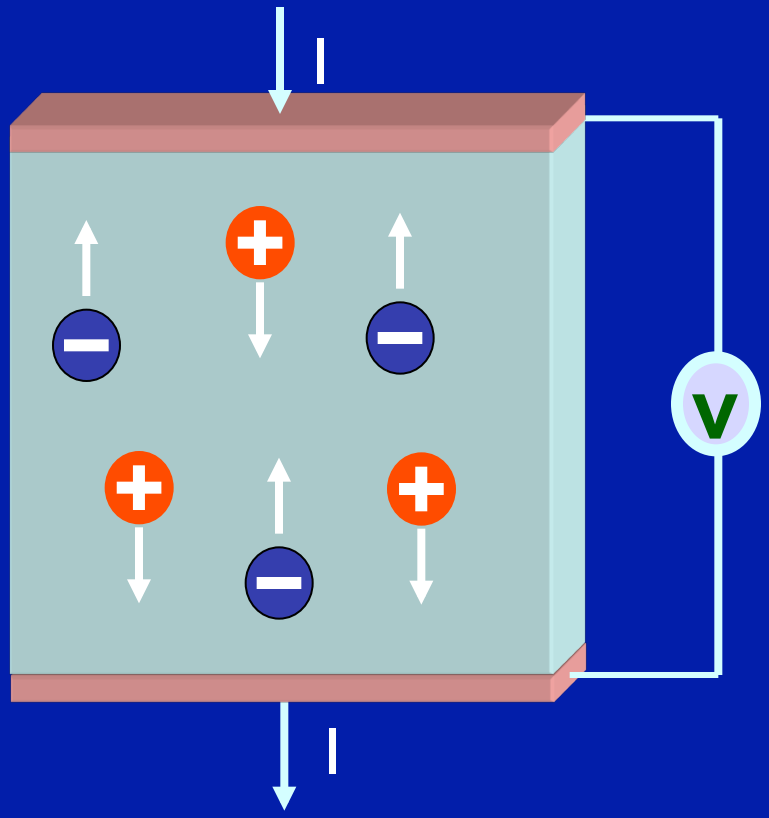
Focused Impedance Method (FIM)

Innovative medical diagnostics and imaging for health stations in developing countries

Professor K Siddique-e Rabbani
Dept of Biomedical Physics & Technology,
University of Dhaka,
Bangladesh

Biological Electrical Resistivity

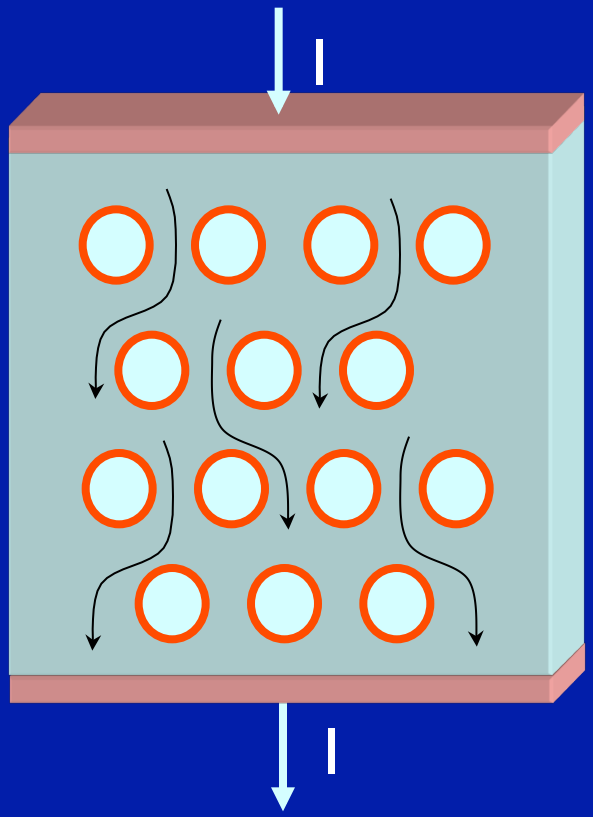


Body is a fluid

both positive & negative ions move to carry electrical current

Unlike metals, where atoms do not move, only electrons flow

Current pattern in biological tissues



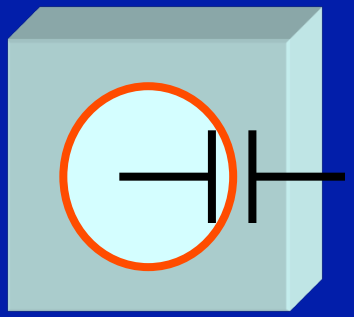
at dc and at low frequency ac:

