under translaminar lumbar epidural steroid injections.

LUMBAR FACET BLOCKS

The lumbar facet joints are a potential source of axial back pain [9]. These joints have been shown to contain pain fibers, which if irritated can cause axial back pain as well as lower back pain radiating to the buttocks and lower extremities. X-ray studies have been unreliable in diagnosing facet joint cause of low back pain. A lumbar facet joint block is the current standard for diagnosing facet joint related pain [5]. When performing a lumbar facet block fluoroscopic technique is used [4]. A pillow may be placed under the abdomen to open the joint thereby allowing easy needle access. The back is prepped and draped in the usual fashion and the fluoroscope is rotated into an oblique position to allow visualization of the lumbar facet joints. A 45-degree oblique view is used for the L4-L5 and L5-S1 joint visualization and a 30-degree oblique view is used for the upper lumbar joints. Following the

skin prep 1% lidocaine is infiltrated medial to the inferior articular process. A 22-guage spinal needle is then advanced using fluoroscopic guidance to engage the inferior articular process. It is then advanced laterally to enter the joint. Complications of this technique include infection, spinal or epidural anesthesia, and rupture of the joint capsule if large volumes are injected. Care should be taken not to inject more than a total volume of 1 cc to prevent capsular rupture.

Medial branch blocks can be performed before these nerves enter the facet joint. A lumbar medial branch block can be performed using fluoroscopic guidance using the same preparation as noted above. The C-arm is rotated to allow visualization of the junction between the transverse process and the superior articular process. Lidocaine infiltration of the skin is performed and a 22-guage spinal needle was inserted under fluoroscopic guidance until the needle tip rests on the junction between the base of the superior articular process and the transverse process. Complications of this technique include infection, and spread to the subarachnoid or epidural space. A combination of bupivacaine and/or methylprednisolone can be injected to facilitate pain relief.

RADIOFREQUENCY ABLATION OF THE LUMBAR MEDIAN BRANCH NERVES

Facet joint pain accounts for an estimated 15-45% of the causes of lower back pain [1]. Conservative treatments include oral medications, physical therapy, trigger point injections, and medial branch blocks.Medial branch nerve blocks serve both a diagnostic and therapeutic modality, which help confirm the diagnosis of a facet joint etiology of the lower back pain. Radiofrequency ablation is used for treatment of facet joint arthropathy as an etiology for the cause of low back pain following confirmatory diagnosis with median branch nerve blocks [8]. This procedure is performed using fluoroscopic guidance. The patient usually presents with axial low back pain with occasional radiation to the buttocks and lower extremities [10]. Radiofrequency involves the use of thermal energy to ablate the median branch nerves and create facet denervation thereby relieving the pain.

Procedure.
The patient is kept awake for this procedure since continuous oral contact with the patient is necessary. Therefore, minimal sedation if any is used. The prone position is used on the fluoroscopic table. A pillow is placed under the abdomen and all pressure points are checked and padded if necessary. The pertinent lumbar vertebral levels are marked and an anterior posterior fluoroscopic film is obtained. The location for the entry zone at each vertebral level is marked over the junction between the transverse process and the superior articular process. Local anesthetic is infiltrated under the skin and a radiofrequency needle is subsequently inserted and advanced until the needle tip makes contact with the bony landmarks noted above. The radiofrequency needle is then connected to the radiofrequency probe after final positioning of the needle. A sensory stimulation test is then performed at 50 Hz and the patient should feel either tingling or pressure in the back at a voltage level of less than 0.5 volts. If the patient complains of radicular pain in the ipsilateral extremity the needle tip is moved slightly and the sensory stimulation test is performed again to obtain the parameter noted above. Prior to the start of radiofrequency ablation a motor stimulation test is performed at 2 Hz and 3 volts. The patient should not experience any muscle contractions in the ipsilateral buttock or leg. If contractures are noted in the ipsilateral extremity the needle must be repositioned. Following final position of needle 1 cc of 1% lidocaine is injected through the radiofrequency needle prior to the start of the radiofrequency lesioning. The radiofrequency lesioning is generally performed at 80 degrees centigrade for 60 to 90 seconds. Depending upon which machine is used up to three levels may be lesioned at the same time. Following the procedure the patient may complain of transient numbness in the ipsilateral extremity due to local anesthesia entering the intervertebral foramen on the ipsilateral side. This side effect is usually short lived and resolves fairly quickly. In addition, the patient may complain of burning pain in the lower extremities or localized pain at the site of the injection, which usually resolves in about two weeks. Other possible side effects include infection, backache, and muscle spasm.

STELLATE GANGLION BLOCK

The stellate ganglion consists of preganglionic fibers that originate in the first and second thoracic spine. These sympathetic fibers innervate the head and the neck. There are several cervical paravertebral sympathetic trunks where these preganglionic fibers synapse. These include the superior, middle,

and inferior cervical ganglion. The stellate ganglion refers to the inferior cervical ganglion and all preganglionic fibers mentioned above either synapse or pass through this particular ganglion. In some instances, the inferior cervical ganglion and the first thoracic ganglion fuse to form the stellate ganglion [3]. The stellate ganglion is located between the base of the seventh cervical transverse process and the first rib. It usually lies on the lateral border of the longus colli muscle. The ganglion lies posterior to the subclavian artery, anterior to the transverse process, and medially to the scalene muscles.

Procedure.
The anterior approach is most commonly performed at the C6 level [7]. The patient is placed in a supine position with a roll under the shoulders in order to hyperextend the neck. The fluoroscope is positioned at the level of the C6 vertebra. Following sterile prep and local anesthesia a 22-gauge spinal needle (3-1/2 inch) is advanced through the entry point at the C6 level about 1-2 cm from the midline. Chassaignac's tubercle can usually be palpated at the medial border of the sternocleidomastoid muscle lateral to the cricoid cartilage. While the stellate ganglion block is performed retraction of the carotid artery laterally from the needle entry port should be done to prevent intravascular insertion of the procedure needle. The needle is advanced medially at the C6 level to the junction between Chassaignac's tubercle and the C6 vertebral body. Contact is made with bone. The position of the needle can be confirmed by injection of iodinated dye and confirmation of the proper position by a fluoroscopy film. Aspiration for blood should be performed prior to the injection of any medications. Following confirmation of proper needle position local anesthetic is injected slowly such as bupivacaine 0.125%. A test dose of 3 cc is performed followed by frequent aspirations after every 3 cc of bupivacaine that is injected. A usual volume between 10 cc and 13 cc of local anesthetic is required to block the sympathetic innervation of the upper extremity. Radiofrequency ablation has been used to provide long-standing blockade using the same technique as noted above. Following a successful stellate ganglion block the patient will usually develop an ipsilateral Horner's syndrome consisting ptosis, miosis and anhidrosis. In addition, the patient may also develop nasal congestion, conjunctival injection as well as a temperature increase in the ipsilateral upper extremity when compared to the contralateral upper extremity. This is due to increased blood flow to the ipsilateral extremity. Other complications include intravascular injection nerve damage, spinal and or epidural block.

LUMBAR SYMPATHETIC BLOCK

The lumbar sympathetic chain is a continuation of the sympathetic chain in the lumbar region. There are two trunks on either side of the vertebrae, which are each connected to the spinal cord by preganglionic neurons. These preganglionic neurons exit the spinal cord as white rami communicantes and connect with the sympathetic chain in the paravertebral ganglion. They exit the chain as postganglionic efferent fibers and innervate the pelvic viscera. Other fibers go to the superior and inferior hypogastric plexuses as well as the aortic plexus. There are some other fibers that travel with the lumbar nerves from L1 through L5 and end up in the lumbosacral plexus. A lumbar sympathetic block is performed for patients who have been diagnosed with reflex sympathetic dystrophy/complex regional pain syndrome involving the lower extremity [2]. It is also indicated for treatment of circulatory insufficiency of the lower extremity and for pain syndromes of the lower abdomen or pelvis.

Procedure.
The patient is placed in the prone position on the fluoroscopy table and an anterior-posterior fluoroscopy film is obtained of the lumbar spine. The C-arm of the fluoroscopy machine is then placed at an oblique angle at approximately 35 degrees. A mark is made at the skin that overlies the target area, which is approximately 1 mm lateral and slightly caudal to the middle of the corresponding vertebrae at the L2 level. Following Betadine prep, local infiltration of the skin is performed with lidocaine 1% and a 5 inch 22-gauge spinal needle is then inserted. The needle tip is advanced until the needle tip contacts the vertebrae over the lateral aspect region of the upper half of the L2 vertebrae. The needle is then slightly pulled out and redirected towards the edge of the vertebrae and then advanced along the lateral aspect until it reaches the anterolateral border of the L2 vertebrae. Water-soluble contrast is then injected through the needle and the contrast should spread linearly in a superior and inferior direction outlining the sympathetic chain, 10 cc of 0.125% bupivacaine plus methylprednisolone 40 mg is then injected slowly (3 cc test dose followed by 7 cc of the remaining fluid) with frequent aspiration to rule out any intravascular injection. A successful block will usually be demonstrated by a temperature increase in the ipsilateral foot as compared with the contralateral foot.

Contradictions to lumbar sympathetic blocks include infection, coagulopathies or use of anticoagulants. Side effects include increased temperature; post procedure muscle spasms, backache, genitofemoral, neuralgia, intravascular injection and subarachnoid injection.

LUMBAR EPIDURAL STEROID INJECTIONS

Epidural steroid injections has been long used both in acute and chronic pain management. In conjunction with epidural catheter anesthesia can be delivered for obstetrics and for surgeries of the lower extremities. Historically the conceptual basis for these injections started in 1925. Subsequently about 10 years later Mixter and Barr identified the intervertebral herniated disc as a source of "sciatica" and lower extremity radicular pain. The misconceived series of three injections was commonplace by the 1980s. These were all performed without fluoroscopy, "blind" technique either in the caudal, or interlaminar approach. Epidural steroid injections and obstetric setting performed seated position with a curved, rounded posterior lumbar spine and is done "blind" with often a 17gauge Touhy epidural needle. This chapter however focuses more on injection of local anesthetic, steroid, saline or chronic pain management secondary to herniated discs, radiculitis, annular fissures for discogenic pain, and occasionally for treatment of viral infections such as herpes Zoster or post herpetic neuralgia. When explaining the procedure to patients it is important to emphasize that the epidural space is a potential space and not the name of the injection. This potential space is where drugs can be deposited or a catheter anchored. [15]

Indications/contraindications.
There's good evidence based medicine suggest epidural steroid injections useful for the treatment of spinal stenosis, acute and chronic lumbar radiculopathy, lumbar post laminectomy pain syndrome, vertebral compression fractures, neuropathies due diabetes, postherpetic, and chemotherapy. Placement of a catheter and continuous infiltration of local anesthetic and/or opioids malignancies, postoperative, capitation, reflex sympathetic dystrophy conditions.

Table 1. Evidence summary.

Procedure	Caudal epidural injections	Interlaminar epidural injections	Selective nerve root injections	Transforaminal epidural injections
Short-term relief	Strong evidence chronic low back, radicular pain.	Strong	moderate for preoperative evaluation of inconclusive findings	strong
Long-term relief	Moderate	Limited		Limited

Absolute contraindications include coagulopathies, local or systemic infections and severe allergic reactions to any of the components injected. Relative contraindications include positioning difficulties, previous surgery at the site, previous history of difficulty accessing epidural space. Of note, typically in patients who have already had spinal surgery where the anatomy of epidural space has been disrupted, access can be more easily obtained from a caudal approach through the coccygeal ligament or lateral transforaminal approach. In general, there are three ways to access the epidural space. The first is the inter-laminar approach which accesses the space between adjacent lamina, the caudal approach which accesses to the sacro coccygeal ligament through the caudal canal, for the transforaminal approach which accesses via a lateral sub pedicular approach. Each has a different value. For example, the transforaminal approach is especially useful in post laminectomy pain syndromes where a single nerve or group of nerves need to be isolated and injected. This can also be diagnostic when local anesthetic alone is used. The epidural space is highly vascular. Complications of inadver-

tent needle placement include bleeding, inadvertent intrathecal administration of steroid and/or local anesthetic which could possibly result in high spinal blocks, or respiratory depression if opioids are administered intrathecal he, subdural administration because patchy anesthesia of prolonged duration. Spinal puncture with these large epidural needles can result in posterior oral culture headaches with the risk of less than 1%. The caudal approach is a safer technique in the setting of anticoagulation. The transforaminal approach has inherent risks associated with trauma to the dorsal root, intravascular injection of particulate steroids and bleeding, and even disastrous consequences of clotting of the artery of Adamkowiez.

Anatomy/physiology.
Anatomically epidural space extends superiorly from the spinal dural layers near the base of the brain or the foramen magnum and inferiorly it continues down to the sacrococcygeal membrane. The lateral borders extend to the vertebral pedicle anteriorly it is bounded by the posterior longitudinal ligament and posteriorly it extends to the vertebral laminar bodies. The space contains connective tissue epidural fat veins arteries and lymphatics. It is interesting to note that the epidural veins do not have valves. This is important because abdominal pressure can cause reflex engorgement of the epidural veins. The space also varies in the cervical region where it can be anywhere between 1 to 2 mm down to the widest area and the lumbar space up to 6 mm. The area is widest in the cervical region between C7 and T1, which forms an ideal access point for cervical epidural steroid injections.

Technique.
Most epidural steroid injections, whether cervical, thoracic, or lumbar are done in the fluoroscopic room with non-ionic contrast enhancement for documentation epidural space. Steroids that are most often used include long acting steroids Depo-Medrol, triamcinolone, or dexamethasone. After consent is obtained the patient is positioned in the prone position and fluoroscopic images are taken of the area. The end plate of vertebral bodies is squared and the spinous process is positioned midline. The interim of her opening is identified and after local anesthesia is administered and epidural needle is advanced into the space traversing the skin connective tissue, supraspinous, inter-spinous, and ligament flavum. At this point the needle will be engaged in this tough ligament and further advancement will be done for the loss of resistance syringe either plastic or glass, containing 2 to 3 ML of air, saline, or a combination of air and saline. An abrupt loss of resistance indicates the traversing of the tough connective tissue and entrance into the epidural space. Confirmation is made to ensure absence of blood, cerebrospinal fluid, and then 2 to 3 mL of non-ionic contrast either Isovue, or Omnipaque is injected under live fluoroscopic guidance. Documentation of the spread of the contrast media showing often a “soap bubble” appearance where the contrast spreads around the epidural fat, confirms accurate needle tip location. Steroid solution mixed with saline and or a long-acting local anesthetic such as preservative free bupivacaine 0.25% is injected in incremental doses under periodic fluoroscopic imagery. The caudal approach requires fluoroscopic views initially in the lateral view the sacro coccygeal ligamentous curve. The needle is advanced through the ligament and into the caudal canal, contrast is then again administered confirming cephalad spread lateral view, which follows the contour of the sacrum, and a Christmas tree appearance in the PA view often with contrast enhancement of lower sacral roots. The loss of resistance syringe using the caudal approach is typically not required. The transforaminal approach requires a three-quarter “Scottie dog” radiological view and typically a 22gauge blunt bevel needle is advanced just under the pedicle into the foramen. Contrast is injected under direct flight fluoroscopic view in the PA view demonstrating highlighting of the nerve root. Digital subtraction imagery can be helpful to eliminate the inadvertent injection into the blood vessel. Most physicians will choose a non-particulate steroid such as dexamethasone, which may avoid inadvertent particulate injection into the radicular artery.

FACET BLOCKS AND RF

Facet blocks including medial branch peri-articular and intra-articular injections are useful in the treatment of inflammation, arthritic conditions including trauma to the facet or zygopophyseal or z-joints joints. These are divided into cervical, thoracic and lumbar facets. The angulation of the facets differs in each of these regions based on the required movement of that segment of the spine. Evidence based medicine literature support for diagnostic medial branch blocks show a diagnostic predictability of 75 to 100% as compared to limited value for diagnostic intra- articular or peri articular blocks. [15]

Indications/contraindications.
Spinal pain can because by many different neural sensitive structures including nerves, discs, ligaments, joints and fascia and muscle. Facets form anchoring points on either side of the posterior aspect of the disk. Depending on the angulation the facet joints allow motion in the cervical thoracic and lumbar region. Simple degeneration, trauma, infectious processes, or fractures can injure these joints, similar to any other articular surface joints in the body. As the inter-vertebral disc degenerates weight is transmitted laterally onto the joints causing the joints to have increased weight bearing, and they compensate with increased bone growth some of which can protrude into the spinal canal resulting in subsequent bony spinal stenosis. Facet pain has a very different distribution of pain as compared to radicular pain. Facet joint pain is non-dermatomal. Aggravation of cervical facets typically cause pain in the neck occasionally associated with headaches and referred radiation to the shoulder and between the shoulder blades as the lower cervical facets are involved. Facet arthropathy causes localized and proximally radiating non-dermatome pattern pain. Similar to other joint arthropathies facet joint pain is often worsened in the morning and is relieved somewhat with activity, heat and NSAIDs. Mechanical motion at the affected joint causes reproduction of pain. This diagnostic specificity is utilized to advantage assessing pain, pre-and post facet joint medial branch blocks, and documented. The specificity of this is over 95%.

Anatomy/physiology.
Facet joints are formed by the superior and inferior articular facet services of connecting vertebral levels. Like articulating joints anywhere else in the body the spinal facets are considered true joints with in articular surface, synovial fluid, and specific angulation and limitation of motion. The nerve supply of the facets is from two adjacent level medial branches. Posterior primary rami divide into three divisions, lateral intermediate and medial branches. The medial branch hugs close to the superior articular process where it connects to the transverse process, and passes in a groove, under a small ligament called the mammillo accessory ligament, that bridge between two small bony prominences called mammary bodies. These are more pronounced in the lumbar region. The medial branch gives innervating fibers to the same level and passes a branch to the level below. This is why in order to enervate his single level the medial branch one level higher must also be blocked. In other words, each medial branch provides innervation to half the joint at the same level and half the joint one level below. This relationship has an exception at the L5 level where it is the dorsal ramus instead of a medial branch that goes over the SAP over the sacral medial ala.

Technique.
Today facet blocks are performed with fluoroscopic guidance. Ultrasound guidance is an emerging potential in the near future. The blind technique has fallen out of favor. Physicians who specialize in interventional techniques of the spine are best suited to perform cervical and thoracic blocks. For medial branch blocks, the level above and at the affected joint is targeted due to the dual innervation off of the posterior primary ramus. All are performed in the prone position except for the upper cervical levels, which can be performed in lateral decubitus.

Cervical medial branch blocks: Patient position: prone, cervical pillow, and chest raised with hard pillow to allow a gentle flexion of the neck. Some physicians use the lateral position, affected side up, for the higher cervical facet levels. Materials: 23 gauge or 22 gauge 3.5" spinal needles. Three ml syringe, five ml syringe, 25, or 27gauge local anesthetic needle, long clamp to identify target under fluoroscopy. Medication: Bupivacaine 0.25%, triamcinolone 40 mg per ml. The 'waist' of the articular pillar is identified and the target located at the narrowest part on PA view, and at the center of the parallelogram of the facet on a lateral view. The volume injected should be less than ½ ml.

