Therapeutic Ultrasound – Are Textbook Parameters One Size Fits All?

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MS in Advanced AT PD
Objectives:

- Describe the evolution and research support for therapeutic ultrasound textbook parameters.
- Explain the differences in heating rates among a variety of therapeutic ultrasound brands.
- Explain the support for clinical use of ERA, transducer speeds, and frequency.
- Evaluate one’s own clinical parameters and compare them to the evidence discussed.
- Formulate a plan to change current clinical parameters based on the evidence.
History of Sound

- Therapeutic ultrasound has been used for over 60 years, however, the use of soundwaves in medicine has been around for nearly 100 years.

- One of the first studies on sound used in medicine was by Wood & Loomis¹ in 1927. They examined the physical & biological effects of ultrasonic waves at higher frequencies.

- In 1938, Pohlman et al.² demonstrated “therapeutic” effects of ultrasonic waves in human tissues and incorporated it into his everyday medical practice.
History of Sound

- Deforest et al.\(^3\) were one of the first to examine ultrasonic waves and its effects on growing bone in 1953.

- Justus Lehmann published several articles from 1954-1978 examining therapeutic ultrasound.
  - In 1967, he published one of the first articles examining heating rates using 1 MHz US.\(^4\)
  - In 1978, Ter Haar\(^5\) used theoretical models and produced the 0.8°C increase per minute for 1 MHz US.
Understanding Soundwaves
History of Sound

- Draper et al.\textsuperscript{6} performed the first known in vivo study in 1995 using 3 MHz ultrasound.

- Using data from Lehmann et al.\textsuperscript{4} and ter Haar\textsuperscript{5}, and his own research with the Omnisound 3000\textsuperscript{™}, Dr. David Draper established heating rates for 1 MHz and 3 MHz ultrasound that we commonly see in textbooks. \textsuperscript{7–9}
History of Sound

1927
One of the first published studies using ultrasonic waves

1938
First study to show “therapeutic” effects of ultrasonic waves

1953
Ultrasonic waves and their effects on growing bone were examined

1967
First heating rates of 1 MHz US published

1978
Theoretical heating rates introduced

1995
1 MHz and 3 MHz heating rates determined by study on human subjects

2017
?????
Treatment Temperature Goals

- Every US treatment should be performed with a goal in mind. These goals should be tissue temperature dependent.

- One researcher suggests tissues must be raised to 40-45°C for a minimum of 5 minutes to achieve physiological effects.¹⁰
Specific Treatment Temperature Goals

- Other guidelines are more specific, explaining what each degree of tissue temperature increase achieves physiologically. \(^{6-9}\)

- Mild heating = 1°C ↑ of Tissue Temp.
- Moderate heating = 2°- 3°C ↑ of Tissue Temp.
- Vigorous heating = 4°C ↑ of Tissue Temp.
Specific Treatment Temperature Goals

- 1°C tissue temperature increase (Mild heating) $^{6-9}$
  - Increase metabolic rate
  - Reduces mild inflammation
  - Treats hematomas
Specific Treatment
Temperature Goals

- **2 - 3°C tissue temperature increase** (Moderate heating) $^6_{-9}$
  - Reduce pain
  - Reduce muscle spasm
  - Reduce chronic inflammation
  - Increase blood flow
  - Treats trigger points
Specific Treatment
Temperature Goals

- 4°C tissue temperature increase (Vigorous heating)⁶⁻⁹
  - Increases tissue extensibility*
  - Scar tissue reduction*
  - Inhibits sympathetic activity

* Much more effective with IMMEDIATE stretch or mobilization (Stretching window)
Heating Rates

- In order to reach these specific tissue temperature goals we must know the correct heating rates of each US machine.
Heating Rates

- Textbook recommendations chart showing heating rates per minute\(^{7-9}\)

<table>
<thead>
<tr>
<th>Intensity</th>
<th>1 MHz</th>
<th>3 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.04°C</td>
<td>0.3°C</td>
</tr>
<tr>
<td>1.0</td>
<td>0.2°C</td>
<td>0.6°C</td>
</tr>
<tr>
<td>1.5</td>
<td>0.3°C</td>
<td>0.9°C</td>
</tr>
<tr>
<td>2.0</td>
<td>0.4°C</td>
<td>1.4°C</td>
</tr>
</tbody>
</table>
Heat Decay
(Dr. Draper’s Stretching Window)

• Not only do we have to be concerned of our tissue temperature increases, we also need to be concerned how quickly that heat leaves the target area after the US treatment is complete.

