Therapeutic modalities in rehabilitation

- Interventions having physiological effects on soft tissue.
- Procedures used in conjunction with other interventions (e.g. stretching, strengthening, gait training).

Classifications of therapeutic modalities

Physical Agents

Electrotherapeutic Modalities

Mechanical Modalities

Physical Agents

Classifications by tissue response

Superficial Heat
- Hot packs
- Paraffin
- Fluidotherapy
- Hydrotherapy

Cryotherapy
- Cold Packs
- Ice bags
- Ice massage
- Contrast bath

Deep Heat
- Ultrasound
- Diathermy

Electrotherapeutic Modalities

Pain modulation, muscle performance, tissue healing

Electrical Stimulation
- Transcutaneous Nerve Stimulation (TENS)
- Neuromuscular Stimulation (NMES)
- Iontophoresis

Surface EMG
- Muscle re-education
- Relaxation training

Mechanical Modalities

Mechanical manipulation of soft tissue

- Traction – lumbar and cervical
- Compression
- Massage
- Mechanical Motion Devices (CPM)
- Gravity assisted devices
  (tilt table & standing frames)
Cryotherapy

Thermotherapy: Methods of Heat Transfer

- Conduction
- Convection
- Radiation
- Evaporation

Infrared Energy:
- Tissue penetration is superficial (≤ 1 cm)
- Direct effects are on cutaneous blood vessels & nerve receptors

Electromagnetic Spectrum

Cryotherapy

Indications:
- Acute injury or inflammation
- Edema
- Acute or chronic pain
- Acute or chronic muscle spasm
- Spasticity
- Limited ROM due to pain

Contraindications:
- Peripheral vascular disease
- Hypertension
- Wound healing - especially after 48-72 hrs. post injury
- Regenerating peripheral nerves
- Cold hypersensitivity responses

Cryotherapy for Acute Injuries: R.I.C.E.

Rest + Ice + Compression + Elevation
1. ↓Histamine response, ↓Metabolism, ↓Interstitial fluid
2. Controls edema formation
3. Facilitates fluid reabsorption into lymphatics
4. Facilitates venous return
5. Pain Modulation
Cryotherapy: Stages of Cooling

*The patient will feel:*
1. Cold
2. Stinging or burning
3. Aching
4. Complete numbness

Cryotherapy for Acute Injuries

**Cold + Static Compression**
- Ice + ace wrap
- Controlled cold unit

**Cold + Intermittent Compression:** May be more beneficial than static compression
*Example: Vasopneumatic pump + cold*

**Focal vs. Uniform compression**
*Example: U-shaped pad around malleolus for ankle sprain*

**Cryokinetics:** Active movement after icing

Cryotherapy: Parameters

**Tissue cooling time depends on:**
- Subcutaneous tissue thickness
- Temperature of the cooling agent

**General recommendations:**
- Cold packs: 15-20 minutes
- Cold ice bath or ice massage: 5-10 minutes
- Water temperature: 55-67°F (13-19°C)

Heat Applications: *Superficial & Deep Heat*

- **Hydrocollator Packs**
- **Fluidotherapy**
- **Paraffin**
- **Ultrasound**
- **Hydrotherapy**

**WHY DO WE TAKE THIS SERIOUSLY?**

*Modality related claims:*
- Burns = 27%
- Whirlpool = 11%
- Equipment & traction = 10%
- Falls and fractures = 51%
**Heat Application: Indications**

- Limited joint ROM due to soft tissue shortening
- Joint stiffness
- Reduced collagen extensibility
- Pain
- Muscle spasms (in non-acute situations)

**Heat Application: Contraindications**

- Acute inflammation
- **Impaired sensation**
- Peripheral vascular disease/vascular insufficiency
- Ischemic tissue
- Malignancy
- Infected areas
- Pregnancy (applied to torso)
- Diminished consciousness
- Unreliable situations
- Open wounds (hydrocollator packs and paraffin)
- Application over liniments or heat rubs
- Extensive scar area
- Bleeding tendencies

**Heat Application: Precautions**

- Bony Prominences
- Mild impairments in sensation  (i.e. reduced temp sensation with aging)
- Reduced mobility
- Lying on the hot pack
- Reduced tolerance to heat
- Comorbid conditions (CVD, diabetes)

**Biophysical Effects of Temperature Elevation**

**Direct Effects:**
- ↑ Collagen extensibility
- ↑ Metabolism (↑ phagocytosis, healing, repair)
- ↑ Dilation vessels
- ↑ Nerve stimulation (axon reflex, sensory)
- ↑ Local Temp Rise → Hypothalamus

**Indirect Effects:**
- ↑ Vasodilation via axonal stim
- Via axonal reflex
- Via cutaneous thermal receptors
- Via tissue healing due to ↑ metabolism

**Biophysical Effects of Temperature Elevation**

**Metabolic Reactions:**
- ↑ Chemical activity in cells
- ↑ Metabolic rate 2-3x for every 10° C (50° F)
- ↑ Oxygen uptake
- Tissue Temp > 45° C (>113-122° F) → Tissue burn

**Heat: Tissue Temperatures**

- Temp > 113° F (45°C) damages tissue
- Tissue temp of 104°-113° F (40-45° C)
  - Example: Direct effect on collagen tissue elongation.
Effects of Tissue Temperature Rise

