PREPARED BY THE AMERICAN COLLEGE OF SURGEONS
DIVISION OF EDUCATION & SURGICAL ERGONOMICS COMMITTEE

Surgical Ergonomics Recommendations

ACS Education

American College of Surgeons

Introduction

It is well-documented that poor ergonomics significantly increases the risk of musculoskeletal injuries and substantially impacts surgeons' performance quality in the operating room (OR). Many have reported experiencing physical and cognitive symptoms as well as health complications attributable to their surgical practice. While many researchers have investigated this crucial area over the last three decades, many surgeons continue to seek effective solutions for reducing their physical and mental strain during surgery while ensuring the best patient safety and outcomes.

The American College of Surgeons (ACS) Division of Education Surgical Ergonomics Committee was formed to systematically address the ergonomic challenges experienced by surgeons and to improve their ergonomic wellbeing under the aegis of the American College of Surgeons. This committee invited various subject matter experts, including experienced surgeons, physical and cognitive ergonomics and human factors researchers, an industrial and systems engineer, an occupational safety scientist, a health design architect, and a physical therapist, to address the full spectrum of surgeon-related ergonomic issues in the operating room and prepare concise best-practice recommendations. The goal of this program is to reduce ergonomic-related injuries and burnout while increasing productivity and practice longevity among surgeons.

The ACS Surgical Ergonomics Committee is excited to announce the result of this initiative: the Surgical Ergonomic Recommendations. This recommendations document includes general recommendations (e.g., optimal OR table height), which can be applicable across different surgical techniques (i.e., open, laparoscopic, and robotic surgeries), as well as surgical technique-specific recommendations (e.g., optimal monitor positioning for laparoscopic surgery). This critical resource is designed to be surgeon-friendly and directly applicable to their practice in the OR—the document may be printed and laminated to be posted in the OR as well as accessed on the ACS website. The Surgical Ergonomics Recommendations will be updated as the ACS Surgical Ergonomics Committee establishes new recommendations on both the currently addressed surgical techniques (open, laparoscopic, and robotic surgeries) as well as other surgical techniques such as endoscopic and microscopic surgeries.

THE PROBLEM

Incorrect posture can lead to fatigue, discomfort, stiffness, and numbness in the back, neck, shoulder, and legs, as well as long-term disability or the need for corrective surgery.

1. Posture: Monitor Placement

Summary Recommendation
Place a display monitor directly in front of a user with the upper edge of the display at eye level and the center of the screen slightly below eye level

INTRAOPERATIVE SOLUTIONS

- Place display monitors directly in front of the surgeon and assistant (ideally using a boom).
- The upper edge of the display should be at eye level so that the center of the monitor would be slightly below eye level to maintain a neutral (vertical) neck posture *(see Figure 1)*.
- Avoid prolonged static postures by incorporating simple range-of-motion (ROM) stretches (micro-breaks) every 30-60 minutes *(see Appendix 1)*.

SOLUTIONS BEFORE AND BETWEEN CASES

- Preplan and adjust monitor locations and heights to achieve the best positioning.
- Preplan and identify the timings for quick intraoperative breaks.
- Incorporate pre- and postcase stretching and stabilization exercises *(see Appendix 1)*.
- Use a foam roller to improve thoracic and cervical mobility.

LONG-TERM PREVENTION AND MAINTENANCE

- Follow the recommended ergonomic guidelines for each type of operation.
- Establish an exercise and stretching program for the neck and shoulders.

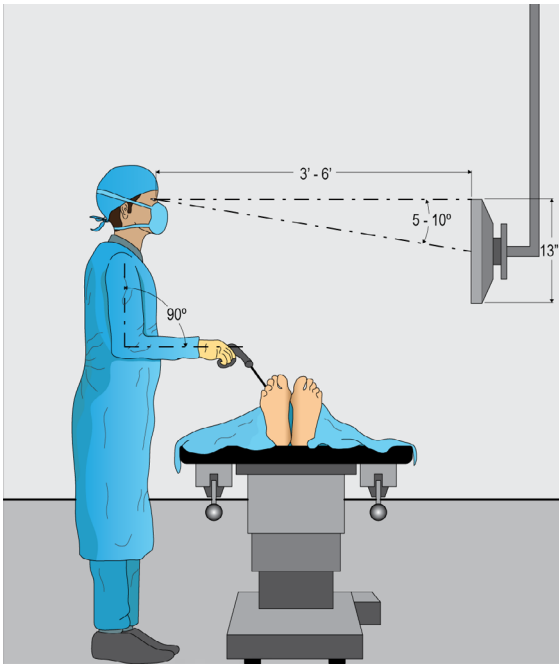

Figure 1. Monitor placement for laparoscopy

* Monitor distance and angle calculated based on 13" high monitor. Adjust dimensions depending on actual monitor height.

