RM MULTIPARAMETRICA E SUE PRINCIPIALI APPLICAZIONI

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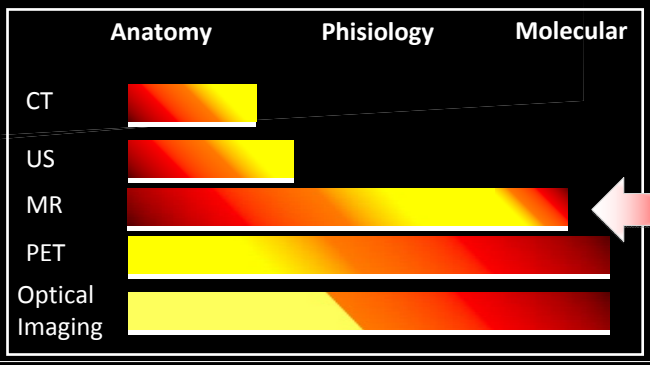
BACKGROUND: IMAGING CAPABILITIES



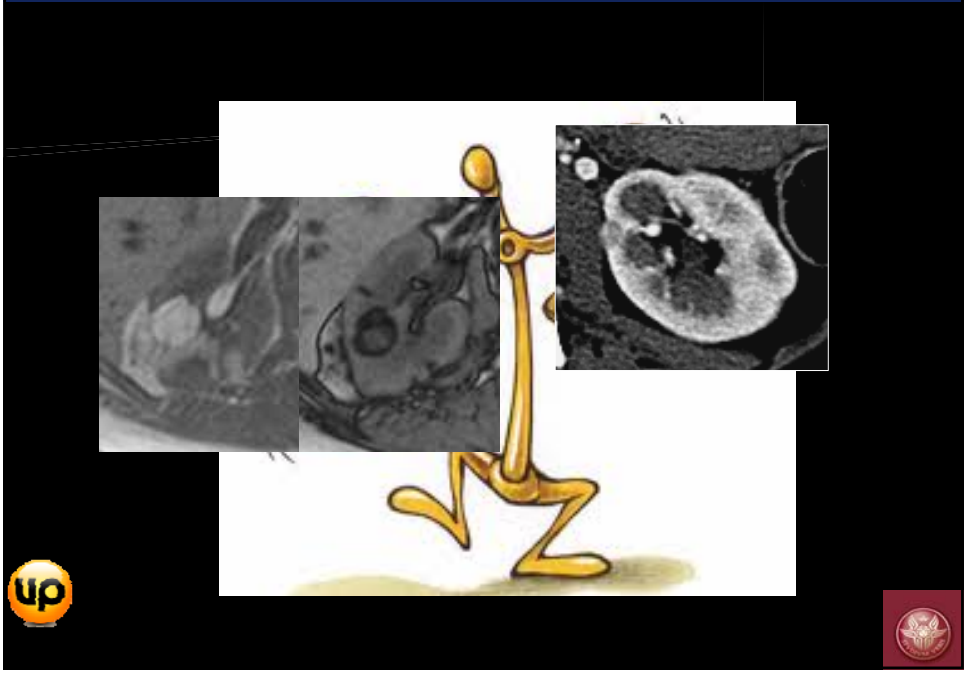
"With the deeper understanding of the molecular basis of disease that has been gained by imaging studies and the transformative promise of imaging is likely to be fulfilled soon"

