

ACUTE COMPARTMENT SYNDROME

IN THE HAND AND FOREARM

Definition

- Compartment syndrome is caused by increased pressure in a closed fascial space leading to tissue ischaemia, death and fibrosis.

Physiology

- **$LBF = Pa - Pv / R$**
- When local tissue pressure increases, veins collapse and Pv increases
- Local Blood Flow can be reduced to the point where it no longer meets the metabolic needs of the muscles and nerves
- Drop of Pa compounds the effect

Causes

Increased volume within compartment

- Fractures (high energy)
- Crush injuries / contusions
- Bleeding
- Vascular injuries
- Reperfusion
- Extravasations

Compartment constriction / External compression

- Tight casts / bandages
- Circumferential burns
- Unconscious patients
 - IVDU / ITU / Theatre

Diagnosis – The 5 Ps

- Pain
- Paraesthesia
- Paralysis
- Pallor
- Pulselessness

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Pain

- Out of proportion to injury
- Stretch pain
- On palpation

Tense compartment

- CARE – Nerve blocks / epidurals

Diagnosis – The 5 Ps

- Pain
- Paraesthesia
- Paralysis
- Pallor
- Pulselessness

Paraesthesia

Paralysis

- Proprioception is first to go, then touch and last is motor innervation
- Progression is highly suggestive
- Identifying the nerve identifies the tense compartment

Diagnosis – The 5 Ps

Pallor

- Pain
 - Paraesthesia
 - Paralysis
 - Pallor
 - Pulselessness
- Only if cutaneous circulation is impaired

Diagnosis – The 5 Ps

- Pain
- Paraesthesia
- Paralysis
- Pallor
- Pulselessness

Pulselessness

- Only if compartment pressure higher than systolic pressure
- Very late – Very rare

Diagnosis – The 5 Ps

- The most reliable physical findings indicating a forearm compartment syndrome were marked pain on passive digital extension and reduced hand sensibility or paresthesias. Pressure determinations were most helpful in evaluating comatose patients and patients with equivocal physical findings

Gelberman ClinOrthopRelRes 1981

- Pain with passive motion is the most reliable physical finding; however, compartment pressure measurement is the only truly reliable method of diagnosis.