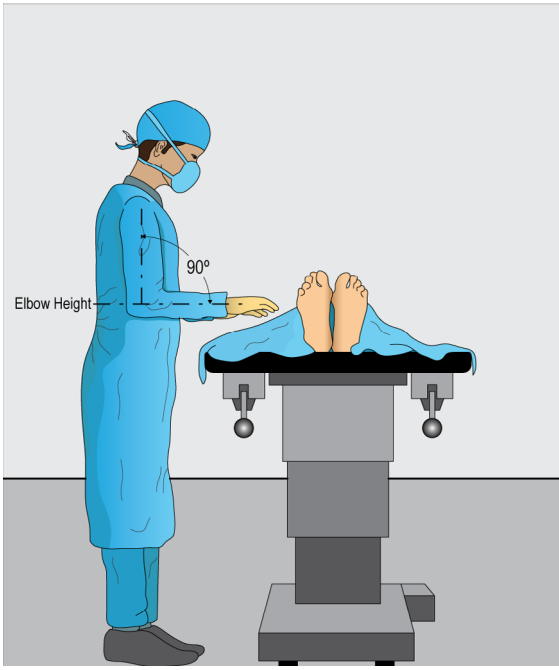

Figure 2. Table height for open surgery

2. Posture: Operating Table Height Adjustment

Summary Recommendation
Adjust the height of the operating room table to maintain the hands close to elbow height with the elbows at 90 degrees and the upper arms and shoulders relaxed

INTRAOPERATIVE SOLUTIONS

- Adjust table height
- **For open surgery**, keep the hands near elbow height *(see Figure 2)*.
- **For laparoscopic surgery**, the operating table should be at a lower height than open surgery to keep the hands near or below elbow height *(see Figure 3)*. The optimal OR table height may be affected by the type of instrument handle and patient habitus. Consider adjusting the table height based on the handle design of the instruments that will be used during each part of the procedure (e.g., dissection vs. suturing).
- **For robotic surgery,** the armrest should be adjusted to keep the surgeon's hands near elbow level. Use the clutches to bring both master controllers to the center of the workspace while maintaining the forearms resting on the armrest comfortably *(see Figure 4)*. Also, choose an appropriate seat for the console and adjust it to allow for comfortable positioning of the feet on the pedals *(see Figure 4)*.
- When surgeons of different heights are present, the table height may be adjusted for the tallest surgeons, and all other surgeons may utilize a lift (step/stool) for the best ergonomic setting.
- Avoid prolonged static postures by incorporating simple range-of-motion (ROM) stretches (micro-breaks) every 30-60 minutes *(see Appendix 1)*.
- Avoid prolonged uneven standing postures (putting more weight on one leg or the other).
  - Position the patient's torso, arms, and legs to optimize operating posture.
  - Place video monitors in front of the surgeon and assistant.
  - Foot pedals should be placed at foot level in front of or slightly to the side of the operator. If there is a divider or ridge between pedals, it may be used as a footrest to minimize the ankle dorsiflexion on the pedal foot and the pressure on the opposite foot and leg between pedal presses.

SOLUTIONS BEFORE AND BETWEEN CASES

- Preplan the operating table height and patient position considering the patient size.
- Preplan the timings for quick intraoperative breaks.
- Incorporate pre- and postcase stretching and stabilization exercises *(see Appendix 1)*.
- Use a foam roller to improve thoracic and cervical mobility.