• The “stretching window” is defined as the period of vigorous heating when tissues will undergo the greatest extensibility and elongation.¹¹
# Heat Decay

## (Dr. Draper’s Stretching Window)

<table>
<thead>
<tr>
<th>Degrees lost</th>
<th>1 MHz, 2.5 cm deep (minutes)¹²</th>
<th>1 MHz, 5 cm deep (minutes)¹²</th>
<th>3 MHz, 1.2 cm deep (minutes)¹¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1°C Decrease</td>
<td>2:45</td>
<td>2:31</td>
<td>1:20</td>
</tr>
<tr>
<td>2°C Decrease</td>
<td>6:35</td>
<td>6:50</td>
<td>3:22</td>
</tr>
<tr>
<td>3°C Decrease</td>
<td>12:10</td>
<td>14:32</td>
<td>5:50</td>
</tr>
<tr>
<td>4°C Decrease</td>
<td>21:14</td>
<td>27:49</td>
<td>9:13</td>
</tr>
<tr>
<td>5°C Decrease</td>
<td>NA</td>
<td>NA</td>
<td>14:55</td>
</tr>
<tr>
<td>Back to Baseline</td>
<td>21:14</td>
<td>27:49</td>
<td>18:00</td>
</tr>
</tbody>
</table>

¹² Data from [source](#)

## NDSU NORTH DAKOTA STATE UNIVERSITY
Optimal Time after US Treatment for Stretching/Mobilizations

- $5^\circ C \uparrow 3 \text{ MHz US} = \sim 3.3 \text{ minutes}^{11}$

- $4^\circ C \uparrow 3 \text{ MHz US} = \text{less than 2 minutes}^{11}$

- $4^\circ C \uparrow 1 \text{ MHz US} = \sim 5 \text{ minutes}^{12}$
Variation in US Machines

- The FDA currently has no regulatory guidelines on the spatial average intensity (SAI) setting, however, it does regulate the accuracy of the timer and the total displayed power vs actual energy produce, but they permit a ±20% error band on both!
Variation in US Machines

- Several studies have been done comparing US machine brands and heating rates.\(^{13-15}\)

- One study compared the 3 different Omnisound 3000’s and compared the heating rates.\(^{16}\)
Variation in US Machines

• Holcomb et al.¹³ compared the Omnisound 3000 to the Forte 400 combo ultrasound machine.
  – 3MHz at 1.0 W/cm² for 10 minutes.
    Thermocouples were at a 1.2 cm depth
  – The Omnisound’s heating rate = ~0.58 °C/min
  – The Forte 400’s heating rate = ~0.39 °C/min
Variation in US Machines

- Merrick et al. examined heating rates amongst the Omnisound 3000C, Dynatron 950 and Excel Ultra III ultrasound machines.
  - 3MHz at 1.5 W/cm² for 10 minutes. Thermocouples were at a 1.6 cm depth
    - The Omnisound’s heating rate = ~1.0 °C/min
    - The Dynatron 950’s heating rate = ~0.4 °C/min
    - The Excel Ultra III’s heating rate = ~0.41 °C/min
Variation in US Machines

• Demchak et al.\textsuperscript{16} researched heating rates amongst 3 different Omnisound 3000 ultrasound machines.
  
  – 1MHz at 1.2 W/cm\textsuperscript{2} for 10 minutes.
  
  Thermocouples were at a 3 cm depth
  • Omnisound A’s heating rate = \( \approx 0.32 \) C\degree/min*
  • Omnisound B’s heating rate = \( \approx 0.31 \) C\degree/min*
  • Omnisound C’s heating rate = \( \approx 0.5 \) C\degree/min*

*Averages at the greatest tissue temperature increase
Frequency

1. Textbook Recommendations
4. Franson (2013)**
1 MHz – crystal deforms 1 million times/sec
3 MHz – crystal deforms 3 million times/sec
1. Textbook Recommendations

- **3 MHz**: up to 2.5-3 cm
- **1 MHz**: up to 5 cm

- **3 MHz**: up to 1-2 cm
- **1 MHz**: up to 2-5 cm

- **3 MHz**: up to 2.5 cm
- **1 MHz**: 2-5 cm
2. Draper et al. (1995)
Rate of Temperature Increase in Human Muscle During 1 MHz and 3 MHz