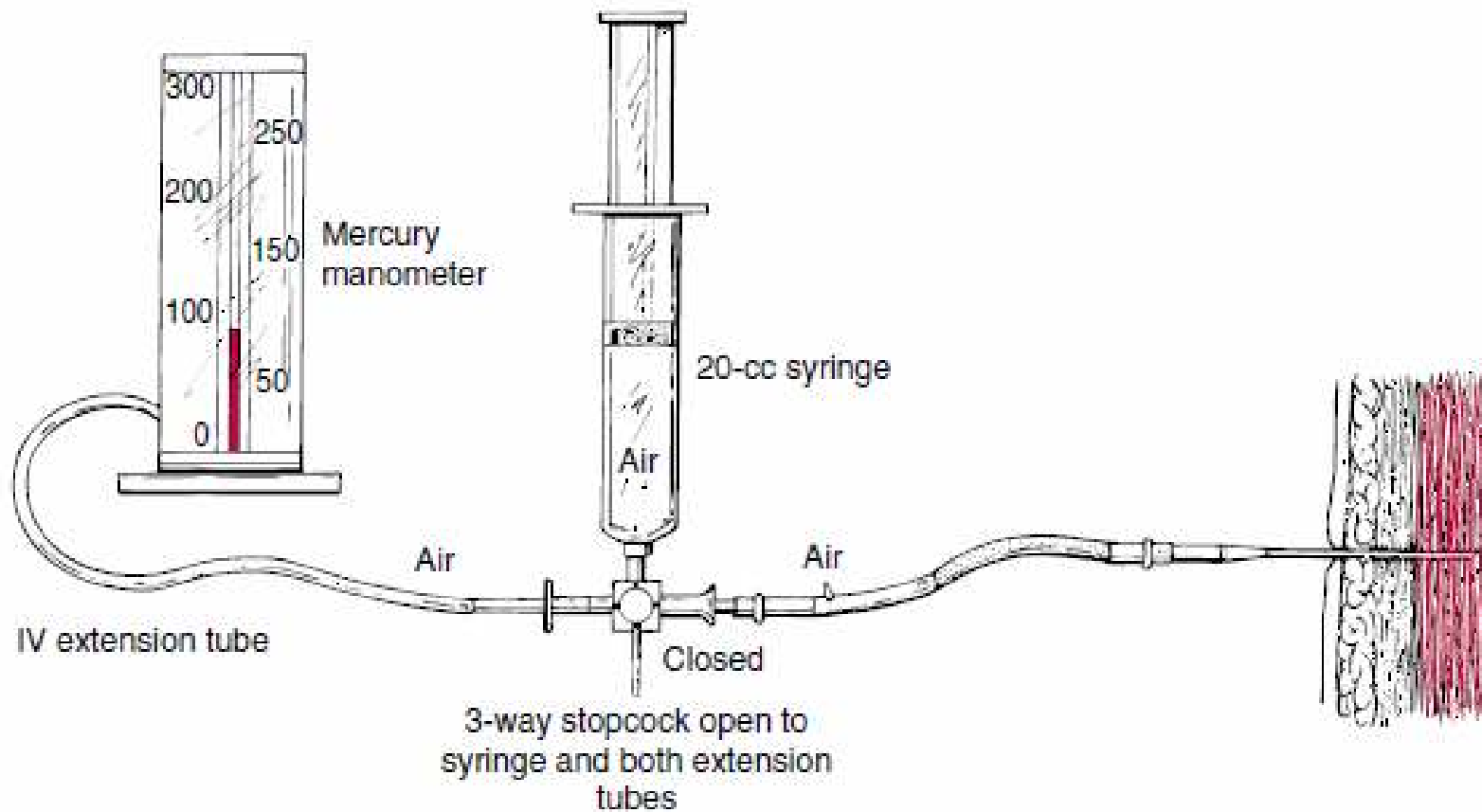
Naidu HandClin 1994

Diagnosis - Measurement

- Infusion Technique (Whitesides)
- Wick Catheter Technique (Mubarack)
- Slit Catheter Technique (Rorabeck)
- Continuous monitoring technique (Matsen)
- Commercially available pressure monitor systems – STRYKER (Whitesides)

Infusion Technique

Whitesides et.al. ClinOrthop 1975

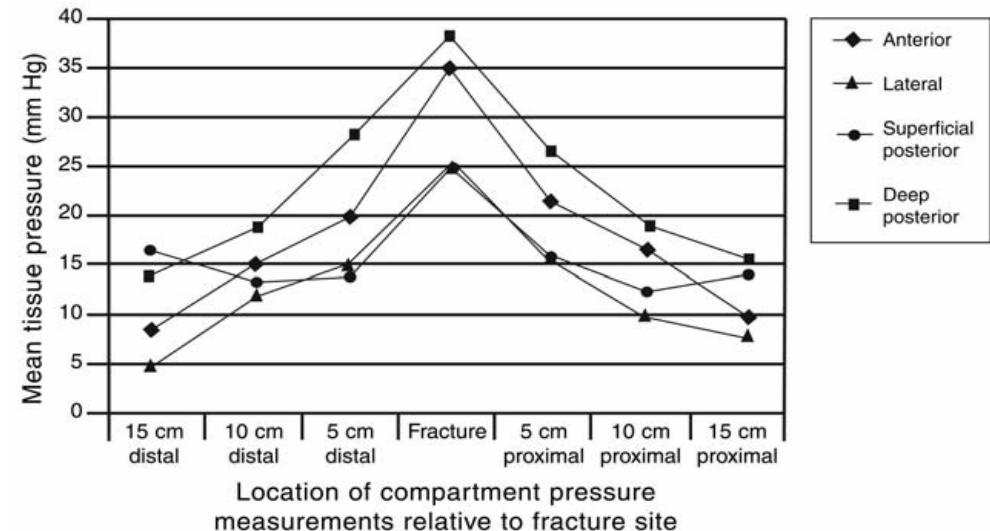


Stryker – STIC Monitor



Diagnosis - Measurement

- In closed tibial fractures, the compartment pressure varies according to the location of the needle.
- Insert needle at site of fracture or maximum injury and repeat proximally and distally. Use the highest reading.



