

# DIAGNOSTICS AND TREATMENT OF THE UPPER EXTREMITY GUNSHOT COMPARTMENT SYNDROME

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УКРАЇНА

ЛУГАНСЬКА  
ОБЛАСТЬ

ХАРКІВСЬКА  
ОБЛАСТЬ

ДНІПРОПЕТРОВСЬКА  
ОБЛАСТЬ

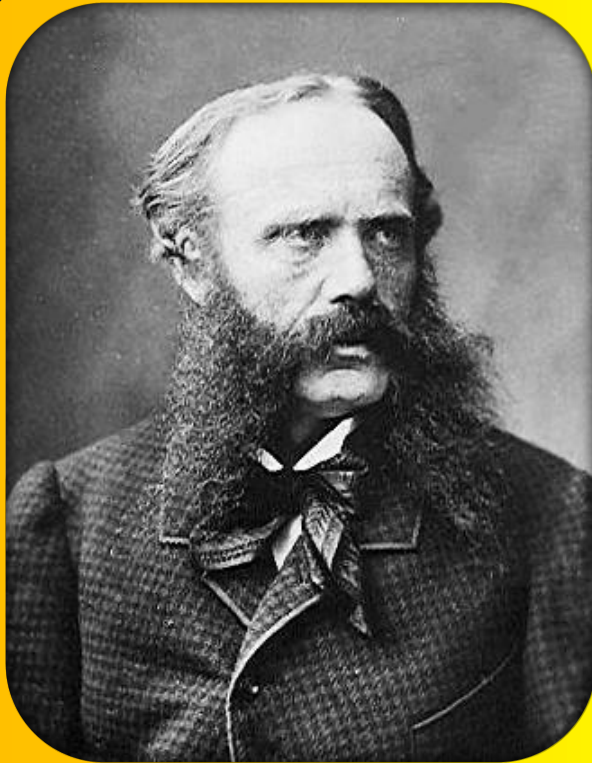
ДОНЕЦЬКА  
ОБЛАСТЬ

ЗАПОРІЗЬКА  
ОБЛАСТЬ

РОСІЯ



- Сватове
- Старобільськ
- Біловодськ
- Мілове
- Новоруський
- Красна Талівка
- Ушаковка
- Станиця Луганська
- Новоайдар
- Сєверодонецьк
- Лисичанськ
- Трьохізбенка
- Слов'янськ
- Сіверськ
- Слов'яносербськ
- Луганськ
- Сабівка
- Первомайськ
- Стаханов
- Алчевськ
- Новоганнівка
- Ізварине
- Красний Яр
- Краснодон
- Каменськ-Шахтинський
- Краматорськ
- Попасна
- Артемівськ
- Світлодарськ
- Дебальцеве
- Городище
- Антрацит
- Свердловськ
- Ровеньки
- Червонопартизанськ
- Гуково
- Добропілля
- Костянтинівка
- Майорське
- Горлівка
- Шахтарськ
- Лісне
- Макіївка
- Торез
- Красний Луч
- Дякове
- Зеленопілля
- Довжанський
- Красноармійськ
- Авдіївка
- Піски
- Красногорівка
- Мар'їнка
- Донецьк
- Ілловайськ
- Савур-могила
- Мар'янівка
- Амвросіївка
- Петропавлівка
- Новошахтинськ
- Велика Новосілка
- Старобешеве
- Кумачове
- Марфинка
- Волноваха
- Тельманове
- Водолазьке



**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.

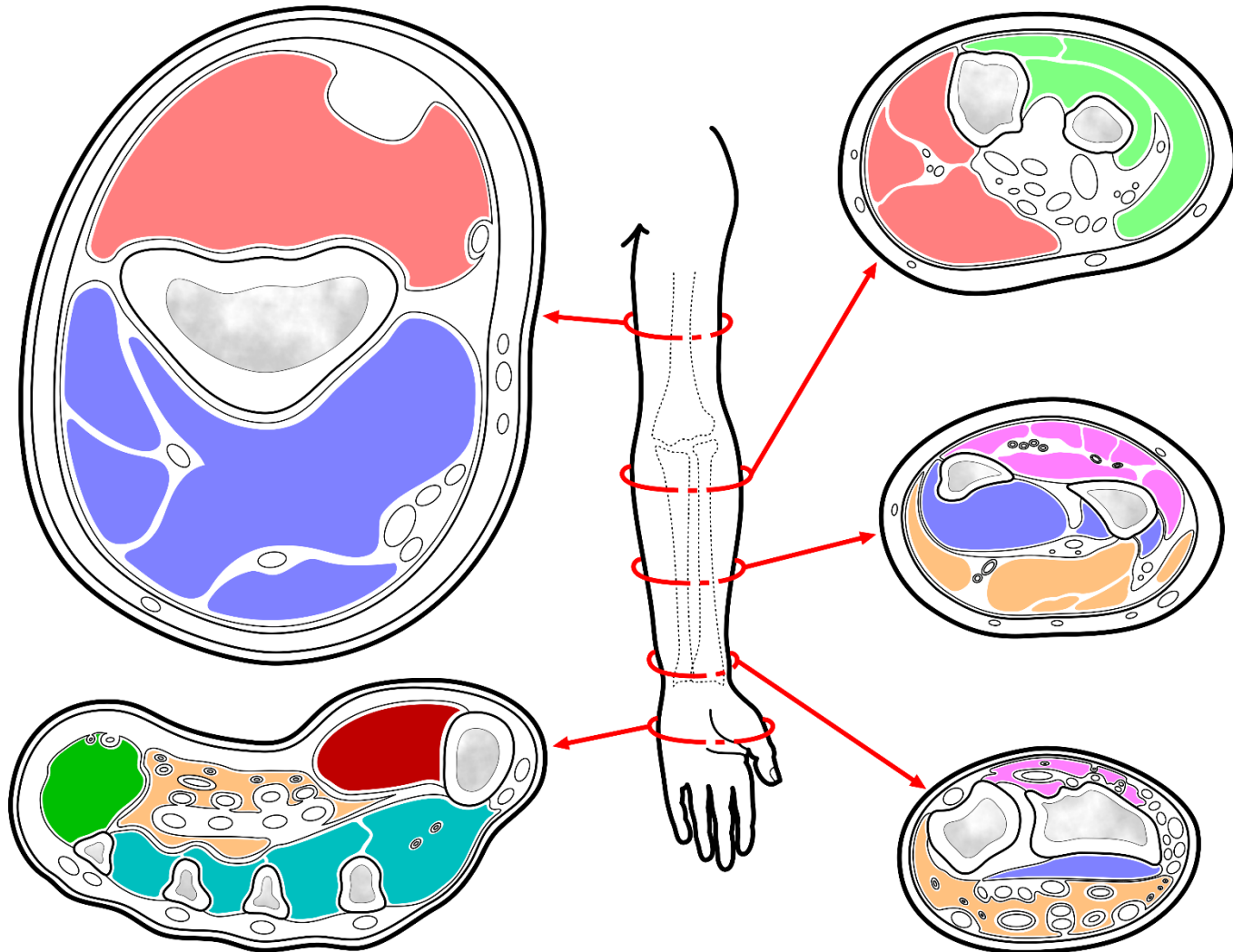
After 6-8 hours decompensated tissue ischemia becomes irrevocable.