With an insulating membrane, a CELL acts like an insulated object

Current bends around the cells

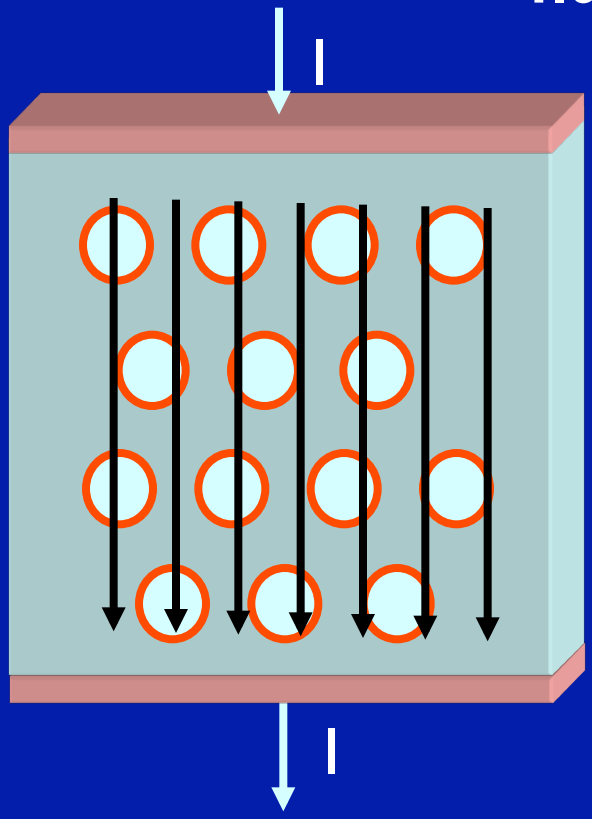
→ High resistance

Current pattern in biological tissues



at high frequency ac:

cell membrane acts as a capacitor - sandwitched between conducting fluids, inside and out