Thoracic medial branch blocks: Patient position: prone. Materials: 23gauge or 22gauge 3.5" spinal needles. Three ml syringe, five ml syringe, 25, or 27gauge local anesthetic needle, long clamp to identify under fluoroscopy. Medication: Bupivacaine 0.25%, triamcinolone 40 mg per MLNeedles are targeted in the PA view to avoid inadvertent needle traversing the lung.

Lumbar medial branch blocks: Patient position: prone. Materials: 23 gauge or 22 gauge 3.5" spinal needles, three ml syringe, five ml syringe, 25, or 27gauge local anesthetic needle, long clamp to identify under fluoroscopy. Medication: Bupivacaine 0.25%, triamcinolone 40 mg per ml. Procedure: As with most blocks of the spine it is important to start with a true AP view. Square off the superior end plate of S1. The L5 medial branch block is typically blocked first. Mark off the sacral ala at the junction with the superior articular process, this is the target location.

Advance a 22gauge spinal needle through an anesthetized skin weal and under fluoroscopic guidance advance needle tip to target. For the remaining lumbar levels, return to a true PA position, square off the vertebral body endplates, then rolled the C-arm toward the affected side until a three-quarter view, or a "Scottie dog" view was obtained. The target will be the "eye" of the Scottie dog, this is where the superior articular process base meets the transverse process. Touch the needle tip to the bone, document images in both this view and in a PA view. Contrast is typically not necessary. This area is not vascular. Inject a total volume of half mL local anesthetic (lidocaine or Bupivacaine). Steroid can also be injected in this area however the patient must be examined within one-hour post procedure to determine effect. [15]

Intra articular Facet Joint blocks: These are injections into the joint itself. The facet joint is seen as between the superior and inferior articular processes in a squared PA view with slight lateral or medial oblique rotation until the joint is visible and this space is viewable. Thoracic and cervical facet joint injections are complex and carry a much higher risk of inadvertent cord injury and should be considered only by pain medicine specialists. The materials and technique is similar with the exception of the target area. Resistance is encountered as the spinal needle traverses the joint. Care is taken not to pass through the anterior aspect of the joint. [15]

Radiofrequency of the medial branches are done using a similar technique. The needle is insulated with and exposed active tip. The needle is often placed and a slight upward angulation in order to allow greatest contact of the exposed needle tip with the area of anticipated nerve location. This allows for the largest possible lesion. Repeat radiofrequency ablations are usually limited to three times per year. Often the pain relief can be upwards of 10 months, the time it takes for the nerve to regenerate.

Author's tips:

1. If sedation is used to provide comfort for patient during procedures it is important to avoid the use of any opioids. This can mask a patient's response two and in accurately placed needle. Instead, use only midazolam or propofol.
2. Curving the tip of your spinal needle to approximately 15° makes course corrections much simpler during the needle advancement.
3. Try using a 25gauge 3.5" spinal needle to avoid skin local anesthesia infiltration.
4. Inject Lidocaine as spinal needle is being withdrawn to avoid any paraspinal muscle spasms.
5. Re-examine the patient 30 minutes post procedure to reproduce facet joint pain, document. Document the improvement.
6. For radiofrequency procedures, document the response to both sensory and motor stimulation and save final needle positions images.

SACROILIAC JOINT BLOCKS AND RF

Because of the complexity of the sacroiliac joint and biomechanics, there has not been any singular diagnostic test to isolate the pain generator. The sacroiliac joint can be responsible for up to 20% back and leg pain. Injuries to the sacroiliac joint are often seen with fall on the buttocks, or in rear-ended motor vehicle accidents causing full movement of the sacroiliac joint at the time of impact. [15]

Table 2. Evidence summary.

Procedure	Diagnostic injections	Intra- articular blocks	SIJ neurotomy) Conventional and pulsed RF
Short-term relief		Limited	Limited
Long-term relief		Limited	Limited
Diagnostic Predictability	Moderately useful		

Indications/contraindications.
Absolute contraindications include coagulopathies, local or systemic infections and severe allergic reactions to any of the components injected. Relative contraindications include positioning difficulties, previous surgery at the site, previous history of difficulty accessing the joint. Complications include inadvertent nerve damage to the large sciatic nerve, which travels in close proximity to the inferior portion of the joint. For the initial injection or the therapeutic phase injection should be limited to no more than 4 to 6 per year. Documentation of at least greater than 50% decrease in pain lasting over six weeks is required. Sacroiliac joint radiofrequency ablation typically is done no more than three times per year again assuming the above 50% decrease in pain for four months is documented.

Anatomy/physiology.
This joint is a true diarthodial synovial joint with extensive innervation and a comment yet undiagnosed cause of low back pain in adults. Immobile in males, hormonal changes in females during the third trimester allows the joint some mobility.

Technique.
Patient position: prone. Materials: 23 gauge or 22 gauge 3.5" spinal needles. Three ml syringe, five ml syringe, 25, or 27 gauge local anesthetic needle, long clamp to identify target under fluoroscopy. Medication: Bupivacaine 0.25%, triamcinolone 40 mg per ml. Fluoroscopic images are taken and the inferior portion of the joint is identified. Using a cranial caudal and oblique rotation of the C-arm the inferior portion of the joint is identified between two lines. This is sometimes described as overlapping the "rivers". The 22 or 23gauge spinal needle is placed through sterile and anesthetized skin and advanced until bony contact is made at the inferior portion of the joint. The needle is advanced until resistance is encountered in the ligament. Frequent fluoroscopic images are required during bony contact to identify the redirection of the needle tip. Once in position contrast is injected and typically seen traversing upwards into the joint. PA and lateral views are documented. It is important to have the patient able to respond and identify if the larger underlying somatic nervous contacted. This would cause reproduction of radicular pain. Steroid with local anesthetic is injected. Post procedure the patient should be re-examined in the degree of pain relief documented.

Radiofrequency ablation of the sacroiliac joint: After fluoroscopic identification of the joint as described above, a radiofrequency probe, with a 10 mm exposed tip is advanced into the joint. Sensory stimulation at 50 Hz and motor stimulation at 2 Hz is performed with the patient able to respond and identify the source of pain and to rule out inadvertent sciatic nerve stimulation. Ablation of either 75 or 90°C is carried out for 60 to 90 seconds. Further radiofrequency lesions are carried superiorly along the course of the joint. The L5 medial branch/posterior primary ramus is targeted and the depression of the sacral ala infero lateral to the L5 transverse process.

INTRADISCAL THERAPIES

It has been long recognized that the intervertebral discs carry a rich innervation particularly along the annulus. Disrupted discs and tears tend to have highly sensitized annular fibers. This is often seen either as low back pain or low back and radicular pain. Diagnosis of these conditions, disc pathology, can be difficult with MRI and CAT scans. Provocation discography, which involves injection of contrast material into the nucleus pulposus of discs with the patient able to respond, has proved effective in locating annular tears and sensitive discs. Percutaneous discectomy has been suggested as an alternative to an open discectomy. These include laser discectomy's, radiofrequency collation or nucleoplasty, mechanical and manual or decompression either with an automated device or by use of a long clamp followed by subsequent cauterization of the interior annular fibers have been used. The rationale has been that reduction of internal disk volume decreases tension and pressure on the annular wall and subsequent nerve root reducing pain. [15]

Table 4. Evidence summary.

Procedure	Lumbar discography	Intra-discal electro thermal therapy (IDET)	Radiofrequency posterior annuloplasty
Short-term relief		Limited	Limited
Long-term relief		Indeterminate	Indeterminate
Diagnostic Predictability	Strong for diagnosing discogenic pain in conjunction with other diagnostic injections		

Table 5. Evidence summary.

Procedure	Automated percutaneous lumbar discectomy	Percutaneous laser discectomy	DeKompressor	Nucleoplasty
Short-term relief	Moderate	Moderate	Limited	Limited

Indications/contraindications.
Absolute contraindications include coagulopathies, local or systemic infections and severe allergic reactions to any of the components injected. Relative contraindications include positioning difficulties, previous surgery at the site, previous history of difficulty accessing the joint. Complications include discitis, a particularly difficult to treat condition often requiring surgical intervention.

Anatomy/physiology.
Intervertebral disc procedures are typically limited to the lumbar spine. Occasionally the thoracic spine may be attempted. The key identifying points for disc related procedures in the lumbar spine or identification of the superior articular process and adequate squaring of the vertebral and plates above and below. Cervical disc procedures should be limited to physicians who have extensive expertise. The L5/S1 intervertebral disc can be difficult to access in males due to the high iliac crest.

Technique.
Patient position: prone, pillow under abdomen to reduce the lumbar lordosis. Full surgical prep and drape. Materials: Three ml syringe, five ml syringe, 25, or 27-gauge local anesthetic needle, long clamp to identify target under fluoroscopy. Preoperative antibiotics are ministered within 30 minutes of the procedure. Postoperative antibiotics are usually not required. For provocation discography, immediate CAT scan post procedure is required. Medication: Bupivacaine 0.25%, triamcinolone 40 mg per ml. Fluoroscopic images are taken and the target disk is squared with and plates above and below. The C-arm is rotated obliquely until the superior articular process transects the disc by approximately 50%. The target point is just anterior to the superior articular process and the midpoint of the disc. To access the disk more posteriorly further oblique rotation may be required. This is particularly the case for posterior herniations. A 16gauge or 14gauge (manufacture provide) is advanced through sterile and anesthetized skin and soft tissues to contact the anterior portion of the superior articular process. The patient must be awake enough to respond if the traversing route is contacted. Resistance is encountered as the needle is pushed past the annular fibers and into the pulposus. Contrast is often injected into the disk to confirm proper placement of the needle. Images are recorded. The remainder of the procedure is performed based on the manufacturer's recommendations. Disc material that is removed is sent for pathology for quantification and assessment. Post procedure a small quantity of steroid lidocaine antibiotic mixture is injected into the disk.

VERTEBRAL AUGMENTATION

The aging population has seen an increase in low back pain secondary to vertebral compression fractures. These fractures cause pain at the fracture site at the level of the vertebral body, can cause spinal instability and kyphoscoliotic changes. Vertebroplasty and kyphoplasty are two effective methods for treating these conditions; both involving placing a needle into the vertebral body and injecting radiopaque bone cement. In the latter procedure the vertebral body is expanded either by a balloon or other expansion device to create a central cavity to accommodate the bone cement. [15]

Table 6. Evidence summary.

Procedure	Vertebroplasty	Kyphoplasty
Short-term relief	Moderate	Moderate
Long-term relief	Moderate	Moderate

Indications/contraindications.
Absolute contraindications include coagulopathies, local or systemic infections and severe allergic reactions to any of the components injected. Relative contraindications include positioning difficulties, previous surgery at the site, previous history of difficulty accessing the spine. Complications include inadvertent leakage of bone cement into the area of the neural foramen or epidural space. This may require subsequent neurosurgical decompression and/or fusion.

Anatomy/physiology.
The thoracic and lumbar vertebral bodies are typically treated. The key to this procedure is to identify and center the pedicle of the affected level. In the lumbar spine compression fractures are typically in the L1/L2 levels.

Technique.
Patient position: prone with pillow under abdomen to decreased lumbar lordosis Manufacturer provided needle and bone cement mixer. Medication: local anesthetic, preoperative antibiotics. Full surgical prep and drape. Materials: 23 gauge or 22 gauge 3.5" spinal needles. Three ml syringe, five ml syringe, 25, or 27 gauge local anesthetic needle, long clamp to identify target under fluoroscopy. The affected vertebral compression fracture is identified and the endplate squared. The C-arm is open leaked until the pedicle is seen at approximately the 50% midline of the vertebral body. Using the manufacturer provided needle/trocar this is advanced through previously anesthetize skin until bony contact at the midpoint of the pedicle is made. Then using multiple PA and lateral views this is advanced into the pedicle taking care not to fracture it. A manufacturer provided sterile mallet is used to gently tap the trocar into place. Final needle position is confirmed in the PA and lateral views. Manufacturer provided cement mixer and cement is then gently pumped into the collapse vertebral body with continuous first topic confirmation. For kyphoplasty a balloon is advanced and inflated under pressure to create a cavity. The needle is removed by reducing the injected pressure to prevent leaving a bone cement tail. The patient during this procedure is likely sedated with a small amount of opioid however is able to respond to any questions.

IMPLANTABLE THERAPIES

These procedures are of two types. The first involves an electrical current of controlled frequency and amplitude to scramble to pain in the dorsal column of the spine. The second involves drug delivery directly into the intrathecal space for less common conditions the epidural space for continuous drug delivery. Both procedures involve an initial diagnostic phase or trial. Intrathecal therapies can be useful in patients with spasticity disorders and malignancies. Intrathecal medication can reduce common side effects associated with large doses of opioids orally. [15]

Table 7. Evidence summary.

Procedure	Spinal cord stimulation	Implantable intrathecal drug administration
Short-term relief	Strong	Strong for neuropathic or malignancy pain
Long-term relief	Strong	Moderate

Indications/contraindications.
Absolute contraindications include coagulopathies, local or systemic infections and severe allergic reactions to any of the components injected. Relative contraindications include positioning difficulties, previous surgery at the site, previous history of difficulty accessing the space. Complications include inadvertent placement of the electrode lead into the intrathecal space, or inadvertent contact and trauma to the spinal cord. Hematomas in this region can cause profound neurologic effects requiring further surgery.

Anatomy/physiology.
The key points to understand in this anatomy are to accurately document and count the lumbar/thoracic levels. Placement of the tip of either the electrode for in the case of spinal cord stim leads or the catheter in the case of intrathecal or epidural drug delivery systems is important. The patient documents the pain relief. 50% or greater decrease in pain and clinical re-examination are required along with a lengthy discussion before the decision is made for permanent electrode or lamitrode placement. Prior to intrathecal pump implantation a trial is performed. Different trials have been tried however the evidence is greatest with continuous intrathecal medication delivery in an in-hospital setting. Single shot epidural opioids as well as continuous epidural opioids are not as predictive.

Technique.
Patient position: prone, pillow under abdomen to reduce the lumbar lordosis. Full surgical prep and drape. Materials: Three ml syringe, five ml syringe, 25, or 27-gauge local anesthetic needle, long clamp to identify target under fluoroscopy. Preoperative antibiotics are ministered within 30 minutes of the procedure. Postoperative antibiotics are usually not required. For provocation discography, immediate CAT scan post procedure is required. Medication: local anesthetic. Fluoroscopic images are taken and the target level, the point of entrance for the epidural space is marked. The space is accessed in a much steeper caudal/cephalic approach. This is to ensure that there is no inadvertent puncture of the dura for spinal cord stimulator placement. For spinal cord stimulator's two electrodes are placed for the trial. The patient is then allowed to map his pain while different frequency combinations are tried. The electrode is adjusted cephalad or caudal accordingly. The final position is then documented fluoroscopically and secured with sutures to the skin. Sterile dressing is applied and the electrodes connected to an external generator. These electrodes are then removed one week later. Continuous antibiotics are usually not required. Intrathecal catheters are similarly placed into the intrathecal space. Permanent placement involves a tunneled catheter with a pre-agreed upon pump reservoir position.

EPIDURAL INJECTED STEROIDS

In April 2014, the FDA issued new box learnings on the safety of epidural he injected steroids. This warning is unrelated to the contamination of steroids that was reported previously. This warning was added to recommend practitioners discussed the risks of injected steroids and inform patients of the possibility of vascular occlusion, paraplegic, death. The FDA did not discourage the usage of steroids for epidural injections.

Epidural steroids include triamcinolone, betamethasone, dexamethasone, and methylprednisolone. All of these are considered intermediate the long acting steroids with varying degrees of glucocorticoid and mineral cord quite effects. The particulate steroids include triamcinolone and methylprednisolone. Non-particulate includes the dexamethasone and the betamethasone. [16]

Dexamethasone and betamethasone or non-particulate steroid. Dexamethasone has been associated with transient side effects including tingling along the nerve, headache and paralysis. These are all manage conservatively long-lasting effects were noted. [18]

Steroids may be prepared with preservatives or without. It is unclear whether preservatives pose any problems especially since they're diluted with local anesthetic and saline prior to injection.

Epidural injected steroids have been used safely in the epidural, for over 40 years despite the FDA approval.

Confusion exists among the public and often practitioners about the role of the FDA and its regulation and medication. FDA can issue warnings an additional labeling, however the ultimate judicious use of the medication has awfully able is determined by the physician. Many medications are used in off label use, a notable example is gabapentin which was first introduced as a safe non-hepatic metabolized renal excreted antiepileptic medication. However, it's predominant use today is in neuropathic pain conditions an off label use.

However, there are risks associated with neuraxial steroid injections which factor operator technique, volume of injectate, route injected, and choice of steroid.

Particulate steroids which include triamcinolone and betamethasone have been suggested as a cause of vascular occlusion in procedures such as transforaminal's in the cervical thoracic and lumbar spine. Case reports of transient or even permanent paraplegia have also been reported with interlaminar and caudal epidural steroid injections however most of these cases are related to unrecognized arteriovenous abnormalities causing pre-existing cord compression that was likely exacerbated with simply the volume of injected material. [17]

So in summary the choice of steroids and technique are dependent on the physician however avoiding particulate steroids during transforaminal procedures may be prudent. Whether or not to use a preservative free solution is more controversial. And of course, having adequate training in the technique is paramount.

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CHAPTER 5.
REHABILITATION TECHNIQUES

Bradley Cash MD.

Rehabilitation specialists focus on the body as a whole. Examination of posture, range of motion, motor strength, body mechanics and core strength are essential in determining the pathology of body dysfunction or pain and the function as a whole person in determining the best options for corrective action. Pain management is complex and includes various types of conservative options for treatments. The three main categories of conservative management include therapeutic treatment options, pharmacologic management and injection therapies. In this chapter the focus will remain on therapeutic techniques for pain management.

The Rehabilitation of an individual includes both physical and mental reconditioning. The complex components of both somatic and cognitive deficits are the goal of the various techniques to enhance function. The various options include those with purely somatic, some with purely psychological and those with mixed elements. There is never a "correct" option as treatment must be individualized. Learn from experience which methods are the most effective.

PHYSICAL THERAPY TECHNIQUES

Manipulative Therapy

Also known as Manual Therapy and is done by Massage Therapists, Physical Therapists, Chiropractors, Osteopaths and Occupational Therapists. It encompasses various methods to treat musculoskeletal pain and disability thru different types of manipulation, joint mobilization, "kneading", massage, gentle adjustments and soft tissue mobilization.