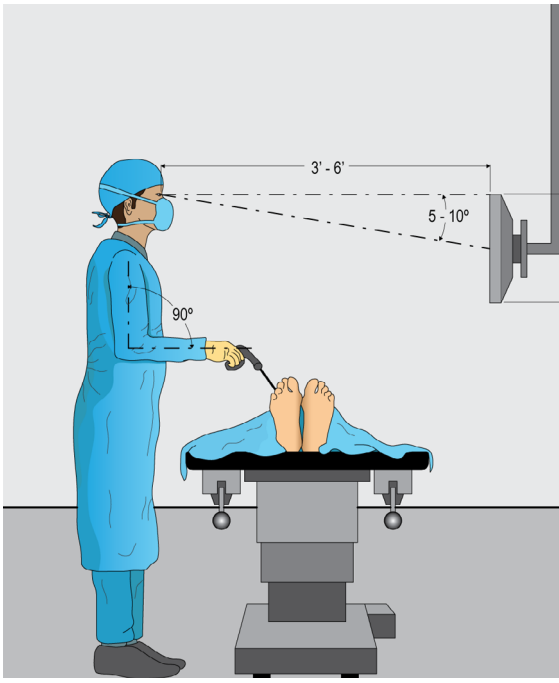

Figure 3. Table height for laparoscopy

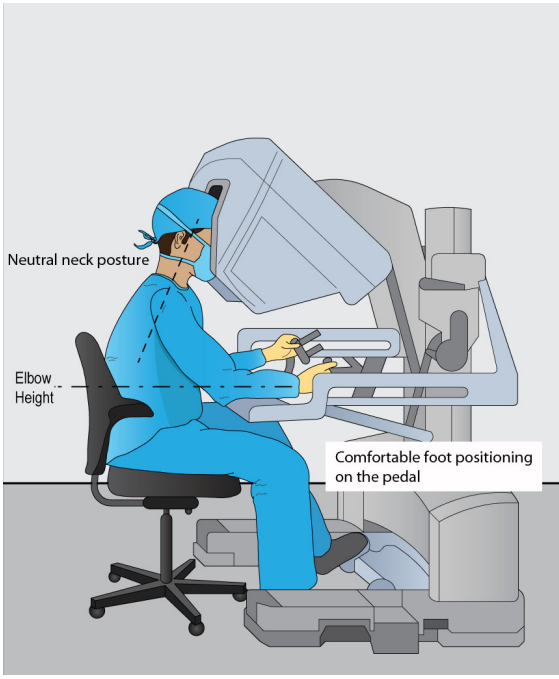

Figure 4. Armrest height, seat, and pedal positioning for robotic surgery

LONG-TERM PREVENTION AND MAINTENANCE

- Follow the recommended ergonomic guidelines for each type of operation.
- Establish a comprehensive ergonomic strategy for all operations, including table height.
- Establish an exercise and stretching program for the neck, shoulder, and low back *(see Appendix 1)*.
- Consider seated surgery or robotic surgery.

3. Posture: Hands and Instruments

Summary Recommendation 1
Adjust the table height and surgeon's standing position to maintain the hands near elbow height with a near-neutral posture at the wrist ("work in the box")

INTRAOPERATIVE SOLUTIONS *(see Figures 2, 3, 4, & 5)*

- Adjust the table height as described in the "2. Posture – The optimum operating table height" section.
- Work in the box *(see Figure 5)*.
- Wrists should be straight, elbows near 90 degrees, and the arms not crossing the midline.
- Avoid reaching near the end of the range of motion and twisting the wrists and arms.
- When possible, use body supports to offload the weight of the body segment (e.g., armrests and seats).
- Avoid static/sustained postures through frequent movements of the fingers, wrists, and arms.

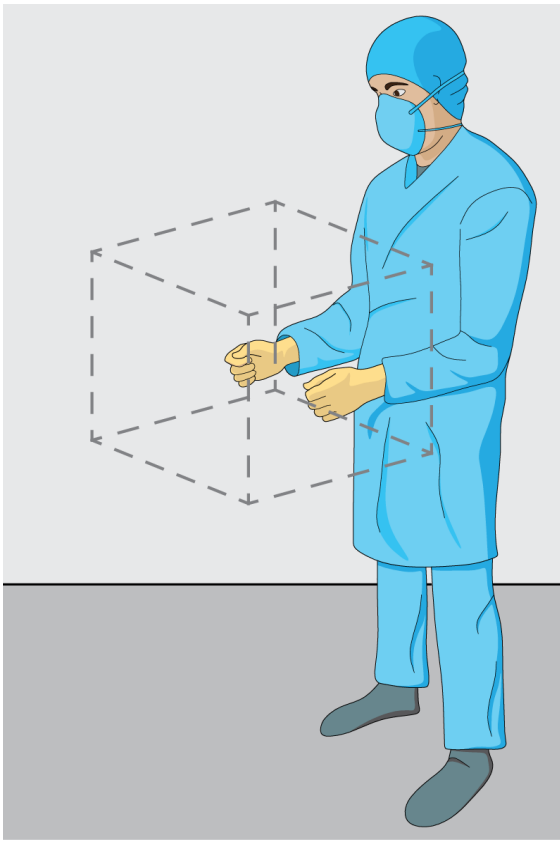

Figure 5. Work in the box

Summary Recommendation 2
Select the instrument size and shape based on the individual surgeon and the specific task

INTRAOPERATIVE SOLUTIONS

- General recommendations:
  - Avoid instruments or tools with high-pressure contact areas and sharp edges.
  - Use trigger locks, ratchets, or other features to minimize the sustained gripping and squeezing forces.
- Hold instruments using a power grip to minimize finger fatigue whenever possible *(see Figures 7 & 9)*.
  - Choose powered tools where available to reduce hand force requirements.
  - Choose instruments with finger holes that are large enough to fit the fingers comfortably.

