APPLIANCE OF MATHEMATICS AND INFORMATIC

IN RADIOLOGY

- Mathematical principles basic for proceedings imaging
- X ray beam,ultrasound waves and magnetic fields

CONVENTIONAL RADIOLOGY

- **Image acquired after absorption of X ray beam in the object. Attenuated X ray beam expose photo emulsion and processed**

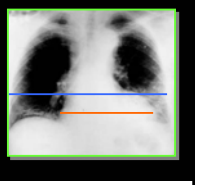
TASK FOR MATHEMATICS:

- **Measure of distance – film -> object important because (exponential attenuation- total X ray beam doses decrease in a half, with x² of distance**
- **Calculation of kV and mA (depend of constitution of the patient)**

SIMPLE MATHEMATICAL METHODES IN CONVENTIONAL RADIOLOGY

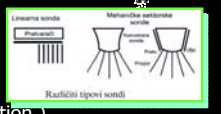
Measuring of the size of organs and pathological changes

- Describe size, shape, relations, length...



Mathematic in ULTRASOUND

- Use of ultrasound mechanical waves in originate of image
- Transducer, different frequencies,
- Acustic impendance = different tissue **x** speed of sound in material
- Degree of attenuation
- Spatial resolution



Type of US image:

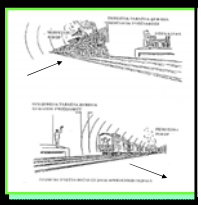
- One dimensional
  A-mod (amplitude – mathematical function)
  M mod (time motion)
- Two dimensional
  B mode image – grey scale
  (white = fibrous tissue, gray= soft tissue / fluid)
- **4D** beside 3D one more dimension...TIME

Mathematic in INTERVETIONAL ULTRASOUND

Measuring the size of organs, area, relations, angle for needle and catheters, depth...

DOPPLER EFFECT

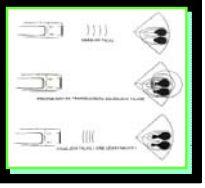
- Psyhic Johan Cristian Doppler 1842.
- DOPLER US – based on doppler effect
  Change of freq.of sound, light or other waves caused by moving source or object (red blood cells...)



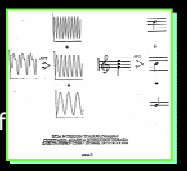
HOW can we evaluate blod flow ?

$$Vx\cos\theta = \frac{CxFp}{2xFo}$$

- V flow
- C speed of US in tissue (1540 m/s)
- Fp frequency change
- Fo frequency of US
- Cos θ cosinus angle θ between US wave and blood flow



- RBC move with diferent speed → diferent freq.
- Mathematics analyse use Fast Furie transformation FFT
- Result is spectral analyse of Doppler change give graphical presentation of blod flow

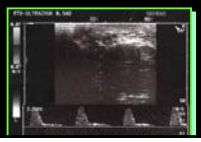


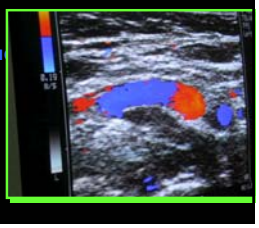
COLOR FLOW DOPPLER

Different color for direction of movement

TO transducer and **FROM transdu**

Volume, index of the resistance...

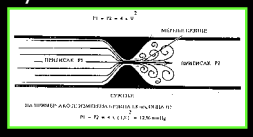




DOPPLER US diagnostic of blood vessel

- Stenosis and oclusion result in decrease of the fluide pressure = gradient presure
- Before occlusion fluid have higher pressure
- Link between pressure gradient and speed mesured after stenosis is simplified by Bernulie's function:

$$P1 - P2 = 4 \times V^2$$



•US equipment have great technical possibility for quality processing of the image (index of resistence)

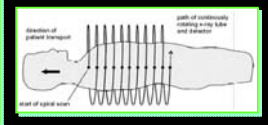
•From simple mathematics measuring to the most complicate mathematics image processing

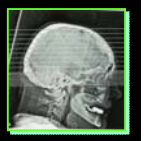
Appliance of Mathematics in Angio Rooms

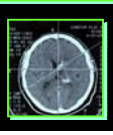
- **Positioning of examination table/patients**
- **Angles of tube rotation, magnification...**
- **Bloodflow, pressure, time of contrast appliance**
- **Measurements of perceived changes and mathematical calculation of narrowed space...**