There are discreet differences between manipulation, mobilization and massage. Manipulation involves the introduction of a rapid rotation, shear or distraction force into an articulation. Manipulation is often associated with an audible "popping" caused by the instantaneous breakdown of the gas bubbles that form during a joint cavitation. Mobilization is a slower, more controlled process of articular and myofascial stretching with the intention to improve myofascial and biomechanical elasticity. Massage is typical the repetitive rubbing, kneading or stripping of myofascial tissues to improve interstitial fluid dynamics. The key difference in a manipulation versus mobilization is that once the manipulation is initiated the process must undergo full completion.

Manipulative Therapy is done more commonly now by Physical Therapists. Most undergo special training and receive a certificate regarding their abilities to treat patients with manipulation. One of the more common theories is the Maitland technique which has an Australian origin. Historically, it was Chiropractors that were involved in manipulative therapies. The greater forces were required to improve mobility especially in patients that there was profound deficits. A more recent technique which has been even more aggressive performed by Chiropractors and other practitioners is Manipulation under Anesthesia. During this technique the patient is sedated. After sedation a joint or spinal segment is manipulated to undergo its full range of motion. The goal is to enhance range of motion where deficits exist due to soft tissue restrictions. The sedation allows the patient to be in a relaxed state and be fully ranged beyond what pain or spasms may allow in an awake state. This is not fully accepted in the medical world due to the underlying fear that during sedation the normal feedback mechanisms are not functional to allow a patient to be guarded or "stop" a painful range of motion, with the fear of causing soft tissue, tendon or ligament damage. Therefore the benefits of manipulation under anesthesia must clearly outweigh the risks, before deciding to proceed.

Feldenkrais

This is a Somatic Educational System which was designed by Moshe Feldenkrais to reduce pain, improve range of motion, improve physical function and promote general well-being, by improving the patient's awareness of themselves and by improving movement abilities. Education about the reduction of pain and removal of biomechanical unsound movement habits is part of the process. The education of biomechanics, posture and efficiency of movements of various activities is essential with this method. Without the elimination of inefficient biomechanical processes, the method is not successful.

The approach believes that increasing a person's proprioceptive and kinesthetic self-awareness can lead to greater function and ease and pleasure of movement. This technique is most similar to the Alexander Technique which provides more education about movement and not a hands on manipulative type of treatment. The practitioner directs attention to habitual movements which are inefficient or strained causing pain, and then teaches new patterns using gentle, slow repeated movements. Slow repetition of the new pattern is a key feature to teaching the proper new biomechanical process. The movements may be either passive (done by the practitioner) or active (done by the patient)

(Knaster, Mirka 1996) Discovering the Bodies Wisdom: A Comprehensive Guide to more than 50 Mind-Body Process; Bantam pages 232-8

Rosen Method

The Rosen Method of Rosen Method Bodywork was developed by a Physical Therapist, Marion Rosen as a type of Complimentary or Alternative technique to healing. It is described as a "psychosomatic" of mind over body technique which attempts to integrate the emotional or mental patterns within the body with the physical expression. The goal is to identify or uncover the "unconscious" pattern of physical stress that is held within the body as muscular holding or tension, feeling or behavior. The main theory is that a person protects themselves within the body from past painful experiences by blocking patterns in the mind and separating them from the true self. The most common protective mechanism is through musculoskeletal tension and pain which can be observed by the bodywork practitioners. The patterns that are observed are musculoskeletal tensions, abnormal postures and shortness of breath. The method is practices by non-intrusive touch, verbal interaction and creating an awareness of each breath. This method has the goal to integrate the body, mind, emotions and spirit and "unlock" the unconscious.

(Raso, Jack 1997) "Unnaturalistic Methods" The Expanded Dictionary of Metaphysical Healthcare, Alternative Medicine, Paranormal Healing and Related Methods)

Craniosacral Therapy

This is a unique type of alternative therapy with a bodywork of therapeutic touch. The idea is that the practitioner using the minuscule movements of the synarthrodial joints of the cranium with a gentle touch to alter or manipulate the flow of cerebrospinal fluid and aids in "primary respiration". The practitioner also may apply gentle touch or movements to the lower spine or pelvis around the area of the sacrum. Patients report deep relaxation during treatment and the therapeutic effects are thought to be responsive to endorphins and the endocannabinoid system. Craniosacral therapy was originated in the 1970's by a team of Osteopaths after years of research in the field of Osteopathy regarding the movements between the temporal bones and the parietal bones.

The "primary respiratory mechanism" is theorized to be responsive to the inherent motility in the central nervous system, fluctuation in cerebrospinal fluid, mobility of the intracranial and intraspinal dural membranes, mobility of the cranial bones and involuntary movement between the sacrum and pelvis. Practitioners note that there are small rhythmic movements between the cranial bones that contribute to cerebrospinal spinal fluid and arterial pressures. It is the manipulation between these bones that contribute to the therapeutic effect.

Most craniosacral therapists are Physical Therapist that have taken specialized courses to teach the technique. The clinical studies of effectiveness are somewhat controversial but there is much anecdotal relief in various case studies.

(Russell J, Rovere A, (2009) " Craniosacral Therapy" American Cancer Society Complete Guide to Complementary and Alternative Cancer therapies, (2nd edition) American Cancer Society pages 187-9

Trager Approach

This method is also typically done as a subset of Physical Therapy. It is done with extensive amounts of somatic education. It uses both deep physical and mental patterns in order to promote; deep relaxation, increased physical mobility and mental clarity. The approach is named after its founder who was a Psychiatrist by training and used the deep seated psychological relaxation to enhance the physical state of well-being. It was originally used to treat patients with neuromuscular and neurological conditions. It was used to enhance function but has not altered either medical or surgical treatments.

At the beginning of a treatment session, the practitioner creates a state of meditation. Once in the hyper-relaxed state, the use of gentle touch combined with active and passive fine movements, the body is taught how to mobilize using less effort. Body contact may range from gentle to firm but it is not applied with firm resistance. It uses the body's natural mobility to enhance function. The idea not to use any strain or resistance is to not induce pain. The approach teaches to body to move more efficiently without inducing pain. The patient is taught how to move with the least amount of effort with reduction of the fear of pain. The teaching is to move with the path of least resistance and the least amount of tension possible. Success in this treatment must involve the patient's ability to achieve deep relaxation and allow the practitioner to guide them through the series of movements. It typically is done without any other external stimuli

PHYSICAL MODALITIES

Physical Therapists use these types of passive treatments to supplement active treatments such as therapeutic exercise and manual techniques. The idea is to help strength, relax, heal and reduce pain and inflammation with the use of modalities. Modalities alone are not effective but are used to adjunct treatment to Physical Therapy or Chiropractor to prepare a patient for the therapeutic session.

Electrical Stimulation/TENS

A series of electrical currents are applied to the body thru electrodes that are strategically placed along a specific muscle, muscle group or along a nerve pathway. The current may be altered through the unit and varies in frequency and intensity. The idea is to relax the muscle and reduce pain via the Gate Theory. By stimulating the neural pathways, the pain fibers are blocked. This helps reduce painful spasms and contributes to the alleviation of pain. A practitioner may use a large unit called an "E-stim" to treat a patient in a therapeutic session combined with moist heat. This is the most common during treatment. A patient may also be given a TENS unit which is a smaller portable unit that can be worn at various intervals throughout the day under the clothing. This also can be adjusted in intensity and frequency for various pain conditions, but is not nearly as strong as the E-stim used in office treatment.

Laser Therapy

Low level lasers are used to stimulate cells and enhance functions as opposed to higher level lasers which are used to cut and destroy tissues. It is also known as Cold Laser therapy. There are variable dose wavelengths which are used for treatment of both acute and chronic pain. The treatment is focalized toward a specific site of "damaged" tissue and is applied typically for a few minutes. It seems to be most effective in treatment of muscle and soft tissue injuries especially chronic back pain and spasms and less effective in chronic arthritic conditions. It does help in acute flare ups of arthritic conditions for reduction of inflammation. The exact mechanism is unknown but it seems that the low level laser light might react with the mitochondria affecting the electron transport chain to reduce painful spasms and swelling. It also may enhance blood flow to specific areas to promote healing. Laser research continues at a furious pace to find effective treatments for various clinical situations. At this point, it is still considered somewhat experimental and many insurance carriers will not reimburse the treatment.

Ultrasound

This technique has been used by Therapists since the 1940's for treatment of painful inflammatory and arthritic conditions. It is accomplished by transmitting sound waves through a round headed or wand like probe with direct contact to the skin through a gel which helps transmit the waves from the metal probe through the skin. Therapeutic ultrasound is in a range of 0.8 to 3.0 MHz

The waves are generated electrically through a vibration of crystals within the probe and transmitted through the skin causing a vibration of local tissues and generating heated. Heat variations can be made by using a continuous ultrasound or pulsed ultrasound. One would use a pulsed ultrasound when excessive heat formation is not desired, such as a newer acute tissue injury.

Ultrasound causes increased tissue relaxation, increased local blood flow and scar tissue breakdown. The intensity and density of the ultrasound wave may be adjusted to achieve the desired result. Ultrasound depth varies from 5-10cm.

There are contraindications to ultrasound which include; malignancy, growth plates in children, local metal implants, local infection, local acute inflammation, vascular abnormalities, and pregnancy and over the eyes, skull, spinal cord in laminectomy site and testicles.

Moist Heat/Cold Packs

Heat therapy is also known as Thermal Therapy and is used to treat local pain, spasms and reducing inflammatory conditions. For rehabilitation techniques it is the most common form of pre-treatment to increase extensibility of collagen tissues, decrease joint stiffness, reduce pain, reduce spasms, increasing blood flow and reducing soft tissue edema. Moist heat is believed to be more effective in energy transfer than dry heat and is more comfortable for a patient to tolerate, but studies indicate that it is the heat itself that promotes vasodilation and enhanced blood flow to stimulate tissue recovery and enhance soft tissue mobility. It is typical to apply local heat superficially when penetrates up to 5cm used as pre-treatment for a therapeutic technique.

Cold therapy or Cryotherapy is the local use of cold temperatures in medical therapy. This is one of the oldest forms of treatment, dating back 300 years and is used to reduce inflammation and reduce blood flow to locally damaged tissue and additionally reduce pain and spasms which are a direct result of the injury. The goal is to cause vasoconstriction of small blood vessels to decrease cell growth and reproduction, increase cell survival, decrease inflammation, decrease pain and decrease spasms. Oxygen consumption is reduced as well as nerve conduction activity which reduces pain. Also the after effects of vasoconstriction is a reflective vasodilation and healing of injured tissues.

Cryotherapy is used to enhance thermal transfer of energy from damaged tissue to the therapeutic modality. Ice is typically applied for 15-20 minute intervals.

CHIROPRACTIC TECHNIQUES

This is the most popular form of alternative medicine which focus on mechanical disorders of the musculoskeletal system especially the spine. The general health is affected via the nervous system and centered on the spine. Although most Chiropractors focus on the neurological and musculoskeletal systems, many try to incorporate general medical and primary care conditions.

The main treatment technique is manual therapy via spinal manipulation and is focused around the theory of vertebral subluxation which is not only alters spinal mechanics and causes pain, but involved in general health. The field was founded in the 1890's and has been promoted widely. Studies suggest that the most effective techniques yield the best results for lumbar spine disorders The field has always been controversial but more recent evidence based medicine has contributed to its greater acceptance in society

Most of the new age practitioners use a combination of "low velocity" adjustments with therapeutic techniques that Physical Therapy practices with the use of modalities. The more traditional techniques involve more "high velocity" adjustment techniques to treat vertebral subluxations. These techniques provide more controversial results with variable medical efficacy. Chiropractors provide significant pain management as part of the rehabilitation process.

OSTEOPATHIC MANIPULATION

A Doctor of Osteopathy receives additional training on how to use the hands to manipulate the body to promote healing. This method of manipulation provides some Chiropractic principles. Osteopathic Manipulative Medicine is a hands on method to apply pressure to the muscles and joints to stretch and provide resistance. It focuses on treating the body as a whole and utilizing the spinal column as the core. Structural problems around the spinal column are the focus of "soft tissue techniques" in which pressure is applied to the muscles close to the spinal cord, or the paraspinal muscles. The "muscle energy technique" asks the patient to flex the muscles in a specific direction while providing resistance to counter the flexion. These are more gentle manipulations than typical Chiropractic mobilizations.

The technique is most useful to treat neck and back pain, but contraindicated in conditions of cancer or spinal fusion.

CORE STRENGTHENING TECHNIQUES

Yoga

Yoga has originated in India as a physical, mental and spiritual practice or discipline. It is a physical method that centers on the spine and core which had first been practiced over 1000 years ago and became popular in the Western world on since 1980. There is a Hindu and Buddhist origin which refers to higher levels of concentration to a mind over body experience with the purpose of attaining a goal for the body.

The physical postures of Modern Yoga are designed to alleviate health problems, reduce stress and make the spine supple. Yoga is designed to complete exercise programs to focus on the core in Physical Therapy programs. It is a popular technique used to promote stretching and core strengthening while promoting mental and spiritual awareness of the body.

Pilates

This is another core strengthening method which is a physical fitness system which was developed in the 20th century. It is a method of controlled movements which improves flexibility, builds strength, develop control and endurance throughout the entire body. It emphasizes alignment, breathing and development of a strong core while improving coordination and balance.

Different exercises can be modified to reflect variable levels of expertise from beginner to advanced levels.

The major principle behind Pilates is the "control" of body movements, exercise and to concentrate on all movements during the exercise and be aware of the muscles that are being isolated. The concentration about the exercise and muscle recruitment is more important than the exercise itself. The breathing technique is associated with the concentration during exercise. Pilates may also be done as part of a mat exercise or with a reformer. Typically mat exercise uses gravity as resistance to strengthen the core and the use of a reformer gives an extra level of strengthening. Pilates is typically used as an extension to Physical Therapy when a program is complete. This is a method of home exercise program.

Core Methods (Barre)

This is designed to combine principles of Pilates, Yoga and Ballet classes to provide lean muscle mass with increased tone and strength. It combines weights to isolate muscles in the extremities, floor exercises to work on the core and seated exercise to work specifically on abdominal muscles. It is usually taught in a class setting but may be one on one. It is also an extension of Physical Therapy and may be used after a program is complete as a method of home exercise. The method itself not only works on tone and strengthening but also has an element of cardiovascular exercise as the heart rate increases/decreases during certain activities.

REIKI METHOD

This is a Japanese technique for stress reduction and relaxation that promotes healing. The word itself can be broken down as follows "Rei" means Gods Wisdom or the Higher Power and "Ki" means life force energy. So the concept is spiritually or psychologically guided. Alterations in life force energy is directly correlated with health and with sickness.

Reiki treats the person as a whole including body, emotions, mind and spirit creating many beneficial effects that include relaxation, feelings of peace, security and well-being. It is a simple, natural and safe method of healing and self-improvement that everyone can use. The practitioner does this by "laying the hands" on specific areas of the body and creating energy flow. It is a mental technique which is useful to work alongside a physical technique to promote healing. A Reiki Master teaches a student to tap into a supply of "life force energy" and use this to promote healing.

Conscious healing is important to accept as a principle to promote continued healing. A Reiki student learns these ideas of transfer of energy and promotes healing from within. It is used to treat painful syndromes with conscious efforts to heal and promote recovery.

MENTAL IMAGERY

Mental imagery is an adjunct alternative treatment which helps transform thought into action. The practitioner uses various meditation and soft talking techniques to help the patient envision a better scenario and offset the negative thoughts associated with pain or disability to focus on more positive thoughts. This is a hands off technique with the theory of mind over matter. The use of mental imagery is a description of the body undergoing a specific movement that it would normally be unable to do. The body must imagine the movement or activity. It is theorized that the brains centers responsible for the movement undergo a physiological phenomenon during the imagination of the movement. With repeated sessions the imagination sense is strong to overcome the inability, to become a real ability.

Overall, Mental imagery is a cognitive task in which a function, a behavior or a performance is rehearsed mentally, as if a person is actually performing it.

ALEXANDER TECHNIQUE

This is a technique which is frequently used after a therapeutic technique is completed and pain is under control which was first developed in the 1890's. It is not an alternative type of treatment for acute pain. However it is a method of education which is helpful to prevent recurrence of behaviors which are negative for posture and muscle re-education. It is a type of maintenance education which focuses on body posture and functional movements for everyday activity.

The techniques first goal is to "unlearn" poor posture and movement habits. It is based on the understanding that the balance of tension between the head, neck and back profoundly influences our entire body and the way we move. The application of the technique is thru body awareness and conscious thought. It is used to relearn the "correct way" with the best posture and body movements to do everyday activities, i.e. getting out of bed, getting up from a chair without arms, and getting into/out of a car.

The Alexander technique overall is a skill to learn to relieve pain, reduce stress and enhance health and well-being. It teaches movement and posture in the most natural and optimal way for the body, maintaining good posture, and balanced muscle tone and easy breathing. The goal of teaching is to remove harmful body habits from excess tension and strain to manage and reduce stress and strain.

Anyone with poor posture or excess stress or strain in the muscles can benefit from learning the Alexander Technique.

ROLFING

This is another alternative form of treatment which utilizes a holistic approach of soft tissue manipulation and movement education which organizes the whole body in gravity. The technique is a type of structural integration utilizing techniques of Osteopathy of manual manipulation and craniosacral techniques. Rolfing was founded in the 1950's and is considered a hands on type of technique. Some massage therapists consider it a type of aggressive deep tissue massage.

The primary goal of Rolfing is to improve the alignment and movement of the body while optimizing the function of the body. The practitioner manipulates the fascia in order to maintain optimal relationship in conjunction with the muscles and other soft tissues in relation to gravity. Rolfers use a combination of passive and active soft tissue manipulation for movement retraining. The theory behind it is that fascia become "bound up" and the restrictions of this connective tissue reduces the mobility of all muscles. Many patients that experience sessions of Rolfing may complain that it is painful and there is soreness to follow, however, it is the release of the fascia which enhance movement and cause positive results. There are patients that may have light bruising after treatments. [1]

BRACING

Providing supportive bracing to the spinal column may be used to alleviate pain, provide stability and correct deformities. Bracing is done for therapeutic reasons for soft tissues when there is spasms of muscles and strains of ligaments. It limits some mobility and provides relative "rest" to the core tissues used to support the upper body. Long term use of soft or flexible braces can eventually become detrimental as it may weaken the core. Braces are doing some of the work of the "core muscles" which support the mid-section of the body, which after prolonged time cause core weakness and reliance on the braces for support.

Hard Braces or Lumbar-Sacral Orthoses are used for periods of several weeks to reduce range of motion to promote healing of fractures or any areas of instability. These period are very well defined and based on healing. The use of hard or plastic braces are somewhat uncomfortable for patients to wear for extending periods of time. The rigid support provides significant limitation of range of motion compared to soft braces or binders.

Bracing for spinal deformities also utilizes hard or rigid bracing techniques, however braces typically extend higher or lower than the site of the lesion in order to counter-act forces or apply opposite forces to the area of deformity to perform corrective action. Bracing for deformities typically requires bracing for 23 hours per day for a period of several months.

