Handling Endoscopic Surgery as a woman surgeon:
Ergonomics in instruments and physical approach to avoid physical discomfort

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OSTETRICHE E SCIENZE UROLOGICHE
POLICLINICO UMBERTO I
Talk plan

- Introduction
- Problems for laparoscopic surgeons
- Physical dangers, mental fatigue, occupational diseases
- Women surgeon problems
- Prevention
- Conclusions
Ergonomics is "the science that deals with the design of things that people use in their work and everyday life and the environments in which they work and live, taking into consideration the human characteristics".
Ergonomics is the research of the best relationship between function, equipment and user.
Skills and characteristics required in mini-invasive surgery

- Intellectual background
- Optimal Physical condition
- Efficient and high standard work environment
Problems for laparoscopic surgeons

- Laparoscopy provides great advantages to the patient.
- However, it causes ergonomic inconveniences for surgeons, which may result in decreasing the surgeons' performance and musculoskeletal disorders.

IN FACT, IT OBLIGES THE SURGEON TO ADAPT TO:

- Different operative room organization
- Altered posture
- 2D vision of the operating field magnified on a 3D screen
- Specific instruments
- Reduced proprioception
- Different eye-hand coordination
- Particular surgical movements
During laparoscopic procedures, surgeons are required to adopt awkward body postures, perform repetitive and precise movements and maintain prolonged static muscle contraction to achieve the best patient outcomes.
NEGATIVE ASPECTS OF LAPAROSCOPY

• Procedure can last long
• Dexterity limited due to the fixed access port position
• Only 4 degrees of freedom of instruments
• Altered and reduced haptic “perception” of the tissue characteristics
• Paradoxical movement due to fulcrum effect (the instrument tips move in opposite directions with respect to the handles)
• The fulcrum effect does not permit the surgeon to change his or her body posture
• Elongated instruments: tremor enhancement.
• Increased strength required to hold the instruments (6-fold strength required)
• “User-gap”: only one measure for different hands.
Increased time and fatigue
Static, forced, and awkward long-term postures.
Body deviation from the neutral position: musculoskeletal disorders
Surgical Fatigue Syndrome: >4 h of intense surgical work causes: mental confusion, irritation, reduced judgment, reduced ability and physical dexterity
Visual fatigue
- Unknown long term effect
Possible significant cardiovascular stress
USEFULNESS OF ERGONOMICS

• Tension and muscular fatigue cause errors and slowness.
• The muscles can work for hours if they use 15% of their maximum strength.
• The application of the ergonomic principles reduces the quantity of applied muscular strength and it allows to reduce fatigue and to improve safety and surgical time.
Both male and female surgeons are exposed to physical and mental effect of laparoscopic surgery.

However women have proved to be more exposed than men because:

- They are often shorter than men
- They have smaller hands and thumbs
- They are generally less strong than men
- Instruments are designed for men
CAUSES OF DRAWBACKS

- Long lasting static position of the surgeons
- Abnormal upper limb movements
- Time and motion
- Instruments characteristics
- Position of the monitor
- Operating table height
- Foot pedal position

Physical dangers, mental fatigue, occupational diseases
PHYSICAL EFFECTS

- Discomfort and physical damage
- Musculoskeletal disorders (paresthesia, neuropathic compression) in different sites
- Hyperextension of the cervical rachis and tension of the neck;
- Back pain (standing position with continuous and repetitive traumas to the lumbosacral column)
- Fatigue
Posture defects

Physical dangers, mental fatigue, occupational diseases
Surgeons’ Static Posture and Movement Repetitions in Open and Laparoscopic Surgery

- Surgeons generally maintained a more extended and static neck posture during laparoscopic procedures.
- There were statistically significant differences in mean neck posture and mean left shoulder abduction posture between the two types of surgery.