• 1st in vivo study with 3 MHz

• 24 subjects; 12 in each group

• Omnisound 3000
  – ERA = 4.1 cm²
  – BNR = 1.8:1
• **Procedures:**
  - Left medial triceps surae muscle
  - **Depths:**
    - 3 MHz = 0.8 cm and 1.6 cm
    - 1 MHz = 2.5 cm and 5 cm
  - **Template:**
    - 2x ERA
  - **4 US Rx:** random order
    - 0.5, 1.0, 1.5, 2.0 W/cm²
  - **Time = 10 min**
• No significant differences between:
  – 0.8 and 1.6cm
  – 2.5 and 5 cm

• 3 MHz depth penetration = >1.6 cm
• 1 MHz depth penetration = 2.5-5 cm

• Which frequency for medium-depth tissues?
• Absolute tissue temps vs above baseline
  – time to reach 40°C vs 4°C above baseline

Rich-Mar Theratouch 7.7:
• 5 cm² transducer
• ERA reported as 5 cm²
• BNR = 5.5:1
**Procedures:**
- 18 subjects
- 1 MHz, 3 MHz, and Sham
- 1.5 W/cm$^2 \times 10$ min
- 2.5 cm depth
- Template 2x transducer
- Speed 3-4 cm/s (metronome)
• 1 MHz Rx:
  – Didn’t heat to \( \geq 4^\circ C \) or \( 40^\circ C \)

<table>
<thead>
<tr>
<th>Treatment*</th>
<th>Baseline</th>
<th>End Treatment†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 MHz</td>
<td>35.3 ± 0.4</td>
<td>36.6 ± 0.3</td>
</tr>
<tr>
<td>3 MHz</td>
<td>35.5 ± 0.4</td>
<td>40.0 ± 0.0</td>
</tr>
<tr>
<td>Control (sham)</td>
<td>35.6 ± 0.4</td>
<td>34.8 ± 0.3</td>
</tr>
</tbody>
</table>

• 3 MHz Rx:
  – All Rx were DC before 10 min
  – \( 4^\circ C \) increase = \( 3.35 \pm 1.23 \) min
  – \( 40^\circ C \) = \( 4.13 \pm 1.69 \) min
    • Rate = \( 1.19^\circ C/\text{min} \) @ 2.5 cm
• 3 MHz deeper than thought:
  – Double $\frac{1}{2}$-value layer thought to be limit of temp increase
    • 1.6 cm

• 4°C vs 40°C rate:
  – Difference of 39 seconds
    • Sig difference

• More research needed to see if 3 MHz more appropriate than 1 MHz for 2.5 cm depths
  – Determine max depth for 3 MHz
4. Franson et al. (2013)

- Based on Hayes et al results:
  - 3 MHz penetrate to 3.0 cm and 3.5 cm
  - 20 subjects
    - 15 US; 5 Sham

- Omnisound
  - 5cm\(^2\) transducer
  - ERA = 4.2 cm
  - BNR = 3:1

- 3 MHz @ 1.4 W/cm\(^2\)
- 8 minutes
- Depths:
  - 3 cm
  - 3.5 cm
• 3 cm depth = 4.4°C ± 0.9° (vigorous)
• 3.5 cm depth = 3.5°C ± 1.2° (moderate)

1 MHz:
• 2.5 – 5cm?

3 MHz:
• Up to 3cm?
• ½ value depth: 1.5cm
Intensity

1. Textbook Recommendations
2. Draper et al. (1995)
Spatial Average Intensity (SAI)

- SAI:
  - Rate of energy delivered per unit of area
  - Watts/ERA = W/cm$^2$

- Intensities:
  - >10 W/cm$^2$ = surgically destroy tissue
  - Up to 3 W/cm$^2$ = safe for therapeutic Rx
  - <0.1 W/cm$^2$ = for diagnostic purposes
1. Textbook Recommendations

- No Specific Guidelines
- Lowest intensity to achieve desired therapeutic effect
2. Draper et al. (1995)
Rate of Temperature Increase in Human Muscle During 1 MHz and 3 MHz

- 3 MHz & 1 MHz @ various intensities
- 24 subjects; 12 in each group
- Omnisound 3000
  - ERA = 4.1 cm²
  - BNR = 1.8:1
• **Procedures:**
  • Left medial triceps surae muscle