TRACTION-DECOMPRESSION

Skeletal traction and Spinal Decompression are techniques for relieving pressure on the long bones or spinal column using external forces. The purpose of traction is to regain length or alignment of bones or vertebrae, lessen or eliminate muscle spasms, relieve pressure on spinal nerves and prevent deformities or muscle contractures. Chiropractors use a computerized spinal decompression machine designed to custom fit a patient's spine in series for multiple weeks to relieve pressure from a herniated disc and impingement of a nerve. Physical Therapists use a traditional traction machine in which they can specifically adjust the forces by changing the weight or angle/alignment of the force applied. Cervical and Lumbar traction is typically done as part of a Physical Therapy treated for any patient with disc displacement. It is considered to help over time alleviate the pressure on the nerve root. The negative pressure in the disc space promotes reduction of edema and theorized to help draw the disc from impinging the nerve root. Clinical studies suggest no medical efficacy in long term studies, however various case reports demonstrate significant improvement. Traction is contraindicated in cases with acute injury, fracture and spinal instability.

KINESIOTAPING

Kinesiotape was developed over 25 years ago in Japan by Dr. Kenzo Kase. The objective is to create a therapeutic tape and taping technique to support joints and muscles without restricting range of motion. It is unlike traditional and standard taping techniques such as athletic taping and strapping, which reduce range of motion, do not support fascia and may actually inhibit the actual healing process of traumatized tissue. Kinesiotape is identical to human skin in both thickness and elasticity, which allows kinesiotape to be worn without binding, constricting or restriction of movement. Kinesiotape is a non-restrictive latex free taping applied over muscles to reduce pain and inflammation, relax overused tired muscles and support muscles in movement. It is water proof and may be worn 24 hours/day for several days straight, as a patient may shower with it. Kinesiotape facilitates lymphatic drainage by microscopically lifting the skin. The lifting effect causes convolutions in the skin which increase the interstitial space and facilitate reduction of inflammation. Kinesiotaping facilitates the body's natural healing process while providing support and stability to muscles and joints as well as providing extended soft tissue manipulation to prolong the benefits of manual therapy. Kinesiotaping successfully treats a variety of musculoskeletal, neuromuscular and neurological medical conditions.

MEDICAL MASSAGE

Medical Massage is one of the oldest forms of treatment that was first documented more than 5000 years ago by the Chinese. It is done through a thorough evaluation and assessment and apply manual forces with the hands to a specific location of the body. Medical massage is used most often to reduce spasms and improve mobility to soft tissues areas; including, tendons, ligaments, fascia, skin, scar tissue and of course skeletal muscle. There is no specific massage style or method which is accepted as Medical Massage, but rather may be any type of massage that the practitioner chooses to use.

The results of Medical Massage are based on outcomes. The patient typically has improved mobility, range of motion and function. Massage may be used for many type of medical conditions, as the manual technique is also known to improve blood flow to the targeted tissue. A Licensed Massage Therapist (LMT) is certified to perform all types of massages on patients. Physical Therapists typically do some manual therapy or medical massage on patients in need. Some of the more known types of massage are Swedish, Shiatsu, Thai and Deep Tissue. Patients generally tolerate all types of massage with the most common adverse event being muscle soreness which feels like strain from overstretch or exercise.

BIOFEEDBACK

Overall, Biofeedback is a popular method to gain control over normally involuntary bodily functions such as heart rate and blood pressure. The involuntary responses that are sought to be controlled by Biofeedback are all nervous system responses. Biofeedback is commonly used to prevent or treat conditions of chronic pain, Migraine headaches, incontinence and high blood pressure.

The exact mechanism of action of Biofeedback is widely unknown but the idea of using the mind to improve awareness of what is going on inside the body is a method to improve overall health. A hypothesis is that Biofeedback promotes relaxation which may relieved a number of conditions related to stress. When the body is under stress the heart rate increases, blood pressure rises, muscles increase tension or spasms, respiration increase and perspiration occurs.

During a Biofeedback session sensors or electrodes are attached to the skin or the fingers. The sensors then send a signal to a monitor which in turn displays a sound, light or image which is representative of the involuntary bodily response which occur involving the heart and blood pressure, skin temperature, sweating or muscle activity. Other more advanced monitoring systems may include EMG and EEG.

Based on these immediate feedback reactions, responses are altered to eliminate the unwanted negative responses. The mind becomes more aware of the involuntary responses and through the use of sensory feedback on the monitor, the conditions are treated. Traditional Biofeedback sessions are done in a Therapist office but there are computer programs that can hook up sensors and monitors to keep track of longer term control, from outside in the community.

A biofeedback therapist focuses on relaxation techniques for fine tuning bodily functions. There are several types of relaxation techniques that are employed; deep breathing; alternating muscle relaxation and tightening; guided imagery (focus on a specific image to enhance relaxation) and Mindfulness Meditation (focused thoughts to reduce negative emotions). Outcomes are measured when a patient can reduce stress without the use of monitors.

REFLEXOLOGY

This is an alternative form of medicine involving application of pressure to the feet and hands with specific thumb, finger and hand techniques without the use of any lubricants, including oils or lotions. It is based on a system of zones or reflex areas which supposedly reflect different parts of the body via images on the hands or feet with the idea that manipulation or pressure on the area will have an effect of that part of the body and reflected by physical change.

According to all the latest medical evidence and research there is no convincing medical evidence to support that Reflexology has any statistical improvement in outcomes for any condition. The belief that Reflexologists have is that by manipulating one of the zones on the hand or foot, the bodily response may be influenced thru the Qi. The Qi is the bodily energy or life force that can have an influence on a health condition. They believe that blockage of the energy field can prevent healing and that manipulation can help the flow of energy and influence healing by relieving stress. According to the theory, the body is divided into ten equal vertical zones, five on the left and five on the right and there are reflected thru areas on the foot or hand. Another theory is that pressure on the feet send signals to "balance" the nervous system and release the endogenous endorphins that promote healing and relieve stress. It is important to note that since there are no clinical studies that demonstrate clinical efficacy with treatment, a practitioner must not delay diagnostic testing when a patient is getting Reflexology, as there are no proven benefit.

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CHAPTER 6.
STEM CELLS

Isaac J. Kreizman MD, Richard A. Gasalberti MD, Aziz Abdurakhimov MD.

Stem cells are undifferentiated cells that can divide thought mitosis and provide specific progenitor cells. The following three criteria commonly used to describe stem cells: (1) Self renewal, (2) differentiation into specific progeny and (3) in vivo reconstruction of damaged organ. There three types of stem cells can be considered to regenerate damaged tissue in practice (see Figure 1).

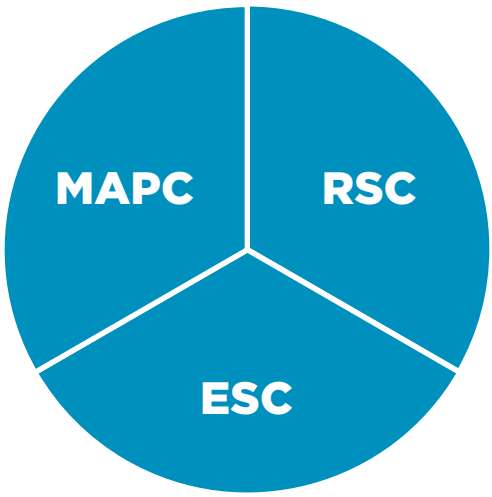

Figure 1. MAPC-multipotent adult progenitor cells (they have high plasticity, an excellent option for transplantation); RSC-resident stem cells (they are located within related tissue); ESC-embryonic stem cells (they are pluripotent, however, immunogenic and may produce tumors).

EMBRYONIC STEM CELLS

ESCs are pluripotent stem cells, i.e., cells that can give rise to any fetal or adult cell type. They derived from the inner cell mass of a blastocyst, an early-stage preimplantation embryo. Embryonic stem cells can be found in a number of tissues, including umbilical cord blood. ESCs restricted in use for human trials due to immunogenicity and carcinogenicity.

ADULT STEM CELLS

Adult stem cell undergoes symmetrical division to form two identical daughter cells. Newly formed daughter cells can remain on their initial state or differentiate to progenitor cell. Adult stem cells are found throughout the body in many tissues. They have high self-renewal capacity to maintain stem cell pool and undergo differentiation into progenitor cell to generate the entire cell types of the organ from which originate. The surrounding stem cell microenvironment called the stem cell niche provides intrinsic factors and extrinsic cues to regulate the cell quantity, division, self-renewal and differentiation.

Adult stem cells are multipotent, i.e., differentiate into multiple cell types with restriction to a given tissue. Wnt, Notch, Sonic Hedgehog are the main regulatory signaling pathways of ASC differentiation. The primary role of stem cells is to maintain and repair the tissue in which they are located. Many studies indicating high differentiation potential of adult stem cells. Regenerative medicine uses adult stem cells for therapeutic purposes of genetic and degenerative disorders. Genes encoding for “stem-cell-ness” of embryonic stem cells introduced in vitro into a differentiated somatic cells, which leads to reprogramming of the cell nucleus, giving rise to cells called induced pluripotent stem cells. [1]

Hematopoietic stem cells

Hematopoietic stem cells (HSCs) during ontogeny, arise within embryonic yolk sac and aorta-gonad-mesonephros, then expended in the fetal liver and spleen prior to migration to the bone marrow before birth2. Within the bone HCSs migrate from inner surface toward the center during differentiation and give rise to divers lineages of blood cells (see Figure 2).

ISOLATION. Most of HSCs found under normal steady-state conditions in bone marrow however some are able to migrate from bone marrow into the circulation and home to hematopoietic organs in order to drive the process of hematopoiesis. Some of them may migrate to thymus and develop into T-cells in infants. The combinations of SCF, GM-CSF & G-CSF therapy are showed to be most effective for stem cell mobilization. In response to mobilizing agents the number of circulating stem cells can be increased. Hematopoietic stem cells can be harvested from bone marrow and peripheral blood. Monoclonal antibodies against stem cell surface antigens are extensively used for isolation from hemopoietic tissues. In vitro and in vivo assay systems such as LTBM culture, the pre-CFU assay and CFU blast assay used for testing candidate cells. Isolated HSCs and progenitor stem cells can be used for transplantation and gene therapy.

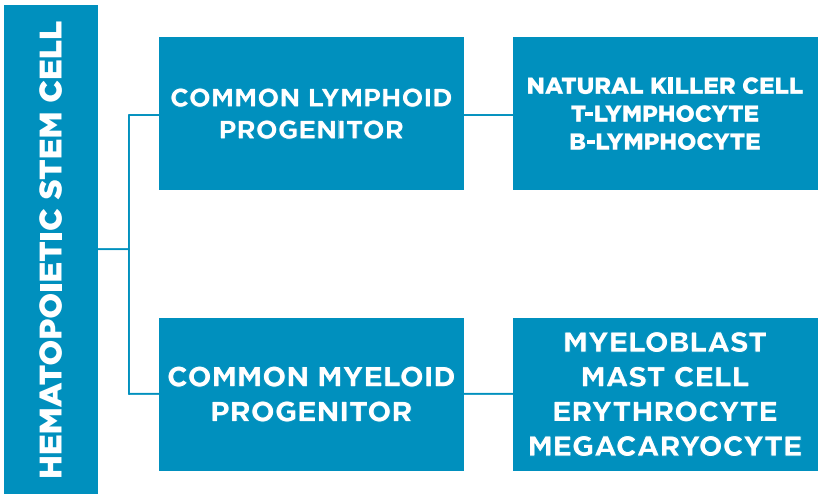

Figure 2. Hematopoietic stem cell differentiation.

Mesenchymal stem cells

Multipotent stem cells are located on the tissue side of every blood vessel known as pericytes. They commonly found in adipose, bone marrow, circulating blood (few) and joints. MCSs contribute to mature tissues by entering specific linage pathways (see Figure 3).

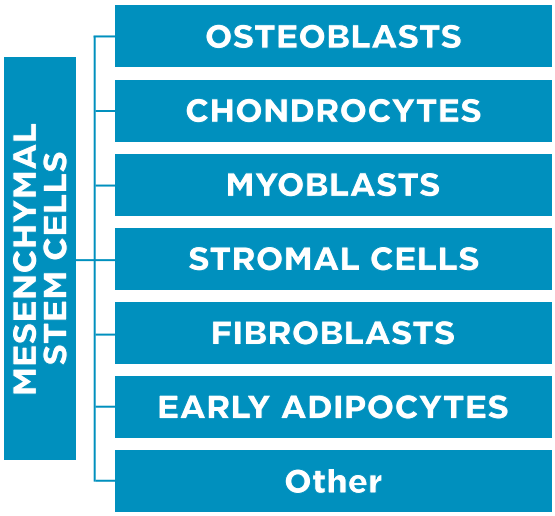

Figure 3. The mesenchymal stem cell differentiation.

Due to injury activated MSCs secrete an array of cytokines and chemokines involved with anti-inflammation, immunomodulation, anti-apoptosis, proangiogenesis, proliferation and chemoattraction. The key immunomodulatory cytokines include PG2, TGF-β1, HGF, SDF-1, IL-4, IL-6, IL-10. MSCs orchestrate the process of differentiation with differentiated and undifferentiated cells. No risk of genetic disease transmission or rejection.

MSCs are easily can be isolated from a bone marrow aspirates or adipose tissue. Some isolated monoclonal antibodies (SH2, SH3 and SH4) preferentially bind to cell surface antigens on marrow derived mesenchymal cells, used for MSC isolation [3]. Isolated cells can be used for bone repair, cartilage repair, marrow regeneration, plastic surgeries, tendon repair and gene therapy. Several components can affect proliferation of MSCs, such as platelet rich plasma (PRP), hyaluronic acid and protein scaffolds.

Bone marrow derived stem cells

Bone marrow derived multipotent stem cells (BM-MSCs) differentiate to chondrogenic phenotype when induced in vitro that can be used as optimal seed cells for cartilage tissue engineering. Cartilage tissue damage in adults incapable for regeneration.

Bone marrow aspirate harvested by bone marrow aspiration from the anterior or posterior iliac crest (approximately 10 ccs aspirated at different sites) and population of cells placed in different media components that include FBS for growth. Aspirated bone marrow concentrate contains MSCs, HSCs and platelets. Under fluoroscopic/ultrasound guidance BM-MSCs combined with growth factors (platelet lysate) can be injected into affected tissue.

Adipose derived stem cells

Adipose tissue contains a subset of progenitor cells exhibiting multipotent plasticity with osteogenic, chondrogenic, adipogenic and myogenic differentiation potential. Adipose tissue is an excellent source of autologous stem cells [4]. High amount of multipotent cells have been found within the stromal vascular fraction (SVF) of adipose tissue. Adipose tissue composed of adipocytes, erythrocytes, leukocytes, fibroblast and multipotent adipose derived stem cells (ADSCs).

Adipose tissue removed by direct lipectomy or routine liposuction techniques (closed syringe system harvest is used). Acquired SVF grafts can be prepared for injection by gravity separation, by density gradient centrifugation (3-4 min, 1000 gr force) and by commercially available filtration (Figure 4). Combination of AD-SVF and PRP or BMAC improves healing of arthritic joints, degenerated cartilaginous structures, muscle tears, tendinosis and tendon tears that have failed conservative treatment and radiation necrosis.

In patients with degenerative and musculoskeletal defects AD-SVF combined with 5 ml of PRP (AFG:PRP ratio 50%) and injected into the affected areas. Adult stem cell injections are always followed by 2-3 monthly PRP injections, that contains a variety of growth factors and secretory proteins that enhance the healing process and recruitment.

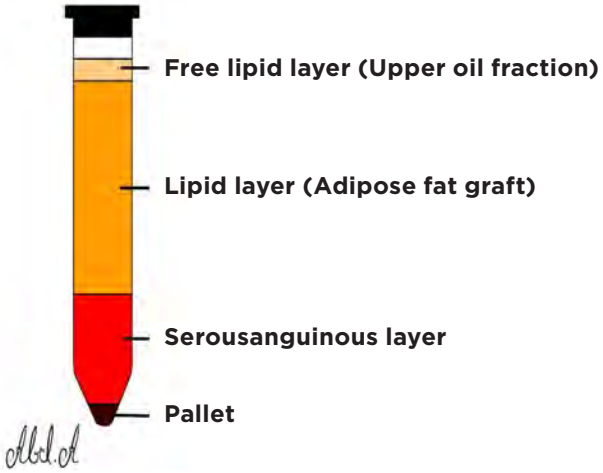

Figure 4. Shows centrifuged lipoaspirate tube with layers of cells. Pallet layer contains high concentration of endothelial and mesenchymal cells. (by Aziz Abdurakhimov MD.)

JOINT INJECTIONS

Joint pain caused by osteoarthritis, osteonecrosis and cartilage injuries is treated by injecting a stem cells into the affected tissue, which provides pain relief and regeneration of lesions [5].

Knee osteoarthritis.
Intra-articular knee joint injection by AD-MSCs or infrapatellar fat pad-derived MSCs combined with 3 cc of PRP, reduces pain and decreases articular cartilage defect. Injections are guided under ultrasound control (see Figure 5).

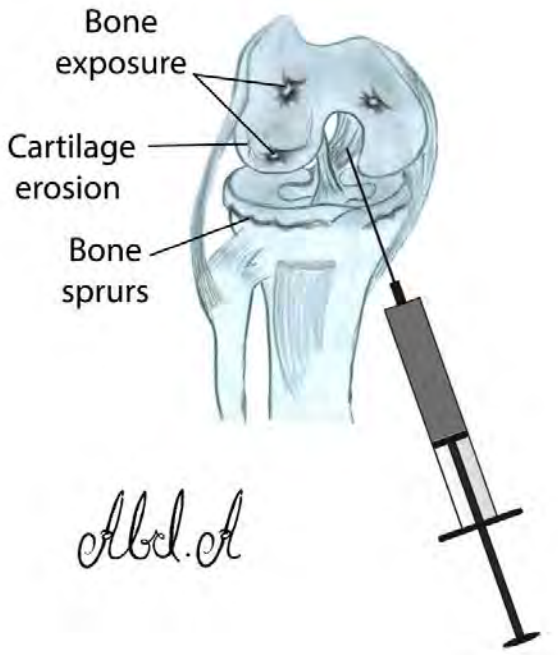

Figure 5. Anterior aspect of the right arthritic knee joint showing percutaneous intra-articular injection. (by Aziz Abdurakhimov MD.)

Meniscal lesions.
Percutaneous injections of PRP into and around the meniscus under ultrasound guidance are performed for treatment of meniscal lesions. Large meniscal lesions can be injected with combination of PRP and ASCs. 0.5-1 cc of PRP is injected three time times with seven-day interval (see Figure 6).