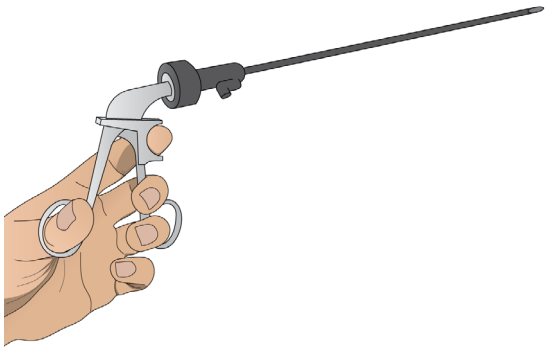

Figure 6. Lap finger grip

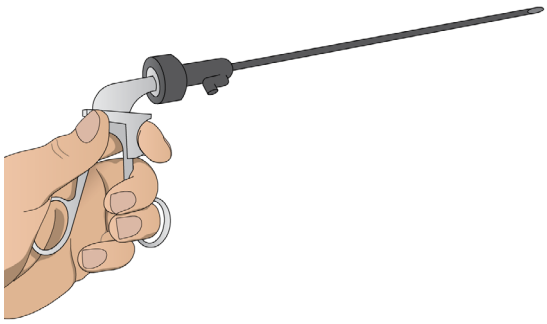

Figure 7. Lap power grip

- **For laparoscopic surgery:**
  - When available, use the instruments' articulation and/or rotation to avoid awkward postures of the wrist, arm, and shoulder.
  - Consider trocar location in relation to the grasping angle needed for each instrument.
  - Select the instrument handle type (e.g., pistol-shaped vs. inline) to allow a neutral wrist position.
- **For robotic surgery:**
  - Use the system clutch to move the master controllers to the center of the workspace.
  - Use the armrest to offload arm weight while keeping the shoulders down.

SOLUTIONS BEFORE AND BETWEEN CASES

- Preplan the optimum instruments and request them for each case.
- Pre- and postcase stretching of the hands *(see Appendix 2)*.

LONG-TERM PREVENTION AND MAINTENANCE

- Grip strengthening and regular stretching of the hands can help maintain functional performance *(see Appendix 2)*.

4. Visualization

KNOWN ISSUES

Improper lighting and display orientation can have an adverse effect on task performance as well as cause eye strain and musculoskeletal fatigue, potentially leading to limitation of practice, long-term disability, and the need for corrective surgery.

Summary Recommendations:

- Ensure that the open surgical field has high illuminance using two or more OR lights at different angles
- When using a display monitor, place it directly in front of a user with the upper boundary of the display at eye level and the center of the screen slightly below eye level *(1. Posture: Monitor Placement)*

INTRAOPERATIVE SOLUTIONS

- **For open surgery:**
  - Place the overhead lights between the surgeon and assistant in most cases *(see Figure 10)*.
  - Avoid creating shadows from a single light source caused by the surgeon/assistant's head *(see Figure 11)*.

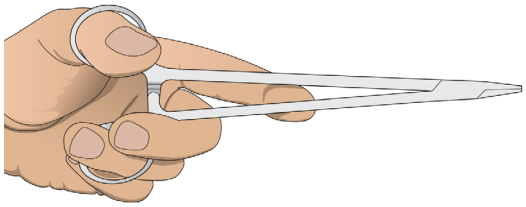

Figure 8. Open finger grip

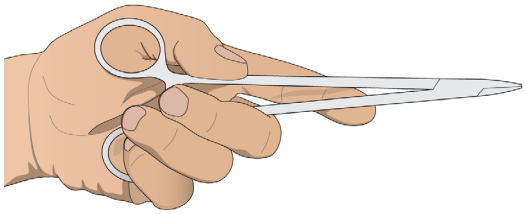

Figure 9. Open power grip

Figure 10. Correct light placement

- **For laparoscopic surgery:**
  - Ensure room lights are dimmed to reduce the glare and contrast on the display monitor but not completely dark to allow the OR team to move safely throughout the room.
  - Position the display monitors as described in the "1. Posture: Monitor Placement" section *(see Figure 1)*.
- **For robotic surgery** *(see Figure 12)*:
  - Adjust the viewer height so that the user's back is not crouching.
  - Adjust the viewer tilt to minimize forward flexion.
  - Do not push the forehead excessively into the console's headrest when focusing on a case.
  - Take advantage of the 3D visualization to improve depth perception.

SOLUTIONS BEFORE AND BETWEEN CASES

- Preplan lighting and monitor positioning.
- Use a stretching program for the neck and shoulders *(see Appendix 1)*.
- Use a foam roller to improve thoracic and cervical mobility.

LONG-TERM PREVENTION AND MAINTENANCE

- Implement a stretching program for the neck and shoulder *(see Appendix 1)*.
- Consider transitioning to a robotics-centered practice when appropriate to improve the ergonomics.

5. Stress

KNOWN ISSUES

Surgery-related stress may be caused by time pressures, equipment problems, poor OR layouts, crowding, new technologies, unexpectedly challenging patients, conflicting goals, distractions, communication difficulties, physical/cognitive workload differences, and variable skills and experience within the team. These stressors may accumulate over time and can manifest in many forms, including excessive fatigue, reduced performance, mood swings, and reduced quality of life.