<table>
<thead>
<tr>
<th>Tissue Temperature Increase</th>
<th>Effect on Tissue</th>
</tr>
</thead>
</table>
| Mild: 1.8° F (1°C) (to 100.4° F; 38°C) | - Increase metabolism  
- Decrease mild inflammation |
| Moderate: 3.6°-5.4° F (2°-3° C) (to 102.2°-104° F; 39.4°-40°C) | - Pain modulation  
- Decrease spasm  
- Increase blood flow |
| Vigorous: 7.2° F (4° C) (to 105.8° F; 41° C) | - Increase collagen extensibility  
- ↓ Muscle guarding & spasms  
- Increase joint ROM |

Deep Heat

Deep Heating Modalities

- Tissue temperature elevation of deep structures without excessive heating of superficial tissues
- **Ultrasound** - High frequency sound waves (1 MHz & 3 MHz)
- **Diathermy** - Electromagnetic radiation

Ultrasound Instrumentation

- Power supply
- Oscillator - 1MHz or 3 MHz
- Amplifier
- Transducer – piezoelectric crystal
  - Natural quartz or synthetic
  - Crystal inside the transducer head

US Instrumentation:
*Generation of sound waves*

- Reverse Piezoelectric effect
  - apply electric current to same material and it causes a change in shape
  - apply an oscillating electric current and material can change shape at the same frequency as the current.
US waves in tissue: Attenuation resulting from absorption, reflection & refraction of energy

US Frequency: Depth of tissue penetration

- 3 MHz is more superficial (1-3 cm)
- 1 MHz is deeper (3-5 cm)

**US: Exposure Factors**

- US Intensity ≠ US Dosage*
- Power output of US beam
- Effective Radiating Area (ERA) of the crystal
- US Frequency
- Duration of Exposure
- Surface area of exposure (size of treatment field)
- Tissue Depth

**Contraindications: Ultrasound**

- All contraindications to heat application
- **Impaired sensation is an absolute contraindication for ultrasound application.**
- Over growth plates (epiphyseal plates) in children & adolescence
- Malignant tumor
- Pregnancy
- Over CNS tissue
- Over joint cement and plastic components (joint replacement)
- Pacemaker (area around pacemaker)
- Thrombophlebitis
- Over the eyes
- Over reproductive organs

**Electrical Stimulation**
Electrotherapy: **Indications**

- Acute tissue inflammation
- Pain modulation
- Edema control
- Transcutaneous medication delivery (iontophoresis)
- Tissue healing (e.g. wound care)
- Neuromuscular electrical stimulation (NMES)
  - Neuromuscular re-education
  - Muscle strength & endurance training
  - Functional electrical stimulation (FES)
- Neuromodulation
- Electrical stimulation of target muscles

---

Electrotherapy: **Contraindications**

- Indwelling cardiac catheters
- Demand Pacemakers
- Electrode placement across the axis of the heart
- Stimulation over the anterior chest and neck (Carotid sinus)
- H/O cardiac arrhythmia, congestive heart failure, or recent MI
- Pregnancy – torso
- Deep vein thrombosis (DVT)
- Near surgical staples or external fixation devices
- In the region of neoplasm or infection
- Electrical stimulation should not be used in close proximity to diathermy devices

---

Electrotherapy: **Precautions**

- Unable to provide clear feedback
- Lack of sensation
- Prone to seizures
- Hypertension or hypotension
- Automatic dysreflexia
- Fragile skin, abrasions, scar tissue
- Areas with large amount of adipose tissue
- Reflex sympathetic dystrophy (RSD)
- Limited physical tolerance or psychological acceptance

---

Electrotherapeutic Modalities

**Pain modulation:**
- Transcutaneous Nerve Stimulation (TENS)
- Iontophoresis

**Muscle re-education:**
- Neuromuscular Stimulation (NMES)
- Surface EMG (Biofeedback)

---

Electrotherapy: **Pain Modulation Theories**

1. **Gate Control Theory**
   - Pain message blocked via ascending pathways
   - Large afferent fiber stimulation
   - Sensory level stimulation

2. **Beta-Endorphin Theory (Opioid)**
   - Release of endorphin and enkephalins
   - A-delta and C fiber stim
   - Motor level stimulation

3. **Central Biasing/Central Control**
   - Descending thalamic and brainstem impulses
   - Blocks pain messages at level of dorsal horn
   - Hyperstimulation Analgesia

---

Electrode placement for pain modulation

**Bracket pain and/or Nerve Root**

**Motor Point**

**Trigger Point**
Strength Duration Curve & Pain Modulation

Pulsed Biphasic Currents for Pain Modulation

- Low voltage Stimulators (0-150 volts)
- Balanced waveform (zero net charge)
- Variations in shape, duration, amplitude, frequency

Medium Frequency Currents for Pain Modulation (2,000 - 10,000 Hz)

- Interferential (IFC) and Premodulated Current (4000 Hz intersects with 4100 HZ → 100 beats/second)

High Voltage Pulsed Current (HPVC) for Pain Modulation and Tissue Healing

- High voltage stimulators (100-500 volts)
- Twin-peak, monophasic waveform, + or – polarity
- Lower total charge/pulse than low voltage stimulators
- Tissue Healing (wounds) & Pain modulation

Neuromuscular Electrical Stimulation (NMES)

Applications:
- Strength & Conditioning
- Muscle Facilitation
- Spasticity management
- Functional Training
- Neuroprosthesis