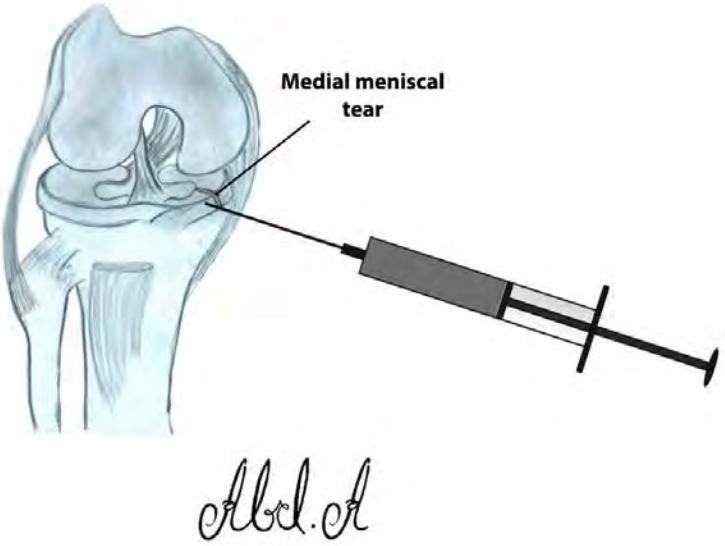

Figure 6. Anterior aspect of the right knee joint with medial meniscal tear showing percutaneous injection of medial meniscus. (by Aziz Abdurakhimov MD.)

Avascular necrosis of the femoral head.
Intra-articular core decompensation under fluoroscopic guidance followed by PRP saturation are used in patients with osteonecrosis grade I or IIA. 10 cc of PRP are delivered into the necrotic area though a previously inserted trocar (see Figure 7).

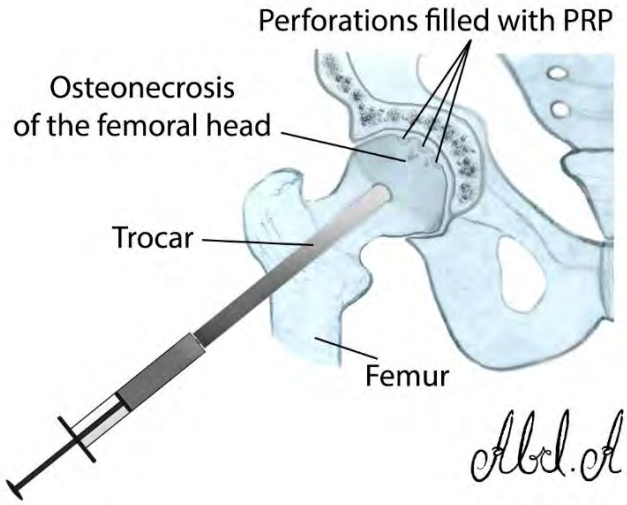

Figure 7. Anterior aspect of the hip joint showing perforations filled with PRP via previously inserted trocar. (by Aziz Abdurakhimov MD.)

INTERVERTEBRAL DISC INJECTIONS

Chronic back pain caused by degenerative intervertebral disc disease can be effectively treated by injecting stem cells into the nucleus pulposus. Transplanted cells promote intervertebral disc repair (see Figure 8).

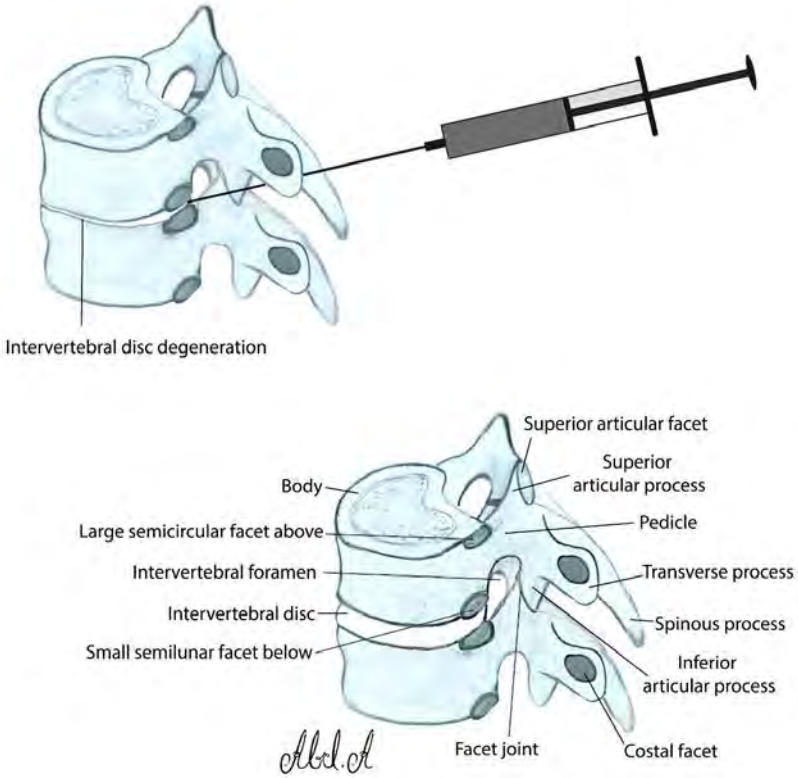

Figure 8. Shows antero-lateral aspect of the eighth and ninth thoracic vertebrae with degenerative intervertebral disc injection (at the top). Normal intervertebral disc after stem cells transplantation (at the bottom). (by Aziz Abdurakhimov MD.)

TENDON INJECTIONS

Tendon injuries are a common clinical problem that can progress leading to patient disability. Chronic tendinopathies such as Achilles tendinitis, patellar tendinitis, iliotibial band syndrome, supraspinatus tendonitis and lateral or medial epicondylitis are successfully treated by injections of PRP into the injured tissue. 5 cc PRP is generated from 50 cc of centrifuged blood drawn from patient, and injected into the affected tissue under ultrasound or fluoroscopic guidance for accurate placement (see Figure 9).

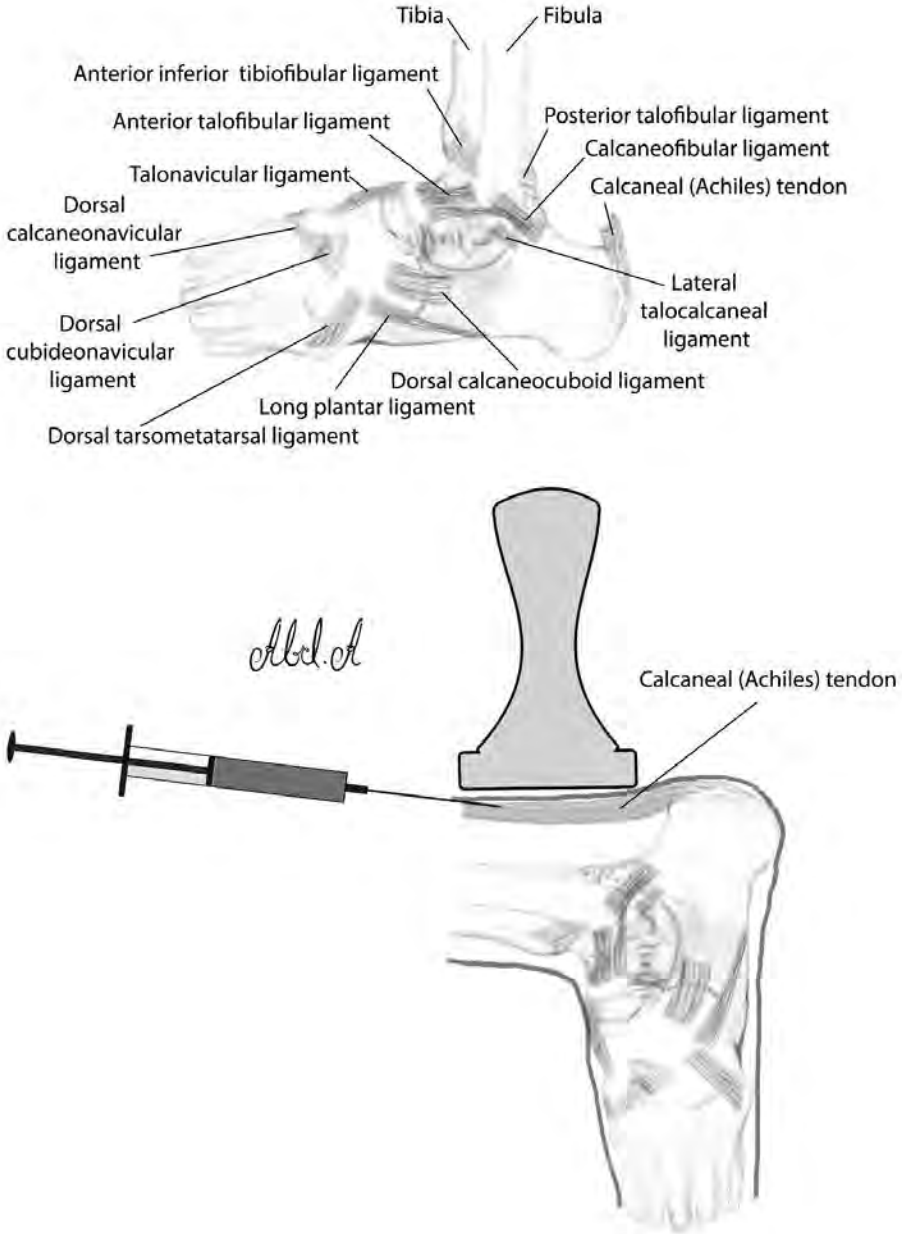

Figure 9. Shows the lateral aspect of the left ankle with ligaments (at the top) and the injection into the Achilles tendon under ultrasound guidance (at the bottom). Patient position prone with foot hanging over the table. (by Aziz Abdurakhimov MD.)

In biocellular regenerative medicine combination of ADSCs with PRP or bone marrow aspirate concentrate (BMAC) seems more effective for musculoskeletal applications. Target location and paracrine signals regulates direction and outcome of cellular proliferation and differentiation. For example, implanted extensive bioactive extracellular matrix (ECM) scaffold into patients with damaged muscle group, started weight bearing physical therapy postoperatively to cause recruited stem cells receive signals to differentiate into muscle tissue. After 6 weeks biopsy showed mononuclear infiltrate, after 6 months skeletal myocytes [6].

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CHAPTER 7.
COMPLEMENTARY AND ALTERNATIVE MEDICINE

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Isaac J. Kreizman MD, Frank Schirripa DO.

Complementary and alternative medicine (CAM) is defined as medical products, practices, and approaches outside of mainstream, or conventional medicine.

The two terms complementary and alternative refer to different concepts. Complementary refers to the use of a non mainstream approach along with conventional medicine. Meanwhile alternative medicine refers to the use of a non mainstream approach only, without conventional medicine method. [1]

Musculoskeletal pain is the most common reason for complementary and alternative medicine (CAM) use, with degenerative arthritis, rheumatoid arthritis, osteoarthritis, myofascial pain, chronic headache, low back pain, and bone pain being the most common forms of musculoskeletal disorders.

Although the relationship between conventional treatment and the CAM remains equivocal, the scientific evidence suggest that particular CAM health approaches may help manage chronic painful musculoskeletal conditions when conventional therapy has not yielded satisfactory results. [2]

ACUPUNCTURE

Analgesic effects of acupuncture are explained by release of endogenous opioids, serotonin and noradrenalin. Acupuncture can cause multiple biological responses that can occur locally, i.e. at or close to the site of application, or at a distance. These responses are mainly mediated by sensory neurons that release peptides including neurotransmitters and endogenous opioids in the central nervous system and the periphery causing changes in neuroendocrine function. This can lead to activation of pathways affecting various physiological systems in the brain as well as in the periphery.

Acupuncture may have a role in constricting or dilating blood vessels due to release of vasodilators such as histamine, as well as controlling pain by closing the gates of nerve fibers that results in pain perception.

Acupuncture is used to treat low back pain (see Figure 1), neck pain, labor pain, headaches, menstrual pain, and pain associated with fibromyalgia and osteoarthritis. [3]

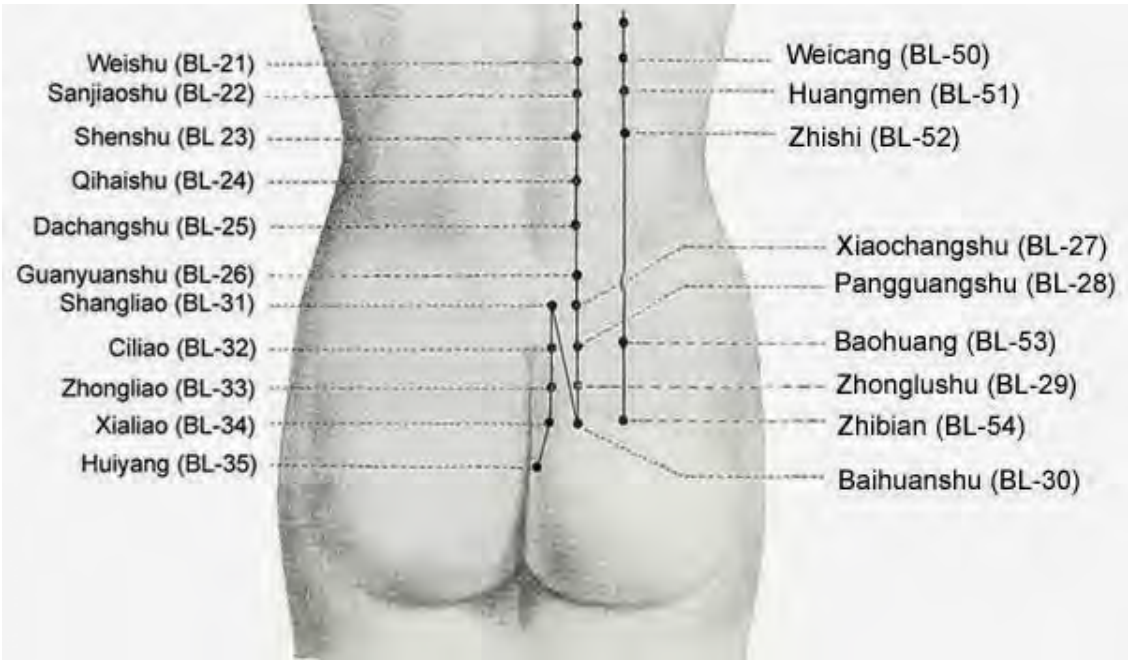

Figure 1. Acupuncture points for lower back pain.

TAI CHI

Tai Chi, being a mind-body exercise therapy, involves integrated dynamic musculoskeletal breathing and meditation training along with slow motion and weight shifting.

Tai chi has three major components:

1. Movement. All of the major muscle groups and joints are needed for the slow, gentle movements in tai chi. Tai chi improves balance, agility, strength, flexibility, stamina, muscle tone, and coordination.
2. Meditation. Research shows that meditation soothes the mind, enhances concentration, reduces anxiety, and lowers blood pressure and heart rate.
3. Deep breathing.

It is typically used to manage chronic back and neck pain and pain associated with arthritis especially among the elderly because of the gentle nature of the exercise and safety. [4][5]

HERBAL PREPARATIONS

Herbal medicines are among the most popular forms of complementary treatments. A large proportion of these herbal remedies is used for musculoskeletal pain relief. Most of the herbal medicines have an effect on the eicosanoid metabolism, inhibiting one or both of the cyclooxygenase and lipoxygenase pathways. The ingredients of phytomedicines may be synergistic or antagonistic.

The most popular herbal analgesics are:

- **Cayenne** (Capsicum frutescens). Patients with fibromyalgia experience less tenderness and significant increase in grip strength. [6]
- **Devil's claw** (Harpagophytum procumbens) preparation produces reduction in pain and increase in mobility in patients with osteoarthritis. [7]
- **Phytodolor** (a proprietary preparation that contains Populus tremula, Fraxinus excelsior, and Solidago virgaurea [goldenrod]) has demonstrated efficacy for painful arthritic conditions in a number of studies. [8]
- **Gamma-linolenic acid** (GLA)-containing herbs. Blackcurrant (Ribes nigrum) seeds, borage (Boragio officinalis), evening primrose (Oenothera biennis) oil contain high amounts of GLA, an essential fatty acid that exerts anti-inflammatory activity by interfering with prostaglandin metabolism. These herbs showed objective signs of reduced disease activity and pain relief in paints with osteoarthritis, active synovitis and rheumatoid arthritis. [9]

NUTRITIONAL SUPPLEMENTS

Avocado-soybean unsaponifiables (ASU), glucosamine and chondroitin may be effective in treatment of osteoarthritic pain. Fish oil and docosahexaenoic acid both have anti-inflammatory activity through their effects on prostaglandin metabolism and have clinical effect in rheumatoid arthritis [10][11].

- **Univestin** derived from standardized extracts from the roots of Scutellaria baicalensis and the heartwood of Acacia catechu combined with ginger, rutin (a flavonoid), and bromelain and papain (plant enzymes) combats pain in osteoarthritis. [21]
- **Fish oil** fatty acids reduce pain and swelling. Fish that are especially rich in the beneficial oils known as omega-3 fatty acids include mackerel, herring, tuna, salmon, cod liver, whale blubber, and seal blubber. Two of the most important omega-3 fatty acids contained in fish oil are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) [22]
- **Glucosamine and Chondroitin Sulfate.** This combination may provide additional pain relief for some people with knee and hand osteoarthritis. The benefit is usually modest (about 8 to 10 percent improvement) and it works slowly (up to 3 months). [23]
- **DMSO & MSM** (dimethyl sulfoxide and methylsulfonylmethane). These two sulfur com pounds share similar properties. Their potent anti-inflammatory actions block the pain response in

nerve fibers. Remarkable feature of these substances is that they can be used orally, intrave nously, or topically. Most patients with arthritis find topical application the most convenient. [24]

- **Capsaicin.** Capsicum frutescens. Capsaicin works by depleting substance P, a neuropeptide produced by the nerves that carry pain sensation. Skin ointments containing capsaicin have been shown to significantly relieve arthritis pain. The first application often causes a burning sensation; however, as substance-P is depleted, this discomfort goes away. [25]

MASSAGE

Massage is one of the most popular CAM methods for neck and back pain [12]. Massage can reduce pain in patients with metastatic bone pain on an immediate, intermediate and long term time frame. It may also relieve pain of wide variety of etiologies: headache pain, postoperative pain, back and leg pain in pregnant women, chronic pain, myalgia, carpal tunnel syndrome, pain from distal radial trauma [13][14]. Massage promotes pain relief through the use of mechanical manipulation of body tissues with rhythmic pressure and stroking [15], this in turn increases blood circulation, reduce inflammation, promote mitochondrial biogenesis in the skeletal muscle, increase vagal activity and decrease cortisol levels [16]. Altogether these factors contribute to reduction of painful sensations.

