The role of ultrasound in the early assessment of sarcopenia

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Disclosure

I have nothing to disclose.

There are no relevant financial relations interfering with this presentation.
Objective of today

In a glance
Overview of current sarcopenia screening

In two glances
Overview of where and why ultrasound can be of help herein

Keep it simple and logical
Content

• Introduction

• Screening

• Muscle mass

• Ultrasound

• Future

• Take home messages
Content

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Ultrasound - history
Ultrasound - history
Content

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Screening for sarcopenia

Why would we want to screen?

What would we want to screen?

How will we do the screening?
Why screening?

Sarcopenia is related to

Frailty, decreased muscle strength, problems with mobility, falls, decreased activity levels, loss of physical function, loss of independence

Osteoporosis, fractures, middle-age weight gain, diabetes (increased insulin resistance), worse outcomes after surgery and oncologic treatment, more postoperative complications, increased readmission, prolonged hospital stay

Quality of life, mortality
Why screening?

Pubmed search ‘sarcopenia’ and ‘mortality’
### What to screen?

#### EWGSOP Working Definition of Sarcopenia

<table>
<thead>
<tr>
<th>Stage</th>
<th>Muscle mass</th>
<th>Muscle strength</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presarcopenia</td>
<td>↓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarcopenia</td>
<td>↓</td>
<td>↓</td>
<td>Or ↓</td>
</tr>
<tr>
<td>Severe sarcopenia</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
</tbody>
</table>
What to screen?

- Older subject (> 65 years)
  - Measure gait speed
    - > 0.8 m/s
      - Measure grip strength
        - Normal
          - No sarcopenia
        - Low
          - Sarcopenia
    - ≤ 0.8 m/s
      - Measure muscle mass
        - Low
          - Sarcopenia
        - Normal
          - No sarcopenia

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Muscle

Largest organ of the body - 40% bodyweight

Largest protein reservoir

Muscle mass and quality
• regarded as biomarkers
• patient's physiologic reserves
Measuring muscle mass

Many different methods

24-hour urinary creatinine method
Total body potassium
Bio-electrical impedance analysis (BIA) – practice/research
Dual energy X-ray absorptiometry (DEXA) – practice/research
Computed tomography (CT) - research
Magnetic resonance imaging (MRI) - research
Questions for the audience

For routine muscle mass screening, who has access to BIA? DEXA? CT? MRI?

Who has incorporated muscle mass screening in his daily clinical routine?

So who would like to have access to an easy way of assessing/screening muscle mass?
Content

- Introduction
- Screening
- Muscle mass

- Ultrasound
  - Advantages / disadvantages
  - What is there to measure

- Future
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Measuring muscle mass: where is the ultrasound?
Ultrasound: first thing you need to know
Ultrasound: advantages

Cheap

- Low cost/maintenance

fast

- Quickness of execution, no preparation time

easy

- Easy to use, availability at bedside
Expected problems / difficulties

Technique related: reproducibility (probe, settings, ...)

Patient related: body type

Muscle related: rest versus contraction

⇒ No standardization or strict protocol = no reliable or reproducible results

⇒ Protocol different in every study
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Ultrasound: what can we measure?

• Regional assessment of muscle quantity (size/mass) and quality (echo intensity)

• Five main parameters
  • Muscle thickness
  • Muscle cross-sectional area
  • Fascicle length
  • Pennation angle
  • Echo-intensity
Muscle thickness
Muscle thickness

- Muscle thickness is highly correlated with maximum voluntary contraction force

- Total skeletal muscle may be estimated using muscle thickness, with a strong correlation with both MRI and DEXA.

- Changes can be measured after 6 weeks of training

- Caveat: rest versus contraction
Muscle cross-sectional area
Muscle cross-sectional area

- Area is measured perpendicular to fiber length
- CSA: inter- and intrareader reliability similar to those for MRI
- Correlated with postoperative complications
- Changes can be measured after 6 weeks of training
- Anatomical CSA (ACSA) ≠ physiological CSA (PCSA)
Fascicle length

Total fascicle length (FL) = L₁ + h/sine(α)

- Resting:
  - Estimated fascicle length (L₂)
  - Fascicle length (L₁)
  - β = 14.4°
  - FL = 85.4 mm

- Isometric Reference:
  - α
  - β = 14.5°
  - FL = 80.3 mm

- Isometric Steady State:
  - α
  - β = 12.6°
  - FL = 87.2 mm
Fascicle length

• Increases with training (sprint versus endurance)