Electrode placement for NMES
Strength Duration Curve:  
Pulse Amplitude Vs. Duration

Thank you
Therapeutic Modalities
Ellen McGough, PT, PhD
32nd Annual Review Course in Physical Medicine & Rehabilitation
March 15, 2015

Therapeutic Modalities:
- Interventions that have physiological effects on soft tissue
- Interventions applied for pain modulation
- Interventions applied for muscle re-education
- Procedures used in conjunction with other rehabilitation interventions

Classifications of Therapeutic Modalities:
- Physical Agents - Cryotherapy, superficial heat, deep heat
- Electrotherapeutic Modalities - Electrical stimulation, Surface EMG
- Mechanical Modalities - Traction, compression therapies, massage

I. Cryotherapy
A. Indications for Cryotherapy
   - Acute injury or inflammation
   - Edema
   - Acute or chronic pain
   - Acute or chronic muscle spasm
   - Spasticity
   - Limited ROM due to pain

B. Physiological Effects of Cold
   1. Vasoconstriction
      - Reflex cutaneous vasoconstriction
      - Reduces bleeding
      - Reduces blood flow to the area
      - Increases viscosity of blood
      - Reduces blood flow to the area
   2. Decreases metabolic rate and vasoactive agents
      - Decreases the release of histamine
      - Reduces inflammation
      - Reduces fluid filtration into the interstitium
   3. Decreases nerve conduction velocity and synaptic activity
   4. Increases pain threshold
   5. Decreases muscle spasms
      - Decreases sensitivity of muscle spindle afferent
      - Decreases pain level
   6. Decreases tissue elasticity
C. Contraindications to Cryotherapy
1. Peripheral vascular disease
2. Hypertension
3. Wound healing- especially after 48-72 hrs post injury
4. Regenerating peripheral nerves
5. Cold hypersensitivity responses:
   • Cold urticaria
     - due to histamine release from mast cell degranulation
     - Signs: Wheals, local erythema and swelling; May have a Systemic response such as respiratory, syncope or GI response
   • Raynaud’s phenomenon
     - Vasospastic disorder with changes in skin circulation
     - Signs: Blanching, cyanosis and rubor (in that order)
   • Cryoglobulinemia
     - Assoc. with high serum levels of circulating cold precipitating Ig.
     - Signs: skin lesions, arthralgias, acute renal failure, vasculitis
     - Cause: Hep B or other viral, bacterial or fungal infection
   • Cold induced hemolysis
     Paroxysmal cold hemoglobinuria – Hemoglobin leaves blood and enters urine. Rare now, was assoc. with tertiary syphilis.
   • Cold agglutinin disease - agglutination of RBC at lower temps. Assoc. with mycoplasma pneumonia. Mononucleosis and lymphoid neoplasms

D. Precautions for Cryotherapy
1. Risk of peripheral nerve injury with prolonged exposure (e.g. Peroneal N.)
2. Older adults have a reduced ability to conserve heat

E. Cryotherapy Applications
1) Commercial gel packs - Stored at 8-10°F for at least 2 hrs before initial use
   • Commercially available packs - a semigel substance & durable plastic cover
   • Stored in a standard freezer or a cold hydrocollator unit
   • Discard cold packs that have leaks
   • Store at least 30 minutes between uses
   • Duration: 10 - 20 minutes
2) Ice bags – crushed or shaved ice in a plastic bag
   • Place a thin towel (wet or dry) between the bag and the person’s skin
   • A wet towel will improve cold conduction
   • Duration 10-15 minutes
3) Ice Massage –ice cup or Popsicle to massage localized area:
   • Continuously rub ice over the treatment area using small, overlapping circles.
   • Wipe away any water as it melts
   • Apply for 5-10 minutes or until analgesia is reached
   • Lightly touch treatment area to feel if numbness has reached
   • Inspect skin for wheals or rash while you are applying the ice.
4) Controlled Cold Unit (Cryocuff)
   • Available for home use
   • Specific sleeves for different body parts
   • Amount of compression
5) Cold Compression Units
   • Combine compression (static or intermittent) with cold.
   • Amount of compression:
     o most important thing is comfort
     o light to moderate compression

6) Cold Water Immersion Baths:
   • Equipment: container, ice, towels & chair for patient.
   • Temperatures: Cold water immersion – used for an extremity
     Cool 67\(^\circ\) – 80\(^\circ\) F 19\(^\circ\) – 27\(^\circ\) C
     Cold 55\(^\circ\) – 67\(^\circ\) F 13\(^\circ\) – 19\(^\circ\) C
     Very Cold 32\(^\circ\) – 55\(^\circ\) F 0\(^\circ\) – 13\(^\circ\) C

7) Contrast Bath - Alternating between warm and cold baths
   • Procedure: Alternate between warm & cold baths (repeat cycle 3-4 times)
     o 1:3 - 1 min cold/3 min. warm
     o 1:4 - 1 min cold: 4 min warm

8) Cryokinetics - Cold + Exercise
   • Use of cryotherapy for pain inhibition to allow greater effort with exercise

7) Home ice packs can be made with a 4:1 ratio of water: rubbing alcohol contained in a freezer bag.