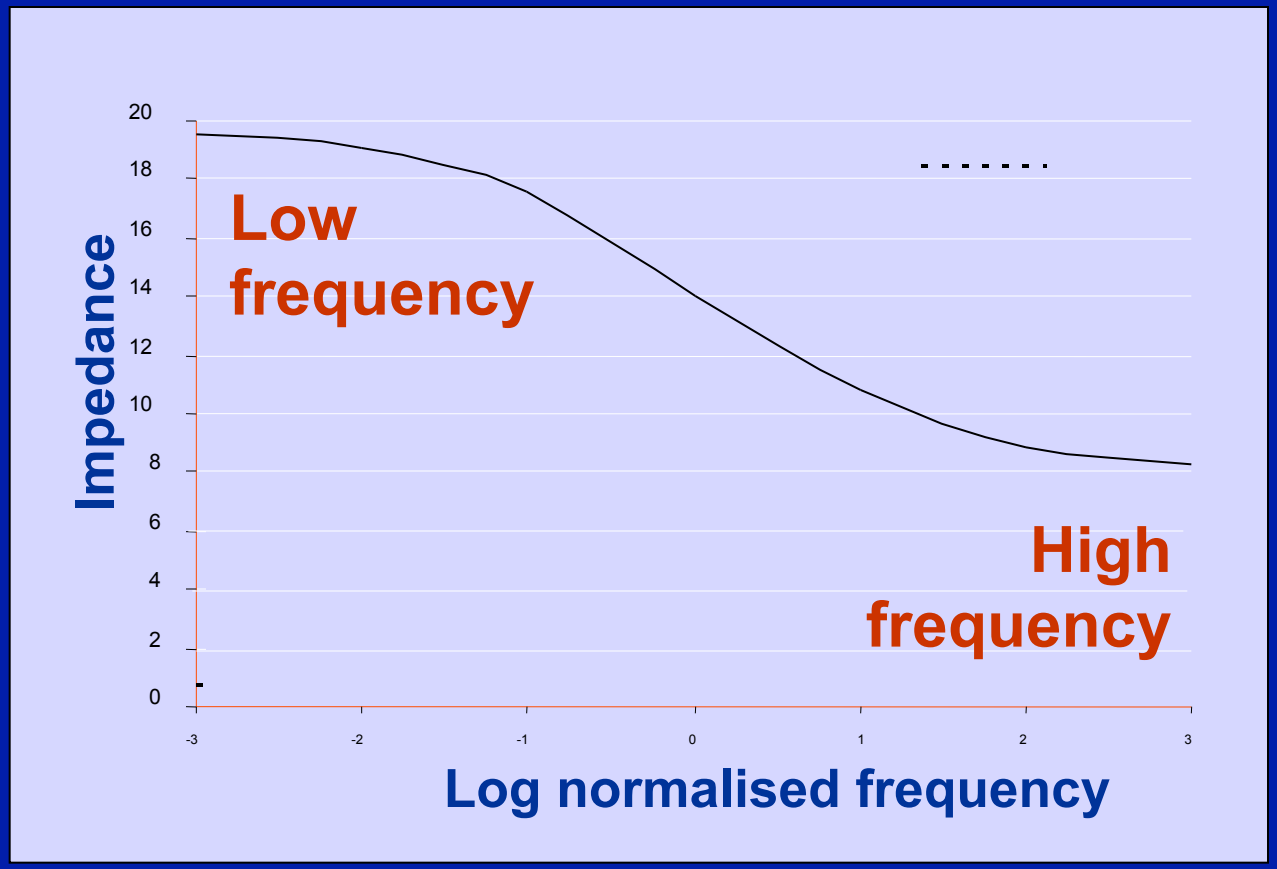


current enters the cells

→ Low resistance

Capacitive reactance α 1/ freq

Impedance (Z) in biological tissues



Capacitive reactance
α
1/ freq

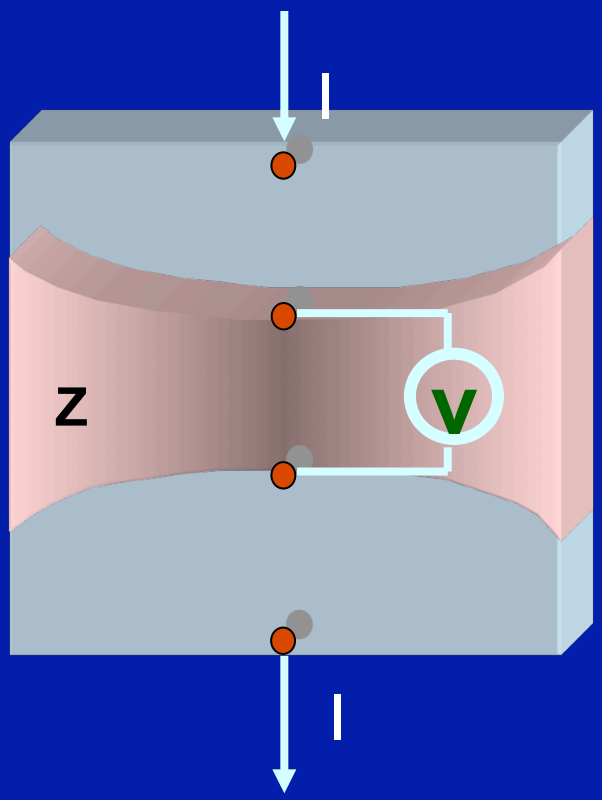
Resistence is frequency independent
Reactance: frequency dependent
Impedance: Resistance + Reactance

Electrical resistivity of body tissues (at low freq)

Tissue	(Ω-m)
CSF	0.65
Blood	1.46-1.76
Skeletal muscle (longitudinal)	1.25-3.45
Skeletal muscle (transverse)	6.75-18.0
Lung – full inspiration	17.0
Lung – full expiration	8.0
Brain – grey matter	2.8
Brian – white matter	6.8
Fat	20
Bone	>40

Potential in identifying different types of tissues

Tetra-Polar Electrode Impedance Measurement (TPIM)



Alternating current (I) is passed through outer pair of electrodes, Potential (V) is measured across the inner pair.

Impedance of shaded zone, Z = V / I

If I is kept constant, then Z is proportional to V.

Main advantage: Since voltmeter takes no current, effect of electrode contact impedance is eliminated. Z is that of the bulk region.