• **Depths:**
  • 3 MHz = 0.8 cm and 1.6 cm
  • 1 MHz = 2.5 cm and 5 cm

• **Template:**
  • 2x ERA

• 4 US Rx Intensities: random order
  • 0.5, 1.0, 1.5, 2.0 W/cm\(^2\)

• **Time = 10 min**
1 MHz

- Sig. diff between all intensities
- $1.5 \text{ W/cm}^2$ vs $1.0 \text{ W/cm}^2 =$ heated 100% faster
- $2.0 \text{ W/cm}^2$ vs $1.0 \text{ W/cm}^2 = 2.3x$ faster vs $1.5 \text{ W/cm}^2 = 15\%$ faster
- $0.5 \text{ W/cm}^2 = 25\%$ of $1.0 \text{ W/cm}^2$**

**Figure 7. One-MHz rate of temperature increase at the four doses (2.5 cm).**

**Figure 8. One-MHz rate of temperature increase at the four doses (5.0 cm).**
3 MHz

- Sig differences between all intensities

- 0.5 W/cm² vs 1.0 W/cm² = heated 51%
- 1.5 W/cm² vs 1.0 W/cm² = heated 51% faster
- 2.0 W/cm² vs 1.0 W/cm² = 2.4x faster
  vs 1.5 W/cm² = 43% faster
Take Home Message

• 3 MHz heated 4x faster than 1 MHz
  – @ ½ value depths

• The longer the treatment, the higher the temp
• The higher the intensity, the greater the temp increase

• Not all temps met predictions = methodology?

- Examine 1 MHz and intensity levels
- 19 subjects

- **Rich-Mar Theratouch 7.7:**
  - 5 cm² transducer
  - ERA reported as 4.5 cm²
  - BNR = 5.5:1
• **Procedures:**
  – 1 MHz; 10 min
  – 0.5, 1.0, 1.5, and 2.0 W/cm$^2$
  – Thermocouple depth = 4 cm
  – 2x ERA template
  – 4 cm/sec (metronome)

  – 5 treatments discontinued due to pain
• Sig. difference between 1.0 W/cm$^2$ and 2.0 W/cm$^2$

• 2.0 W/cm$^2$ heated less than 1.0 W/cm$^2$
Possible Explanations

• Theratouch BNR = 5.5:1

• Not an Omnisound

• FDA Regulation of US machines

• 1.0 W/cm² heated 1.9°C in 10 min
  – 2.0 increased 0.7°C
"You're not allowed to use the sprinkler system to keep your audience awake."
Transducer Velocity & ERA

1. Textbook Recommendations
1. Textbook Recommendations

- Move slowly
- 4 cm/sec**
- 3-4 cm/sec
Weaver et al. (2006)
Effect of Transducer Velocity on Intramuscular Temperature During a 1-MHz Ultrasound Treatment. *J Ortho Sports PT*,

- Transducer velocity absent from literature
- Textbooks recommend 2-4 cm/sec
  - Clinical velocity = faster

- Examine 3 transducer velocities:
  - 2-3 cm/sec
  - 4-5 cm/sec
  - 7-8 cm/sec
• Procedures:
  – 11 healthy volunteers – received ea. speed
  – 3cm below adipose on medial triceps surae
  – Metronome – traveled 2.4 cm/beat

• Omnisound 3000C
  – ERA = 5 cm²
  – BNR = 2.1:1
  – 1 MHz, 1.5 W/cm², 10 min
  – 2x transducer template
<table>
<thead>
<tr>
<th>Time</th>
<th>2-3 cm/s</th>
<th>4-5 cm/s</th>
<th>7-8 cm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretreatment</td>
<td>37.9 ± 1.0</td>
<td>37.8 ± 0.8</td>
<td>37.7 ± 0.8</td>
</tr>
<tr>
<td>Posttreatment</td>
<td>42.7 ± 2.3</td>
<td>43.0 ± 2.0</td>
<td>43.1 ± 1.4</td>
</tr>
</tbody>
</table>

- No significant differences between speeds
- Unknown if higher velocity w/o template would be similar

*It does NOT matter how fast the transducer is moved, if it remains w/in a set Rx area.*
ERA

- Always smaller than soundhead/transducer plate
1. Textbook Recommendations

- 2-3x ERA
- 2-3x ERA
- 2-3x ERA
Chan et al. (1998)