After 3-4 days may develop acute renal failure.

Mortality in untreated severe compartment syndrome reaches **47%**

# Anatomical background:

## UPPER LIMB

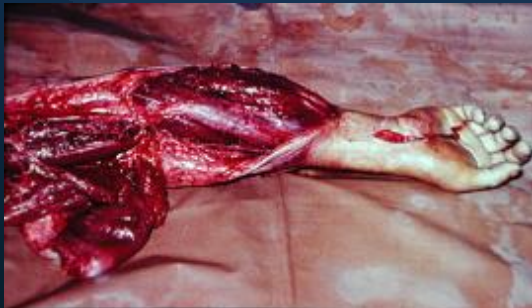


# Actuality

## SEVERE CONSEQUENCES OF COMPARTMENT SYNDROME

### Direct:

- muscle necrosis
- distal limb segment necrosis
- death



# Actuality

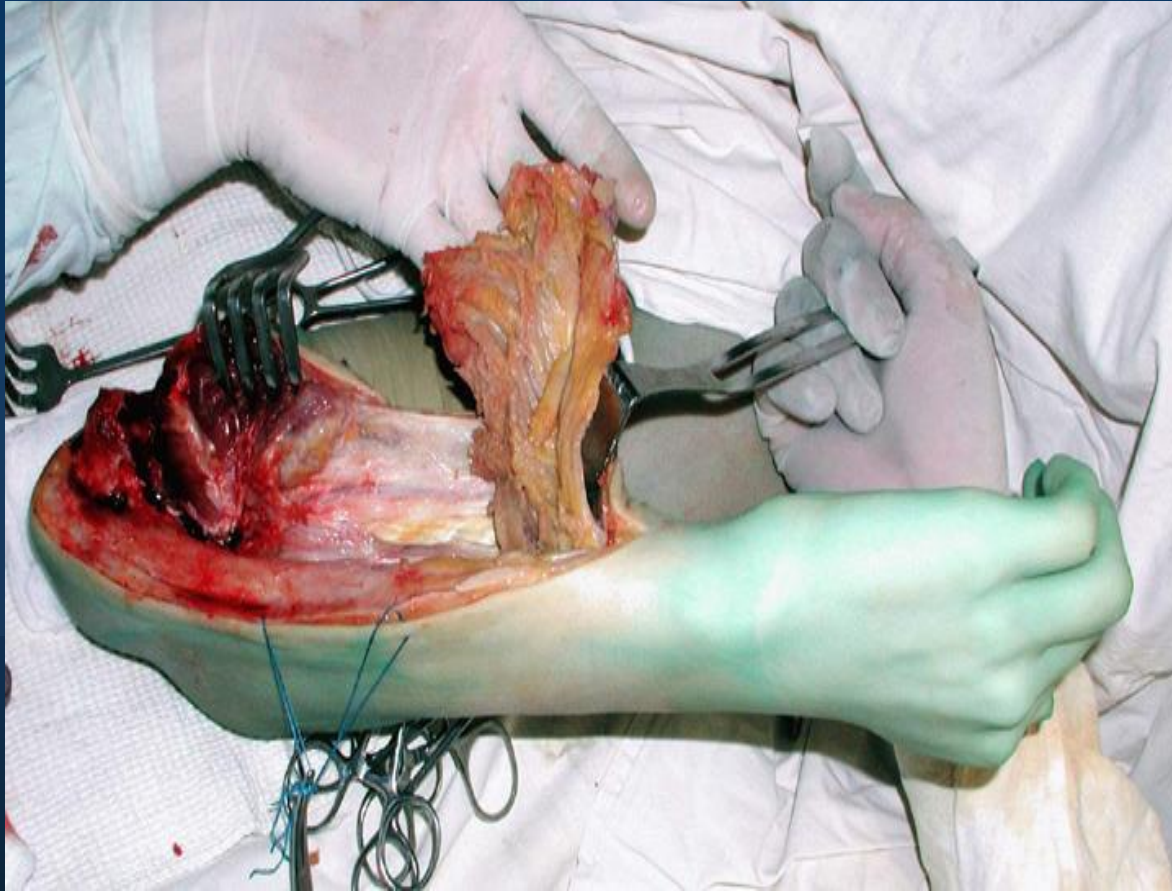
## SEVERE CONSEQUENCES OF COMPARTMENT SYNDROME

### Remote:

- ischemic contracture
- pseudarthrosis and osteomyelitis
- neurotrophic disorders



# Ischemic contracture



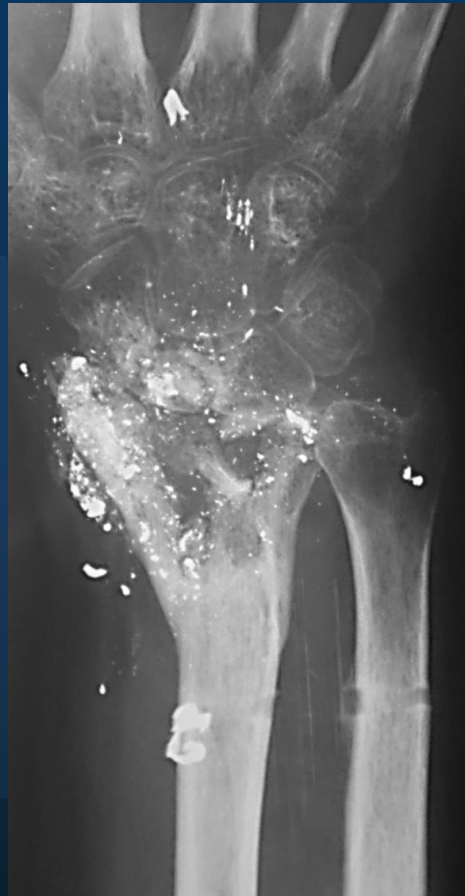
Fibrous-fatty  
degeneration of  
muscle and nervous  
tissue