II. Superficial Heat
   A. Indications for Superficial Heat Applications
      a. Limited joint range of motion due to soft tissue softening
      b. Joint stiffness
      c. Reduced collagen extensibility
      d. Pain
      e. Muscle spasms (in non-acute situations)

   B. Physiological Effects of Superficial Heat Modalities
      **Direct Effects:**
      ↑ Collagen extensibility
      ↑ Metabolism (↑ phagocytosis, healing, repair)
      ↑ Dilation vessels
      ↑ Nerve stimulation (axon reflex, sensory)
      ↑ Local Temp Rise \(\rightarrow\) Hypothalamus

      **Indirect Effects:**
      ↑ Vasodilation via axonal stim
      • Pain modulation due to axonal reflex and cutaneous thermal receptors
      • Tissue healing due to ↑ metabolism
C. Contraindications: Heating Modalities

- Acute inflammation
- Impaired sensation
- Peripheral vascular disease/vascular insufficiency
- Ischemic tissue
- Malignancy
- Infected areas
- Bleeding tendencies (hemophilia, acute trauma, long term steroid therapy)
- Pregnancy (applied to torso)
- Diminished consciousness
- Unreliable situations – environment or social situation
- Open wounds (hydrocollator packs and paraffin)
- Application over liniments or heat rubs
- Extensive scar area
- Thrombophlebitis (blood clot)
- Over topical ointments or creams

D. Precautions: Heating Modalities

- Bony Prominence
- Mild impairments in sensation (i.e. reduced temp sensation with aging)
- Reduced mobility
- Lying on the hot pack * see guidelines
- Reduced tolerance to heat
- Comorbid conditions (CVD, diabetes)
- Metal in the area
- Edema
- Over an open wound
- Demyelinating nerves
- Pregnancy (other than torso areas)

E. Superficial Heating Applications

1) Hydrocollator Packs (Hot Packs)
   a. Hydrocollator Unit
      Thermostatically controlled unit with a water temperature of 158°F – 167°F (70°C – 75°C). Water temperature should be checked prior to treatment. Maintenance: Hydrocollator units should be drained, scrubbed and refilled on a regular basis.
   b. Hydrocollator Packs - heat transfer via conduction
      This involves the application of moist heat using commercial packs. The packs have a canvas or nylon cases and are filled with hydrophilic silicate (bentonite) or sand. They come in a variety of shapes and sizes to accommodate different body parts. Maintenance: Inspect the packs. Packs with tears or leaks should be discarded.
c. Hot Pack Covers
A minimum thickness equivalent to 6-8 layers of terry towels is required between the hot pack and the skin, and more layers when the patient is lying on the pack. The number of layers may vary depending on the thickness of the towels or hot pack covers. A greater thickness in towels is necessary in areas of bony prominence(s). Extra padding for the entire area will be needed for thinner patients or in body regions with less soft tissue.

2) Paraffin Wax Application - heat transfer via conduction
a. Paraffin was has a low melting point of 129°F (54°C). The melting point is lowered by adding mineral oil so that the wax remains molten between 113-129°F (45-54°C). The ideal treatment temperature is 125-127°F. The therapeutic temperature range for paraffin is 118-135°F (48-55°C).

b. Paraffin has a lower specific heat and conducts heat more slowly than water at the same temperature. Commercially available paraffin mixture is 6-7 parts of paraffin to 1 part mineral oil. The paraffin mixture is melted and stored in thermostatically controlled containers. The paraffin wax treatment is most commonly used for distal extremities.

c. Paraffin Application Methods
1. Dip and Wrap Method
The body part to be dipped should be held in a comfortable position, in which the patient can avoid movement of the joints. When dipping the hand, the fingers should be held apart. Dip the extremity and then remove it from the bath. Hold the limb over the bath as the layer partially dries. Avoid moving the joints while letting the paraffin "cloud over". Repeat this dipping procedure 8-10 times. Immediately place the dipped extremity in a plastic bag and then wrap it with several layers of towels. With the patient in a comfortable position, support the extremity in an elevated position for 15-20 minutes.

2. Immersion Bath Method
The body part to be dipped should be held in a comfortable position, in which the patient can avoid movement of the joints. The limb will stay immersed for 15-20 minutes. When immersed, the fingers should be held apart. Immerse the body part in the paraffin bath and instruct the patient to avoid movement and avoid touching the bottom. Layers of solid paraffin will build-up because skin temperature is lower than paraffin.
   • The temperature feels very hot and will not be tolerated by all patients.
   • The extremity is in a dependent position and, therefore, may increase edema.

3. Dip Immersion Method
The body part to be dipped should be held in a comfortable position, in which the patient can avoid movement of the joints. When dipping the hand, the fingers should be held apart. Dip the extremity and then remove it from the bath. Hold the limb over the bath as the layer partially hardening. Avoid moving the joints while letting the paraffin "cloud over". Repeat this dipping procedure 2-3 times. Then immerse in the bath for 15-20 minutes.
   • The hardened layer provides some insulation
• The extremity is in a dependent position and may increase edema.

4. Pour and Paint Method or Gauze dipped in paraffin
The pour or paint methods are used when the areas cannot be dipped (i.e. Shoulder or elbow) or when it is unsanitary to dip (i.e. rash). The body part should be held in a comfortable position, in which the patient can avoid movement of the joints. Pour or paint paraffin onto the skin and allow partial hardening. Then repeat layering 8-10 times. Another option is to wrap dipped gauze on the skin. Wrap in a plastic bag, followed by several layers of towels. With the patient in a comfortable position, support the extremity in an elevated position for 15-20 minutes.