Advantage: Simple instrumentation and measurement

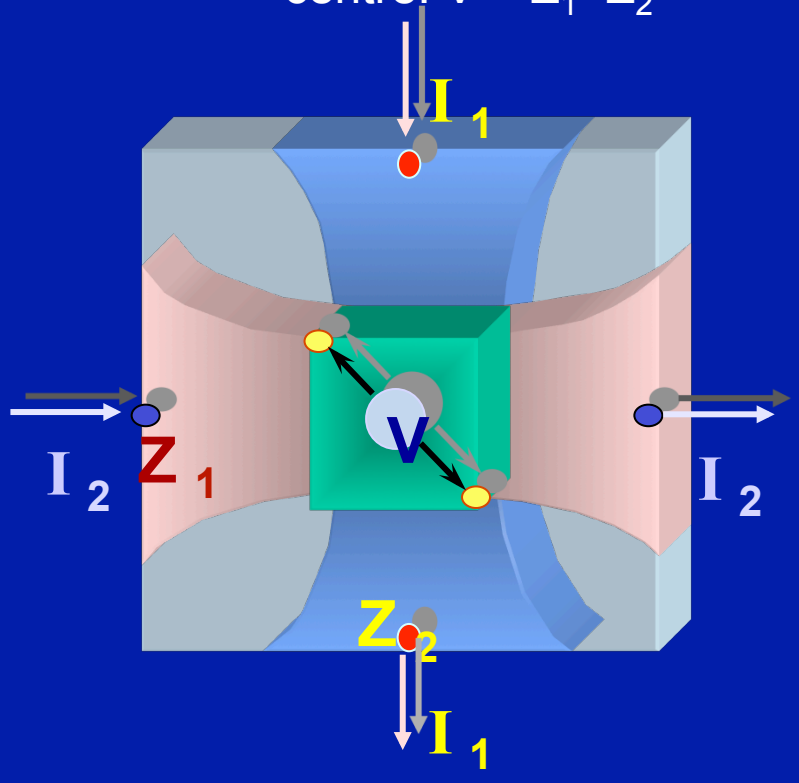
Disadvantage: Wide zone in volume conductor (not focused)

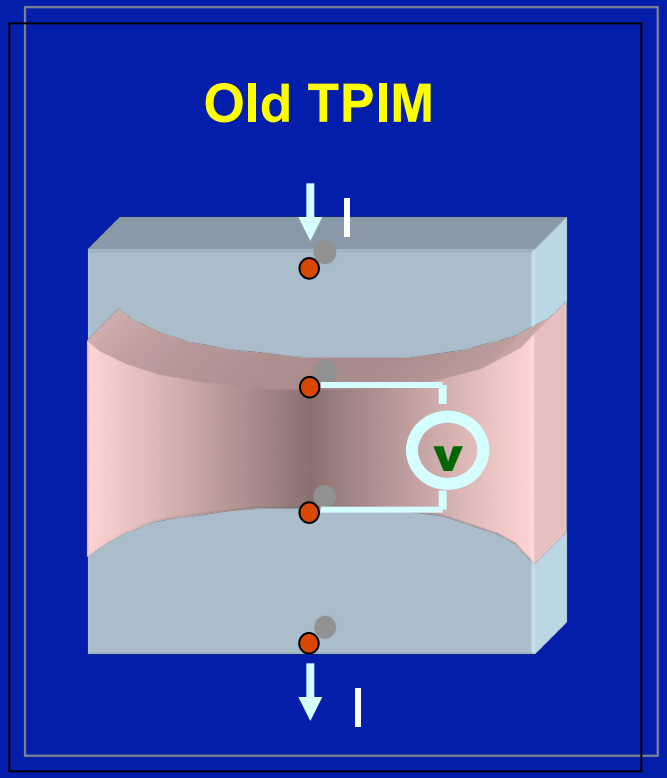
Focused Impedance Method (FIM)

(6 electrode)