# 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



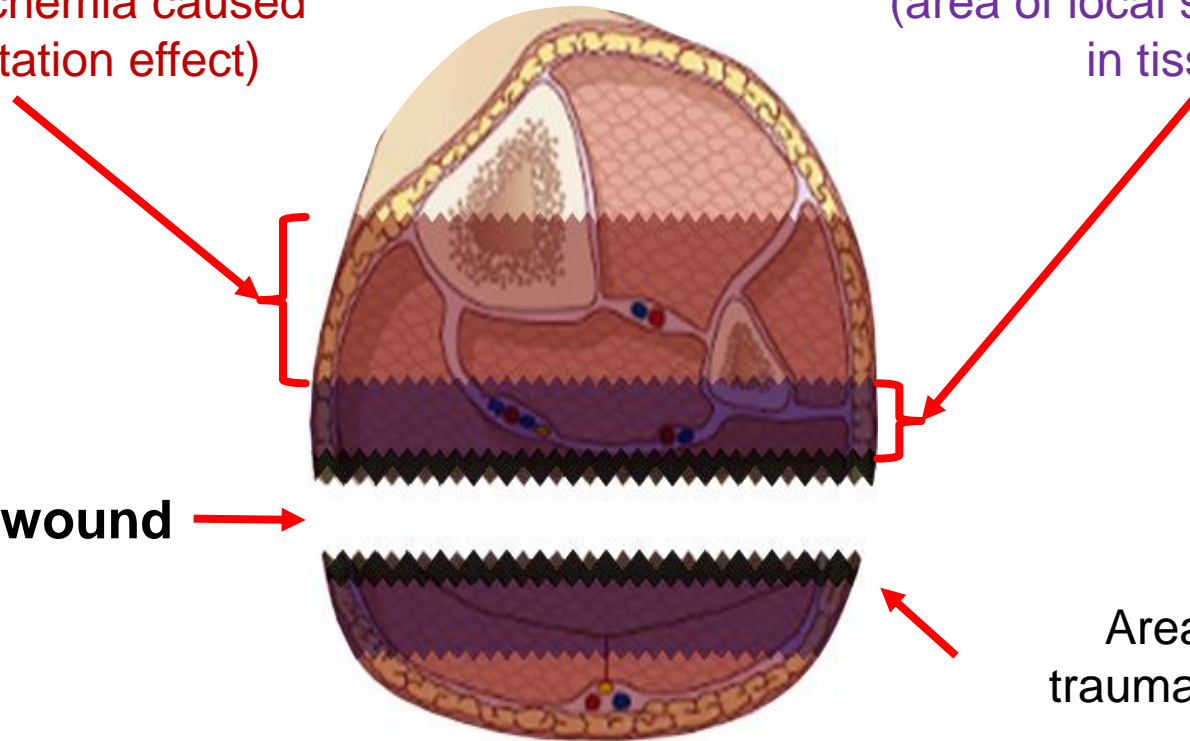
# Soft tissue penetrating gunshot wound

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



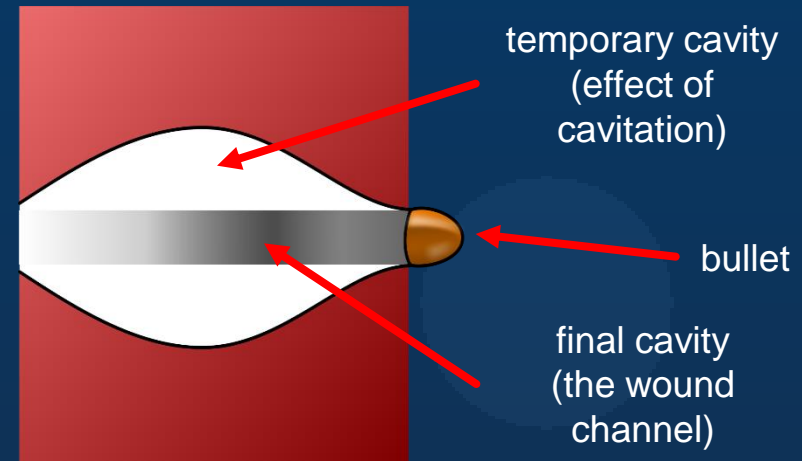
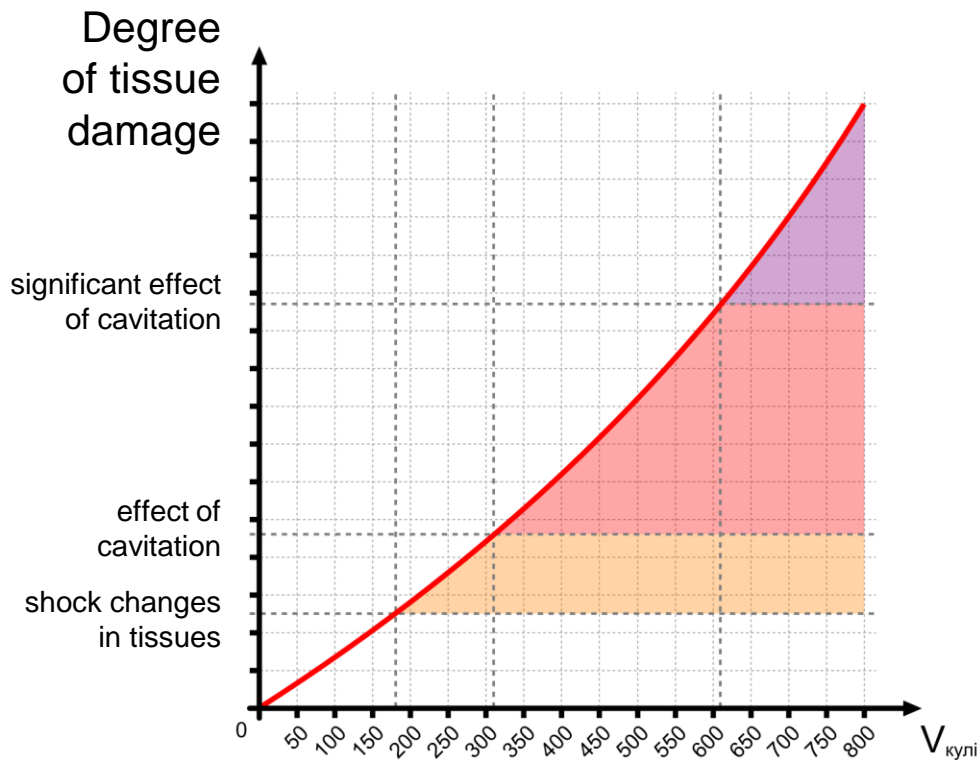
# Interrelation of bullet velocity and changes in the tissues