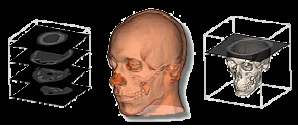
Mathematics and CT (Computerized tomography)

- **Since highly sophisticated software packages and computers are developed, it is possible to process a large amount of received data from the whole-body-scan with classical X-rays, from more angles at the same time or in a short period of time**
- **The picture is formed from received scanned image slices of body in form of "pixel" (2D) and "voxel" (3D)**



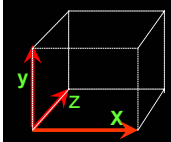


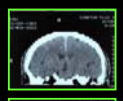


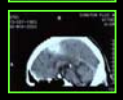


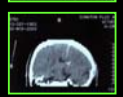
Mathematics and CT (Computerized tomography)

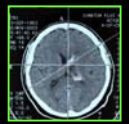
Multiplanar reconstruction









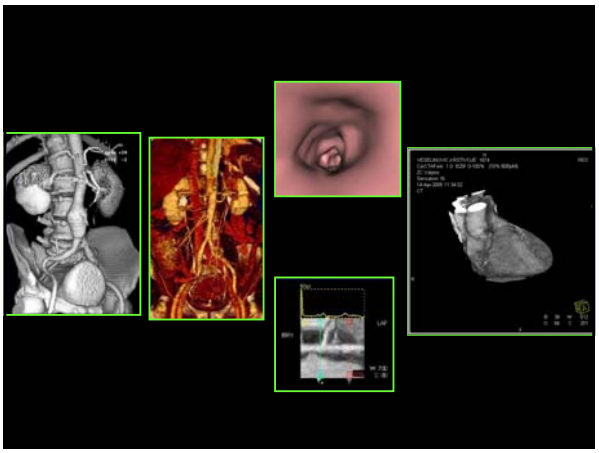


- coronary reconstruction
- sagittal reconstruction
- Paraxial reconstruction

Possibility of tissue measurement (Hounsfield units HU - gray/white scale)

-1000 = air
0 = water
+1000 = bone

- **Convetional scanners with one rotation of the X-ray tube around the object and move for one layer depth- sequent mode**
- **Helical- one spiral around patient**
- **Next generation of multislice CT scanners (2, 4... 14... 64)**
- **Collected data of scanned volumen**
- **Edited in post processing with different software packages, which enables 2D and 3D view**
- **3D picture reconstruction, Shaded Surface Display, Volume Rendering, Vessel View, Fly Through...**
- **CT-angio and CT coronography, CT virtual colonography...**



For all science work at the end you always need ....

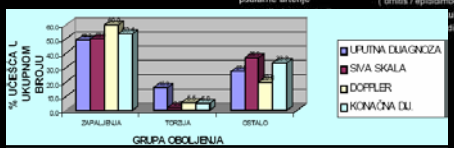
STATISTICS

GRUPA OBOLJENJA	KOEF. KOREL. SIVA/KONAČNA	KOEF. KOREL. DOPPLER/KONAČNA
ZAPALJENJA I TORZIJA	0.86	
RAZNO	0.80	

do ± 0,3 niska korelacija
± 0,3 - ± 0,7 srednja korelacija
± 0,7 - ± 0,9 visoka korelacija
> ±0.9 skoro funkcionalna korelacija

LNA GRUPA
ratestikulame arterije
psulame arterije

Najniži RI
13 - intratestikularne arterije
(orhitis / epididmoorhitis) < 0.5
14 - kapsularne arterije < 0.5
(orhitis / epididmoorhitis)
ularne arterije <
idimoorhitis)



Digitalization of analogue signals and introduction of informatics in radiology

Types of digitalization

Classical X rays

phosphorus plates

Conversion

Digitizer

Conversion

PC

Digital Radiography

1. Immediate Reading
of X-rays, photoconductor amorphous selenium, Photons in electric charge

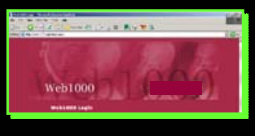
2.Intermediary conversion,
first X-rays to visiable light and then to electric charge over photo detector photo diode with amorphous silico to CCD microchip