R.Weissleder, Nature, 2008

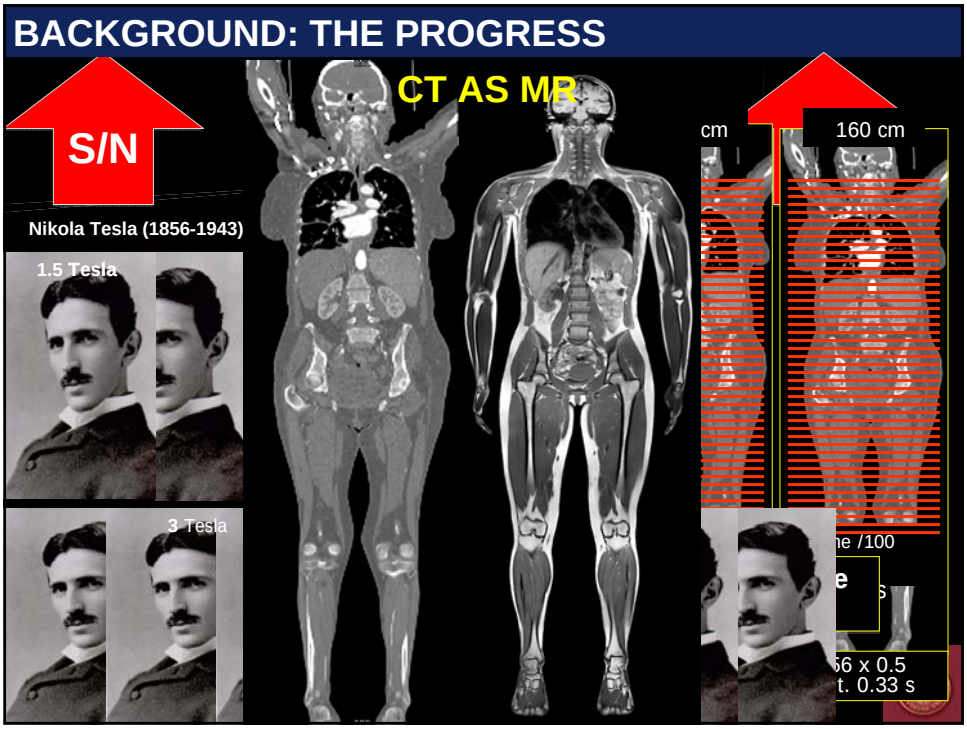
...Trend inversion...