## 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

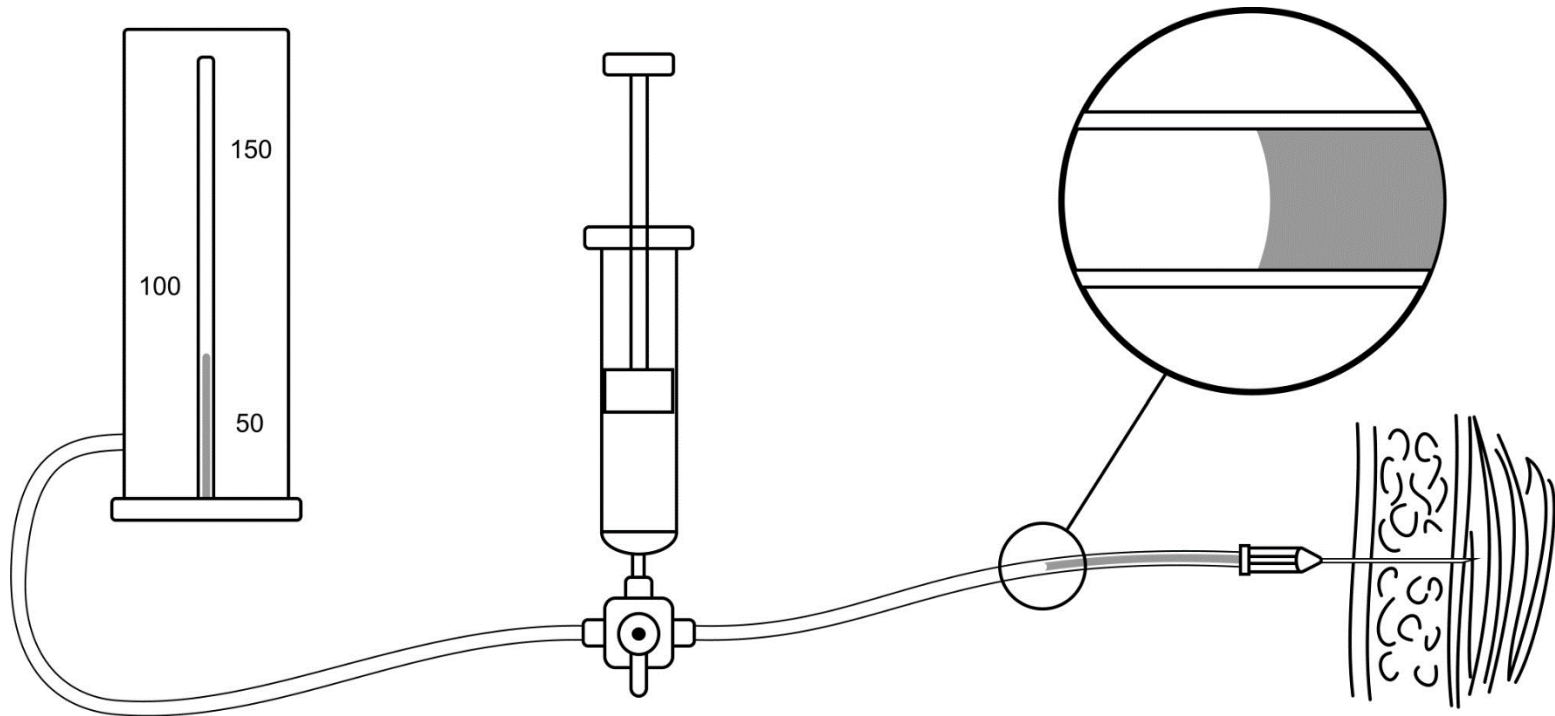
# Characteristics of the gunshot wounds



Effect of cavitation can cause tissue damage more than the bullet diameter

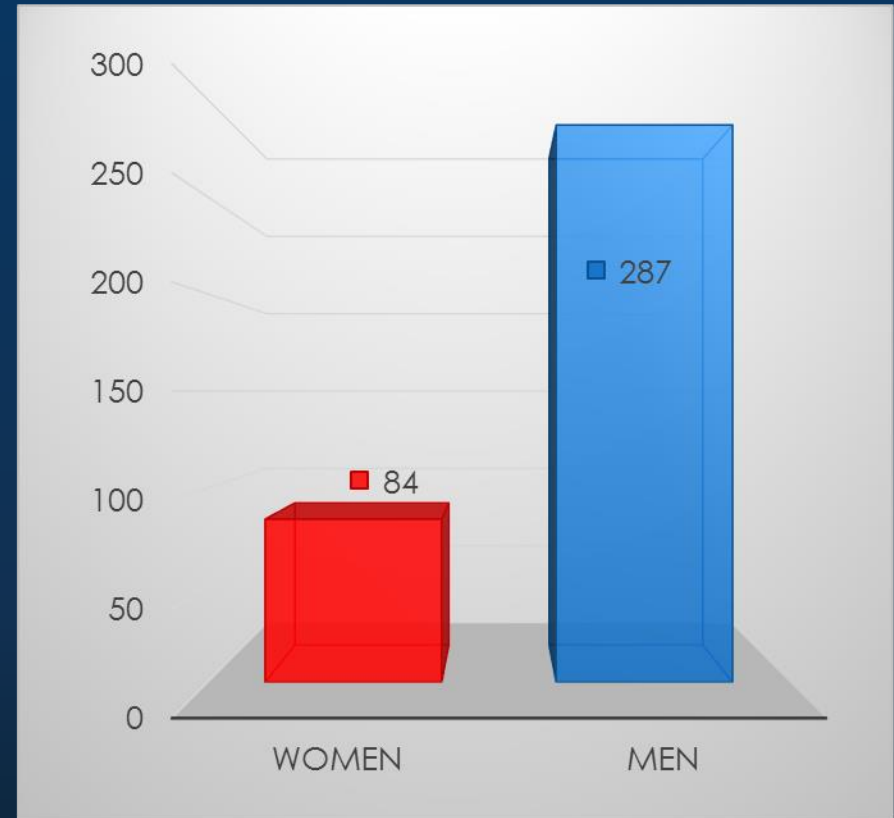
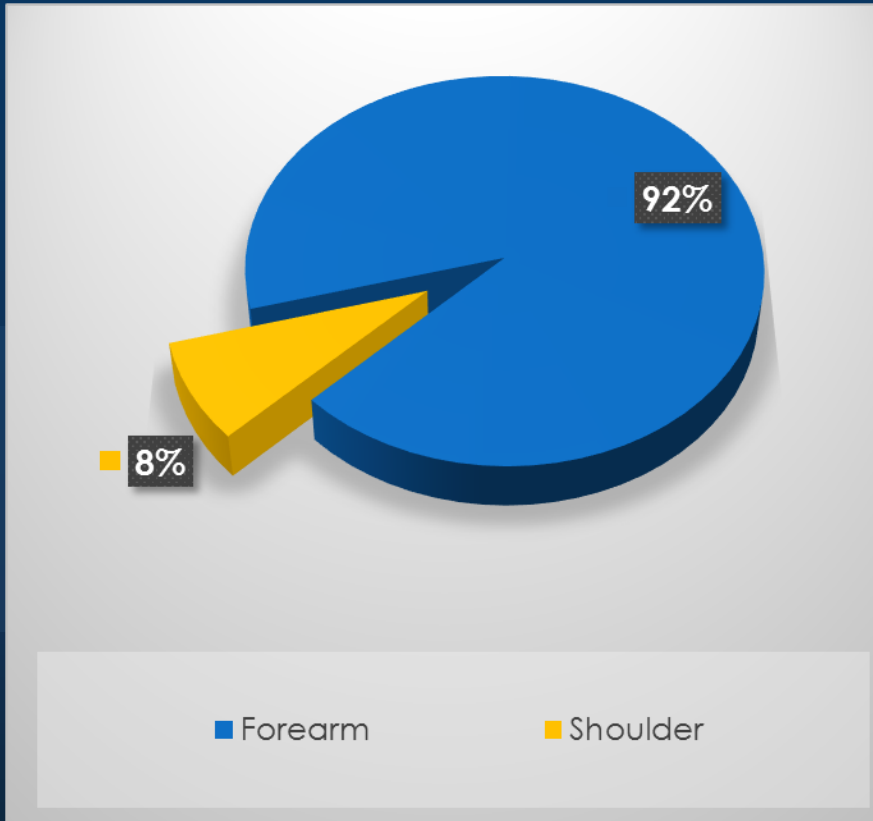