Tzeto et al, Journal of Surgical Research 2012
Physical dangers, mental fatigue, occupational diseases

Park et al 2016
Optimal ergonomics for laparoscopic surgery in minimally invasive surgery suites: a review and guidelines

Review of the literature

Drawback in MIS:

• Misalignment in the eye-hand-target axis because of limited freedom in monitor positioning is the most important ergonomic drawback

Hyperextension of the cervical rachis and tension of the neck
14 SURGEONS:
• 12 MEN
• 2 WOMEN

- MEASUREMENT of Cervical spine movements
- Real-time joint movements in sagittal and coronal planes were recorded during open and laparoscopic surgery for periods ranging from 30 to 80 min.

Long duration of static posture in laparoscopic surgery was closely associated with low-level muscle tension, which may contribute to an increased risk of surgeons developing musculoskeletal disorders.

Sezeto et al., Journal of Surgical Research 2011
HOW SHOULD THE MONITOR BE POSITIONED?

• In the horizontal plane straight in front of each person and aligned with the forearm-instrument motor axis to avoid axial rotation of the spine.

• In the sagittal plane lower than eye level to avoid neck extension.

• The most comfortable viewing direction is approximately 15° downward.
The ergonomics of laparoscopic surgery: a quantitative study of the time and motion of laparoscopic surgeons in live surgical environments

- 150 video recordings of 18 surgeons standing at the patient’s left
- Postoperative processing *quantified surgeon movements* of the neck, shoulders and elbows using computer software to measure *extreme joint angles* and time *spent* within defined joint angle ranges

Physical dangers, mental fatigue, occupational diseases
98% of surgical time spent in neck rotation at 21° (range 0°–52°)

- The non-dominant arm was subjected to more extreme position
- Shorter surgeons maintained significantly greater degrees of neck rotation
- Surgeons with shorter arms spent longer in extreme positions with their non-dominant shoulder at 90° and elbow at 120° compared with taller surgeons.

Aitchison et al, 2016 Surg Endosc
Laparoscopic surgeon’s thumb

- Pain or paresthesia in the thumbs during the long laparoscopic procedure
- Caused by unergonomic instrument handles and their continuous compression of the lateral digital nerve
- Particularly frequent in subjects with small hands (size <7)

The RSRA is a simple and effective ways for preventing laparoscopic surgeon’s thumb.
Operating table and foot pedal

- If the table is too high, muscles apply more force to raise and hold the shoulders and the elbows.
- This position may lead to shoulder muscle fatigue.
- Laparoscopic instrument handles should be slightly below the level of the surgeon's elbows.
- The proper table height keeps shoulders down, and the angle between the lower and upper arm is between 90° and 120°.

- Foot pedals are often poorly positioned and demand awkward and unnatural postures.
- Pedals should be placed near the foot and aligned in the same direction as the instruments, toward the laparoscopic monitor, allowing the surgeon to activate the pedal without twisting the body or leg.
What is ergonomic for a woman surgeon?

Are the problems different for men and women?
The relationship between hand size and difficulty using surgical instruments: A survey of 726 laparoscopic surgeons


Difficulty while using various laparoscopic instruments for 726 surgeons.

In females, the scissors and staplers were more difficult to use for the Small and Medium glove size group compared to the Large size group (p < 0.001).

Difficulty while using various laparoscopic instruments for 159 female surgeons
Musculoskeletal Pain in Gynecologic Surgeons

Anonymous web-based survey with 495 respondents:

- LOWER BACK PAIN (75.6%)
- NECK PAIN (72.9%)
- SHOULDER PAIN (66.6%)
- UPPER BACK PAIN (61.6%)
- WRIST/HAND PAIN (60.9%)

Women are at an approximately twofold risk of pain.
Women surgeon problems

One size does not fit all: current disposable laparoscopic devices do not fit the needs of female laparoscopic surgeons

- 28 women and 37 men, residents in general surgery
- Participants were asked to describe their use of four disposable lap instruments:
  - The lap stapler
  - Lap harmonic scalpel
  - Lap ligasure tm
  - Lap retrieval bag
Women were more likely to use two hands and described these devices as "always awkward."