- 1st study on human tendons
  - Tendon heating rate
  - 2 Rx sizes – 2x, 4x ERA
  - 16 subjects

- Omnisound 3000
  - ERA = 4.5 cm²
  - BNR = 1.8:1
  - 3 MHz, 1.0 W/cm²
Tendon insertion protocol

- Shave and clean area
- Vertical midpoint
  - Imaginary line patellar apex – tibial tuberosity

- Insert thermistor into tendon medially
  - 1cm below apex
  - To vertical midpoint
• Transducer velocity = 2-3 cm/sec
• 4 min Rx
• 20 min cool down
• Switched templates & repeated
• **2 ERA** – increased 8.3 ± 1.7°C
  – Heating rate of 2.1°C/min
  – Reached vigorous heating in 2 min

• **4 ERA** – increased 5.0 ± 1.0°C
  – Heating rate of 1.3°C/min
  – Reached vigorous heating in 3.5 min
• Patellar tendon heats faster than muscle
• 2 ERA heated faster and greater than 4 ERA

• Recommended Rx parameters for patellar tendon:
  – 3 MHz
  – 1.0 W/cm²
  – 2x ERA
  – 4 min
research
[ri-surch, ree-surch], noun
1. what you are doing when you don’t know what you are doing
Research at NDSU

Dynatron Solaris:

3 MHz, 1.0 W/cm²
3 MHz, 1.2 W/cm²
2 MHz, 1.0 W/cm²

Blood flow at 3 MHz, 1.0 W/cm²
Thermocouple Insertion Technique
Dynatron – 3 MHz, 1.0 W/cm²

- 30 healthy college age volunteers
- Parameters:
  - 3 MHz
  - 1.0 W/cm²
  - 20 min
  - 4 cm/sec (w/template)
  - Depths – 1.0, 1.75, and 2.5 cm
# Results

Tissue Temperature Increase to 4 Degrees and Heating Rates

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Baseline Temp (°C)</th>
<th>4°C increase temp (°C)</th>
<th>Δ in °C</th>
<th>Time to 4°C increase</th>
<th>Heating Rate (°C/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>35.82 ± 0.75</td>
<td>40.04 ± 1.54</td>
<td>4.22</td>
<td>6 min</td>
<td>0.70</td>
</tr>
<tr>
<td>1.75</td>
<td>36.04 ± 0.65</td>
<td>39.97 ± 1.87</td>
<td>3.93</td>
<td>10 min</td>
<td>0.39</td>
</tr>
<tr>
<td>2.5</td>
<td>36.03 ± 0.67</td>
<td>39.63 ± 1.87</td>
<td>3.60</td>
<td>&gt;20 min</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Textbook/Draper: rate for 3 MHz at 1.0 W/cm² = 0.6  (7 min)
# Results

## Heating Rates at 10, 15, and 20 min

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Heating Rate at 10 min (°C)</th>
<th>Heating Rate at 15 min (°C)</th>
<th>Heating Rate at 20 min/end (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.55</td>
<td>0.42</td>
<td>0.30</td>
</tr>
<tr>
<td>1.75</td>
<td>0.39</td>
<td>0.32</td>
<td>0.24</td>
</tr>
<tr>
<td>2.5</td>
<td>0.22</td>
<td>0.21</td>
<td>0.18</td>
</tr>
</tbody>
</table>

*Textbook/Draper: rate for 3 MHz at 1.0 W/cm² = 0.6°*
# Results

## Heating Rates for 1°C and 2°C increases

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>1°C Heating Rate (°C)</th>
<th>2°C Heating Rate (°C)</th>
<th>4°C Heating Rate (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.35°C/min</td>
<td>1.11°C/min</td>
<td>0.70°C/min</td>
</tr>
<tr>
<td>1.75</td>
<td>0.73°C/min</td>
<td>0.54°C/min</td>
<td>0.39°C/min</td>
</tr>
<tr>
<td>2.5</td>
<td>0.22°C/min</td>
<td>0.22°C/min</td>
<td>0.18°C/min</td>
</tr>
</tbody>
</table>
Discussion

• Dynatron vs Textbook
  – BNR
  – ERA

• Dynatron Manual
  – 3 MHz = 1.5 cm
  – area to be treated (cm²)/0.8 ERA = min of Rx
    • 2.5 min for vigorous heating w/our parameters