Summary Recommendation
Use preparation, communication tools, and mutual support from your team to decrease stress before, during, and after surgery

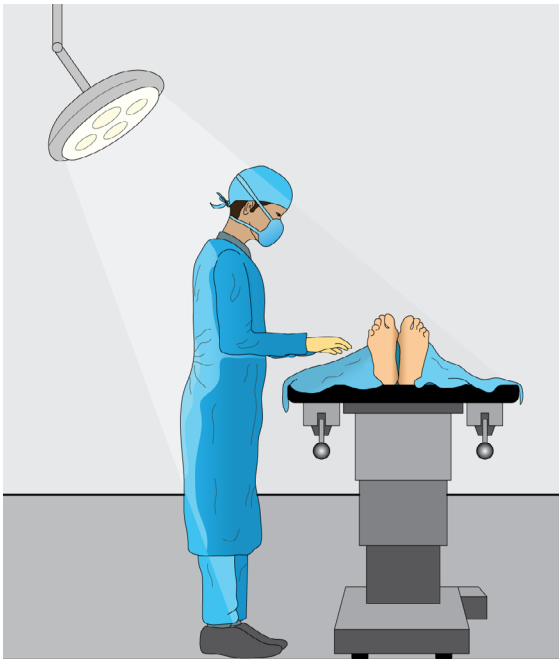

Figure 11. Incorrect light placement

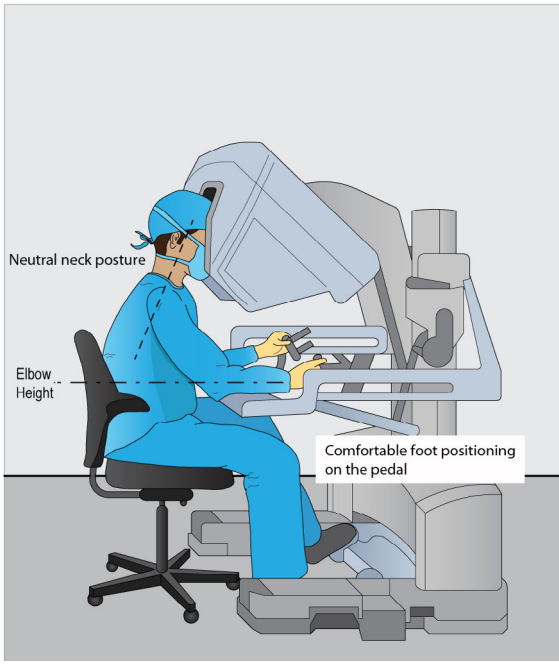

Figure 12. Visualization for robotic surgery

INTRAOPERATIVE SOLUTIONS

- Use a preoperative briefing to coordinate the team, share the plan, establish cohesion, and ensure preparedness for each day's procedure. The briefing can be extremely useful for improving teamwork, operative flow, and performance. This also can be done in conjunction with the surgical safety checklist.
- Employ read-backs, check-backs, and cross-training to develop a shared understanding of the key points of a task (e.g., going on/off bypass; robot docking; converting to open), available resources, and strategies for crisis management. Mature and collaborative teams make an increased number of anticipatory movements to support each other.
- Use the postcase debriefing to review what went well and what did not go well, using a blame-free system that can allow for continuous improvement to address points of stress. This is particularly useful, especially when teams experience recurrent problems.
- Implement checklists to set up team expectations, reduce reliance on memory or expertise, and prepare for anticipated challenges.
- Include brief pauses during the operation to allow the team to refresh themselves cognitively and physically. Checking in with each other and restating the plan can also encourage team cohesion. Adding intraoperative exercises may be considered (see Appendix 1).

SOLUTIONS BEFORE AND BETWEEN CASES

- Use prospective assessment to identify potential hazards before they have a negative impact on surgeons' cognitive process and cause disruption to the surgical team's performance. When introducing new equipment or technologies into the operating room, plan the introduction of new equipment at a time when your most experienced team members are present.

LONG-TERM PREVENTION AND MAINTENANCE

- Acquire deep familiarity with the functions of operating room equipment by continually pursuing new training opportunities to build confidence and maintain calmness when working in the operating room.

Appendix 1.

Pre- and Postcase Stretching and Stabilization Exercises

Intraoperative Exercises for the Neck

1. Range of Movement (ROM)

Cervical: Move your neck in each direction 10 times every 20–40 minutes or when experiencing stiffness in the neck *(see Figure A-1)*.