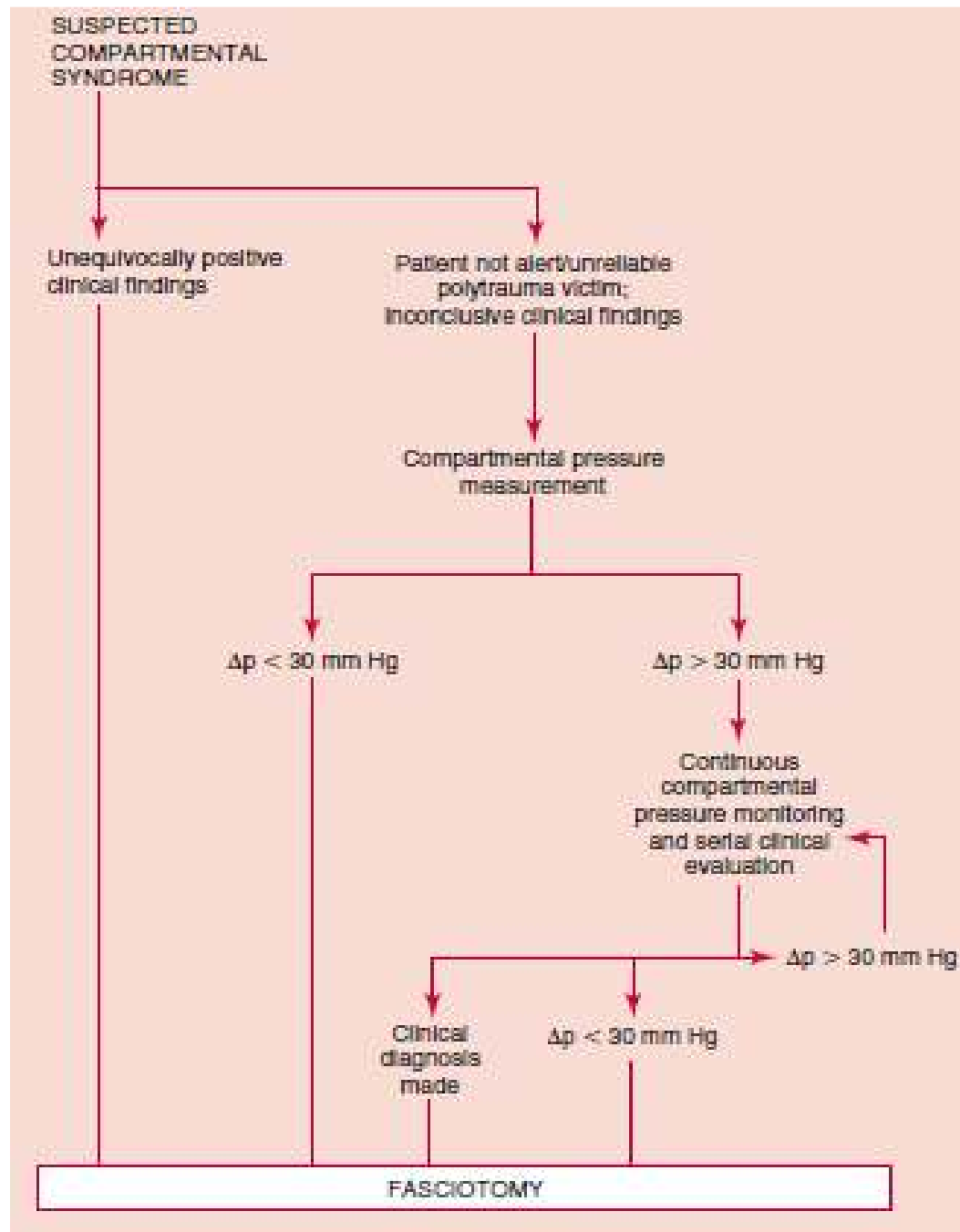
Heckman et.al. JBJS 1994

When to treat? Absolute CP

- Normal resting intramuscular 0-8 mmHg
- 20-30 mmHg: pain and paresthesia
- 30 mmHg+ for 8+ hours: irreversible necrosis (Hargens JBJSAm 81) Dogs
- 30 mmHg cut-off for fasciotomy, no missed cases. (Mubarak JBJSAm 1978) 11/27 cases, various muscles
- 25 mmHg w/o signs; 15 mmHg with signs (Ouellette JBJSAm 96; 17 patients) Hands
- 40 mmHg observe; 50 mmHg operate (Allen JBJSBr 85) No adverse sequelae. Legs

When to treat? Relative CP

- DBP – Compartment Pressure. If < 30 perform fasciotomy (McQueen JBJSBr 1996). Greater specificity without any sacrifice in sensitivity (116 tibias).(Whitesides ClinOrthRelRes 1975)
- MAP – CP. Treat if < 30 (Mars and Hadley Injury 98). Study involving 30 children - forearms(No op in cases with $CP > 30$ no sequelae)



McQueen JBJSBr 96

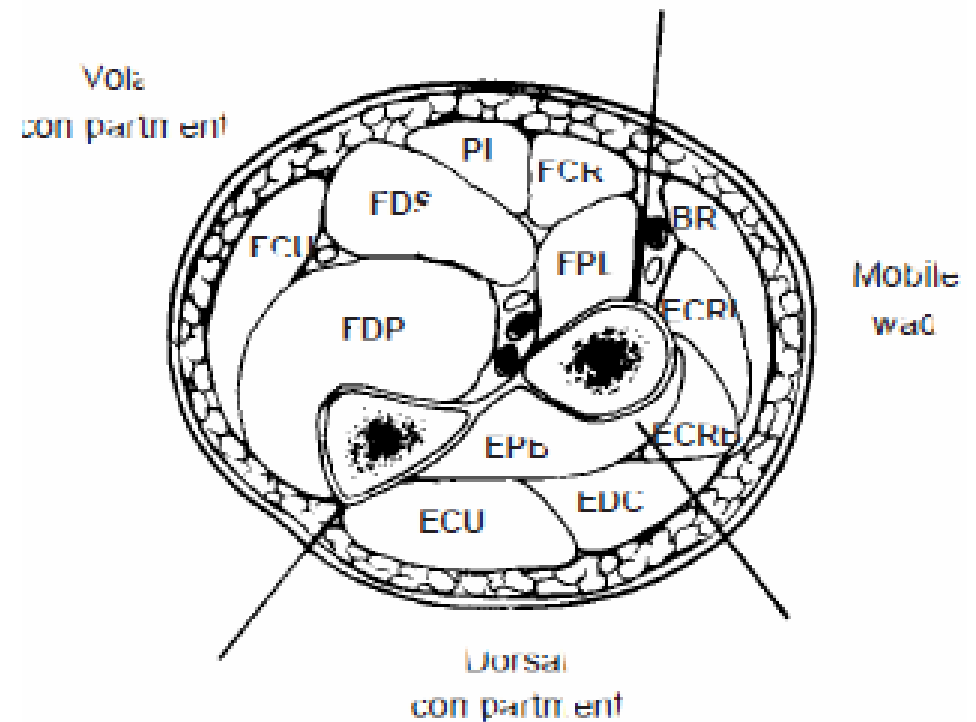
Treatment

- Remove tight bandages / split cast
- Elevate NOT (level of heart)
- Serial evaluations
- Fasciotomies