**Effect of cavitation is a major factor of microcirculatory disorders in the tissues around the wound, and their further ischemia**

# CLINICAL STUDY



# Materials and methods

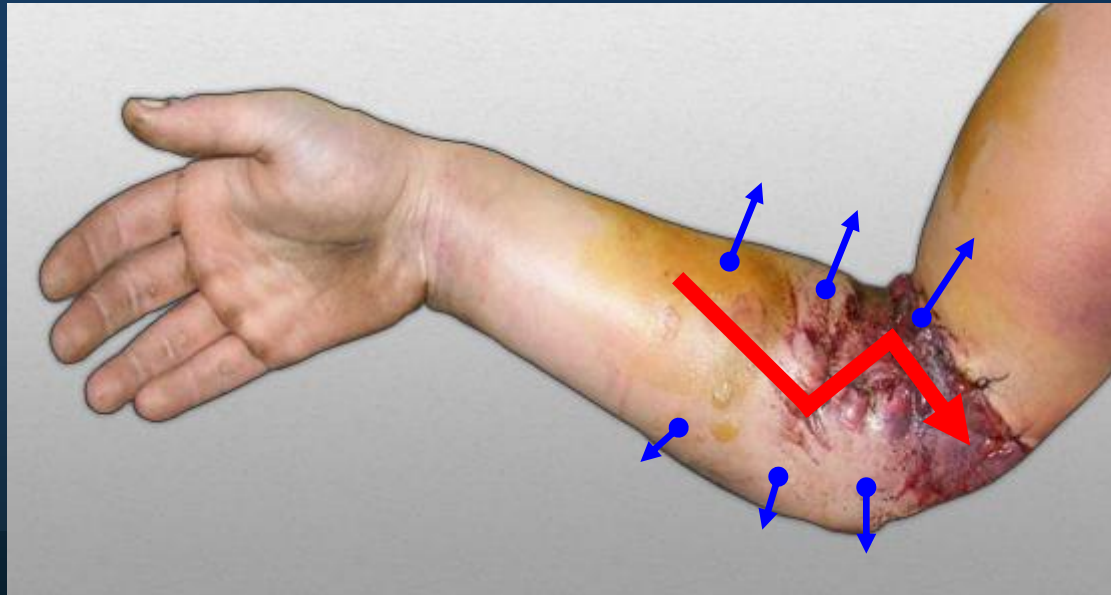
**371 patient** - compartment syndrome and ischemic contracture