-a new idea from
Biomedical Physics Lab
Dhaka University

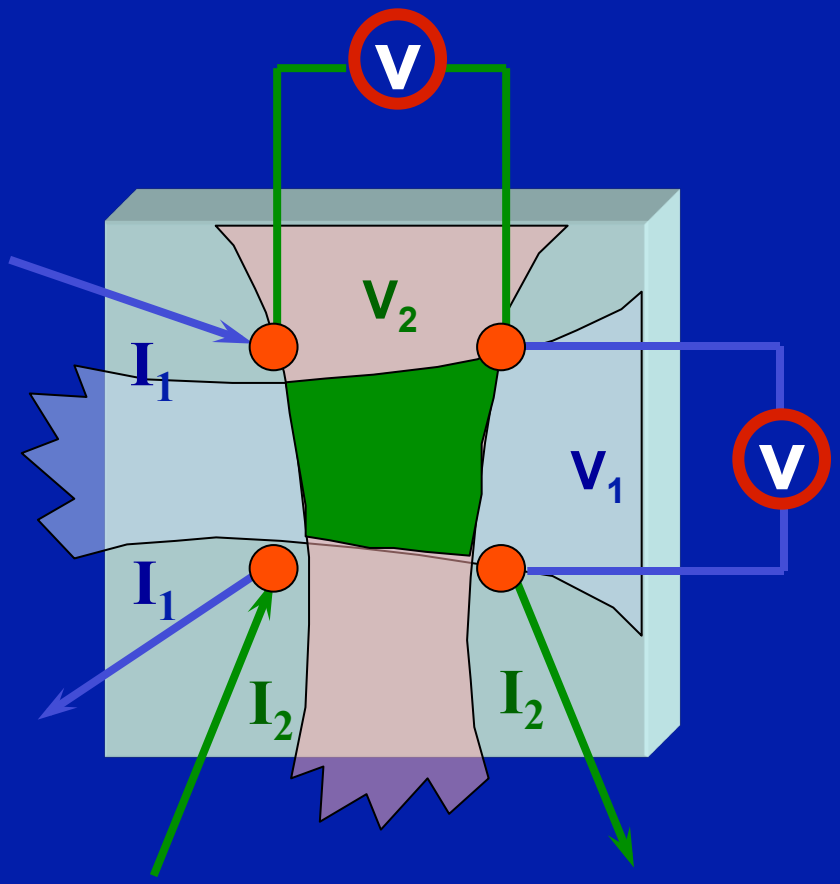
Current, I_1 and I_2 in two perpendicular directions (in phase, but isolated). Potential, V, measured across two diagonally placed electrodes at centre. $V = Z_1 + Z_2$





$(Z_1 + Z_2)$ has more contribution from central region (green), hence, 'Focused'