Forearm

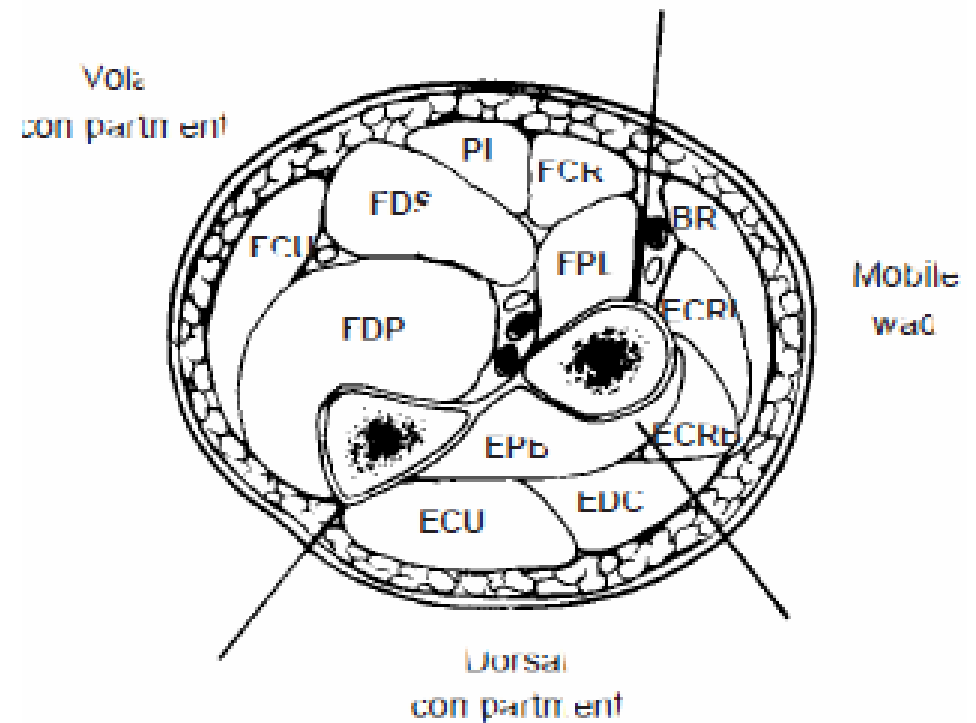
Three Compartments

- Dorsal
 - EPB, ECU, EDC
- Volar
 - Flexors, pronators, supinator
 - (Superficial + deep)
- Mobile Wad
 - Brachioradialis, ECRL, ECRB
- Interconnected. Releasing volar compartment can reduce pressure in dorsal and mobile wad