**AGE ~ 35**

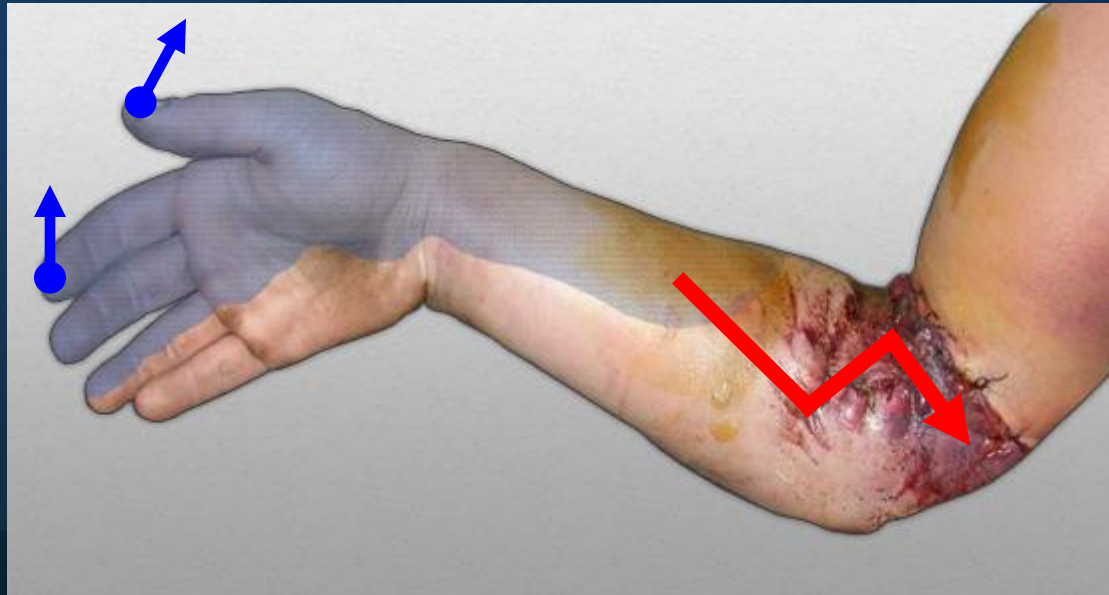
# Clinical diagnostics

- **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

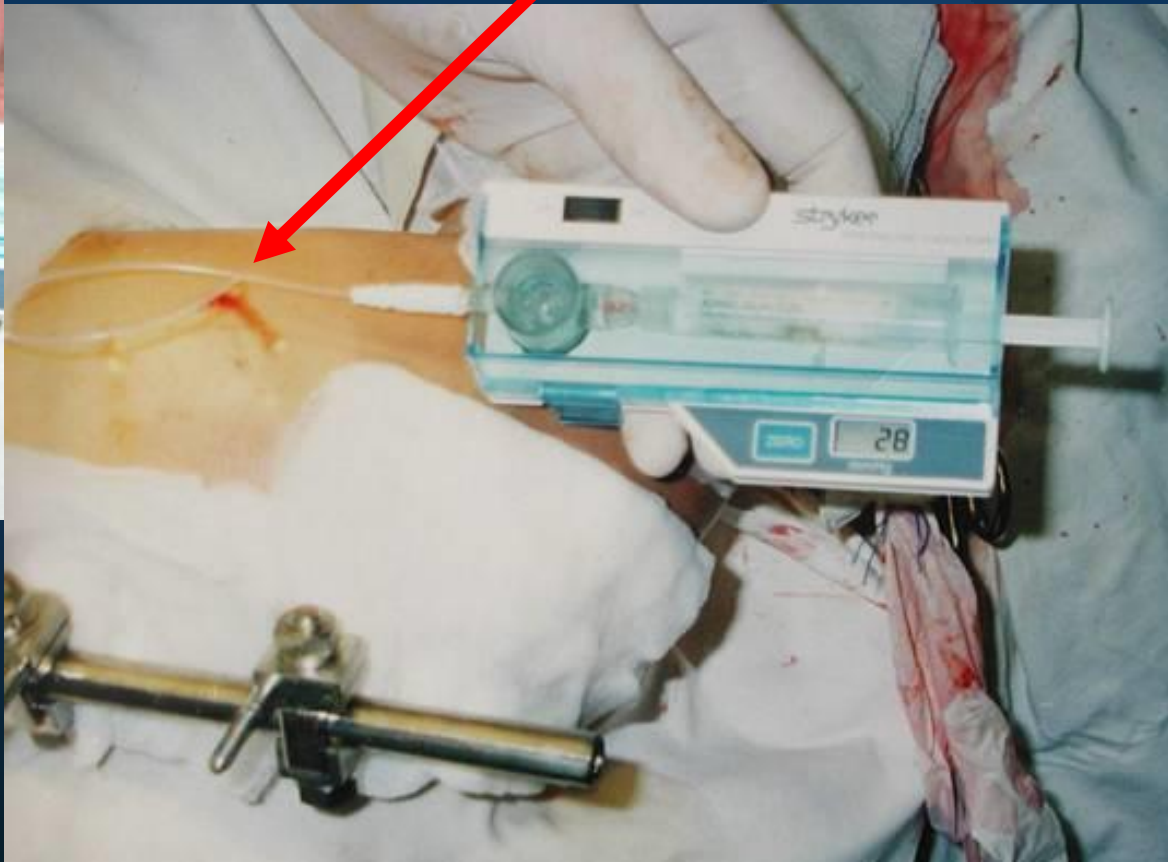


# Monitoring



Multiple  
puncture

Using a catheter



# Classification

## Mild grade:

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

## Average grade:

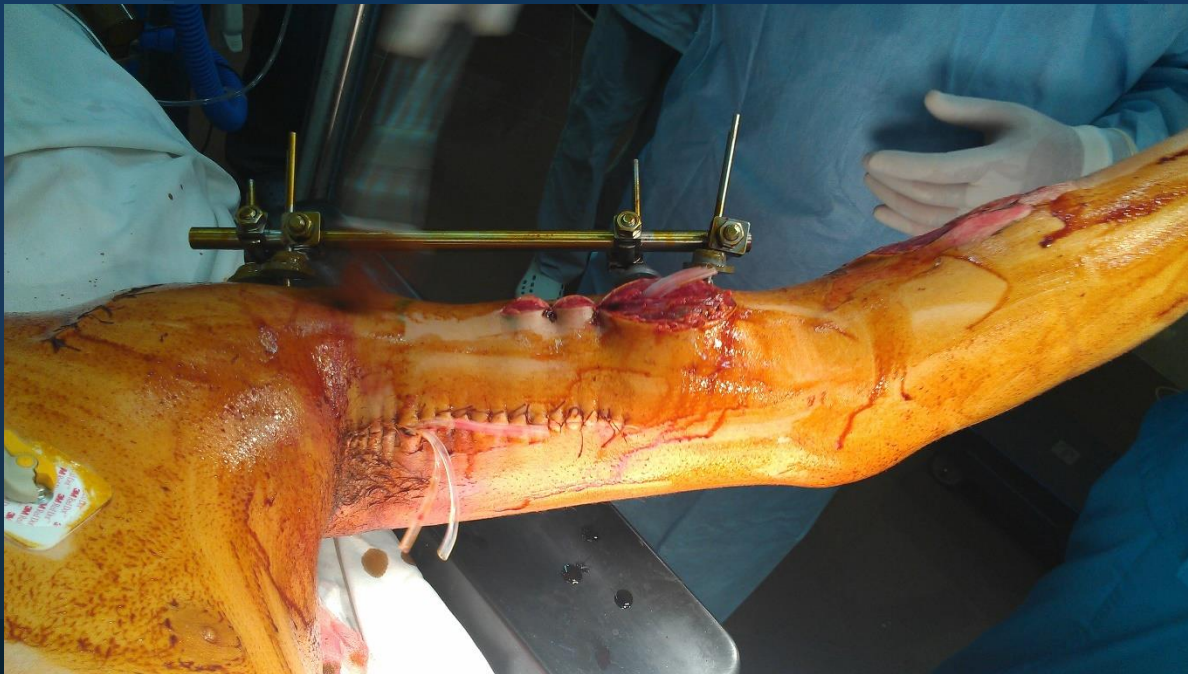
- The temperature of the distal segment - decreased
- Pulse weakened
- Hypoesthesia or anesthesia of fingers
- Subfascial pressure within diastolic