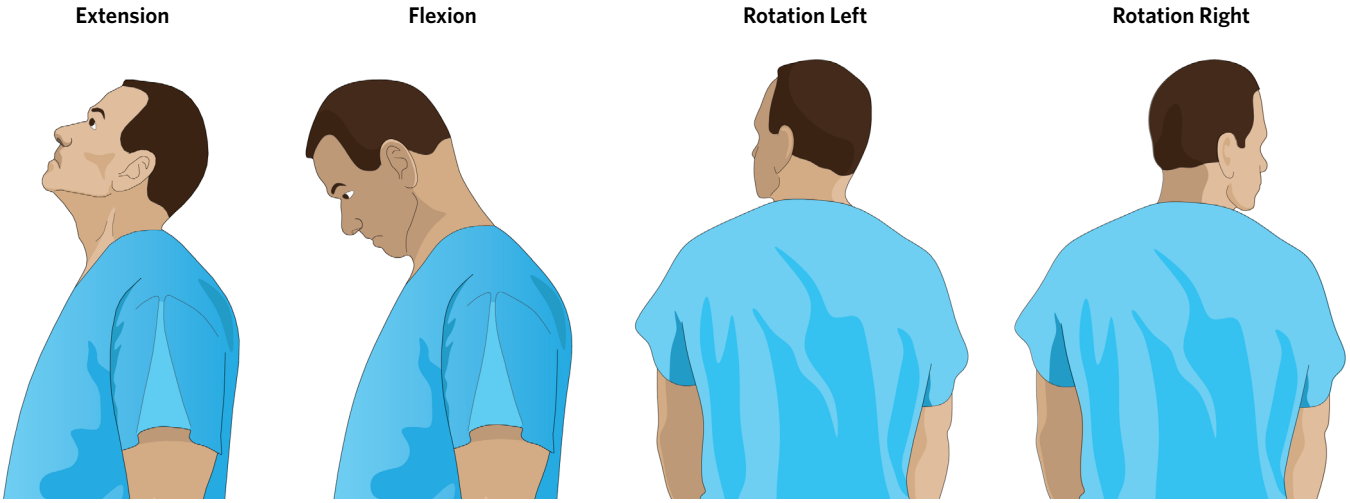

Figure A-1. Cervical ROM Exercise

2. Exercise/Stabilization for the Neck and Shoulder

a. Deep cervical flexor training (nod head up and down as if indicating "yes"): Hold (or imagine holding if scrubbed) your closed fist between your chin and chest and flex your neck for 10 seconds. You should feel the front neck muscles engage. Repeat 10 times throughout the day. **Do this exercise without an actual fist if scrubbed** *(see Figure A-2).*

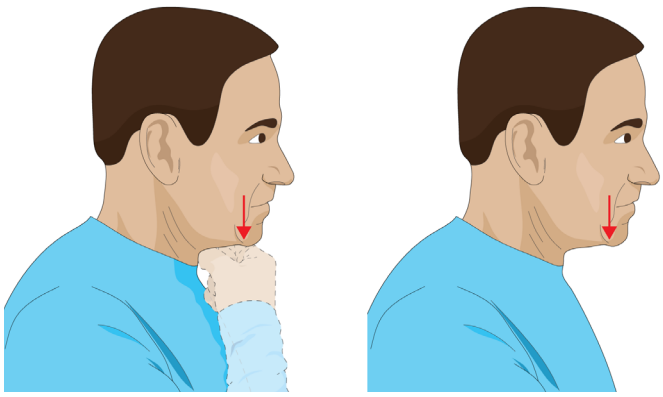

Figure A-2. Deep cervical flexor training

b. Standing Scapular Retraction: Pull shoulder blades down and towards the spine, pulling your upper trapezius down away from the ceiling. Hold for 5–10 seconds. Repeat 10 times *(see Figure A-3).*

Figure A-3. Standing Scapular Retraction

Between Cases Exercises for the Neck and Shoulder

1. Cervical and Shoulder Stretching

a. Upper Trapezius: Gently bring your ear to your shoulder with your hand while placing your opposite hand behind your back. Hold this position for 30 seconds. Repeat two times on each side *(see Figure A-4)*.

Figure A-4. Upper Trapezius Stretching

b. Levator Scapulae: Gently look at your armpit while placing your hand on your head for slight overpressure. Place your opposite hand behind your back. Hold this position for 30 seconds. Repeat 2 times on each side *(see Figure A-5)*.

Figure A-5. Levator Scapulae Stretching

c. Pectoralis: Place your forearm against the corner of a wall and step forward with the ipsilateral foot. While looking ahead, gently bend the forward knee; the contralateral leg remains straight. Do not hyperextend your lumbar spine. You should feel a stretch in the pectoralis/anterior chest wall. Hold this position for 30 seconds. Repeat 2 times on each side *(see Figure A-6)*.

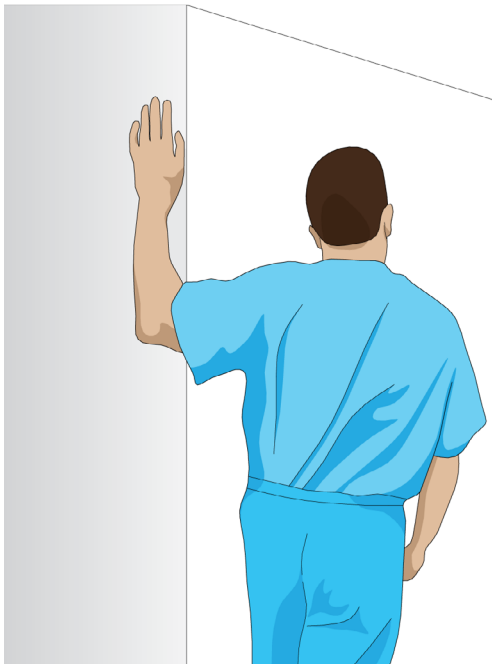

Figure A-6. Pectoralis Stretching

2. Improving Thoracic Mobility

a. Using a foam roller for thoracic/lumbar mobility: Place the foam roller perpendicular to your spine and slowly roll up and down on the foam roller using your feet to move you while arching backward to extend the spine. Be sure to support the neck. Perform for one to two minutes *(see Figure A-7)*.