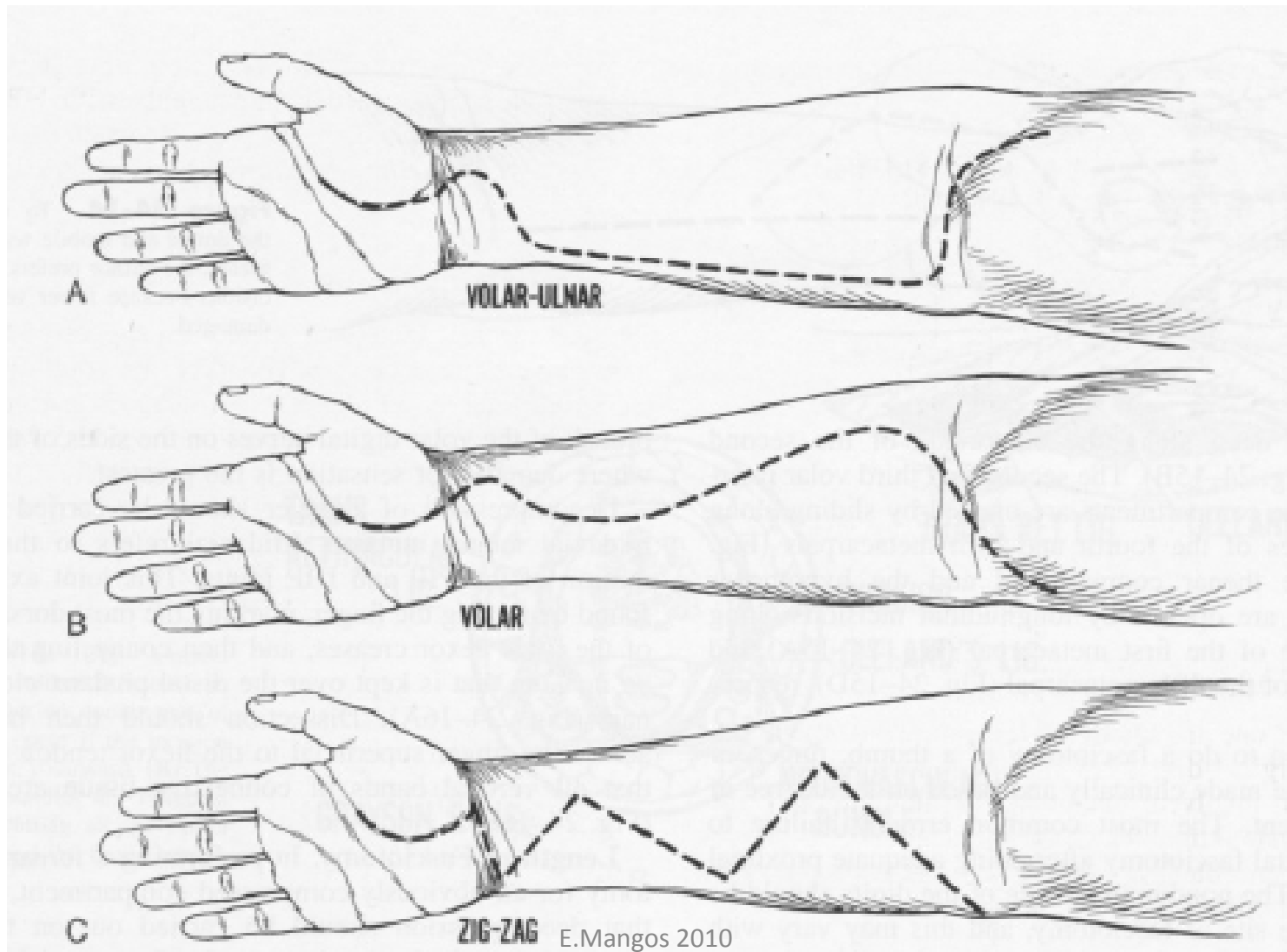


Forearm

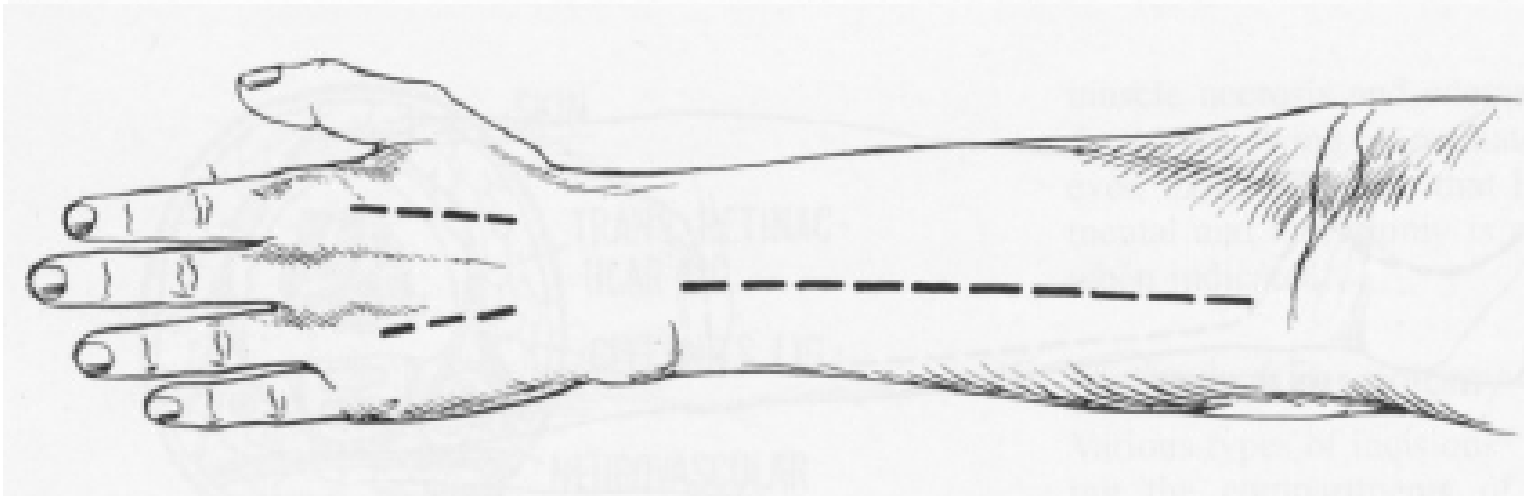
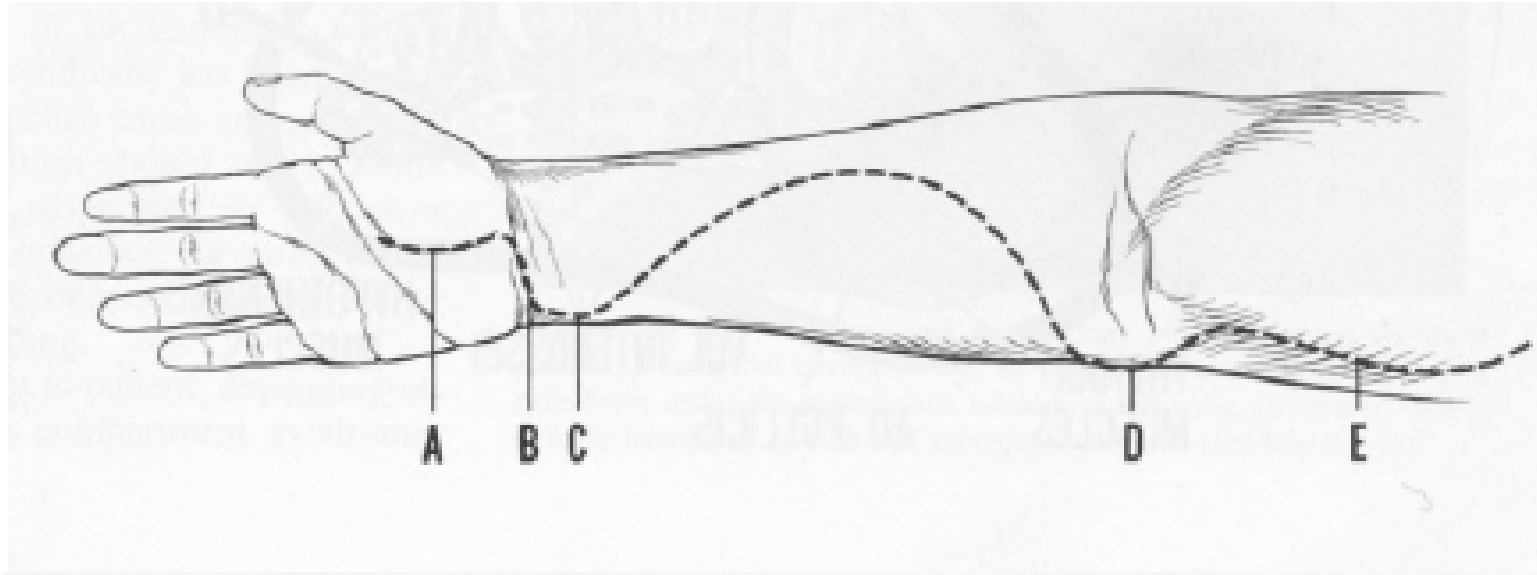
- Volar (Henry) approach
 - Between FCR and Brachioradialis
- Volar Ulnar approach
 - Between FCU & FDS
- + CTR
- Dorsal approach
 - Between ECRB & EDC