Current disposable lap devices are not designed for individuals with small hands.

One size does not fit all: current disposable laparoscopic devices do not fit the needs of female laparoscopic surgeons

A 23-item web-based survey of 2,000 laparoscopic surgeons addressing four categories: demographics, physical symptoms, ergonomics, environment/equipment.

Table 3 Bivariate and multivariate predictors of symptoms experienced by surgeons

<table>
<thead>
<tr>
<th>Experienced treatment for hands</th>
<th>Gender</th>
<th>Female</th>
<th>Male</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(wrist, thumb, fingers)</td>
<td></td>
<td>6/54 (11%)</td>
<td>9/261 (3%)</td>
<td>3.5 (1.19–10.29)</td>
</tr>
<tr>
<td>Experienced discomfort in lower body</td>
<td>Gender</td>
<td>Female</td>
<td>11/54 (20%)</td>
<td>0.48 (0.24–0.97)</td>
</tr>
<tr>
<td>(hips, knees, ankles, feet)</td>
<td></td>
<td></td>
<td>Male</td>
<td>91/261 (35%)</td>
</tr>
<tr>
<td>Surgical glove size</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced</td>
<td></td>
<td>7.49 ± 0.58</td>
<td>7.31 ± 0.66</td>
<td>1.57 (1.07–2.32)</td>
</tr>
<tr>
<td>Did not experience</td>
<td></td>
<td>70.28 ± 2.97</td>
<td>69.24 ± 3.61</td>
<td>1.07 (1.00–1.15)</td>
</tr>
<tr>
<td>Experienced</td>
<td></td>
<td>7.52 ± 0.62</td>
<td>7.27 ± 0.63</td>
<td>1.88 (1.28–2.75)</td>
</tr>
<tr>
<td>Did not experience</td>
<td></td>
<td>70.06 ± 3.37</td>
<td>69.26 ± 3.46</td>
<td>1.07 (1.00–1.15)</td>
</tr>
</tbody>
</table>
### Table 4: Symptoms and treatments experienced by male and female surgeons of the same surgical glove size

<table>
<thead>
<tr>
<th>Surgical glove size</th>
<th>Gender</th>
<th>Frequency</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced treatment for hands (wrist, thumb, fingers)</td>
<td>7–8.5</td>
<td>Female</td>
<td>3/14 (21%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>8/243 (3%)</td>
</tr>
<tr>
<td>Experienced discomfort of shoulder area (neck, shoulder, upper back)</td>
<td>5.5–6.5</td>
<td>Female</td>
<td>30/39 (77%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>3/11 (27%)</td>
</tr>
<tr>
<td>Experienced discomfort in neck</td>
<td>5.5–6.5</td>
<td>Female</td>
<td>24/39 (62%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>2/11 (18%)</td>
</tr>
</tbody>
</table>
POSSIBLE SOLUTIONS ?
New surgical devices and instrument designs have been developed.
Several authors presented novel prototypes.
Effect of a laparoscopic instrument with rotatable handle piece on biomechanical stress during laparoscopic procedures
Steinhilber et al. Surg Endosc 2015

To investigate the effect of a pistol grip with a rotatable handle piece (rot-HP) on biomechanical stress and precision as well as a possible interaction between the instrument and working height (WH).

Conclusions The rot-HP did not decrease biomechanical stress in the shoulder or lower arm muscles. However, wrist angle position may be optimized without affecting precision.
This study analyzed the problems and consequences associated with prolonged use of laparoscopic instruments (dissector and needle holder).

Laparoscopic instruments with axial handle leded to a more ergonomic posture for the wrist compared to a ring handle.