5. Wrap and Dip Method
This method can be used to provide a sustained stretch during the paraffin treatment. To facilitate increased finger flexion, use Coban, paper tape or Microfoam tape to position the finger in comfortable passive flexion. To improve finger extension, tape a tongue blade to the dorsal finger/hand to hold the finger in extension. Dip the hand as described for the dip and wrap method and support the extremity in an elevated position for 15-20 minutes.

3) Fluidotherapy
a. Dry heat modality - circulation air and
b. Heat transfer via conduction and convection
b. Used for extremities
c. Temperature: 110°-125°F (43°-53°C)
d. Duration: 15-20 minutes

4) Hydrotherapy
a. Forces Existing in Water
   1. Buoyancy
      Archimedes' principle of buoyancy – a body immersed in a liquid experiences an upward force equal to the weight of the displaced liquid.
      Assists with exercise
      Reduces stress on joints and muscles
   2. Pressure
      Water provides resistance for exercise
      Hydrostatic pressure increases with depth
   3. Cohesion and Viscosity
      Water molecules are cohesive → greater viscosity of water than air.
      Increased resistance to body movement
b. Methods of Heat Transfer
   1. Conduction - via direct contact
   2. Convection - via movement of warm water (hydrotherapy) or air (fluidotherapy)
   3. Radiation - Dissipation of heat through radiation
   4. Evaporation - Sweating & respiration
      • Greater body surface immersion reduces evaporation and heat dissipation
      • Room temperature and humidity affect evaporation and heat dissipation
c. Hydrotherapy Equipment
   1. Turbine - Water pump which regulates the movement of water and air
      Turbulence = aeration + agitation. Adjustable height and direction of pressure
2. Tanks: Extremity Tanks, Low Boy, High Boy, Hubbard Tank
3. Pulsed Lavage

d. Hydrotherapy Water Temperatures

*Water Temperature – Common Ranges:*

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Fahrenheit</th>
<th>Celsius</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Hot</td>
<td>104.0 - 110°F</td>
<td>40.0 - 43.5°C</td>
</tr>
<tr>
<td>Hot</td>
<td>99.0 - 104°F</td>
<td>37.0 - 40.0°C</td>
</tr>
<tr>
<td>Warm</td>
<td>96.0 - 99°F</td>
<td>33.5 - 35.5°C</td>
</tr>
<tr>
<td>Neutral</td>
<td>92.0 - 96°F</td>
<td>33.5 - 35.5°C</td>
</tr>
</tbody>
</table>

*Recommended Temperatures Depending on Body Region*

<table>
<thead>
<tr>
<th>Body Region</th>
<th>Temperature F</th>
<th>Temperature C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand or Arm</td>
<td>98 – 110° F</td>
<td>37 – 45°C</td>
</tr>
<tr>
<td>Foot/ankle</td>
<td>98 – 110° F</td>
<td>37 – 45°C</td>
</tr>
<tr>
<td>Full leg/large area</td>
<td>98 – 104° F</td>
<td>37 - 40° C</td>
</tr>
<tr>
<td>Full Body</td>
<td>98 – 102° F</td>
<td>37 - 39° C</td>
</tr>
</tbody>
</table>

e. Biophysical Effects of Hydrotherapy

*Thermal Effects:*
- Initial increase in BP, followed by decreased BP
- Increased respiratory rate
- Increased perspiration
- Promotion of muscle relaxation
- Decreased pain and stiffness
- Increased superficial blood flow (vasodilation)
- Increased capillary pressure and cell permeability (hydrostatic pressure)

*Mechanical (Nonthermal) Effects of Agitation:*
- Mechanical stimulation of skin receptors
- Mechanical debridement of wounds

f. Hydrotherapy: Contraindications and Precautions

*Contraindications: Hydrotherapy*
- Acute inflammatory condition
- Cardiac instability
- Hypertension
- Severe hypotension
- Respiratory instability
- Malignancy
- Active bleeding

*Precautions: Hydrotherapy*
- Over heating
- Peripheral vascular disease – lower water temperature (max 99°F/ 37°C)
- Low blood pressure
- Patient confusion
- Instability during transfers
- Obesity
- Exceeds weight limit of lift
- Monitor for over heating
III. Therapeutic Ultrasound

A. Indications for Ultrasound
   • Soft tissue healing and repair (non-thermal US during acute phases)
   • Increase tissue extensibility - collagen - (maturation phase of healing)
   • Scar tissue
   • Joint contracture
   • Pain modulation
   • Muscle spasm
   • Plantar warts
   • myofascial trigger points

B. Contraindications: Ultrasound
   • All contraindications to heat application **Impaired sensation is an absolute contraindication for ultrasound application.**
   • Over growth plates (epiphyseal plates) in children & adolescence
   • Malignant tumor
   • Pregnancy
   • Over CNS tissue
   • Over joint cement and plastic components (joint replacement)
   • Pacemaker (area around pacemaker)
   • Thrombophlebitis
   • Over the eyes
   • Over reproductive organs

C. Precautions: Ultrasound
   a. Acute inflammation
   b. Fractures
   c. Breast implants

D. Application Considerations for Therapeutic Ultrasound
   a. Parameter Selection; Frequency and duty cycle
      1. ERA of the US transducer – selected according to the surface area to be treated.
      2. Size of the area to be treated – treatment area of 2x the ERA
      3. Conduction Medium – selected according to the contour of the body region and the activity during the US treatment (i.e. under water may be better for stretch or ROM exercises during treatment).
      4. Frequency – selected according to the depth of tissue to be treated.
         (1) 1 MHz for tissue up to 5 cm deep
         (2) 3 MHz for tissue 1-3 cm deep
      5. Duty cycle – selected according to the treatment goal
(1) 100% (continuous) when the goal is to increase tissue temperature.
(2) ≤ 20% when the goal is to minimize tissue heating, but introduce mechanical effects of US.
(3) 50% when the goal is mild heating and mechanical effects of ultrasound.