Forearm – Skin Incisions



Forearm – Skin Incisions



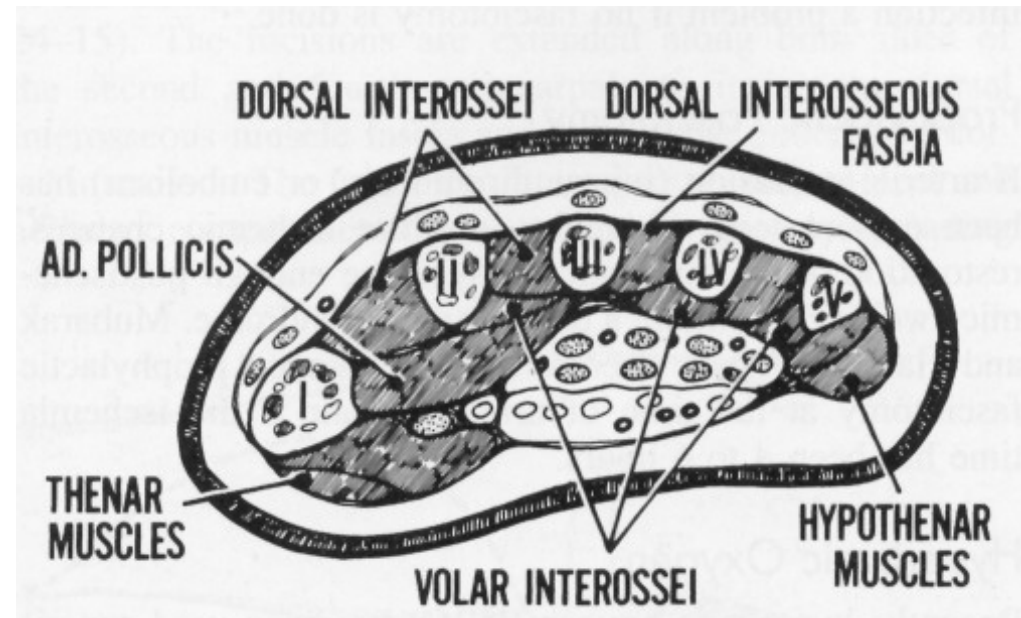
Muscle viability – The 4 Cs

- Colour
 - Consistency
 - Contractility
 - Capacity to bleed
-
- If non viable – EXCISE
 - If not sure – Review in 48 hrs