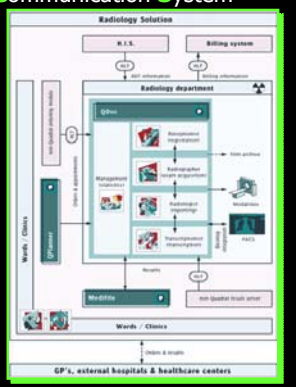
WORKSTATIONS, SERVERS AND NETWORK

P A C S

Picture **A**rchiving and **C**ommunication **S**ystem

- BASIC UNITS
  (classical RTG, US, CT…)
- Workstatio
- ARCHIVE
- NETWORK
  (INTRA- and INTERNET)





ADVANTAGES OF PACS

- **Reduce** pictures
- **Less radiation exposure**
- **Real time** picture availability on a workstation
- **Cost** saving on material used in examination
- No more darkroom, "oups we let the sunshine in...."

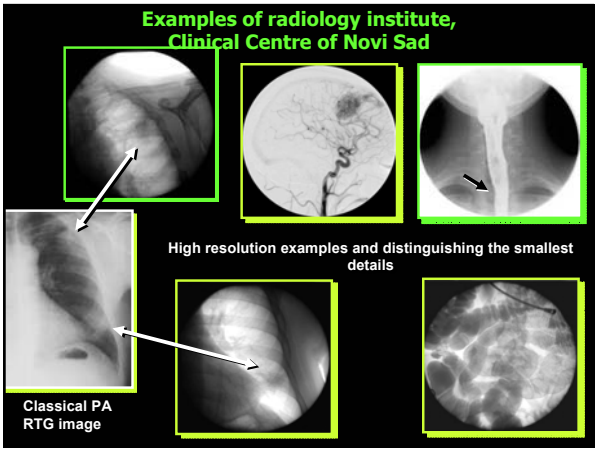
- Excellent picture **quality**, no more "repeat softer or harder"
- Advanced, less dangerous work condition – Less radiation exposure !
- Instant picture availability , no more "please wait , developing... "

- Advantage of **digital archiving**
  - no need for large rooms, or cupboards...
  - losing of images reduced
  - query after many years is very simple
- **Comparison** with other images is **easier** then ever
- **Additional** image **editing** possible (changing brightness and contrast, enlargement, measurement...)

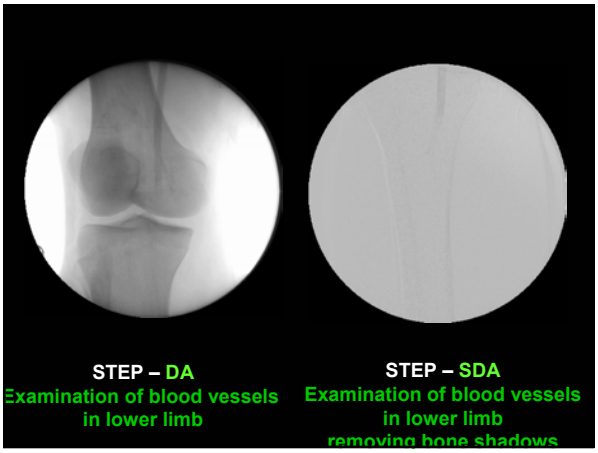
- **Access** to images in any part of hospital/department is possible...
- Case introduction and science works ease
- Better treatment in emergency cases – thanks to **teleradiology**

FLAWS OF PACS

- Installation costs too high (?)
- Errors and damages on main parts (SERVER, READER...) CAUSES BLOCKING OR LOSS OF DATA
- CHANGING HABBITS ?!
- NEED FOR EDUCATION AND HIRING NEW EXPERTS

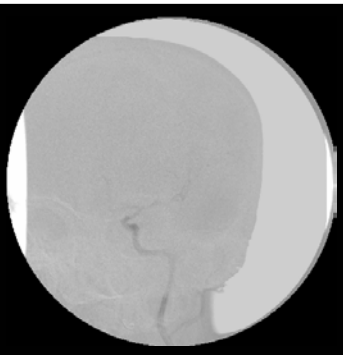


Blood flow are less noticeable in peripherals vessel, They are shown better in Digital Angiography and Digital Ssubtraction Angiography