MORPHOLOGY – PHISIOLOGY - METABOLISM
MOLECULAR

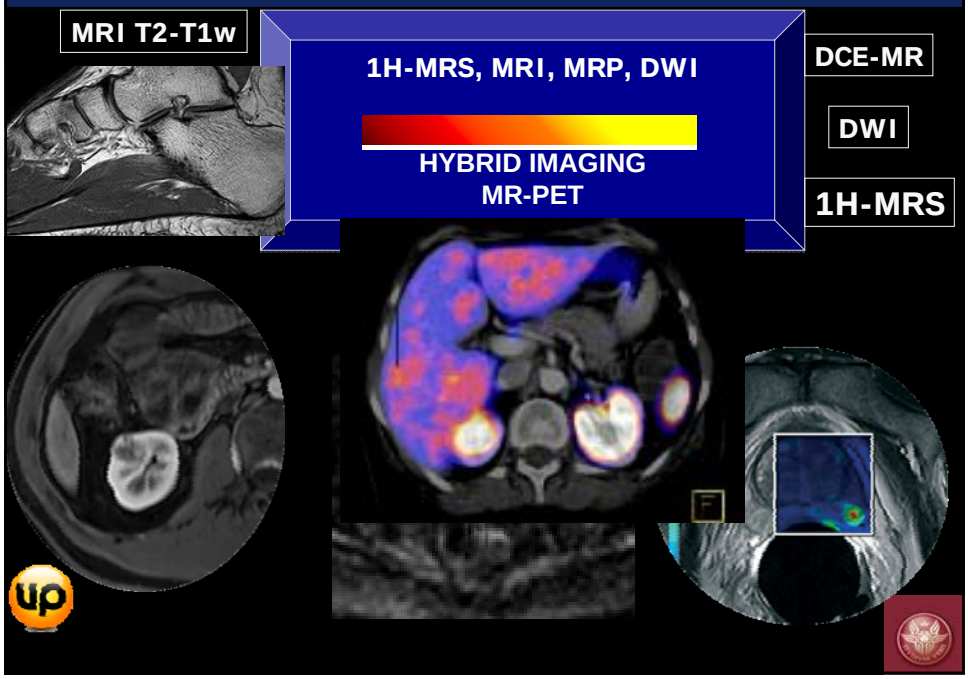
BACKGROUND: IMAGING CAPABILITIES



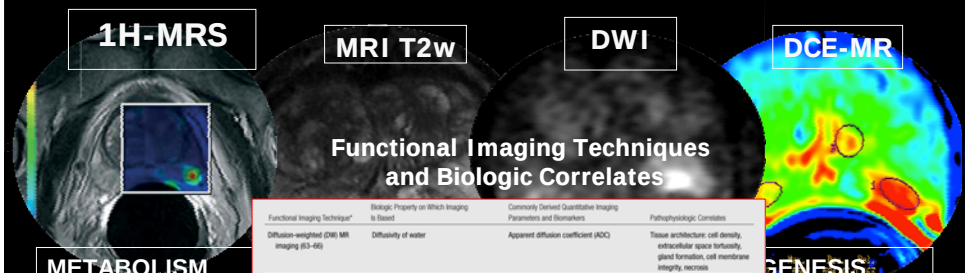
BACKGROUND: THE PROGRESS



MULTIPARAMETRIC IMAGING



MULTIPARAMETRIC IMAGING



Functional Imaging Technique*	Biologic Property on Which Imaging Is Based	Commonly Derived Quantitative Imaging Parameters and Biomarkers	Pathophysiologic Correlates
Diffusion-weighted (DW) MR imaging (63–66)	Diffusivity of water	Apparent diffusion coefficient (ADC)	Tissue architecture: cell density, extracellular space tortuosity, gland formation, cell membrane integrity, necrosis
Dynamic contrast-enhanced (DCE) MR imaging (67–69)	Contrast medium uptake rate in tissues, which is influenced by: Plasma volume fraction Perfusion and transfer rates Extracellular volume	Initial area under the gadolinium curve (IAUGC) Transfer and rate constants Leakage space fraction Fractional plasma volume	Vessel density Vascular permeability Perfusion Tissue cell fraction Plasma volume
Dynamic susceptibility contrast MR imaging (70)	Blood volume and blood flow	Relative blood volume/flow Mean transit times	Vessel density Blood flow
Hydrogen 1 (1H) MR spectroscopic imaging (71,72)	Cell membrane turnover/energetics and replacement of normal tissues	Quantified ratios of metabolites including choline, creatine, lipids, citrate, lactate, and others, depending on echo time	Vessel diameter Tumor grade Proliferation index
Blood oxygenation–level dependent or tissue susceptibility–weighted	Deoxyhemoglobin shows higher relaxivity than oxyhemoglobin; measurements also reflect blood volume, perfusion	Intrinsic tissue relaxation rate	Ferromagnetic properties of tissues Level of tissue oxygenation
DCE (perfusion) CT (75)	Contrast medium uptake rate in tissues, which is influenced by: Perfusion and transfer rates Extracellular volume Plasma volume fraction	Tissue perfusion Blood volume Transit time Permeability	Vessel density Vascular permeability Perfusion Tissue cell fraction
DCE US (76)	Microbubbles reside within the intravascular space; perfusion indexes are derived from model fitting of time–signal intensity curves	Microbubble velocity, fractional bloodvolume; Peak intensity and time to peak intensity; Mean transit time, coefficient of wash-in (ascending slope); Area under the entire curve, wash-in and washout hemicurve	Tissue blood flow Transit time Tissue blood volume Microvessel density

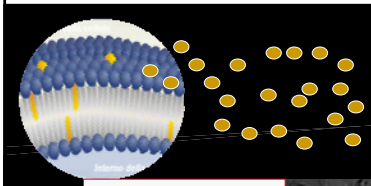
Padhani A R , Miles K A Radiology 2010

Shukla-Dave A, Hricak H, BJU 2007
Zakian KL, Cancer Biomark 2008
Sardanelli F., AJR 2009

Kim JK., J Magn Reson Imaging, 2008
Lim hk, Radiology 2009
Sherr MK., Eur J Radiol 2010
Katahira K., Eur Rad. 2010

JJ Futterer,J. Barensz J Radiology 2006
Noworolski SM, Magn Reson Imaging. 2008
Somford DM,*Barensz J,* Magn Reson I Clin N Am. 2008
Alonzi R., Padhani AR, J Magn Reson Imaging 2010

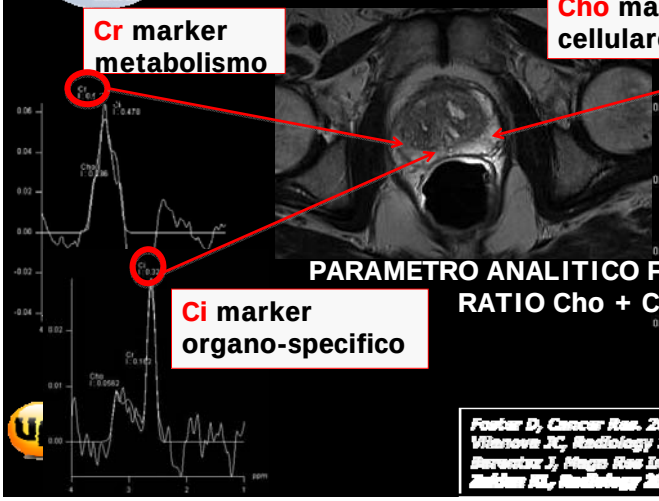
CARCINOGENESI: PROLIFERAZIONE CELLULARE (MRS)