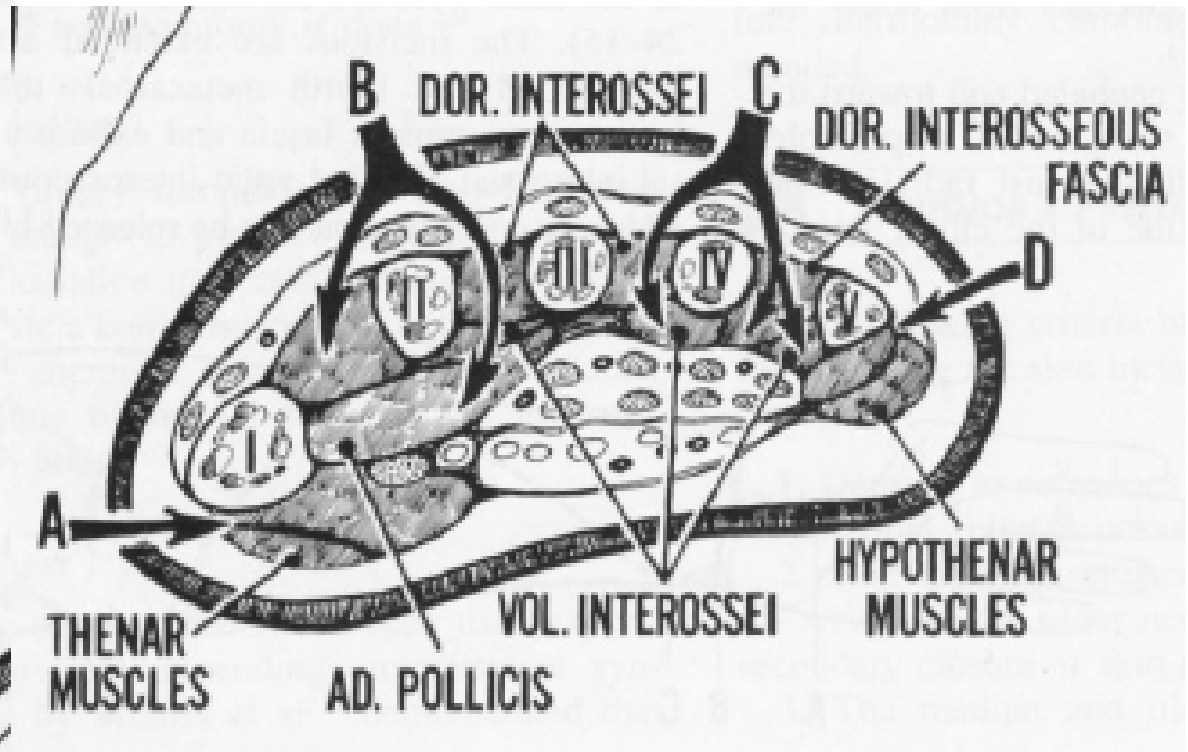
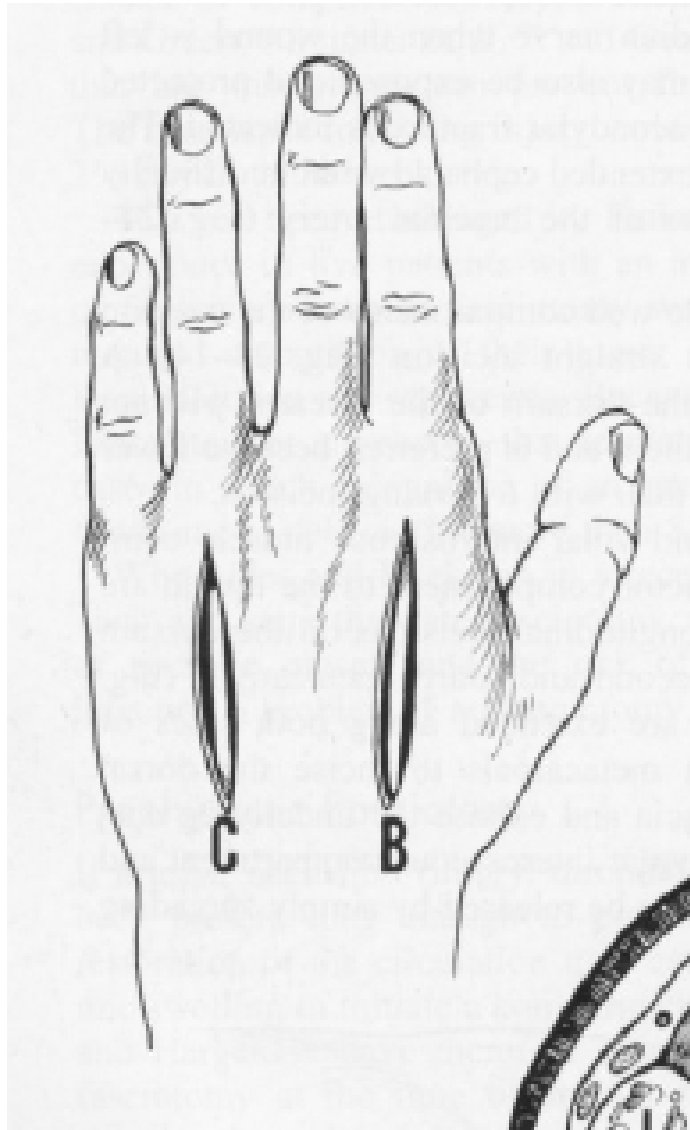
Hand

10 compartments

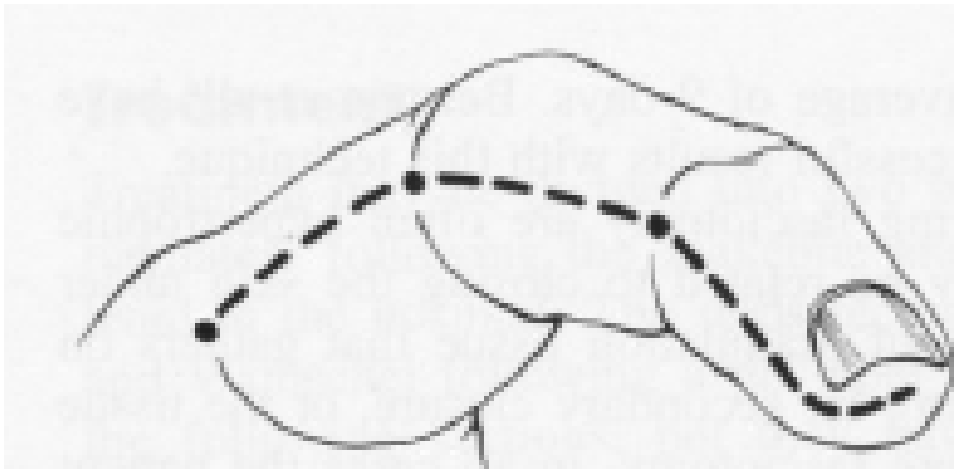
- 4 Dorsal Interossei
- 3 Volar Interossei
- Adductor Pollicis
- Thenar Muscles
- Hypothenar Muscles