Diverticle of esophagus (saccular expansion of wall)
Act of swallowing in real time

AV - MALFORMATION
(pathologically branchy blood vessels of the brain)



R-DSA = ROTATION DIGITAL SUBTRACION ANGIOGRAPHY
Head blood vessels examination in real time removing bone mask
Rotating the tube for 15-900

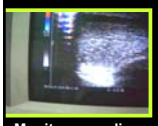
Improvements in image archiving

From US device

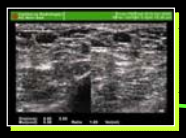
From digital roentgen devices and CT
DICOM format

ermo paper from 1990

Scanned thermo paper



Monitor recording
using photo cameras



Digital US shot .JPG
or DICOM

RESULTS
INSTITUTE OF RADIOLOGY, KC Novi Sad

•70% of patients examined with digitalized method the *checkup quality is greatly enhanced* and the period of examination is reduced (also the exposure to radiation of patient, technician i radiologist is shorter).

• New types of exams are introduced (digital subtraction angiography) quality and *sensibility* of old methods are also improved.

• With digital technique *reediting* of image is possible

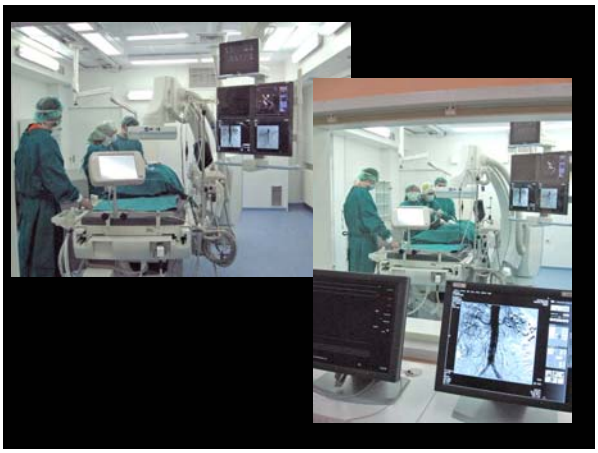
•*„Post processing"*, changes of contrast, brightness, measurement ... on all examined patients, additional tracking of image dynamics in real time, while on classical rtg devices is not possible.

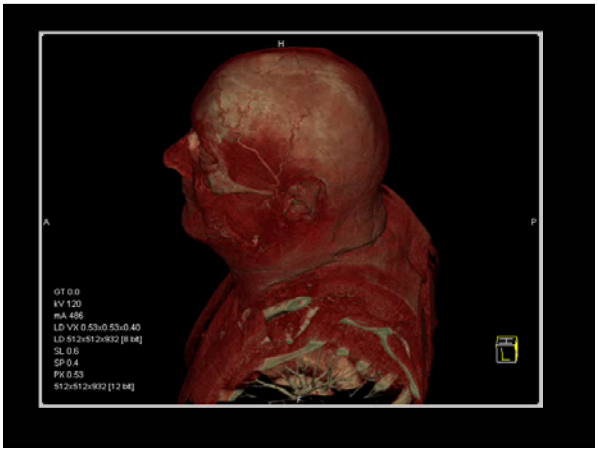
• *Additional improvements* in quality are achieved, also in image archiving, printed on standard thermo paper of ultrasound devices, in comparison to new digital scanning.

• CT scanners are now connected with PCs, additional examination, editing and archiving on disc media.

CONCLUSION:

- Mathematics is the basic tool in achieving and editing analogue and digital radiological images
- Quick examinations and improved quality, pace and reliability of diagnostics itself.
- Cost-effectiveness in material and time, exposure to radiation is reduced for everyone, patient, radiologist and technician.
- Additional editing options, archiving and interchanges enable consulting on distance (teleradiology) and appliance in education.




H
A
P
F
GT 0.0
kV 120
mA 486
LD VX 0.53x0.53x0.40
LD 512x512x932 [8 bit]
SL 0.6
SP 0.4
PX 0.53
512x512x932 [12 bit]