Incremento componenti Membrane
COLINA TOTALE

Cr marker metabolismo

Cho marker di proliferazione cellulare



PARAMETRO ANALITICO FONDAMENTALE
RATIO Cho + Cr / Ci

Ci marker organo-specifico

Foster D, Cancer Res. 2003
Vilanova JC, Radiology 2009
Barrantes J, Magn Res Imaging Clin N Am 2006
Zakian KL, Radiology 2005

1H-Spettroscopia RM

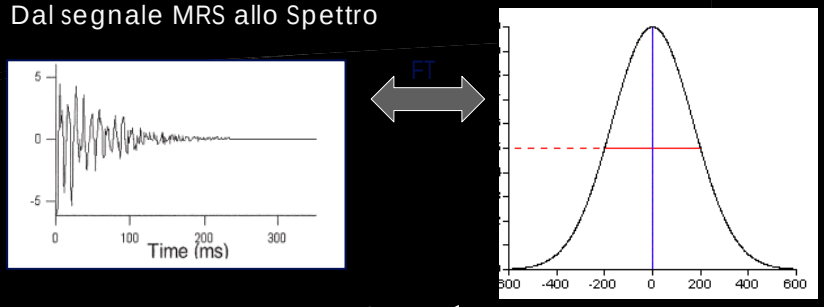
$$\omega = \gamma B_0 \qquad \omega = \gamma B_0 (1-\sigma)$$

Sigma dipende da densità e distribzione spaziale elettroni

- Dopo eccitazione di atomi identici inseriti in molecole diverse e in diverse posizioni della medesima molecola, emettono una DIVERSA FREQUENZA di RISONANZA in relazione alla differente distribuzione spaziale e densità degli elettroni.
- Il chemical shift è causato dal campo magnetico indotto dagli elettroni che circondano il nucleo schermandolo dal campo esterno, ed è funzione del tipo di ambiente chimico e dalle strutture molecolari circostanti l'atomo
- CS: valore "tipico" per ogni molecola

1H-Spettroscopia RM

Dal segnale MRS allo Spettro



Rappresentazione dei tempi (segnale RM)

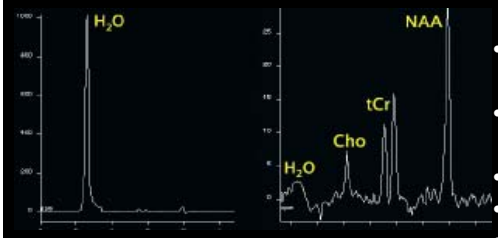
Rappresentazione delle frequenze (spettro)

- Il segnale è costituito da un'oscillazione ad alta frequenza in rapido decadimento
- Mediante FT l'oscillazione viene visualizzata come un grafico dei componenti della frequenza

1H-Spettroscopia RM

Sequenza CHESS

- **La concentrazione dell'acqua è circa 100.000 volte quella di qualsiasi altro metabolita: è quindi necessario sopprimerne il segnale di circa 1000 volte con un preimpulso selettivo a 90°**



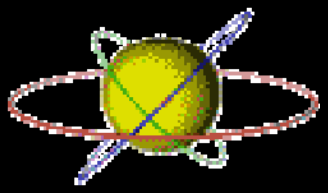
Human Brain 1H-MRSI dopo CHESS

- **Ordinata: ampiezza del segnale ad ogni possibile frequenza**
- **Ascissa: intensità del chemical shift in ppm**
- **H2O: picco dell'acqua**
- **Cho: picco della colina**
- **Cr: picco dellla creatina**

***CHESS = chemical shift selective excitation**

1H-Spettroscopia RM

- RM: intensità di segnale di ogni voxel deriva dalla somma dei segnali di tutte le molecole che contengono idrogeno al suo interno



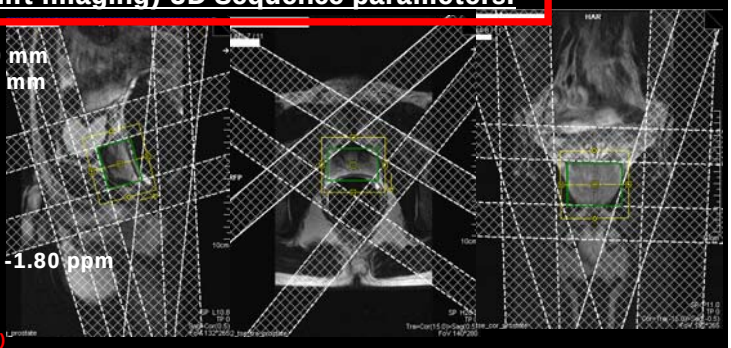
- MRS: il segnale proveniente da un certo nucleo viene separato nelle sue varie componenti, ciascuna delle quali rende conto della presenza nel voxel di una determinata molecola