The most common type and the most widely recognized category of massage is the Swedish massage. The Swedish massage techniques vary from light to vigorous. It involves five styles of strokes: effleurage (sliding or gliding), petrissage (kneading), tapotement (rhythmic tapping), friction (cross fiber or with the fibers) and vibration/shaking. By relieving muscle tension Swedish massage has shown significant results in reducing joint stiffness, improving function in patients with osteoarthritis of the knee and significantly reducing back pain. The effectiveness is shown to last for as long as 15 weeks. [26][27]

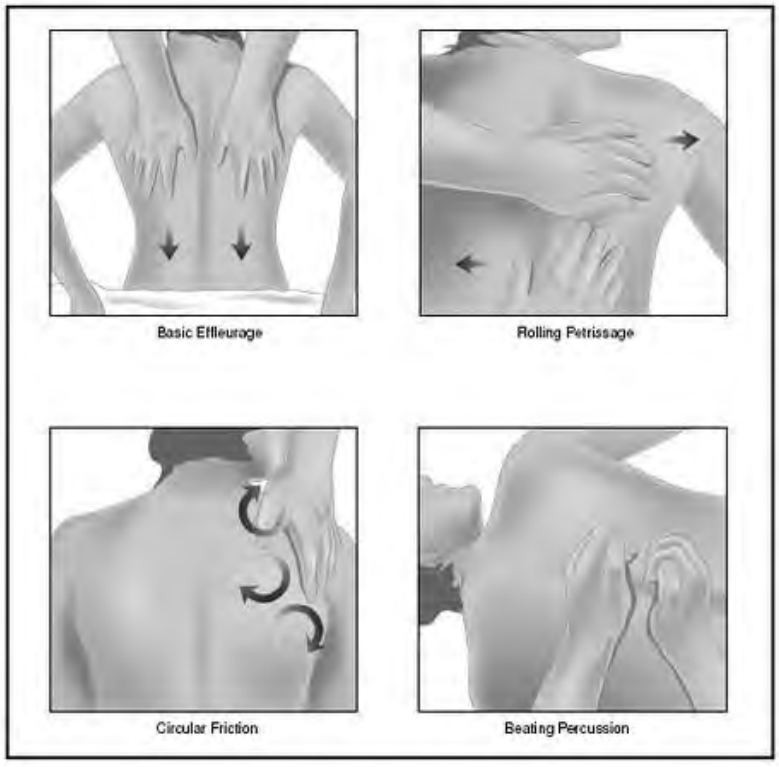

Figure 2. Massage techniques.

- **Effleurage:** a smooth, gliding stroke used to relax soft tissue. (see Figure 2.)
- **Petrissage:** the squeezing, rolling, or kneading that follows effleurage. (see Figure 2.)
- **Friction:** deep, circular movements that cause layers of tissue to rub against each other, helping to increase blood flow and break down scar tissue. (see Figure 2.)
- **Tapotement:** a short, alternating tap done with cupped hands, fingers, or the edge of the hand [28]

YOGA

Yoga is a mind-body and exercise practice that combines breath control, meditation, specific stretches and body positions to strengthen muscles and obtaining tranquility.

Yoga is thought to relief pain by promoting the pain center in brain to regulate the gate-controlling mechanism located in the spinal cord. It also stimulates secretion of natural painkillers (endorphines) in the body. Breathing exercises used in yoga can also contribute to pain reduction. Because muscles tend to relax during exhalation, lengthening the time of exhalation can help produce relaxation and reduce tension and pain. Trials have found that yoga is most effective in improvement symptoms and function for patients with chronic low back pain. [17]

SPINAL MANIPULATION

Spinal manipulation is localized force directed at specific spinal segments. It is performed by using the hands or a device to apply a controlled force to a joint of the spine and is practiced by chiropractors, osteopathic physicians, allopathic physicians, physiotherapists, and other healthcare professionals to treat a range of primarily musculoskeletal problems [18].

The American Chiropractic Association defines spinal manipulation as a passive manual maneuver during which the three joint complex may be carried beyond the normal voluntary physiological range of movement into the para-physiologic space without exceeding the boundaries of anatomic integrity [19].

The essential characteristic is a low- or high-velocity low-amplitude thrust administered briefly, suddenly, and carefully and directed at the thoracolumbar and lumbosacral junctions at the end of the normal passive range of movement. It is done to increase the joint's range of movement. This method is mainly used for lower back pain management [20].

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CHAPTER 8.
EMERGING AND NOVEL THERAPIES

Robert Duarte MD, Todd Schlifstein DO.

Over the past decade there has been a tremendous interest over new and innovative medical therapies created to manage musculoskeletal pain. These new therapeutic modalities, with a focus on regenerative medicine, include but not limited to the prolotherapy, human stem cells, platelet rich plasma therapy, and use of hormones such as the growth hormone oxytocin.

Regenerative medicine in pain management, where the body regenerates or rebuilds itself, is relatively new and rapidly evolving area.

Prolotherapy also known as proliferation therapy is a treatment that employs an injection of an irritant solution, most commonly hyperosmolar dextrose, into a joint space, ligament or tendon insertion in an effort to relieve pain [2]. More recently, Platelet Rich Plasma (PRP) and autologous adult stem cells have been used. These products will be discussed later. The term, prolotherapy, originally described by Dr. George S. Hackett, from the word "proli" meaning offspring and proliferate - to produce new cells in rapid succession. The mechanism of prolotherapy is still under investigation and remains unclear.

However, it is thought to work by stimulating the body's natural healing mechanisms to lay down new tissue in the weakened area. In 2007 Cochrane review found, when used alone, prolotherapy ineffective in treating chronic low back pain. When used in conjunction with manipulation, exercise and other interventions, prolotherapy showed it may improve chronic low back pain and disability. In 2016, a systematic review of dextrose prolotherapy for chronic musculoskeletal pain supported the use of dextrose prolotherapy for the treatment of tendinopathies, knee and finger joint OA and spinal / pelvic pain due to ligament dysfunction. Efficacy in acute pain as first line therapy, and in myofascial pain could not be determined from the literature. Despite some anecdotal evidence and limited well designed research, prolotherapy remains an alternative treatment and, therefore, not accepted by most insurance companies including medicare. [5]

Patients with chronic low back pain, tendonitis, osteoarthritis, and sports related injuries can be considered for prolotherapy [2]. Generally, patients receive prolotherapy treatment every two to 6 weeks for up to 6 months. The patient should be made aware that the injection may result in a temporary increase in pain with mild stiffness and pain. Stem cells have attracted much of the attention in the field of regenerative medicine.

Autologous and recombinant products and technology are at the center of emerging and novel therapies. There is ongoing research into bone, ligament, cartilage, and tendon healing. This research has generated the development of products that stimulate growth factors and secretory proteins. These growth factors and proteins help to maximize the healing of tissues and to expedite the healing process. Unfortunately, many of these new technologies and techniques are not well studied.

Currently, there are several technologies being used today in Pain Medicine. Some of these products presently used include the following. Platelet-Rich Plasma (PRP) is one of the most commonly used products. It has been widely used for many different problems and there are many different ways of producing the PRP. The use of Stem cells has been growing rapidly and its potential role in so many different physical conditions.

There are different types of stem cells. Mesenchymal Stem Cells (MSCs), Bone Marrow Derived MSCs (BMSCSs), and Adipose-Dervied MSCs (AMSCs) Regonkine is a tradename of a autologous product used to help reduce inflammation by Interlukin Factors.

Platelet Rich plasma is an Autologous product first used back in the 1970s to help general surgery and dental procedures help the healing process. PRP assists the healing process by increasing the concentrations of autologous growth factors and secretory proteins factors. It has been well studied well in maxillofacial surgery and general surgery. More recently, orthopedic use has increased tremendously as well as research into orthopedic uses of PRP. The belief is that the PRP enhances healing process , bringing healing and growth factors to an area of need and to an area that may not have blood supply. PRP has been used in orthopedic surgery, sports medicine, wound care, and pain management since

the 1990's. The science behind PRP explains its role in the healing process of ligaments, and tendons. Platelets contain numerous proteins, cytokines, and other bioactive factors that initiate and regulate wound healing. Normal Platelet counts in blood 150 to 350,000/L . Plasma is the fluid portion of blood. PRP concentrate is made from the patient's own blood. After the blood is centrifuged, it separates into serum (top coat), the platelets and white blood cells ("buffy coat"), and the red blood cells (bottom layer). PRP has platelet concentrations 1,000,000/L in 5 mL of plasma is associated with enhanced wound healing. Most PRP preparations have between 3 to 5 times the normal growth factor concentrations. Platelets synthesize and release more than 1,100 biologically active proteins. There are many bioactive factors in PRP. Cytokines in PRP include Transforming growth factor (TGF), Platelet derived growth factor (PDGF), Insulin like growth factor (IGF-I,IGF-II), Fibroblast growth factor (FGF), Vascular endothelial growth factor (VEGF). Wound healing is a complex process. Exogenous delivery of a single growth factor has limited benefit. Non-growth factors contained with dense granules in platelets also play a role- serotonin, histamine, dopamine, calcium, and adenosine. There are three stages of healing inflammation, proliferation and remodeling. . The Clot formation also lays a role as forms "scaffolding" or framework for the healing process. [4][9]

Presently, orthopedic uses of PRP include chronic tendinopathies, acute ligamentous injuries, osteoarthritis, muscle injuries and intra-operative use. These indications are also the most frequently studied uses, and are areas of need in the field of orthopedic and pain medicine.

Chronic or refractory later epicondylitis is one of the most well studied etiologies. Most studies showing favorable results. Studies have focused on Refractory Cases of conservative treatment. MRI or Ultrasound to confirm Extensor Carpi radialis brevis tendinopathy. Strengthen progression post injection. Return to activities over 6 to 8 weeks. Return to Sports with FROM and no pain and no tenderness. This protocol has shown good results in several studies.

Achilles tendonitis or tendinopathy.
Tendon injuries occur from hypovascularity, microtrauma, tendon degeneration, weakness. PRP is suppose to improve vascularity and promote healing of the tendon. Tendons have no direct bloodflow, therefore directly injecting the tendon to deliver healing and growth factors seems logical. There are many smaller studies showing good efficacy. These studies had Varying pathology including tendonitis, tendonosis , fibrosis, and partial tearing. [1]

Plantar fasciitis Patients who failed conservative treatment has been studied. A common problem that is often slow to improve. Injection of PRP into the medial plantar fascia under guidance of ultrasound has been used and studied. Guidance is ned to ensure proper placement of the PRP. Pain and swelling does occur. Inflammation from the injection activates the platelets to release their healing and growth factors. Post injection, immediate weight bearing and ice for the first 48 hours to allow inflammation to activate the process. Return to activities in 6 to 8 weeks. No study looked at torn fascia on fascitis. An area that needs to be investigated.

Chronic patella tendinopathy or jumper's knee.
Current treatment is rest from activities and physical therapy. This problem is often slow to improve and returns often on return to activity. Tendon changes are found to be angiofibroblastic hyperplasia. PRP is thought to be an adjunct to accelerate healing process and to bring healing and growth factors to an area of minimal bloodflow.

Patella tendinopathy has no prospective,large randomized trials. Many studies that are retrospective, many case studies, histological animal studies also have been done. Consider in patients who have failed conservative treatment for 3 months. Clinical findings are supported by MRI and/or ultrasound findings. No NSAIDs 1 week before an injection and for 3 to 4 weeks post injection. [6]

Acute ligamentous injuries in athletes and getting them back to play quickly. Medical collateral ligament injuries are being looked at for PRP. One study looked at professional soccer players with grade II MCL injuries. One injection, within 72 hours post injury. Return to play time shortened by 27%. This significant reduction in healing time demonstrates the potential benefit in ligamentous injuries and in acute injuries. Further research needs to be done in these areas. It maybe difficult to obtain an MRI and get a PRP injection within 72 hours in the non-professional athlete population.

The Goal of PRP is to give a high concentration of platelet growth factors to enhance thehealing process. PRP may be advantageous in sports medicine. Little data aside from many case series to support its use. Widespread use in maxillofacial surgery, plastic surgery and orthopedic surgery continues.

Stem cells are characterized by their ability to renew themselves through cell division and differentiate into a diverse range of specialized cell types (also see Chapter 6). There are many sources for stem cells. Human embryos contain pluripotent stem cells. Induced pluripotent stem cells are generated by taking cells, for example the skin, and then injecting a small number of genes into the cells which converts them to stem cells. A concern with this source of stem cells is the introduction of an oncogene. Most uses today of stem cells utilize adult stem cells. [3]

Sources of adult stem cells include bone marrow, and adipose tissue. Most adult stem cells are multipotent, the cells can differentiate into some cells types but not all cell types.

Mesenchymal stem cells (MSCs) are multi-potent progenitor cells. MSC's can differentiate into osteocytes, adipocytes, and chondrocytes. Autologous stem cells are easily harvested. MSCs inhibit CD+4, CD+8, and Natural Killer Cells. They secrete cytokines including PGE-2, GM-CSF, IL-1RA, IL-7, IL-8, IL-10 and IL-11. MSCs are adult stem cells and do not have the unlimited capacity for self renewal.

The most commonly studies and used MSCs for cartilage repair is Bone Marrow MSCs (BMSCs). It is estimated that about 1000 more times MSCs can be obtained from each gram of adipose tissue when compared to bone marrow.

There have been promising results from injecting BMSCs in mild to moderate osteoarthritis. No serious adverse events have occurred. Most studies are lacking in significant numbers and long term follow up of patients . Many more promising studies have come out recently. [12]

Adipose derived MSCs often harvest the cells, they do not culture them but the cells are derived from adipose cells, then isolated by centrifuging. These cells are not confirmed stem cells. Some of the studies with AMSCs have been done with PRP. These studies have been effective in reducing pain and cartilage regeneration. These studies lack MRI follow up to determine cartilage regrowth, limited number of patients and no long term follow up. [11]

Determining the optimal dose of MSCs was looked at directly in Jo et al in 2014. Low dose 1.0 x 10^7 , medium dose, 5.0 x10^7 and high dose 1.0 x 10^8. Size of the cartilage defect decreased in size in the High dose MSCs study. It is still to be determined what is the optimal dose, for what diagnosis and size of defect.

The previously mentioned techniques have shown promising results. Better results have been shown in most studies with the high dose MSCs, but the optimal dose has yet to be determined. Single dose treatments have been effective but many studies show several treatments maybe necessary. The ultimate solution has yet to be determined.

Hormone based therapy.

Recently oxytocin has emerged as a new and innovative hormone based therapy that has been found to target specific pain receptors to induce analgesia. Historically the polypeptide hormone oxytocin has played a major role in parturition and milk let down reflex. More recently oxytocin serves in a range of psychosocial and psychophysiological phenomenon including the reward system and memory processing. Research during the 1980 and 1990's discovered the role of oxytocin in both neural and behavioral processing. At the time, clinical application was geared towards a wide array of psychiatric disease, most notably drug addiction.

Introduction of oxytocin into the body has been efficacious via intrathecal insertion. This neuropeptide hormone involves both central and peripheral physiological properties. Centrally, oxytocin serves as a neuromodulator in both social behavior and physiological stress response. Furthermore, oxytocin acts as a neurotransmitter and acts on the amygdala activating the hypothalamic-pituitary axis to decrease the stress hormone cortisol and attenuating the influence of stress and anxiety on nociceptive signaling Peripherally, oxytocin modulates the inflammatory response and can improve healing.

Recent studies released by Trigemnina found intranasal oxytocin to be efficacious in the treatment of chronic migraine. In a single dose, placebo controlled, double blind study on 40 people who suffered from chronic migraine, it was found that 42% of patients at 2 hrs and 55% at 4 hrs.hrs. had reduced pain compared to 11% and 28% for placebo.

There have been studies showing that acute and chronic low back pain in humans produced changes of oxytocin levels in the plasma and CSF fluid. In a study conducted by Yang to study the effects of oxytocin on low back was studied through intrathecal injection of oxytocin into rats. Studies concluded that oxytocin had a dose related analgesic effects at low levels.

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CHAPTER 9. TELEMEDICINE

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If a picture is worth a thousand words then the value of a live, moving image is priceless. The ability to have true meaningful exchanges with patients via telemedicine will allow for higher standards of care when coupled with laboratory data, radiologic imaging and other high-tech diagnostic techniques. Telemedicine has immediate applications across primary, specialty, and critical care sub-specialties, and should be promoted and implemented to the fullest that current available technology can allow.

Introduction: Early Adopters

Of course, one of the earliest adopters of telemedicine was radiology. These early adopters used telemedicine to transmit radiological images and their interpretations between radiologists and ordering physicians. Radiologists, who could be located on the other side of the globe, read these images in real time as our daily routines continued. In many cases, by the time we got back to work the next morning, the previous day's scans could be read by the time our morning routines begin.

For physicians in an emergency setting, this turnaround time is invaluable to crisis situations, which require reading and interpretations of imaging stat and often beyond the purview of regular business hours. It is difficult enough to provide radiological services beyond regular business hours for most imaging centers, let alone get the images, be they CT, MR, or x-ray, be read and interpreted. A patient pursuing imaging late at night in New York, would benefit from a teleradiologist operating in California, for by the time said patient's physician is ready to reassess the patient the next morning, fully interpreted scans will have been transmitted across the country, and read securely with a report generated, transcribed and returned.

However within teleradiology these services can usually be seen as being unidirectional, in that it is the sending of static images and then the transmission of either a fax or telephone communication images – sometimes utilizing a DICOM viewer. Interface between the physician and the patient is kept to a minimum and the telemed technology at play here is purely functional. Since its earliest days telemedicine has evolved to include numerous other specialties and subspecialties where diagnostic practice and meaningful patient-physician interactions can occur.

Setting the Stage

In most major American hospitals expanding access to quality medical care is seen as a top priority. Access to specialists should be highlighted for the economic benefits telemedicine can bring to achieve this goal. In the current setting, specialists shuttle from one center to another, and larger patient populations remain hard to reach. This inefficient system can be remedied through centralizing services via an integrated telemedicine platform. Through centralization, sharing specialist resources on demand becomes an efficient and increasingly viable solution. This technique has been utilized across many major North American hospital groups such as NYU, Cornell, and the Cleveland Clinic.

When looking at the general populace, special attention should be paid to beneficiaries of recent healthcare laws such as those looking to rectify low access to qualified medical care. Telemedicine can allow equal access regardless of terrain, weather conditions, climate, or even socio-economic status. This is especially important to rural areas of the United States. Rural states – both wealthy and less so – could benefit from telemed programs. Benefits can be measured in the amount of specialties available in a given rural health clinic, as well as in the quality of care.

A major medical system can establish a connected health program to ensure the same standards of care are met in surrounding areas where there are barriers to access. In New York, for example, quality of care standards from New York City-based hospitals such as Columbia-Presbyterian, NYU or Mt. Sinai can be utilized in a telemedicine program to help ailing communities in upstate New York. This scenario has been in place in a select group of nursing homes in upstate New York since 2010. We have provided the nursing homes with on-demand emergency consultations during evening hours when

on-staff physicians are not available. Since its inception, this telemedicine platform has expanded to create installations at 17 nursing homes, giving effective emergency access to patients in critical care situations 24/7. Given telemedicine's nature, we are now able to truly maximize our resources because team members, whether they are located in Tokyo or New York, can offer support 24/7.

