DIAGNOSTICS AND TREATMENT OF THE UPPER EXTREMITY GUNSHOT COMPARTMENT SYNDROME

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Compartment syndrome (T 79.6) – a condition in which growth of the subfascial pressure in the closed bone-fibrous space decrease tissue perfusion to a level lower than vital.

After 6-8 hours decompensated tissue ischemia becomes irrevocable. After 3-4 days may develop acute renal failure.

Mortality in untreated severe compartment syndrome reaches 47%
Anatomical background:
UPPER LIMB
Actuality
SEVERE CONSEQUENCES OF COMPARTMENT SYNDROME

Direct:

- muscle necrosis
- distal limb segment necrosis
- death
Remote:

- ischemic contracture
- pseudarthrosis and osteomyelitis
- neurotrophic disorders
Ischemic contracture

Fibrous-fatty degeneration of muscle and nervous tissue
Actuality
High frequency of occurrence

At the bone fractures up to 6-20%
Etiology

Reduce blood flow, and decrease muscle tolerance to ischemia:

• Damage of the blood vessels
• Hypotension, shock
• Raised position of the limb
• Anemia, intoxication
**Soft tissue penetrating gunshot wound**

Area of molecular concussion (transitory ischemia caused by the cavitation effect)

Area of parabiosis (area of local shock changes in tissues)

Gunshot wound

Area of initial traumatic necrosis
Interrelation of bullet velocity and changes in the tissues

Bullet velocity:
- Low velocity – 305-610 m/s
- High velocity – > 610 m/s
- Fragments velocity after explosion – 732-884 m/s
  (sometimes even reaching 991 m/s)

- > 183 m/s (pneumatic weapon, ammo type Flaubert) - shock changes in tissues
- > 305 m/s (PSP pneumatic weapon, subsonic patron, a small-caliber weapon, pistol bullet) - effect of cavitation
- > 610 m/s (automatic weapon, firearms of medium and large caliber) - a significant effect of cavitation
- Progressing with increasing velocity
Effect of cavitation can cause tissue damage more than the bullet diameter. Effect of cavitation is a major factor of microcirculatory disorders in the tissues around the wound, and their further ischemia.
Materials and methods

371 patient - compartment syndrome and ischemic contracture

AGE ~ 35
Clinical diagnostics

- **Significant pain**, that does not comply to the severity of injury, and not withdrawn by immobilization

- **Thick, intense edema**
Clinical diagnostics

- Paresthesia or anesthesia in the innervation area of the affected by ischemia nerves
- Pain with passive stretching of the affected muscles
- Paresis or plehiya of the affected muscles
Classical method
Whitesides 1975

Normal subfascial pressure – 3-8 mm Hg
Monitor pressure system
Monitoring

Using a catheter

Multiple puncture
**Classification**

**Mild grade:**
- Distal segment - warm
- Pulse saved
- Hypoesthesia or paresthesia of fingers
- Subfascial pressure - 30-40 mm. Hg below the diastolic

**Average grade:**
- The temperature of the distal segment - decreased
- Pulse weakened
- Hypoesthesia or anesthesia of fingers
- Subfascial pressure within diastolic

**Severe grade:**
- Violation of major arteries patency
- Pulse is missing
- Anesthesia of the fingers
- Subfascial pressure over diastolic
Local treatment

- Dissection of circular bandages
- Weight loss or disassembly of SSE
- Raised limb position
- Avoiding positional compression
- Dosed cooling of the affected muscles
Medical treatment

- Improving blood rheology
- Increased blood oncotic pressure
- Correction of hemodynamic hypotension
- Diuretics
- Analgesics
- Optimization of tissue metabolism
- Anti-inflammatories
- Drugs affecting the vascular endothelium
Mild grade
Subcutaneous fasciotomy
Fasciotomy on forearm

Results after 2 months:
Treatment of the severe grade

1. Dermatofasciotomy
2. Revision of the neurovascular bundles
3. Phased revision and necrectomy
4. Secondary wound closure
**Soft tissue gunshot injury**

**Low velocity gunshot injuries - causing minor damage to the soft tissues!**
- Needing only superficial and sanitation, and should be left for healing by secondary intention
- When the bullet can not be palpated subcutaneously - it should be left

**Hight velocity gunshot injuries - causing significant damage to the soft tissues!**
- Require aggressive debridement, and continuous monitoring
- Foreign bodies must be removed
Bones gunshot injury

Low velocity gunshot bone injuries:
- More common among civilians
- **Have similar characteristics with closed fractures**
- Unstable fractures require surgical stabilization
- Those that can be easily recovered can be treated without surgery.

Hight velocity gunshot injuries:
- **Treatment is based on the protocols of open fractures**
- Very high risk of infection and the occurrence of compartment syndrome
- Fixation with or without fasciotomy - the basis of initial stabilization of the fracture
- **Ballistic fractures of elbow - increase risk for the development of compartment syndrome**
Treatment is based on the protocols of open fractures with massive soft tissue injury.

- Very high risk of infection and the occurrence of compartment syndrome.
- Aggressive surgical tactics with the removal of necrotic tissue.
- Required careful check of major vessels.
- Required fasciotomy.
- The hardware method of primary stabilization of the fracture.
The basic principles of gunshot injuries curation

1. All gunshot injury is contaminated, so they require adequate antibiotic therapy.

2. Gunshot injury requiring control of electrolyte balance (correction of hyperlactatemia, and metabolic acidosis that developing with significant muscle lesions).

3. Gunshot fractures must be stabilized with external fixation devices (preferably onesided).

4. Need to remove all nonviable tissue (it is important to remember that the only sign of muscle vitality is its ability to contract to the electric stimulation) and foreign bodies (given the amount of injuries that will be applied during their removal).

5. Decompression fasciotomy (and sometimes decompression of each muscle) is indicated for:
   - Large vessels damage
   - Gunshot injuries of the proximal forearm
Indications for fasciotomy

- Damage to the vascular-nerve bundles
- Gunshot fractures of proximal third of the forearm and distal third of the arm
- Gunshot injuries of large joints
- The massive soft tissue injury, shotgun gunshot wounds
GUNSHOT FRACTURE + NERVE DAMAGE

- PST
  - Osteosynthesis
    - Wound healing
      - Nerve restoration in 3 months
  - PST
    + Neurolysis, nerve suture
      + Osteosynthesis
Prevention fasciotomy indications

- Multi fragmented fracture of the elbow joint.
- Gunshot fractures of any localization with violation of the main blood flow.
- In cases of polytrauma - in combination with PST of gunshot fractures.
- In cases of prolonged tourniquet (over 2 hours).
- Gunshot fractures of any localization combined with extensive burns.
- Circular burns.
Multiple trauma
(Compartment syndrome – 43%)

Gunshot fractures in the
area of the elbow joint

Hypotension
Hypovolemia

Preventive fasciotomy

Closed bone-fascial sheath

80-100 mm Hg

Artery

Norm (mm Hg)
40-50 mm Hg

Vena

Muscle microcirculation

5-7

HEMATOMA
Prevention fasciotomy

- Ischemic contracture
- Pseudarthrosis and osteomyelitis
- Neurotrophic disorders

no

- Scar
- Reducing power of the hand to 5%

yes
Thank you!
Dziękuję!
Дякую!