• Other Dynatron Heating Rates
  – 150: 3 MHz, 1.0 W/cm² at 2 cm = 0.75°C/min
  – 950: 3 MHz, 1.5 W/cm² at 1.6 cm = 0.40°C/min
## Time to Reach 4°C Increase & rate/min

<table>
<thead>
<tr>
<th>Depth</th>
<th>Temp</th>
<th>Time</th>
<th>Rate/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 cm</td>
<td>4.16 ± 2.56°C</td>
<td>8 min</td>
<td>0.52°C/min</td>
</tr>
<tr>
<td>1.75 cm</td>
<td>4.36 ± 2.24°C</td>
<td>15 min</td>
<td>0.29°C/min</td>
</tr>
<tr>
<td>2.5 cm</td>
<td>3.35 ± 2.14°C</td>
<td>20 min</td>
<td>0.17°C/min</td>
</tr>
</tbody>
</table>
## Dynatron Solaris – 1.0 W/cm² vs 1.2 W/cm²

<table>
<thead>
<tr>
<th>Depth</th>
<th>Intensity</th>
<th>Temp</th>
<th>Time</th>
<th>Rate/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 cm</td>
<td>1.0 W/cm²</td>
<td>4.22 ± 1.58°C</td>
<td>6 min</td>
<td>0.70°C</td>
</tr>
<tr>
<td></td>
<td>1.2 W/cm²</td>
<td>4.16 ± 2.56°C</td>
<td>6 min</td>
<td>0.52°C</td>
</tr>
<tr>
<td>1.75 cm</td>
<td>1.0 W/cm²</td>
<td>3.93 ± 1.93°C</td>
<td>10 min</td>
<td>0.39°C</td>
</tr>
<tr>
<td></td>
<td>1.2 W/cm²</td>
<td>4.36 ± 2.24°C</td>
<td>15 min</td>
<td>0.29°C</td>
</tr>
<tr>
<td>2.5 cm</td>
<td>1.0 W/cm²</td>
<td>3.60 ± 1.86°C</td>
<td>20 min*</td>
<td>0.18°C</td>
</tr>
<tr>
<td></td>
<td>1.2 W/cm²</td>
<td>3.35 ± 2.14°C</td>
<td>20 min*</td>
<td>0.17°C</td>
</tr>
</tbody>
</table>
Dynatron 708 – 2 MHz, 1.0 W/cm²
<table>
<thead>
<tr>
<th>Depth</th>
<th>Rate/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 cm</td>
<td>0.42</td>
</tr>
<tr>
<td>2.5 cm</td>
<td>0.26</td>
</tr>
<tr>
<td>3 cm</td>
<td>0.17</td>
</tr>
</tbody>
</table>

**Textbook:**

3 MHz = 0.6
1 MHz = 0.2

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rx Goal</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 cm</td>
<td>1°C</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>2°C</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>4°</td>
<td>9.6</td>
</tr>
<tr>
<td>2.5 cm</td>
<td>1°C</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>2°C</td>
<td>7.7</td>
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<tr>
<td></td>
<td>4°</td>
<td>15.4</td>
</tr>
<tr>
<td>3.0 cm</td>
<td>1°C</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>2°C</td>
<td>11.8</td>
</tr>
<tr>
<td></td>
<td>4°</td>
<td>23.6</td>
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</table>

<table>
<thead>
<tr>
<th>Depth</th>
<th>10 min increase</th>
<th>20 min increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>4.18 ± 2.45°C</td>
<td>5.22 ± 1.25°C</td>
</tr>
<tr>
<td>2.5</td>
<td>2.56 ± 1.82°C</td>
<td>3.59 ± 1.61°C</td>
</tr>
<tr>
<td>3</td>
<td>1.74 ± 1.52°</td>
<td>2.75 ± 1.48°C</td>
</tr>
</tbody>
</table>
Dynatron – 3 MHz, 1.0 W/cm² & blood flow

- 30 subjects
- 3 MHz, 1.0 W/cm², 5 min

Brachial artery depth = 0.96 ± 0.3 cm
• 3 MHz, 1.0 W/cm\(^2\) for 5 min
  – Significantly increased blood flow \(p = 0.015\)
  – Increased 5.3 cm/sec (47%)
Final Thoughts/Take Home Message

• If you use an Omnisound machine

• If you use a non-Omnisound machine

• Factors that impact variability:
  • ERA, BNR, FDA regulations

Textbook parameters are not one size fits all
QUESTIONS?

Time for Questions


References