6. **Intensity** – Calculate the spatial average temporal average (SATA) intensity to determine the amount of energy being delivered to the tissue. Spatial average temporal peak (SATP) intensity x duty cycle = SATA

   Example: 20% duty cycle: 1.0 W/cm² x .20 = 0.2 W/cm² SATA
   100 % duty cycle: 1.0 W/cm² x 1.0  = 1.0 W/cm² SATA

7. **Duration** - selected according the size of the treatment area and the ERA of the sound head.
   (1) Treatment time/treatment area (2x ERA)
     • If treatment area = 20 cm² & ERA = 10 cm → treatment duration should be 5-10 minutes.
     • If treatment area = 40 cm² & ERA = 10 cm sq → treatment duration should be 10-20 minutes.

8. Determining Ultrasound Dosage * US Intensity ≠ US Dosage*

   **Exposure Factors:**
   • Power output of US beam
   • Effective Radiating Area (ERA) of the crystal
   • US Frequency
   • Duration of Exposure
   • Surface area of exposure (size of treatment field)
   • Tissue Depth

E. Ultrasound Application Methods

1. **Direct Contact Method**
   a. **Conditions** needed for the direct contact method:
      • The contour of the body part must allow for total contact of the sound head.
      • The skin must be able to tolerate pressure from the sound head.
      • The skin must be intact.
      • Continuous movement of the sound head
   b. **Procedure**:
      • Select the appropriate sound head for the treatment (frequency and/or size).
      • Ensure appropriate positioning and draping of the patient.
      • Apply conductive gel to the skin over the treatment area.
      • It is important to maintain good contact.
      • Continuous movement of the sound head for the duration of the treatment.
      • Do not remove the sound head until the intensity is zero. Air is a poor conductor of ultrasound waves and will damage the crystal.
2. **Immersion Method (water bath) for Ultrasound Application**
   
a. **Conditions:** Immersion method is useful when treating small, irregular surfaces such as joints of the hand or feet. It is also indicated for areas which may be too sensitive to touch or with broken skin.

b. **Procedure:** Fill a bucket with warm water and let it stand, so that the air bubbles will not settle on the patient. Air bubbles may interfere with US transmission and cause spotty energy distribution. Place the hand or foot in the bucket. Immerse the sound head in the water (intensity = zero). Position the sound head perpendicular to the treatment area with surface 0.5”-1.0” from the skin. Continuously move the sound head, maintaining a constant distance from the skin and a perpendicular sound head orientation. While constantly moving the sound head, slowly increase the intensity. When finished, turn the intensity to zero before stopping the sound head movement or removing it from the water.

3. **Fluid-filled Bag Method for Ultrasound Application**

   This is an alternative to the immersion method for irregular surfaces. It may be useful for proximal, irregular surfaces such as bony aspects of the scapulae or shoulders. This method requires a thin-membrane bag, such as a surgical glove, and a coupling medium (inside the bag). Degassed water, mineral oil or glycerin is recommended as coupling agents. Tap water is not recommended due to air bubbles, which form in the bag. Remove air bubbles and make sure there is full contact between the sound head and fluid. Apply the bag to the treatment area. If possible apply some coupling medium (same as in the bag) to the skin. With the bag in full contact with the skin, move the sound head within the bag as the intensity is increased. Maintain constant movement and a perpendicular sound head orientation throughout the treatment.

IV. **Diathermy - Shortwave and Microwave**

   A. **Description** - Produces thermal (deep heating) and non-thermal effects on body tissues from high-frequency electromagnetic energy.

   B. **Current use:** Use in the United States has declined significantly over the last 2 decades. Now, used infrequently.

   C. **Contraindications:**
      - Impaired sensation
      - Metal Implants
      - Pacemaker
      - Intrauterine devices
      - Any metal on the body - watches, jewelry, zippers
      - Over Eyes
      - Contact lenses
      - Pregnancy
      - Over fluid filled organs
Over testes
Over pelvic region during menstruation
Acute inflammation
Areas of ischemia
Malignancies
Infection
Over growth plates in children

V. Therapeutic Electrical Stimulation
A. Indications for Electrical Stimulation
- Pain modulation
- Acute tissue inflammation
- Edema control
- Transcutaneous medication delivery
- Tissue healing (e.g. wound care)
- Neuromuscular re-education
- Muscle strength & endurance training
- Functional electrical stimulation