• Contractions can be measured

• Difficult to measure strength of contraction

• Fascicle length affects
  • Motor-unit recruitment
  • Discharge rate
  • Central command: contractions at different lengths give different central output

Change in Muscle Fascicle Length Influences the Recruitment and Discharge Rate of Motor Units During Isometric Contractions. Pasquet et al.
Pennation angle

- Upper aponeurosis
- Fascicular path
- Lower aponeurosis
- Pennation angle, $\theta_p$
Pennation angle

- Symbol commonly used is $\Theta$

- Line of pull of a muscle fiber towards the tendon

- Pennation angle is linked to the force generating potential of a muscle

- Influenced by tendon properties, fat infiltration of the muscle

- Is seen in pennate muscles

- In these muscles, physiological CSA is better used
Intermezzo: parallel versus pennate muscles

Parallel: fibers are parallel to the force-generating axis
Pennate: Fibers are at an angle to the force-generating axis (pennation angle)

PCSA = mass x cos Θ / fiber length x muscle density
Intermezzo: parallel vs pennate

Green lines: PCSA; blue lines: ACSA (U. Gille)

Pennate muscle: PCSA > ACSA

Non-pennate muscle: PCSA = ACSA
Echo-intensity

Echo-intensity

Quantitative gray scale analysis, marker of muscle quality (fat, fibrous)

Negatively correlated with
• Muscle thickness
• Muscle strength (independent of age or muscle thickness)

Caveat:
• Low inter- and intra-operator reproducibility
  • Compression
  • Focus

• System settings will strongly influence values
  • Gain (more gain = more white ≠ less muscle mass)
  • Time gain compensation (TGC)
Echo-intensity

But Wait...

THERE'S MORE!
Ultrasound: can we measure even more?

Additional parameters, not yet “fully operational” in sarcopenia setting:

• Mechanical properties - muscle stiffness
• Vascular flow/microvasculature
• Muscle mobility (fasciculations)
• Belly gearing evaluation

Also, just a glance...
Muscle stiffness / hardness

Muscle stiffness = resistance of a muscle tissue against perpendicular pressure

Muscle stiffness is correlated with pennation angle & muscle thickness

Elastography: different techniques, strain seems to be the most useful

No clear role so far in sarcopenia, but promising!
Vascular flow/microvasculature

Older muscle: diminished vascularization

Use of contrast-enhanced ultrasound (CEUS)

Untargeted CEUS
• Intravenous injection of gas-filled microbubbles
• High degree of echogenicity

Targeted CEUS
• Intravenous injection of specific targeting ligands
• Accumulation in area of interest
• Preclinical development, not FDA approved

No clear role so far in sarcopenia, but promising!
Even less clear role in sarcopenia

Muscle mobility (fasciculations): mainly used in diagnosis of neuromuscular diseases

Belly gearing evaluation: incorporation of tendon properties

- Muscle-tendon gearing is the ratio of the muscle-tendon unit velocity to the fascicle velocity
- Expressed as the product of the gearing within the muscle belly and the gearing due to tendon stretch.

Not to be discussed at this time
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Not the future but the present
Where are we now?

Ultrasound

High concordance with DXA, CT and MRI

High sensitivity and negative predictive value in detecting sarcopenia

Best measurements in proximal leg muscles
Where do we need to be in 5 years?

Standardization, because of many factors available

- Type of probe (linear 4-10 cm, curved, extended field-of-view)
- Position of probe (perpendicular to the skin, inclination, pressure)
- Ultrasound frequency (5-7.5 MHz)
- Type of parameters measured
- Fixed anatomical sites / landmarks for measurements
- Posture of patient (bed, chair), state of muscle (rest vs. contraction)
Where do we need to be in 5 years?

Further assessment and validation of ultrasound as a standard imaging algorithm for sarcopenia

Use of ultrasound in **screening** and **prevention**

International collaboration versus mushroom working

Perhaps even a sarcopenia SIG project...
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Take home messages

• Strong need for routine muscle mass screening

• Ultrasound: think ‘cheap – fast – easy’

• Correlated with DEXA, CT and MRI = reliable and valid tool

• Need for standardized protocol
  and international collaboration
Thank you for your attention! Questions?

Remember: 30 min. walk to the beach = perfect sarcopenia prevention!