**Types of handles normally used**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Dissector Respondents (%)</th>
<th>Needle Holder Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
</tr>
<tr>
<td>Ring handle, pistol grip, thumb manipulation</td>
<td>66 (55.90)</td>
<td>15 (13.40)</td>
</tr>
<tr>
<td>Ring handle, pistol grip, finger manipulation</td>
<td>52 (44.10)</td>
<td>50 (52.70)</td>
</tr>
<tr>
<td>Other</td>
<td>1 (0.80)</td>
<td>33.90</td>
</tr>
<tr>
<td>Axial handle with rings</td>
<td></td>
<td>3.60</td>
</tr>
<tr>
<td>Axial handle</td>
<td></td>
<td>16.10</td>
</tr>
</tbody>
</table>

**Elements causing forced postures**

- Monitor position
- Table height
- Patient position
- Staff position
- Type of surgical instrument
- Foot pedal
- Electrocautery wire

**Dissector**
- (type 1) ring handle, pistol grip, thumb manipulation
- (type 2) ring handle, pistol grip, finger manipulation

**Needle holder**
- (type 1) axial handle with rings
- (type 2) axial handle
- (type 3) pistol handle.
Handle designed using ergonomic principles, to provide:

- More intuitive manipulation of the instrument
- REDUCTION OF HIGH-PRESSURE ZONES IN THE CONTACT WITH THE SURGEON'S HAND.

- The whole surface of the hand is in contact with the handle
- It keeps the hand and wrist close to neutral position during surgery.

- 64.2% expressed their preference for the new handle
- The new handle fitted well in the hand, reducing the pain, providing secure and comfortable handling
- It reduced the high-pressure areas and the extreme motions of the wrist.
Musculoskeletal pain among surgeons performing minimally invasive surgery: a systematic review

- 2685 records were screened but only 15 articles were included in the analysis.
- None of the studies fully fulfilled the criteria.
- Physical and cognitive ergonomics with robotic assistance were significantly less challenging when compared to conventional laparoscopic surgery.
- There is a need for more knowledge on how the surgical techniques impact surgeons physically under real-time surgical conditions.
Most popular counter strategies by surgeons against pain and fatigue.

- A standardized (1.5 minutes) micro-breaks (TSMB) at appropriate 20 to 40-minute intervals
- Targeted the neck, shoulders, upper back, lower back, wrists, hands, knees, and ankles.

Micro-breaks!

**FIGURE 4.** Impact of TSMB on pain scores by anatomic site.

Adrian E. Park et al, Ann Surg 2016
POSSIBLE SOLUTIONS

- Correct posture

- Correct position of the monitor
  - Eye screen axis between the surgeon's arms
  - Appropriate height

- Operating table adapted to the surgeon's height and position:
  - Height of operative table = 0.7 - 0.7 x elbow height

- Correct pedal position

- Ergonomic Laparoscopic instruments designed for women

- Robotic surgery?
WHAT CAN WE DO?

SUGGESTIONS AND HELPFUL TIPS

• "Micro Breaks" every 20-30 minutes
• Avoid painful positions or interrupt a painful activity
• Prompt identification of the first signs of inflammation
• Keep the neutral position
• Avoid long static positions
• Activate the circulation

Change your habits!
• Alternate the movements
• Avoid repetitive and prolonged activities
• Avoid abnormal movements of the wrist
• Frequent interruption to move the hands
CONCLUSIONS

- Injuries or symptoms are reported by 87% of laparoscopic surgeons.
- Ergonomic changes in the organization of the operating room and instruments could significantly reduce the surgeon’s discomfort.
- Female surgeons more often complain of pain or disorders in their hands (including wrist, thumb, and fingers) and the shoulder area (neck, shoulder, upper back).
- It is important to recognize that optimal ergonomics may widely differ between male and female surgeons.

- Ergonomic problems of female surgeons pose new challenges to instruments and equipment production.
- More ergonomic laparoscopic instruments, operating table height and monitor position according to the characteristics of the women are required.
- For both genders ergonomic awareness and physical exercise may be useful to reduce short- and long term discomfort.
THANK YOU FOR YOUR ATTENTION