4-Electrode FIM

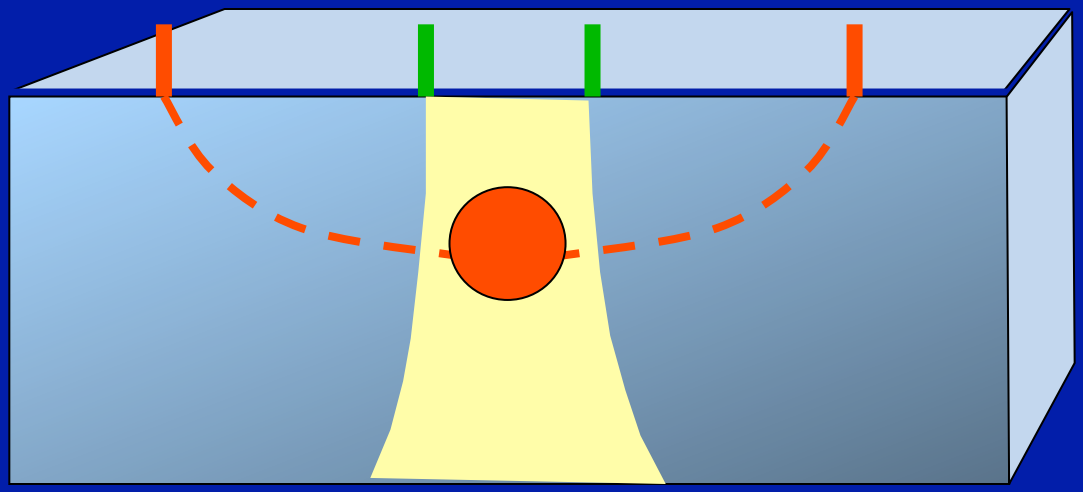


$Z_1 = V_1 / I_1$ Horizontal sensitive zone

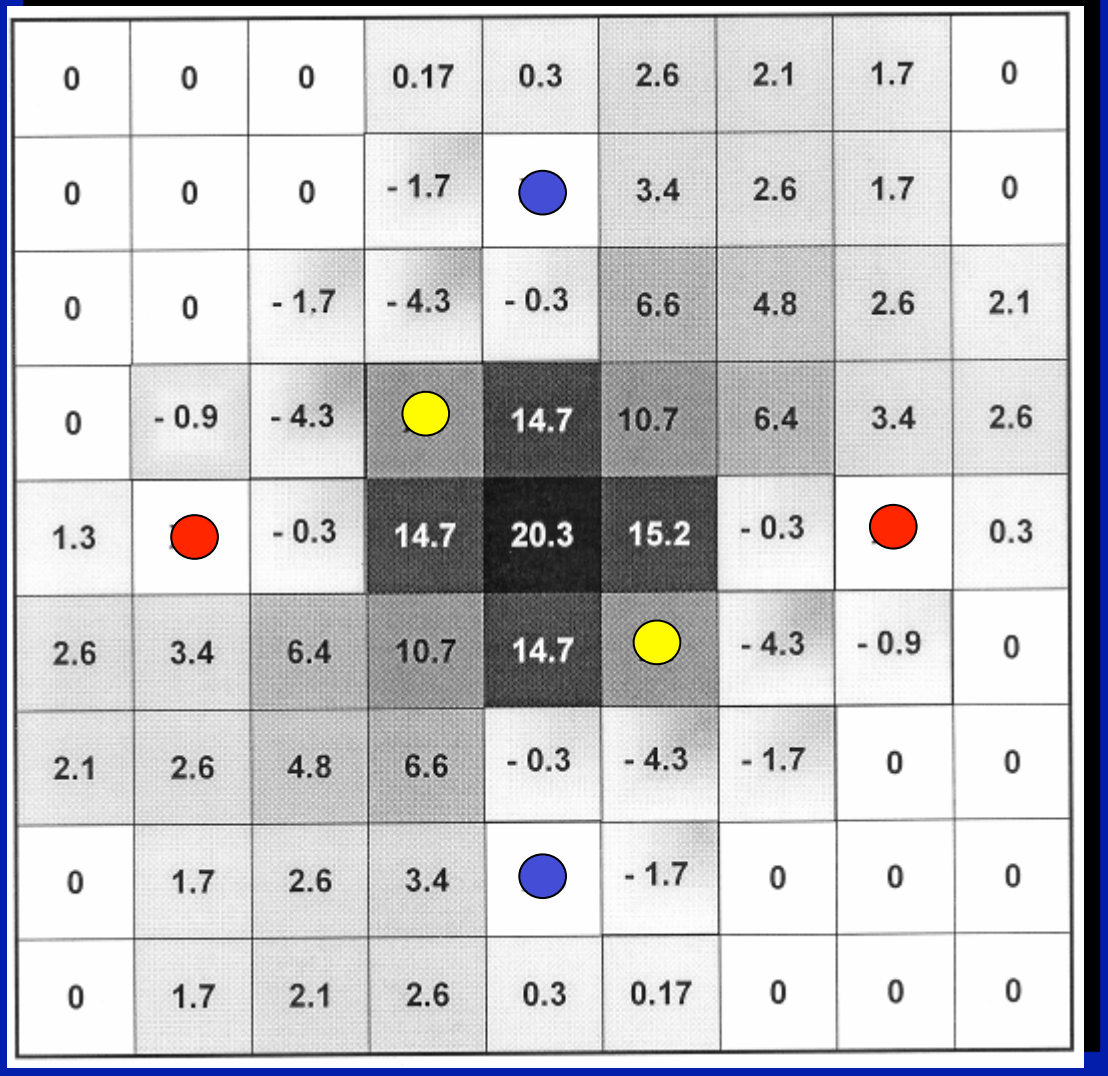
$Z_2 = V_2 / I_2$ Vertical sensitive zone

$Z_1 + Z_2$ gives focused impedance
(central green zone is focused)

3D sensitivity allows deeper organ study



Sensitivity Map of FIM (Phantom study)