Hand

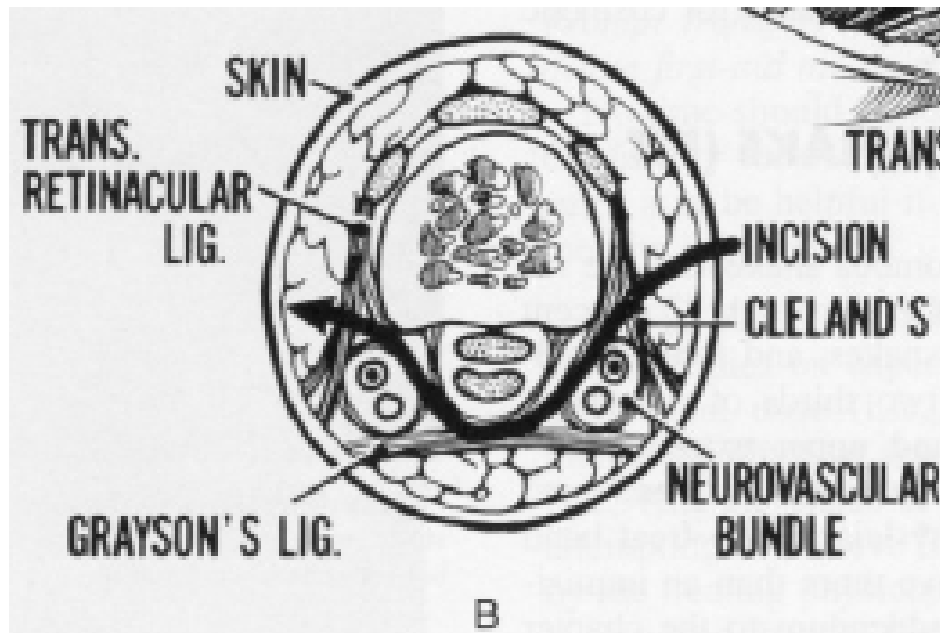


Fingers



- Clinical decision
- Midaxial lateral incision
- Non-dominant side of digit
- Ulnar side: Index, middle and ring fingers
- Radial side: Thumb and little

Fingers



- Incise Cleland's ligament
- Dissect superficial to flexor tendon sheath releasing all vertical bands of connective tissue

Volkman's contracture

- Who was Volkman
 - a. German engineer, co founder (with R.Wagenstern) of famous German car manufacturing company. Injured arm whilst working on car prototype
 - b. Not a person. Swedish for Ice pick axe (Völkman) due to resemblance of deformity with this traditional mountaineering implement
 - c. German physician that practiced in the 19th century

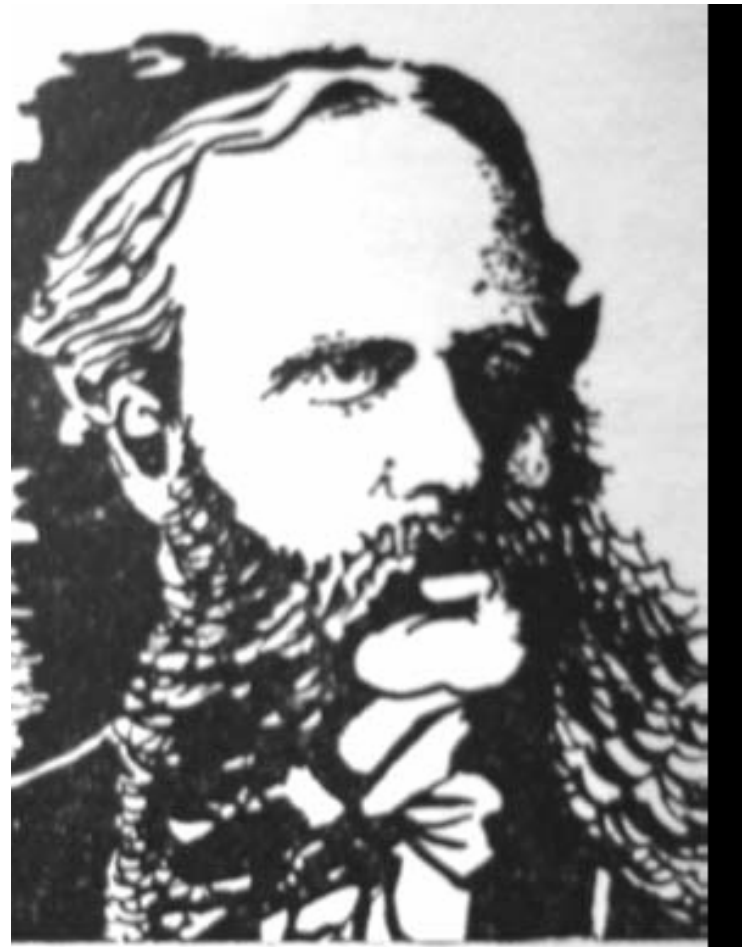


Richard von Volkmann, 1830 – 1889

Director of Surgery , Halle, Saxony

“ For years I have called attention to the fact that the pareses and contractures of limbs following application of tight bandages are caused not by pressure paralysis of nerves, as formerly assumed, but by the rapid and massive deterioration of contractile substance and by...reactive and regenerative processes.”

Die ischämischen Muskellähmungen und Kontracturen. Centralblatt für Chirurgie, Leipzig, 1881, 8: 801-803



Volkmann's contracture

- A post-traumatic forearm, wrist and hand contracture from fibrosis of necrosed forearm musculature.
- FDP and FPL are the most severely affected muscles

Volkman's contracture

- MILD - Wrist flexors
 - Dynamic splinting, tendon lengthening
- MODERATE - Wrist and finger flexors
 - Excision of necrotic muscle, neurolysis, tendon transfers, distal slide of viable muscles
- SEVERE – Flexors and extensors
 - As above but may need free muscle transfer