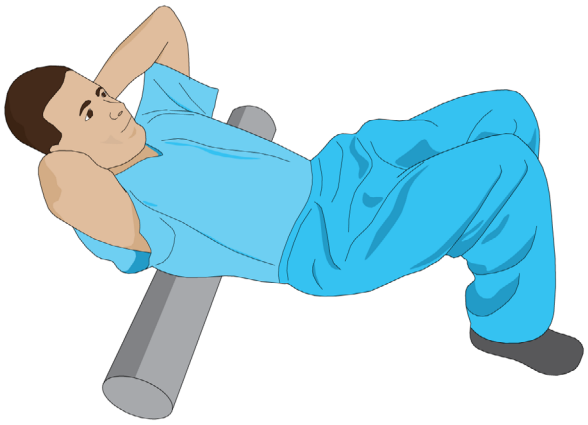

Figure A-7. Using a foam Roller for thoracic/lumbar mobility

b. Using a foam roller for pectoralis stretching: Lie with the foam roller under your spine. Engage your core to maintain full spinal contact with the roller. Allow your arms to extend towards the floor, stretching your anterior chest wall. This position can be held for 30–60 seconds. Repeat 2 or 3 times *(see Figure A-8)*.

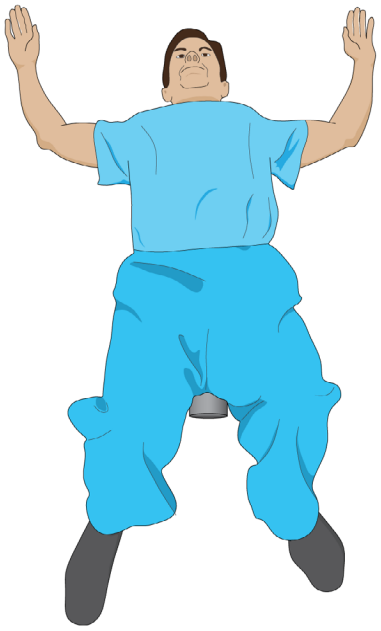

Figure A-8. Using a foam Roller for pectoralis stretching

Appendix 2.

Specific Hand and Arm Stretches and Remedies

1. Lumbrical stretching:

Hold each position A, B, C, and D for 10 seconds alternating with position Z with all digits extended and the wrist in neutral for 5 seconds. Repeat 5–10 times *(see Figure A-9).*