B. Contraindications: Electrical Stimulation
- Indwelling cardiac catheters
- Demand pacemakers
- Electrode placement across the axis of the heart
- Stimulation over the anterior chest and neck
- H/O cardiac arrhythmia, congestive heart failure, or recent MI
- Pregnancy – torso
- Deep vein thrombosis (DVT)
- In the region of neoplasm or infection
- Electrical stimulation should not be used in close proximity to diathermy devices
- **Contraindications for wound care**
  - Osteomyelitis
  - Should not be applied to a wound containing neoplastic cells
  - When topical substances containing metal ions, such as providone-iodine and mercurochrome are used in the wound for bacteriostatic effects, all residue should be flushed from the wound.
  - Electrical stimulation to open wound: the maximum total (average) current delivered should be ≤ 1 mA.
    - For high voltage pulsed current: do not exceed 200V
    - For direct current (DC): do not exceed 1 mA
C. Precautions: Electrical Stimulation

- Patients unable to provide clear feedback
- Individuals prone to seizures
- Hypertension or hypotension
- Automatic dysreflexia
- Avoid electrode placement near surgical staples or external fixation devices
- Fragile skin, abrasions, scar tissue
- Areas with large amount of adipose tissue
- Reflex sympathetic dystrophy (RSD)
- Lack of sensation
- Limited physical tolerance or psychological acceptance
- Direct current: chemical burn risk (alkaline or acidic reaction)

D. Electrotherapy for Pain Modulation

a. Pain Modulation Theories
   1. Gate Control Theory (Large Ascending Fiber Stimulation)
   2. Opiate Pain Modulation Theory (Beta-endorphin & Enkephelins)
   3. Central Biasing Theory (High Intensity)

b. Waveforms for Pain Modulation
   1. Pulsed Currents
      a. Pulsed Biphasic (Low Voltage Stimulators) – i.e. TENS
      b. Pulsed Monophasic (High Voltage Pulsed Current)
   2. Medium Frequency Currents
      a. Interferential Current (IFC)
      b. Pre-modulated

c. Modes of Stimulation
   1. Subsensory-Level Stimulation (Microcurrent)
      - Minimal research supporting electrical stimulation at sub-sensory levels
      - Microcurrent stimulators are low-intensity with a peak amplitude of 1mA.

   2. Sensory-Level Stimulation (usually high frequency)
      Phase duration: 2-50 usec
      Frequency: 50-100 pps
      Current amplitude: Sensory level, below motor threshold
      Duration of treatment: 20-30 min
      Duration of Analgesia: Short lasting - primarily during treatment

   3. Motor-Level Stimulation (usually low frequency)
      Phase duration: >150 usec
      Frequency: 2-4 pps
      Current Amplitude: Motor level, twitch - just above motor threshold
      Duration of treatment: 30-45 min
      Duration of analgesia: Longer lasting - hours
4. **Noxious-Level Stimulation**  
*Parameters:*  
- **Phase duration:** < 1 msec, or up to 0.5 sec  
- **Frequency:** 1-5 pps, or >100 pps  
- **Current Amplitude:** Noxious sensory stim, below motor threshold  
- **Duration of treatment:** Brief - seconds to minutes  
- **Duration of analgesia:** Longer lasting – hours

E. **Electrical Stimulation for Wound Healing and Edema Control**  
   a. **Tissue Healing Theories**  
      1. **Acute inflammatory phase:**  
         - Negative polarity may repel negatively charged cells and proteins from the area.  
         - Evidence from animal studies shows that HVPC reduces microleakage of proteins and blood cells into the interstitial fluid
      2. **Fibroblastic & maturation phase** - muscle pumping
   
   b. **Waveforms for Tissue Healing & Edema Control**  
      1. Pulsed Monophasic - High Voltage Pulsed Current (HVPC) - tissue healing  
      2. Low Intensity Direct Current (LIDC) - tissue healing  
      3. Pulsed Biphasic (Low Voltage Stimulators) - for muscle pumping
   
   c. **Parameters for Stimulation**  
      1. **Polarity** (HVPC and LIDC):  
         - Cathodal stimulation (*negative polarity*) for bactericidal effects.  
         - Anodal stimulation (*positive polarity*) facilitates tissue migration, particularly in the proliferative stage of healing.  
      2. **Frequency:**  
         - Acute inflammatory phase: 50-120 pps (intensity sub-motor threshold)  
         - Fibroblastic & maturation phase for muscle pumping: 20-50 pps (intensity to motor threshold) to produce muscle contraction
   
      3. **Intensity (Sensory vs. Motor-level response):**  
         - Acute inflammatory phase: Sensory (sub-motor threshold)  
         - Fibroblastic & maturation phase: Senory or motor level stimulation depending on goal. To patient tolerance.
   
      4. **Amplitude for open wounds:** Maximum of 100-200 V (0.5-1.0 mA).
   
      5. **Electrode placement:**  
         - Active electrode directly over tissue injury or wound (electrode wrapped in sterile, saline-soaked gauze for open wound).  
         - Dispersive electrode placed proximally (when practical).
F. Neuromuscular Electrical Stimulation (NMES)

a. Indications for NMES
   • Reduced muscle force production
   • Reduced muscle endurance
   • Limited AROM due to weakness
   • Impaired motor control
   • Muscle atrophy following periods of inactivity (e.g. immobilization)

b. Contraindications for NMES - see contraindications for electrical stimulation

c. Precautions for NMES - see precautions for electrical stimulation

d. NMES Applications:
   • Endurance training for muscle weakness and atrophy
   • Power training for muscle weakness
   • Endurance combined with power training
   • Muscle re-education and facilitation
   • Increasing joint range of motion
   • Spasticity management
   • Contracture reduction (increasing joint range of motion)
   • Functional electrical stimulation (FES)
   • Neuroprosthesis or orthotic substitution

f. NMES Waveforms for intact lower motor neuron:
   1. Pulsed Biphasic (PC)
   2. Medium Frequency Currents - Russian Current
      * NMES waveform for lower motor neuron injury (denervated muscle) - must use
direct current (DC). Denervated muscle will not responded to a pulsed or medium
frequncy currents.