current electrode

current electrode

potential electrode

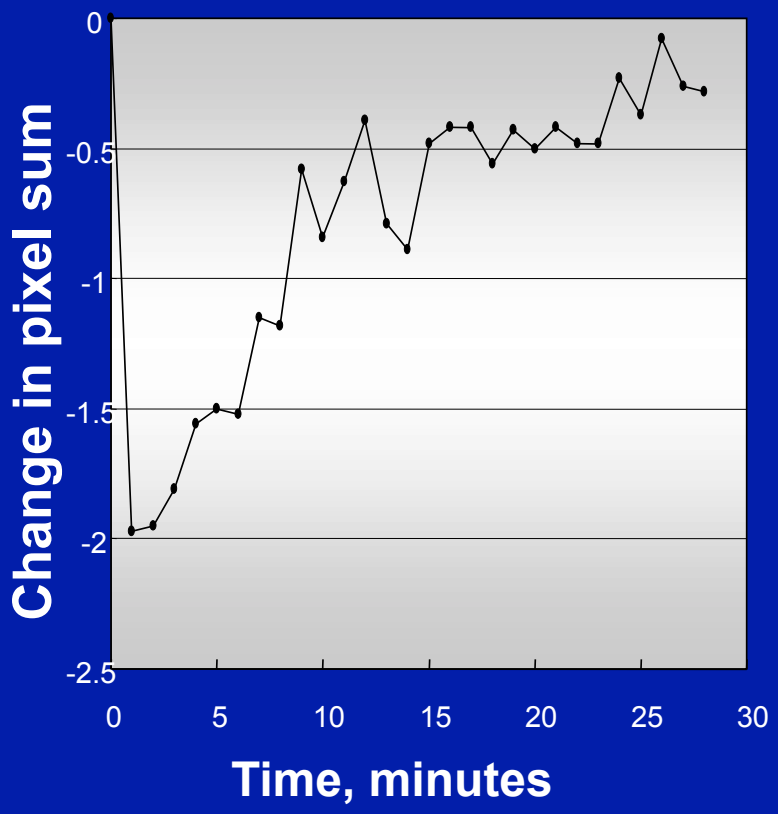
Focusing evident

GASTRIC EMPTYING USING FIM

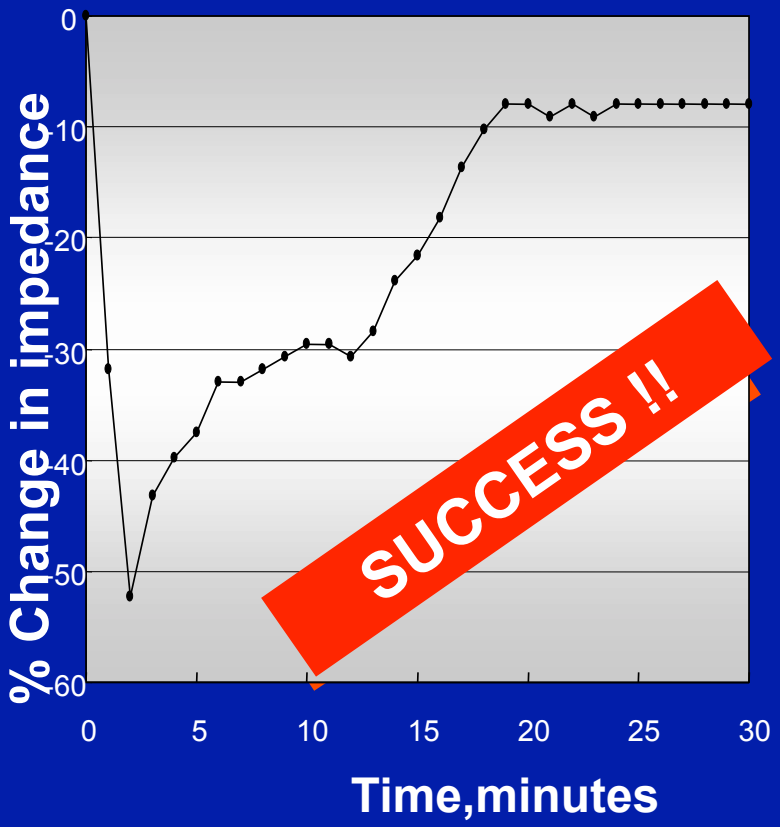
TEST: GASTRIC EMPTYING AFTER A DRINK OF SALINE

EIT

Gold standard

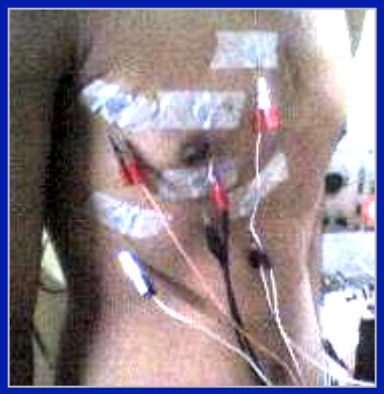


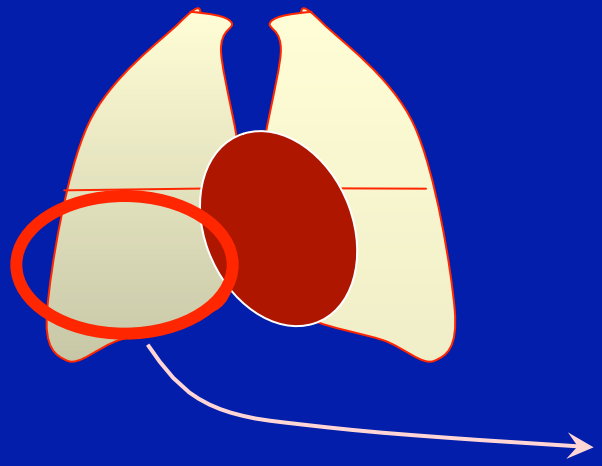
FIM



Could eliminate effect of neighbouring dudenum

Lungs ventilation study

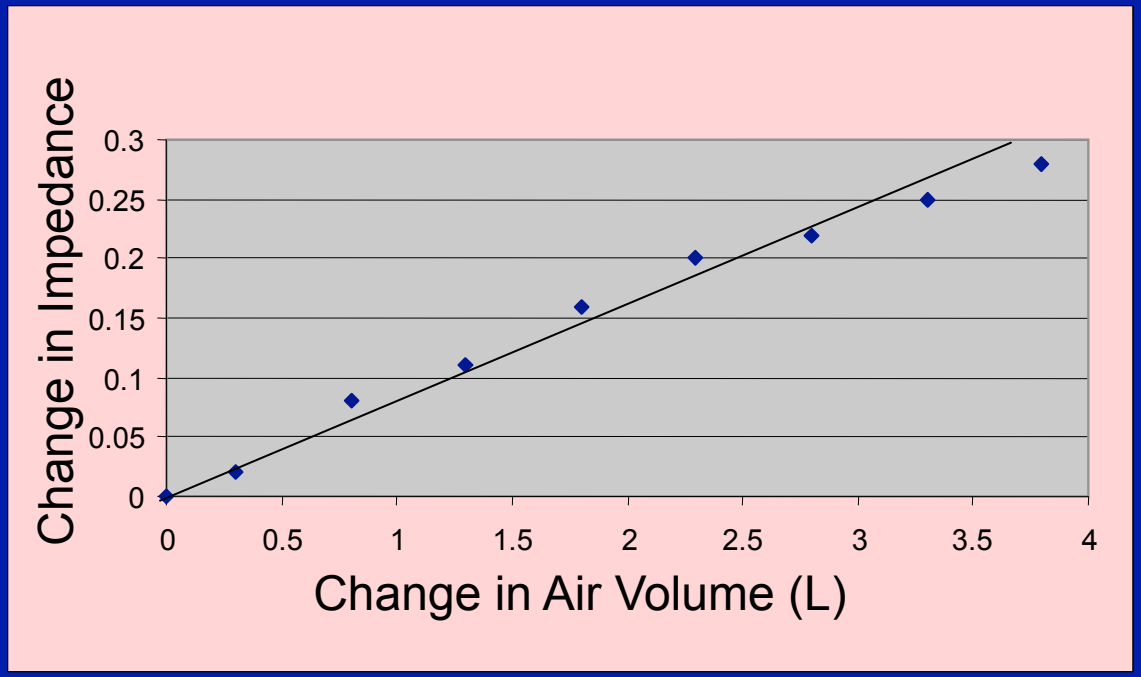




Comparison with Spirometric study:

First breathe in, then breathe out a little & hold, volume of air measured using spirometer.

FIM is linearly related to air volume



FIM : potential in Diagnosis and Physiological study♪

- Study lung ventilation, perfusion and disorders
- Monitor respiration (very useful in artificial respiration)
- Study gastric emptying
- Measure gastric acid secretion
- Measure localized edema
- Measure abdominal fat thickness
- Detection of cervical cancer
- Characterisation of breast tumours – benign or malignant ?
- Monitor tissue ablation in cancer therapy; irreversible electroporation using same electrodes
- Do we require high quality imaging to achieve similar diagnoses?

Recommendations

Section 1

Conclusions and Recommendations

- Drastic need for improvcd communication with health stations.
- Telemedicine to play a vital role in diagnostics and training.
- Focused impedance method could become an important low cost diagnostic method for Health Stations.