Telemedicine services don't simply expand healthcare, they also provide a platform for innovation. With telemedicine programs, providers can provide more personalized healthcare, tailored to the individual patient's needs. We can get the services that are needed to those who need it most within a critical time period and always with a fresh team available regardless of the time of day. These consultative teams are innovative because they can be tailor-made to fit the recipient's profile. As in the nursing home example above, our telemedicine team consists of both emergency medicine and neurology specialists who can address the high number of traumatic and neurological ailments of the geriatric population.

Telemedicine platforms can also be tailored to other niches. Emergency Medical Care NYC is a 24-hour urgent care facility located in the heart of Times Square. The facility's team members are able to service many of the hotels in Midtown allowing for tourists and travelers to be seen and receive full diagnostic work-ups, including CT scans, in the event of a travel emergency. These rapid workups can be performed with patients being seen within 10 minutes of arrival. While they are waiting, patients are able to access telemedicine consultations from various specialists while their cases are reviewed.

Building on the theme of travel medicine, in our Japanese International Clinic, we cater to a niche clientele of Japanese tourists who use overseas travel insurance while visiting New York. In case of a travel emergency, physicians and staff – many of whom speak Japanese – can see patients. However, upon return to Japan, a patient follow-up may be required to assess the patient's status. Telemedicine allowed us to be able to see these patients in Japan and instruct them on follow up care. We are also able to get additional history through coordinating with their primary doctors in their home country.

Diagnostic Technique & Basic Functions

1. Consultations: Assuming the person who requested the consultation is another physician then the consult can be performed from the requesting physician's office to the consulting specialist over a distance whereby the requesting provider is able to demonstrate portions of the exam when requested by the consultant.

2. Diagnostic strategies: Additional testing and consults can be arranged remotely preventing the patient from having to make multiple trips; this also allows for multiple consultations to be performed simultaneously. This is a rare occurrence as multi-disciplinary input while the patient is present usually only takes place within the teaching program or grand rounds.

Legal Framework and Best Practices

Although initial interest was for the implementation within rural communities, where accessibility was a question, it was later understood that even urban communities could benefit from telemedicine. In an urban setting, access was not only constrained by distance but also by the sparse availability of specialists. To travel a short distance within a major American city can sometimes take a very long time – during rush hour, it is not uncommon for a 1.5-mile car trip from the United Nations to Emergency Medical Care to take as long as 45 minutes. Scheduling can also be an issue; many specialist practices are fully booked weeks in advance. After all, within urban agglomerations there is a significantly higher demand for all services. Hence in January 2016 New York became a parity state allowing for the reimbursement of telemedicine services on par with face-to-face encounters of the same E/M level.

This support at the state-level has been a boon to telemedicine providers and has started a trend towards wider acceptance of telemedicine as a valuable alternative to office encounters. Similarly, there has been broad support from the U.S. Department of Health and Human Services as well as interest from the Centers for Medicare and Medicaid for similar laws. This trend of increasing local and state government support will allow telemedicine to be utilized across multiple and diverse environments. Within the highest levels of government this support may bring about national parity and acceptance of telemedicine for American healthcare participants. Future utilization is being discussed with other groups such as the New York National Guard, who have expressed interest in our platforms, as well as

the Canadian Mounted Police and Japan Self Defense Forces. Field applications are just one of numerous applications where telemedicine is seen as beneficial at this time.

In a humanitarian context, the benefits of telemedicine to bring healthcare to rural and locations in need are innumerable. As we have seen before, traditional barriers to healthcare access, such as climate or topography, can be bypassed with technological advances. In 2017, a trial study was undertaken to examine the application of telemedicine services in a more unique locale. In the rural mountain villages of northern Thailand, areas with meager medical resources, we established a telemedicine platform, which we left in the care of GONGOVA at Ban Mai Huay Hia village (in the Chom Thong District of Chiang Mai). One of the doctors we were able to collaborate with – whose grandmother we were treating using our telemedicine platform following a subdural hematoma – successfully demonstrated both the need and practicality of a telemedicine program in the humanitarian context. The patient was followed in Bangkok for more than three months, during which time several MRI's and CT's were performed and successfully reviewed via telemedicine. The patient, whose care was being managed in New York and Bangkok, recovered fully without any sequelae.

With the labor and service costs associated with quality care being successfully distributed between more economical and efficient sectors, the decentralized nature of the telemedicine system has allowed us to not only stretch our resources, but also to expand our medical knowledge as well. Non-medically trained persons – or persons with only minimal experience (or people not trained to U.S. standards) – are able to access high-level consultative care while in the field via telemedicine. This allows for the person who is traveling without a medical expert to have access to expert opinions. In case of an emergency or in a rural area where there is virtually no chance of trained physicians becoming available, this type of knowledge and consultative care can be lifesaving.

The Future

Looking forward, the technology and applications used in telemedicine are constantly evolving. We have pioneered the use of connected tools such as Bluetooth-enabled autoscopes, stethoscopes, heart monitors, and other diagnostic tools to aid us in this task.

Support & Acknowledgments

There are many doctors whose support of this effort in its early years is most notable. My friend and colleague Dr. Richard A. Gasalberti provided a forum to discuss telemedicine issues. Dr. Steve Okhravi, because of his faith in this system, gave us a permanent home to establish multiple centers. In the early years of this technology, Dr. Fink allowed me to demonstrate the many ways that telemedicine could be used – his time and interest were a great source of inspiration. I must also acknowledge the young doctors who supported me during those early years – many of these young researchers are still helping us today.

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CHAPTER 10. THE ROLE OF RADIATION IN PAIN MANAGEMENT

David Gasalberti MD, Richard A. Gasalberti MD, Isaac J. Kreizman MD.

Introduction. Radiotherapy has been a cornerstone of pain management since the discovery of x-rays over a century ago. Advances in the delivery of radiation over the decades allowed for more penetrating x-rays at higher energies. As a consequence, the treatment of painful metastatic bone and visceral lesions with less skin toxicity became a reality. The majority of patients treated with palliative radiation have advanced or metastatic cancers and consequently have a poor overall prognosis. The goal of care in this setting is to provide an acceptable quality of life for the patient by maximizing pain control while minimizing toxicity. While radiotherapy remains an effective means of controlling pain, a survey of hospice care providers conducted by Lutz et al. 2007 demonstrates that only 10% of providers considered Radiation Oncologists as part of a palliative care team despite the fact that 40% of patients receive radiation at some point during treatment. This chapter will review appropriate indications for palliative radiation therapy focusing primarily on pain management in the oncologic setting.

BONE METASTASIS

Background. Over 100,000 people with cancer will develop bone metastasis annually. The most common primary sites are breast, prostate, and lung cancer. The axial skeleton is the most common area of spread with the lumbar spine being the most common site. In the appendicular skeleton, the femur is the most common site. Bony metastatic disease if left untreated can lead to pathologic fractures, spinal cord compression, sleep disturbances and an overall decrease in quality of life. The mechanism of bone pain is unclear and several theories have emerged including periosteal stretching, tumor induced nerve injury, or osteolysis caused by the activation of osteoclasts. Overall, radiation response rates are between 60-70% and patients report an improved or stable quality of life. [4]

Workup. Patients usually present with symptoms that are largely dependent upon the site of metastasis. For instance, a patient complaining of groin or hip pain with a history of prostate cancer could have a femoral metastasis. Palpation over the area in question or bearing weight on the affected limb may elicit pain, but this may not always be the case. Although a thorough medical history can help clinch the diagnosis, a complete musculoskeletal and neurologic exam is essential especially when ruling out benign etiologies such as muscle spasm, herniated disks, advanced osteoarthritis, fracture from trauma, etc. If patients with a history of malignancy report sudden paralysis, parasthesias, difficulty walking, bowel incontinence, or bladder incontinence then it is prudent to suspect a spinal cord compression or cauda equina syndrome which will require urgent evaluation and treatment with radiation and surgery if confirmed. Imaging is an essential part of this workup and there are several modalities that can detect and localize metastatic lesions. The goal in this case is to select an imaging test that is both sensitive, specific, and cost effective. Plain radiographs are easy to obtain and economical, but suffer from a lack of sensitivity. A substantial amount of bone loss (30-50%) must occur before it can be detected with plain radiography thus hampering its sensitivity (see Fig. 1A).

Computed tomography (CT) scans are far more sensitive but speed and cost are sacrificed compared to radiography (see Fig. 1B). However, the clinical yield from a CT scan is far greater than a plain radiograph. They can provide information not only on location and extent but also the degree of cortical involvement, which is helpful in risk stratifying patients for impending pathologic fracture and the need for prophylactic fixation. In addition, they help guide clinicians if a biopsy is required to determine the origin of the primary tumor. Unfortunately, CT imaging cannot distinguish between metastatic disease and more benign processes such as osteoporosis. Magnetic resonance imaging is the most sensitive test available for detecting metastatic disease and is also the most costly and time consuming of the three imaging modalities mentioned. Sensitivity is reported to be 90-100%. MRI is particularly useful at detecting neurovascular involvement with tumors. This is of the utmost importance when ruling out a spinal cord compression. In addition, an MRI can help distinguish between pathologic fractures from osteoporosis or malignancy (see Fig.1C).

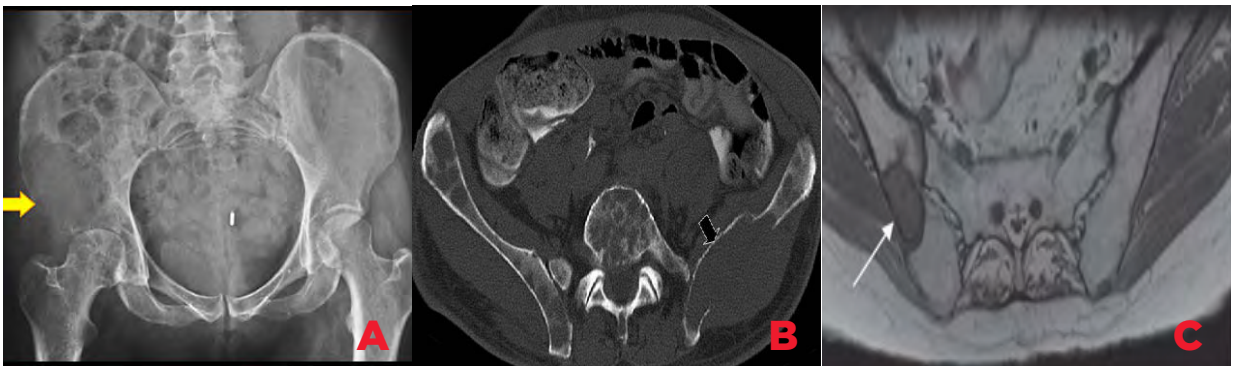

Fig 1A-C. Various Imaging modalities for demonstrating bone metastasis in bony pelvis. A.) Plain Radiograph. B.) Computed Tomography. C.) Magnetic Resonance Imaging

Medical Management. Patients with bone metastasis will inevitably experience pain related to these lesions. Medical therapy for pain control and the systematic escalation of therapy is well illustrated in the World Health Organization analgesic ladder. This ladder consists of three steps which start with the use of non-opioid analgesics such as NSAIDS to potent analgesics such as oxycodone or fentanyl (see Fig. 2). While patients report sustained pain relief with this approach, the side effects of opiate medications such as constipation, nausea, and mood changes can limit pain control.

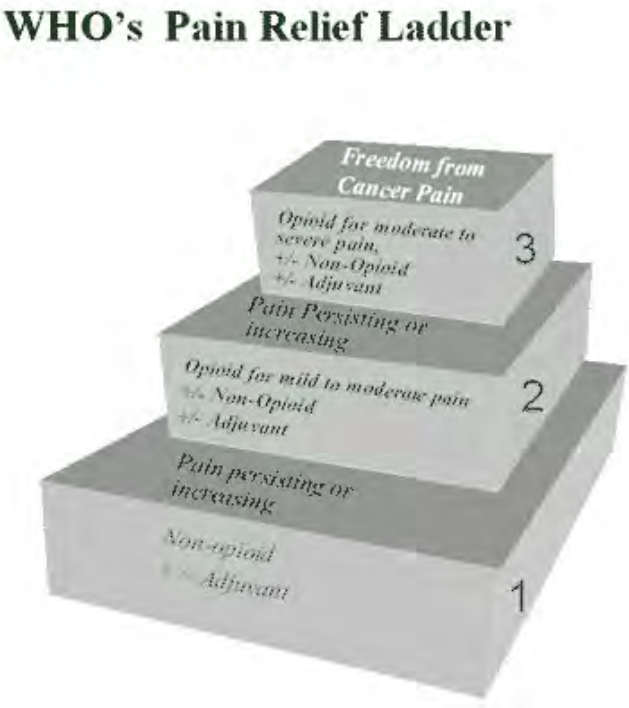

Fig 2. WHO's Pain Relief Ladder

Surgical Intervention. The location of bone metastasis can pose a risk for pathologic fracture especially in weight bearing areas such as the femur or lower spine which can have profound functional implications. Identifying and intervening on these patients before a fracture occurs is far more effective and technically less challenging than delaying until a fracture is encountered. In order to identify these patients, the Mirels scoring system was developed and takes into account location, pain severity, cortical involvement, and radiographic appearance (see Table. 1). A twelve point scoring system ranging from 4-12 is then devised. A score of 8 is correlated with a 15% risk of fracture. Orthopedic evaluation is generally warranted above a score of 8. Two to three weeks post-operatively, the patients are typically taken for radiation of the same area that was stabilized to prevent tumor seeding and recurrence.

SCORE	PAIN	LOCATION	CORTICAL INVOLVEMENT	RADIOGRAPHIC APPEARANCE
1	MILD	UPPER EXTREMITY	<1/3	BLASTIC
2	MODERATE	LOWER EXTREMITY	1/3 - 2/3	MIXED
3	SEVERE	PERITROCHANTERIC	>2/3	LYTIC

Table 1. The Mirels Scoring Criteria for risk stratifying impending pathologic fracture. there are four categories given a score of 1-3. which are added together. The scores range from 4-12. Scores >8 should seek orthopedic evaluation.

Radiotherapy. Radiation is an integral part of pain management, prevention of pathologic fracture, and local tumor control. The treatment and planning in most cases is fairly straightforward. In non-emergent situations, patients undergo a CT simulation over the areas to be treated. The data from these scans will be used to direct the radiation beams avoiding vital structures that may cause unwanted symptoms such as diarrhea, nausea, or vomiting in the case of lumbar vertebral radiation (see Fig. 3). Treatments are delivered through a linear accelerator which generates x-rays and can be projected and modified as a field onto the patient. There are several doses and fractionation schemes utilized for treatment (see Table. 2). Several early studies of various fractionation schemes have been explored in various randomized prospective trials. The important point is that all of these trials show no difference in pain control. The Dutch Bone Metastasis trial evaluated single fraction treatment with 8Gy versus 24Gy in 6 fractions. The overall and complete pain response rates were not statistically different. However, the risk of pathologic fracture (2% vs 4%) was higher in the short course arm and the risk of requiring retreatment was also higher in the single fraction arm (7% vs 25%). Perez et al 2013 enumerate the following conclusions based on thirty years of research into palliation for bone metastasis. They consist of the following:

1. Single fraction treatments of 8Gy provide similar pain relief when compared to more protracted regimens (e.g. 26Gy in 6 fractions or 30Gy in 10 fractions).
2. Retreatment rates are higher with shorter course treatments
3. Patients have better response rates if they are treated at lower pain levels rather than waiting until the pain is unbearable.
4. There is no known dose response for palliative bone metastasis.

With this in mind, the standard in the United States remains 30Gy in 10 fractions for the majority of cases. Concerns about the need for retreatment and the risk of pathologic fracture are often cited by Radiation Oncologists as the most compelling reasons for a longer course of treatment. Single fraction doses could be considered in cases where the anticipated life expectancy is shorter than the average time to retreatment, difficulty in obtaining timely medical transport, or patient preference. Single fraction treatments remain controversial in the United States.

Targeting painful bone metastasis with external beam radiotherapy is quite beneficial for patients and improves overall quality of life. Response rates from palliative radiation are much higher than with chemotherapy [3]. It is a cost effective tool in palliation without the side effects of opiates.

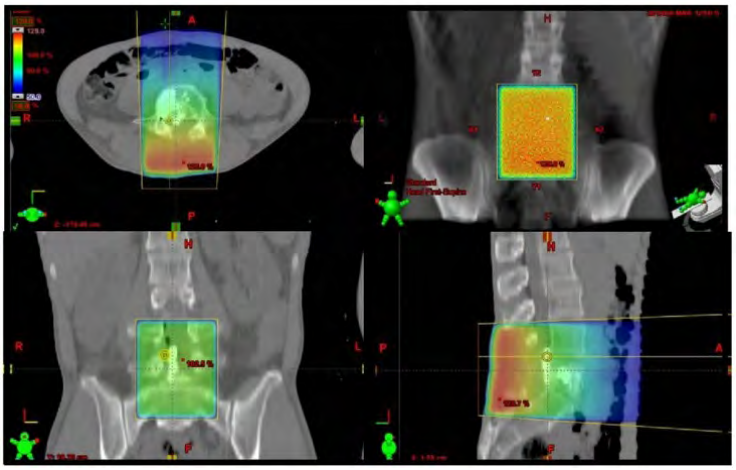

Figure 3. Radiation treatment plan for the Lumbar spine.

Dose (Gy)	Number of Fractions
30	10
8	1
30	15
15	3
20	5
40	15

Table 2. Dose fractionation schemes for bone metastasis

VISCERAL METASTASIS

Background. The most common areas of visceral metastasis include the brain and the lung and for the most part they do not cause pain. However, in some cases, a primary tumor will metastasize to an organ such as the liver or adrenal glands which can cause abdominal pain, early satiety, distention, and obstruction. In addition, recurrent pelvic malignancies such as cervical cancer, endometrial cancer, or rectal cancer may also produce pelvic pain and uncontrollable bleeding. Radiation therapy plays an essential role in both instances.

Liver Metastasis. The liver is a common site of metastasis from breast, lung, and colorectal cancers. Common symptoms include abdominal pain in the right upper quadrant, nausea, weight loss, early satiety, jaundice, and fever. Even in the metastatic setting, patients with limited disease in the liver may be eligible for curative resection. This is particularly true of colorectal cancers. In those cases, it is important to realize that while palliation is important these patients can still be cured despite the extent of disease. However, most patients will present with multiple liver lesions and large disease burden that cannot be cured. In addition to radiotherapy, these patients benefit from systemic chemotherapy as well as interventional procedures such as hepatic arterial chemo-embolization. Typically, palliative radiation is done in circumstances where the patient has large tumor burden and other medical co-morbidities. The limiting factor is Radiation Induced Liver Damage (RILD) which can lead to liver failure and may hasten death. Baseline liver function tests would be advisable prior to starting treatment. In many cases, patients have multiple lesions and require whole liver irradiation. Multiple fractionation schemes exist including 30Gy in 15 fractions, 20Gy in 10 fractions, or 21Gy in 3 fractions [3]. All of these regimens are roughly equivalent with 55% of patients reporting improvement in symptoms.