## Severe grade:

- Violation of major arteries patency
- Pulse is missing
- Anesthesia of the fingers
- Subfascial pressure over diastolic



# TREATMENT OF THE COMPARTMENT SYNDROME



# 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

# Treatment of the compartment syndrome

## Mild grade

Subcutaneous fasciotomy





# Fasciotomy on forearm



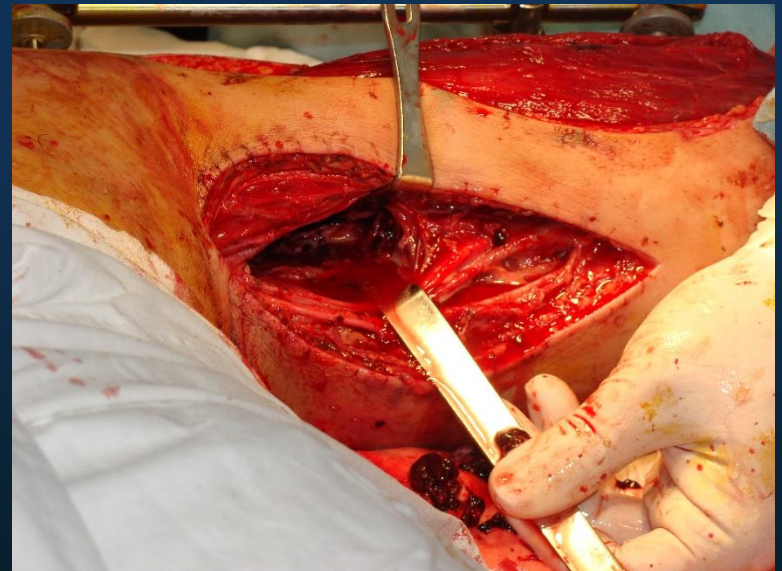
**Results**  
after 2 months:



# 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.

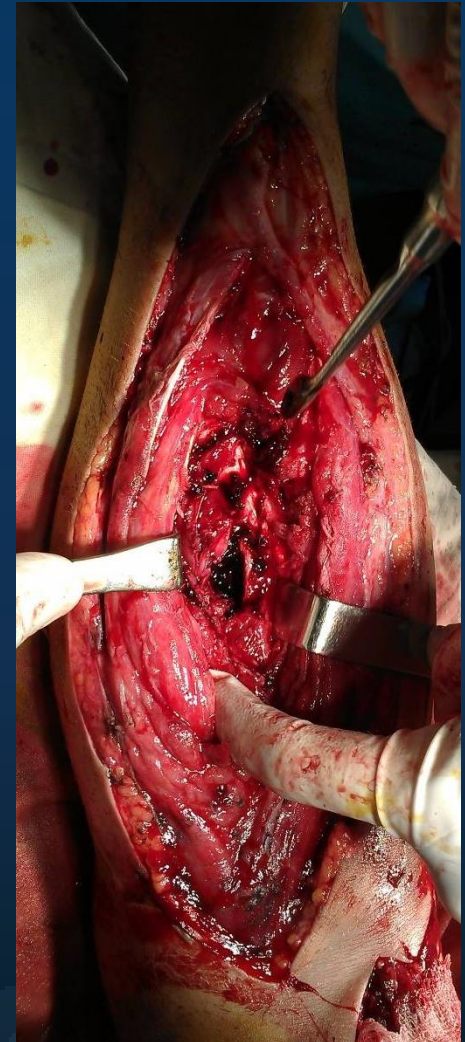
## High velocity gunshot injuries:

- **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**



# Shotgun gunshot wounds

- **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

+

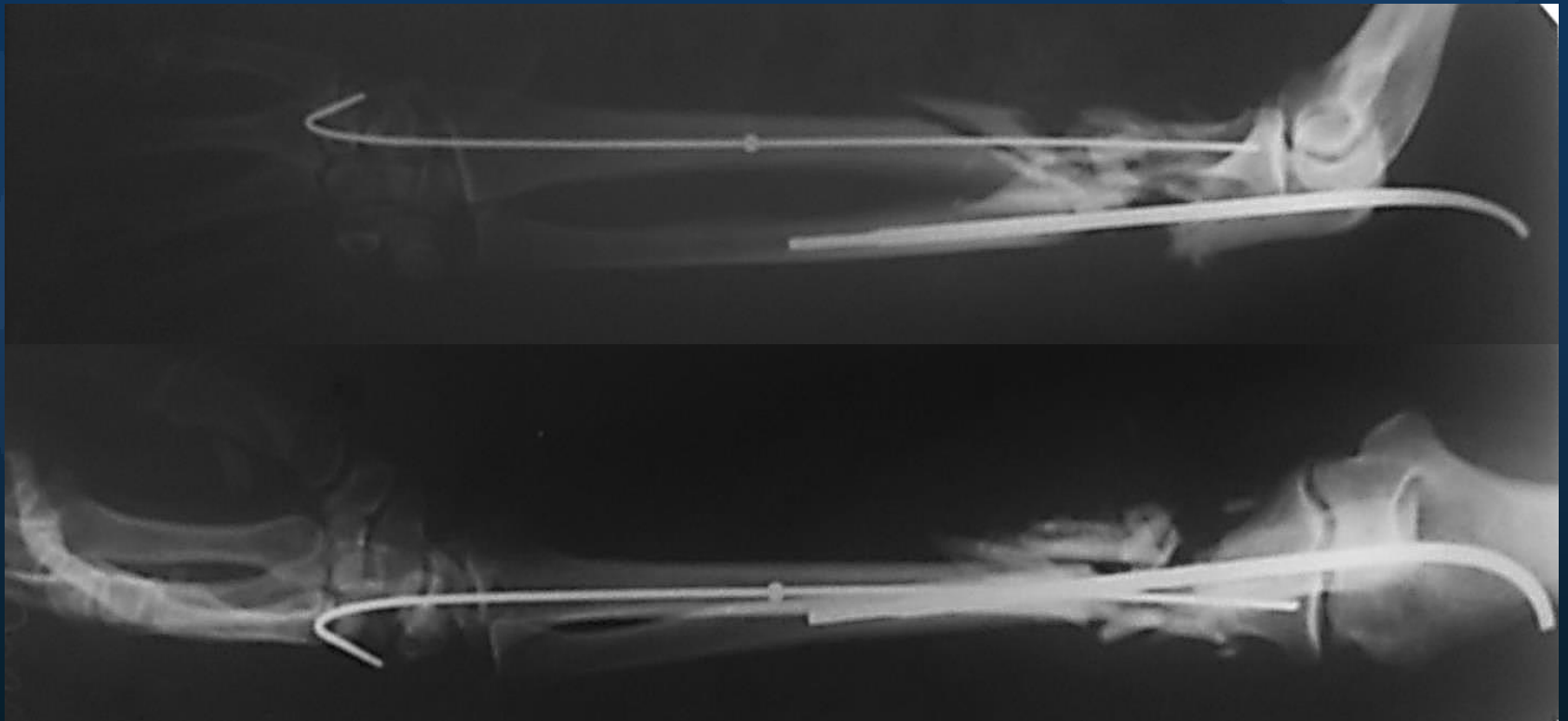
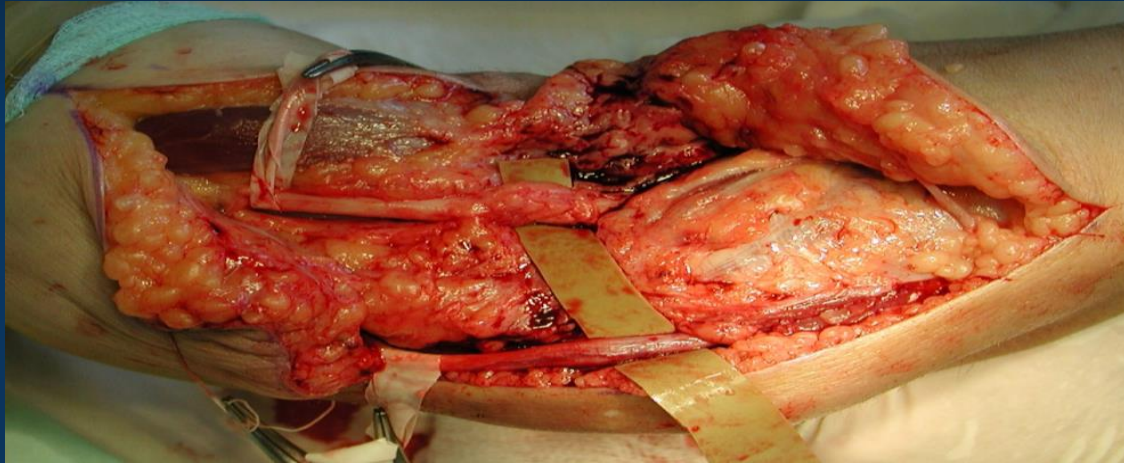
Neurolysis, nerve  
suture

+

Osteosynthesis



# PATIENT A – 60 №522789



# Prevention fasciotomy indications

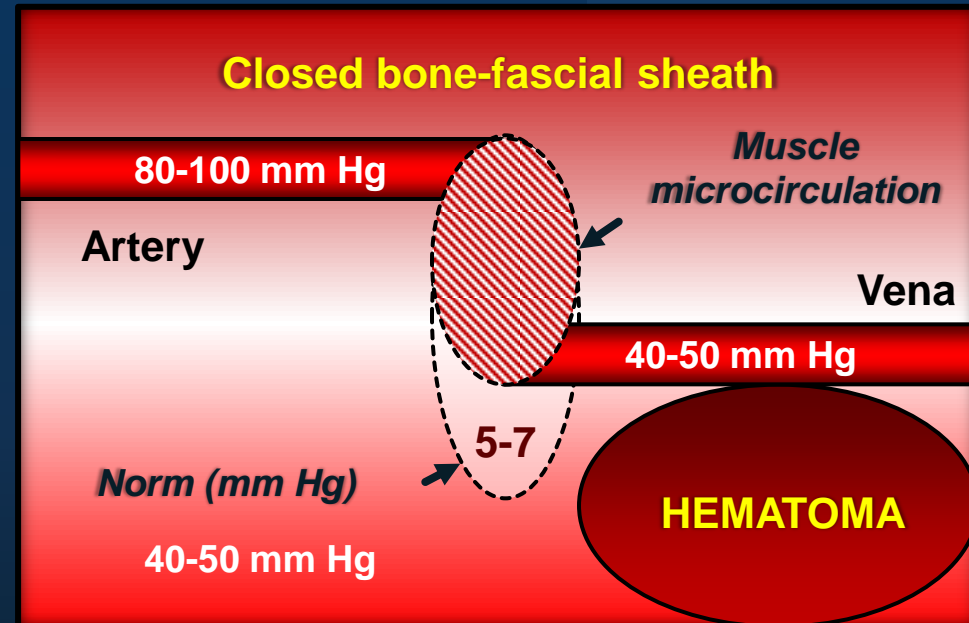
- Multi fragmented fracture of the elbow joint.
- Gunshot fractures of any localization with violation of the main blood flow.
- In cases of polytrauma - in combination with PST of gunshot fractures.
- In cases of prolonged tourniquet (over 2 hours).
- Gunshot fractures of any localization combined with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

**Multiple trauma**  
(Compartment syndrome – 43%)

**Gunshot fractures in the  
area of the elbow joint**

**Hypotension  
Hypovolemia**

**Preventive fasciotomy**



# Prevention fasciotomy

**no**

- Ischemic contracture
- Pseudarthrosis and osteomyelitis
- Neurotrophic disorders

**yes**

- Scar
- Reducing power of the hand to 5%



**Thank you!**

**Dziękuję!**

**Дякую!**