h. Parameters for NMES (PC or med. freq currents):
   1. Electrode placement: Muscle belly, utilize motor points when possibe
   2. Waveform: Pulsed Biphasic (Symmetrical) Current or Russian Current

   3. Duty Cycle (on/off cycle) - Depends on activity (training vs. functional)
      * Shorter off time -> less recovery -> faster fatigue
      * For functional training - set to timing of activity
   4. Ramp Time: Most comon - 2 sec, longer ramp for pain or spasticity.
   5. Pulse Rate: 25 pps - 90 pps, depending on stage of healing and goal.
      * Higher pulse rate -> faster fatigue
   6. Amplitude: Fair+ contraction to 50% max Voluntary Isometric
      Contraction (MVIC), depending on stage of healing and goal.
   7. Duration: Progress 10 → 60 min/day
• Initial session: # repetitions = 10-20 Reps
• Stop session if:
  1. Patient has pain or fatigue
  2. < 50 % of initial force is produced
  3. Significant reduction in ROM
  4. Significant reduction in muscle contraction intensity
• Number of Sessions: Depends on strength and endurance of the patient. Short sessions for severe to moderate atrophy: 2-4 sessions. Longer sessions for minimal to no atrophy: 1-2 sessions/day for 30-60 min.

VI. Mechanical Traction
   A. Indications for Traction
       • Nerve Root Impingement
       • HNP with disc protrusion
       • Degenerative Disc
       • Narrowing of intervertebral foramen
       • DJD and Osteophyte formation
       • Joint hypomobility (with soft tissue stiffness)
       • Facet impingement
       • Discogenic pain
       • Muscle spasm or guarding

   B. Contraindications: Traction
       • Acute Sprains or Strains
       • Acute inflammation
       • Fractures
       • Recent spinal fusion (one year or less)
       • Spinal ligamentous instability
       • Vertebral artery instability (or adverse vertebral A. test signs)
       • Bone disease secondary to tumor or infection
       • Osteoporosis
       • Vascular compromise
       • Hiatal hernia
       • Pregnancy
       • Cardiac or pulmonary problems

   C. Assessment and Treatment Progression for Traction
       a. Assess response to traction – prior to applying mechanical traction apply manual traction to the patient’s response.
b. Assessment of force and duration of treatment
   i. Starting force:
      • Cervical ≤15-20 lbs.
      • Lumber ≤ less than 30 lbs or ¼ body weight
   ii. Duration & force based on response to initial traction (during assessment)

c. Progression of treatment dose
   i. Generally speaking, increase the duration of treatment prior to increasing force.
   ii. Assess response to traction during and after the treatment
      • Symptom relief with traction after first session → increase time to 10-15 minutes without increasing force.
      • Once 15-20 minutes is tolerated and producing symptoms relief → increase force (not duration) gradually over time (up to 50% body weight for lumbar traction)
   iii. Frequency of treatment – Depends on symptoms and length of symptom relief.
      • Daily symptoms that are relieved with traction: treat daily (home unit).
      • As symptoms become more intermittent – reduce the frequency of the traction treatment to 3x/week.

D. Mechanical Traction Lumbosacral Region
   a. Considerations:
      • Body position
      • Force
      • Intermittent vs static
      • Duration

   b. Body position:
      • Neutral spine allows most opening of foramen; may be best for unloading segmental nerve in arthritis, facet irritation, foraminal narrowing and often for discs.
      • Flexion puts stress on ligamentum flavum and can narrow opening of foramen
      • Extension closes foraminal area; for some disc bulges where position of comfort is extension this may be an effective position for traction. However, for foraminal entrapment of nerves this would probably aggravate the symptoms.

   c. Force:
      • First treatment: force should not exceed 25% patient’s body weight.
• **Subsequent treatment session** - can gradually increase force up to a maximum of 50% patient's body weight. Progression is based on patient tolerance and symptom relief.

• **Response to traction:** should be symptom reduction and centralization. Stop the treatment and re-evaluate if symptoms increase in the patient’s extremities (peripheralize).

**d. Intermittent vs. Static Traction:**

• Most other applications can be done intermittently as higher forces can be used more comfortably.

• In all cases patients comfort is most important as they are better able to relax. There is no definitive evidence supporting one technique over the other.

**E. Mechanical Traction Cervical Region:**

**a. Considerations:**

• Body position
• Force
• Intermittent vs static
• Duration

**b. Position:** supine - mechanical traction with head cradle

(Home traction units can be used in supine with pneumatic pump action)

**c. Force:** start with less 20 lbs.

**d. Intermittent or Static:** (often based on patient preference)

Intermittent: 7-10 seconds on, brief rest.

Static: constant

**e. Duration:** start with 10 minutes and evaluate the patient’s response. Gradually progress to 20 minutes over several sessions. In general, increase duration before increasing force.

**f. Other considerations:**

• May combine traction with superficial heat for muscle relaxation before or during traction.

• Older cervical traction units with a head harness & chinstrap are still used. These units are portable and inexpensive. These units have a disadvantage of putting pressure on the TMJ.
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