Selective Internal Radiotherapy (SIRT) is an interventional procedure which introduces Yttrium-90 attached to small resin microspheres into the hepatic arterial system. This would be considered in

patients with diffuse metastasis but otherwise good functional status. Hendlisz et al 2010 conducted a phase III trial with 5FU +/- Y-90 embolization demonstrating the effectiveness of this treatment in chemo-refractory patients with liver metastasis. [5]

Adrenal Metastasis. While an uncommon site of metastasis overall, adrenal metastasis are usually encountered in lung cancer patients. While there may be a role for surgery in those with limited disease burden, most patients are appropriate for palliative radiation. The data on adrenal metastasis is sparse and follow up is limited due to survival being on the order of months. Radiation dose is limited by acute bowel toxicity resulting in nausea. No late effects were seen but this is likely due to the limited life expectancy of the patients. The most common regimen is 30Gy in 10 fractions.

Splenic Metastasis. Tumor spread to the spleen is quite uncommon and more likely to be associated with hematologic malignancies. These patients will typically complain of left upper quadrant pain, early satiety, and abdominal distension. Fortunately, the spleen is quite radiosensitive and responds to doses far smaller than what is employed at other organ sites. Baseline blood counts are advisable in this scenario as patients may quickly develop anemia, thrombocytopenia, and lymphopenia. Doses are typically under 5Gy and delivered twice weekly with a CBC measured after each treatment.

Pelvic Recurrences. Pelvic malignancies are notorious for causing a significant amount of pain as well as bleeding and obstruction. Most common pelvic recurrences include colorectal cancers, endometrial cancers, and cervical cancers. A multimodality approach is usually employed in these patients as it increases the probability of successful palliation of symptoms. For recurrent colorectal cancers, the patient may benefit from a diverting colostomy in the case of obstruction. They may also benefit from chemotherapy and radiation for painful bulky disease in the pelvis. Several studies examining rectal cancer patients that are surgically inoperable given 5-fluorouracil accompanied with radiation appear to have a high success of pain relief. This approach is limited to patients that have not received prior pelvic irradiation. Patients that have received prior radiation to the pelvis usually treated with surgery and/or chemotherapy. There are some instances in which radiation can be employed. This usually requires a review of the prior radiation plan and treatment to a far smaller volume than originally treated. A more conformal treatment modality such as interstitial brachytherapy may be employed. Brachytherapy is a superior modality when targeting a relatively small volume. The doses of radiation are required for palliation in this area are usually around 50Gy with conventional fractionation using external beam. If brachytherapy is utilized, then doses of 10-15Gy delivered in 1 fraction or 5Gy twice per day to a total dose of 30-40Gy which results in long lasting pain relief. If brachytherapy is not an option, a faster but more protracted regimen called the “QUAD-shot” may be employed. It consists of a 3.7Gy BID regimen over a 2 day period followed by a 3-6 week treatment break. This regimen is repeated for 2 additional cycles for a total of 44.4Gy [2]. Seventy-Five percent of the patients that completed the course had remission or stable disease. Those unable to tolerate or continue with a full course of treatment still have a >50% chance of disease remission. Common side effects of all of these treatments include nausea, diarrhea, and dysuria. Brachytherapy carries the additional risk of bowel perforation, infection, and bleeding.

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CHAPTER 11.
GUIDELINES AND NY LAW

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I. What Are Clinical Practice Guidelines?

A Clinical Practice Guideline is a document that defines a standard of diagnosing, care and treatment that is generally accepted and presumed followed by a group of health care providers. Radiologists might have a Clinical Practice Guideline for diagnosing and treating breast cancers; so might oncologists. PMR physicians and Orthopedists might have their own Clinical Practice Guidelines for treatment of various chronic conditions. Sometimes, organizations might have joint guidelines. Some organizations, such as the New York State Pain Society, could generate guidelines that are multi-specialty in nature. A government agency such as the CDC or Workers' Compensation often generates Clinical Practice Guidelines.

The key is if the guideline is based upon reliable standards and measures. The guideline should present a systematic approach to the subject at hand. It should be based upon reliable research and studies. It should draw upon physicians and healthcare providers who are knowledgeable and experienced in the topic at hand. The inherent value of a Clinical Practice Guideline is the willingness of a physician population to adopt the guideline into their daily clinical practice. While a guideline might become part of a law or adopted by an organization, in the end, the guideline is only as good as its quality.

By quality, we mean applicability in a useful way to the patient. If the guideline presents a paradigm for treatment, can a practitioner reasonably follow it? Does the guideline call upon you to perform reasonable actions? Is the bar set too high before a definitive diagnosis can be made? Often, this can only be determined by taking the guidelines out for a test drive. In other words, good guidelines must work in the real world. Impractical guidelines will soon be ignored by the practitioner.

Clinical Practice Guidelines may be used to either defend or prosecute a physician administratively, as with the Office of Professional Medical Conduct, concerning a physician's license. Since the "rules of evidence" are not adopted at administrative hearings, the administrative law judge has wide latitude as to whether or not the guidelines can be admitted as evidence. Administrative hearings include the Office of Professional Medical Conduct and hospital hearings. The physician has a better chance of getting them admitted into evidence if your attorney can make a showing that the guidelines are accepted by the medical community.

Clinical Practice Guidelines also play a potential role in medical malpractice suits in New York. Malpractice suits are civil in nature. As such, the "rules of evidence" apply. By definition, Clinical Practice Guidelines are hearsay. Hearsay is any statement made by somebody else, to prove the truth of the matter being talked about. An example of hearsay is when an expert witness testifies that Dr. Jones' injection of 1cc of 1% lidocaine into the trigger point was efficacious or indicated as per the Clinical Practice Guidelines of the "ABCD Society". Can the judge allow this hearsay into evidence? At the risk of sounding like an attorney, "maybe". There are several hearsay exceptions. The trick is Alternative Dispute Resolution, Professional Discipline, Governmental Investigations, Litigation and Arbitration, Contracts and Business Transactions, White Collar Crime, Regulatory Compliance, Practice Formation, Mergers and Acquisitions, Asset Protection and Estate Planning, Medical Financial Audits.

The highest court in New York State is known as the Court of Appeals, not the Supreme Court. Fortunately, the Court of Appeals actually considered this matter in 2006. There was a medical malpractice case involving an anesthesiologist. As part of that anesthesiologist's testimony, he testified to following a flow chart or paradigm in deciding to allow the surgery to proceed without the patient having a prior cardiac evaluation. The judge allowed the flow chart into evidence. The Court of Appeals agreed. The witness, the treating physician, could use the guidelines or paradigm as evidence because he was not using it to prove the truthfulness of the guideline, but just to inform the Court as to the process he took in formulating his medical opinion prior to the patient's surgery. That might seem to be a distinction without a difference, but there it is! A guideline may be admitted into evidence under the proper conditions. The Court also held that as long as the treating physician partially (not totally) relied on the guideline in his medical decision making, the guideline was allowed

into evidence. Not only that, but the attorney can ask all sorts of questions to the witness about the guidelines, such as who formulated it, who it is endorsed by, and who else uses it. If the guideline is endorsed by a reliable entity and widely used, it will carry more weight with a jury. Hinlicky v Dreyfuss, 6 NY3d 636 Slip Op (2006). It is generally inadmissible for expert, non-treating witnesses to reference Clinical Practice Guidelines. When the defense attorney is cross-examining the plaintiff's expert witness, the defense attorney may ask if the plaintiff's expert considers a Clinical Practice Guideline as authoritative. In the rare instance when the expert admits that he/she considers it authoritative, it may be admissible in a state court. In federal courts, if the judge rules that the guideline in question was established as authoritative, the guidelines may be admitted into evidence. Most, but not all, medical malpractice cases in New York are in state courts.

The National Practitioner Clearinghouse, part of the Federal Government's AHRQ (Agency for Healthcare Research and Quality) is the website for thousands of Clinical Practice Guidelines that meet some pretty stringent federal standards for quality. Frankly, the authors of guidelines that make the cut on this website have jumped through many hoops.

To demonstrate the maze of guidelines that are out there, I typed in the search terms "chronic pain" on the National Practitioner Clearinghouse website. 454 different guidelines appeared! What is useful, and what is not, often involves common sense. If you practice in New York, the Chronic Pain Disorder Medical Treatment Guidelines from the Colorado Division of Workers' Compensation will not be as helpful to you as compared to the New York version. The ACR Appropriateness Criteria Chronic Foot Pain will apply more to a radiologist than a similar guideline written for a physical therapist.

Clinical Practical Guidelines are hardly new. They have been around for over 20 years. Of course, guidelines must be updated periodically to keep up with new treatment regimens and scientific discoveries. Depending on the subject, updates might have to be more frequent. For example, guidelines concerning the Zika virus might have to be updated more often as it is currently more thoroughly studied, than perhaps the efficacy and dosage of Tetracycline.

One of the big raps on Clinical Practice Guidelines is that it promotes cookbook medicine. If properly written, a good guideline will leave room for clinical judgment. A well-written guideline will promote better and more consistent medical decisions.

One might ask what happens if you decide not to follow a generally accepted Clinical Practice Guideline. The short answer is, you better have a good reason for departing from the guideline and you should definitely explain it in that patient's medical record!

II. CDC Practice Guideline for Prescribing Opioids for Chronic Pain

In March of 2016, the Center for Disease Control (CDC) issued national Clinical Practice Guidelines "on prescribing opioids for chronic pain, for patients who are at least 18 years old, outside of active cancer treatment, palliative care and end-of-life care." (CDC Guideline for Prescribing Opioids for Chronic Pain, United States, 2016). This guideline is a potential game-changer for the primary care physician who treats this type of chronic pain. The CDC stated that it felt that the guideline was necessitated by primary care physicians' concern with misusing opioid pain medication in patients with chronic pain, defined as pain more than 3 months. Due to concern of addiction and over-dosage, these physicians desired authoritative guidance in opioid prescribing for chronic pain in non-cancer patients. Many organizations, states and federal agencies, such as the American Pain Society, the American Academy of Pain Medicine, the US Department of Veterans Affairs, have developed their own guidelines for prescribing opioids. The CDC guideline purports to include the most up-to-date scientific evidence along with a systematic review of the evidence, review by experts in this area. The guideline is targeted for use by family physicians and internists who treat patients for chronic pain.

The guideline states: "In summary, evidence on long-term opioid therapy for chronic pain outside of end-of-care remains limited, with insufficient evidence to determine long-term versus no opioid therapy, though evidence suggests risk for serious harms that appears to be dose-dependent." It also states that several non-opioid therapies have been found effective in treating chronic pain, such as exercise therapy, behavioral modification techniques, mixing exercise with psychological approaches, acetaminophen, NSAIDS COX-2 inhibitors, some anticonvulsants and some antidepressants, and for short-term relief of chronic pain, an epidural injection.

The guideline then goes on to deal with 12 issues dealing with determining when to initiate or continue the use of opioids for chronic pain. Each will be discussed after being quoted, with its implications on your practice:

1. Nonpharmacological therapy and nonopioid pharmacological therapy are preferred for chronic pain. Clinicians should consider opioid therapy only if expected benefits for both pain and function are anticipated to outweigh risks to the patient. If opioids are used, they should be combined with nonpharmacologic therapy and nonopioid pharmacologic therapy, as appropriate.

Your chart should indicate, in detail, how you are employing these specific recommendations, including specific reference to how you want the patient to functionally improve. As an example-the goal to walk 10 blocks instead of 1 block. The chart note should state how the patient is progressing or not in this regard. Do not just mention a goal and ignore it later on. What non-opioid therapies have been tried? By whom? How long? Drill down as to detail.

2. Before starting opioid therapy for chronic pain, clinicians should establish treatment goals for all patients, including realistic goals for pain and function and should consider how opioid therapy will be discontinued if benefits do not outweigh risks. Clinicians should continue opioid therapy only if there is clinically meaningful improvement in pain and function that outweigh risks to patient safety.

The "takeaway" from this recommendation, is that your medical chart should list specific realistic goals for each patient. General, lofty goals such as "walk better" are not sufficient. Quantify this in blocks walked. "Improved ability to lift" should be quantified perhaps by the weight of an object to be lifted when the patient is on opioid therapy as opposed to prior to the institution of such treatment. Quantify the pain as to type of pain; what precipitates it and in what ways it is ameliorated by the opioid therapy. Again, generalizations as to "increase function or activities in daily living," will not suffice. If it is found that your patient is not obtaining sufficient benefits that outweigh the risks, an actual plan to wean them off the opioids should be included in your chart. If a patient is at heightened risk to take opioids due to some pathology, that should be noted in the chart and what you, the physician, is doing to monitor this.

3. Before starting and periodically during opioid therapy, clinicians should discuss with patient known risks and realistic benefits of opioid therapy and patient and clinician responsibilities for managing therapy. This recommendation states that there should be informed consent prior to and while the patient is under opioid therapy. Remember, informed consent is not just a signed consent form; it is a process of educating the patient. It is highly recommended that this process be memorialized in your chart. When you educate your patient, which should be noted in your medical record; and not just the first time, but every time the patient is educated. If a pamphlet or handout is given to a patient, note with specificity the handout given to the patient.

4. When starting opioid therapy for chronic pain, clinicians should prescribe immediate-release opioids instead of extended-release/long acting opioids. The key here is that it was found that longer-acting opioids appear to entail greater dosages than when shorter-acting alternatives were given on a p.r.n. basis. If you have a legitimate reason for starting therapy with an extended-release opioid, your record should spell out the reason why this is so.

5. When opioids are started, clinicians should prescribe the lowest effective dosage. Clinicians should use caution when prescribing opioids at any dosage, should carefully reassess evidence of individual benefits and risks when considering increasing dosage to 50 or more morphine milligram equivalents (MME, and should avoid increasing dosage to 90 or more per day or carefully justify a decision to titrate dosage to 90 or more MME/day.

While preparing this guideline, the CDC did not find that high doses of opioids for chronic pain was efficacious. It did find that high doses of opioids potentially compromised patient safety. Most practitioners are already titrating their patients' doses when using opioids. However, it is of the utmost importance to clearly chart the titrating process and letting the reader of your chart into your thought process concerning how you arrived at the dosage you are currently prescribing; if that dosage might be increasing or decreasing, and why. Pain and function are not the only consideration; is the patient at increased risk to become addicted? Was the patient addicted to opioids before? Does the patient have a history of addictive behavior? Does the patient have some type of pathology or genetic predis-

position to having undesirable side-effects if dosage is too high? Your patient care should deal with all of these potential issues. Your chart should reflect that in fact, you did deal with these issues.

6. Long-term opioid use often begins with treatment of acute pain. When opioids are used for acute pain, clinicians should prescribe the lowest effective dose of immediate-release opioids and should prescribe no greater quantity than needed for the expected duration of pain severe enough to require opioids. Three days or less will often be sufficient; more than seven days will rarely be needed.

The guideline now steps into the area of prescribing opioids in acute situations. Although this area is not the primary focus, this recommendation should not be ignored. We get back to medical justification of what dose is prescribed and how long the opioid is given. Your record should justify your prescription. Your record should pay particular attention to acute situations where you want to prescribe for more than seven days.

7. Clinicians should evaluate benefits and harms with patients within 1 to 4 weeks of starting opioid therapy for chronic pain or of dose escalation. Clinicians should evaluate benefits and harms of continued therapy with patients every 3 months, or more frequently. If benefits do not outweigh harms of continued opioid therapy, clinicians should optimize other therapies and work with patients to taper and discontinue opioids.

It is very obvious that lower doses of opioids, less pills, alternate therapies, such as NSAIDS, physical therapy, biofeedback, are preferred. Forewarned is forearmed! Document what you are doing to decrease the dosage of opioids. If you are trying physical therapy, note it. Then, note the progress or lack of same. Note if there is patient compliance or not. You not only have to ask, but you have to chart that you asked and note the answer.

8. Before starting and periodically during continuation of opioid therapy, clinicians should evaluate risk factors for opioid-related harms. Clinicians should incorporate into the management plan, strategies to mitigate risk, including considering offering naloxone when factors that increase risk for opioid overdose, such as history of overdose, history of substance use disorder, higher opioid dosages or concurrent benzodiazepine use, are present.

Does your patient abuse alcohol? Is your patient currently on a benzodiazepine? This should be noted in detail and factored in to your treatment plan. Consider prescribing naloxone for the appropriate patient. Please, note all prescriptions and patient recommendations in your chart.

9. Clinicians should review the patient's history of controlled substance prescriptions using state prescription drug monitoring program data (PDMP) to determine whether the patient is receiving opioid dosages or dangerous combinations that put him or her at high risk for overdose. Clinicians should review PDMP data when starting opioid therapy for chronic pain and periodically during opioid therapy or chronic pain, ranging from every prescription to every 3 months.

In New York, there is the ISTOP program. Obtain the PDMP data as suggested in suggestion 9 for each chronic pain patient taking opioids. Make sure that your records reflect that you checked ISTOP and what was found. It would not hurt to place a copy of that patient's PDMP data in your chart.

10. When prescribing opioids for chronic pain, clinicians should use urine testing before starting opioid therapy and consider urine drug testing at least annually to assess for prescribed medication as well as other controlled prescription drugs and illicit drugs.

This might seem obvious, but do not forget to place the urine drug test results in the patient's chart. Initial them and date it, if your EMR allows. The results should also be incorporated in the body of your progress notes. For example, if the results show patient compliance, the note should state that. If there is any irregularity, such as the patient testing positive for cocaine, the record should state that too. Then, the record must state what action you took as a result of that. That might vary from a warning for the first violation to stopping the patient's opioid prescription for any additional violations.

11. Clinicians should avoid prescribing opioid pain medication and benzodiazepines concurrently whenever possible.

As prescribing opioids and benzodiazepines together places the patient at greater risk for respiratory depression, you should have a very good reason for the medical necessity to combine the two. Use an alternate treatment regime instead and let your record show why.

12. Clinicians should offer or arrange evidence-based treatment (usually medication-assisted treatment with buprenorphine or methadone in combination with behavioral therapies) for patients with opioid use disorder.

You yourself need not provide this treatment; you can refer such patients out for treatment for opioid use disorder. However, your chart should reflect what is occurring and what is recommended, and what you are doing for this patient.

In conclusion, your chart should reflect, in detail, how you are complying with all of the relevant guideline recommendations. Administrative agencies, such as the Office of Professional Medical Conduct might find this CDC Guideline authoritative. That will mean that if you did not follow the guideline's recommendations, there will be a presumption of substandard patient care. Only a carefully worded and detailed medical record will explain why you might have deviated from the guideline recommendations. In any case, a complete and accurate medical record is the single best thing that the primary care provider can do to protect him or herself from the various agencies, insurance companies, malpractice attorneys and criminal prosecutors. If utilized appropriately, clinical guidelines will provide a shield for you and your treatment of your patients.

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