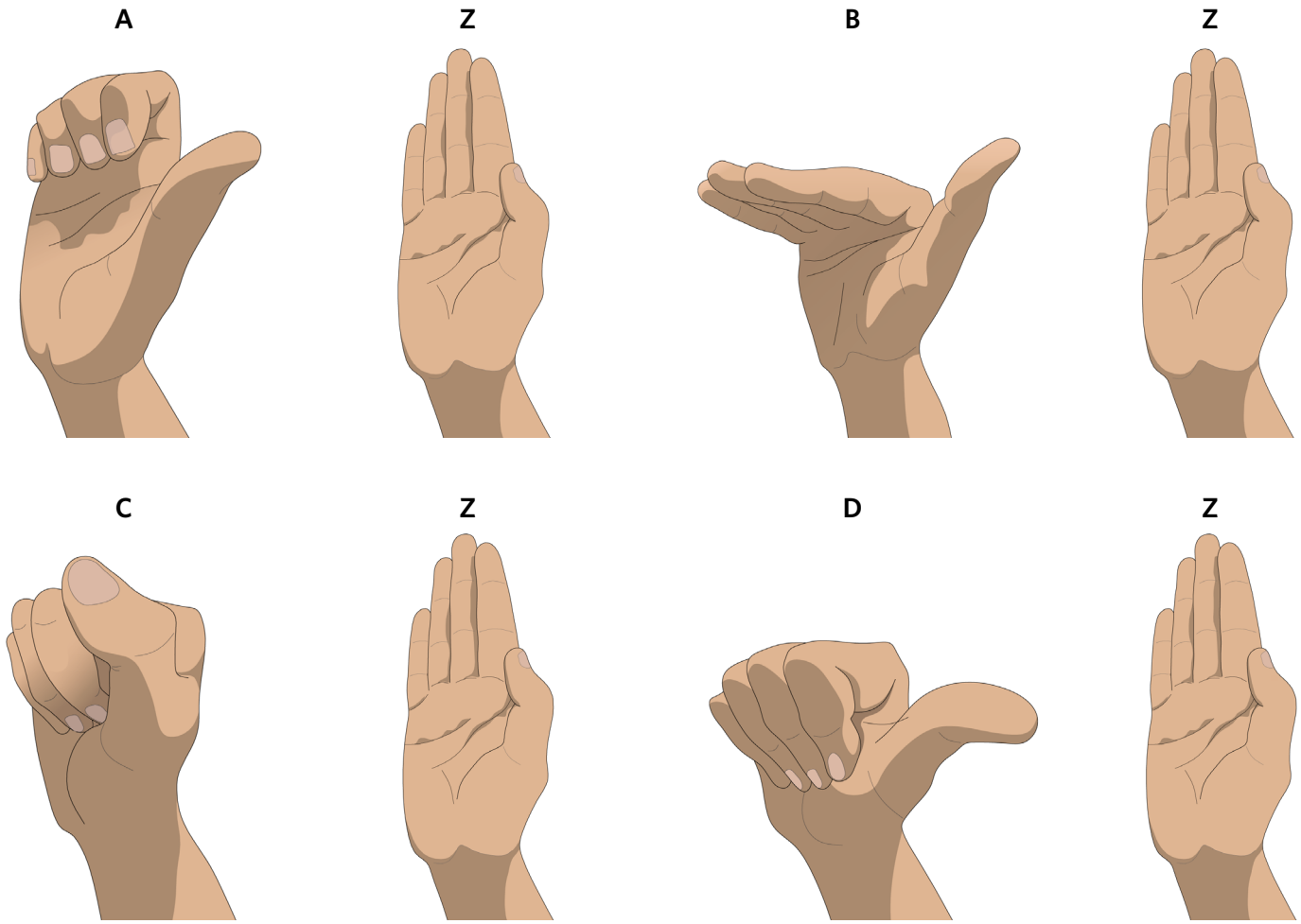

Figure A-9. Lumbrical stretching

2. Passive wrist extension with elbow straight:

With your arm flexed forward, your elbow extended, and your palm of the hand facing upward, gently pull back on your hand and fingers. Hold for 10 seconds. Repeat 5–10 times *(see Figure A-10)*.

Figure A-10. Passive wrist extension with elbow straight

3. Median nerve mobilization:

With your elbow bent by your side and palm facing upward, pull back on your wrist and fingers. Hold for 10 seconds. Repeat 5–10 times *(see Figure A-11)*.

Figure A-11. Median nerve mobilization

Intraoperative Hand/Wrist Stretching

1. Lumbrical stretching *(See Figure A-9)*
2. Passive wrist extension with elbow straight *(See Figure A-10)*
3. Median nerve mobilization *(See Figure A-11)*

Between-cases Hand/Wrist Exercises

1. Lumbrical stretching *(See Figure A-9)*
2. Passive wrist extension with elbow straight *(See Figure A-10)*
3. Median nerve mobilization *(See Figure A-11)*
4. **Median Nerve Flossing:** Place the palm of your hand against the wall, fingers pointing downward. A stretch should be felt at the wrist, elbow, or possibly the shoulder. Take the pressure off the stretch by leaning your head towards the wall. Hold the stretch for 1–2 seconds. Repeat 10–20 times *(see Figure A-12)*.
5. **Others**
   a. Splinting: Use a neutral wrist position splint at night if experiencing carpal tunnel symptoms. Use a thumb spica splint if experiencing any symptoms of DeQuervain's tenosynovitis. This can be store purchased or fabricated by a hand therapist.
   b. Ice: As needed for discomfort.

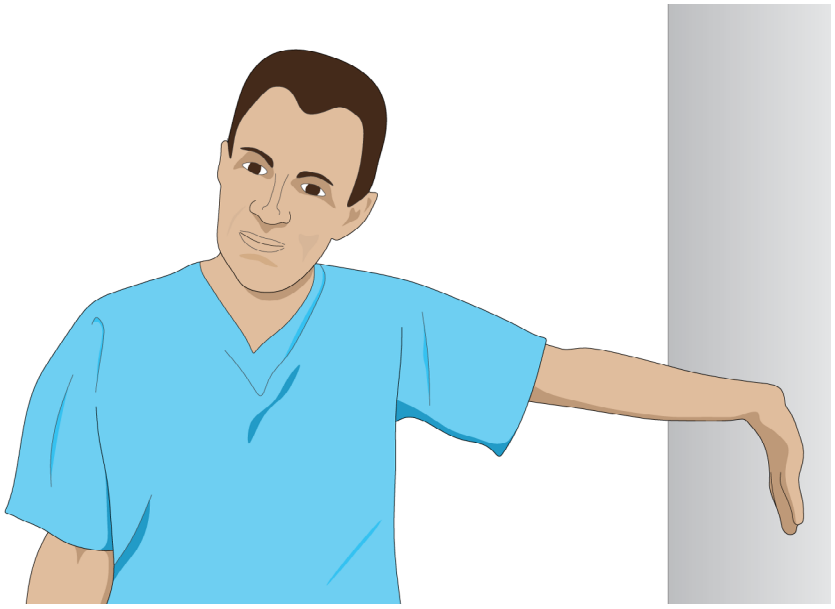

Figure A-12. Median nerve flossing

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