1H-Spettroscopia RM

- **<u>STEP 1:</u> identificare la zona della prostata nelle immagini morfologiche multiplanari ottenute con sequenze TSE T2 pesate**
- **<u>STEP 2:</u> Utilizzare le sequenze spettroscopiche per acquisire informazioni circa lo stato metabolico del tessuto**

<u>CSI (chemical shift imaging) 3D Sequence parameters:</u>

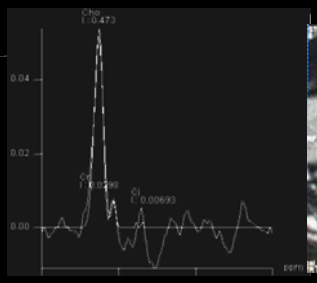
- **FoV: 50 x 50 x 50 mm**
- **Vol: 30 x 30 x 30 mm**
- **TR: 700 mSec**
- **TE: 120 mSec**
- **Flip Angle: 90°**
- **Interpolation: 16**
- **Vector Size: 512**
- **TA: 11.50 min.**
- **Delta Frequency: -1.80 ppm**
- **Average: 6**
- **voxels isotropici**
- **3.4 m m cubici (1.5)**

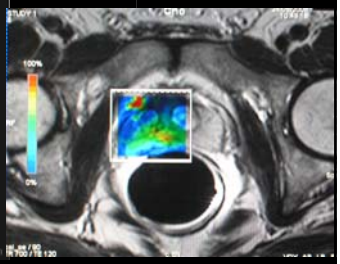


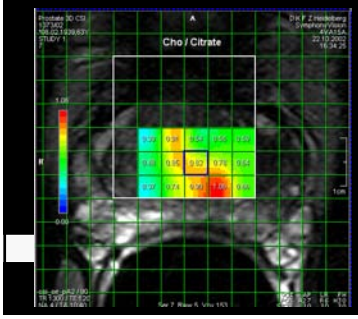
1H-Spettroscopia RM

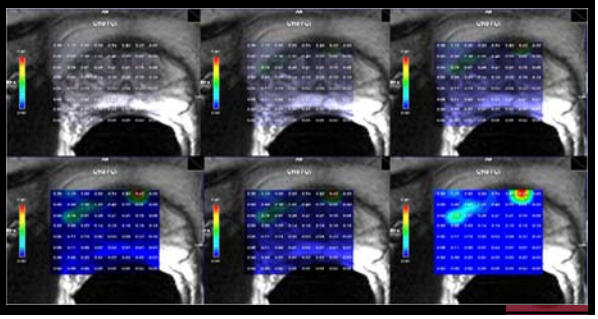
Analisi dei dati

- **Elaborazione di *spettri***
- **Conversione dei dati in *mappe metaboliche***
- **Griglia con media dei rapporti tra i metaboliti**



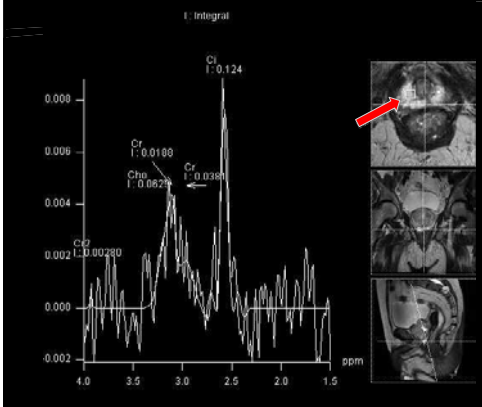


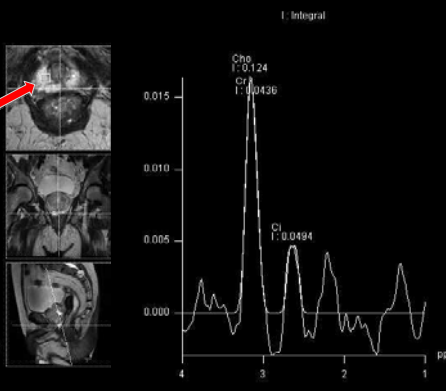


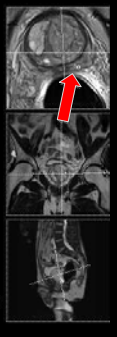


RISOLUZIONE SPETTRALE

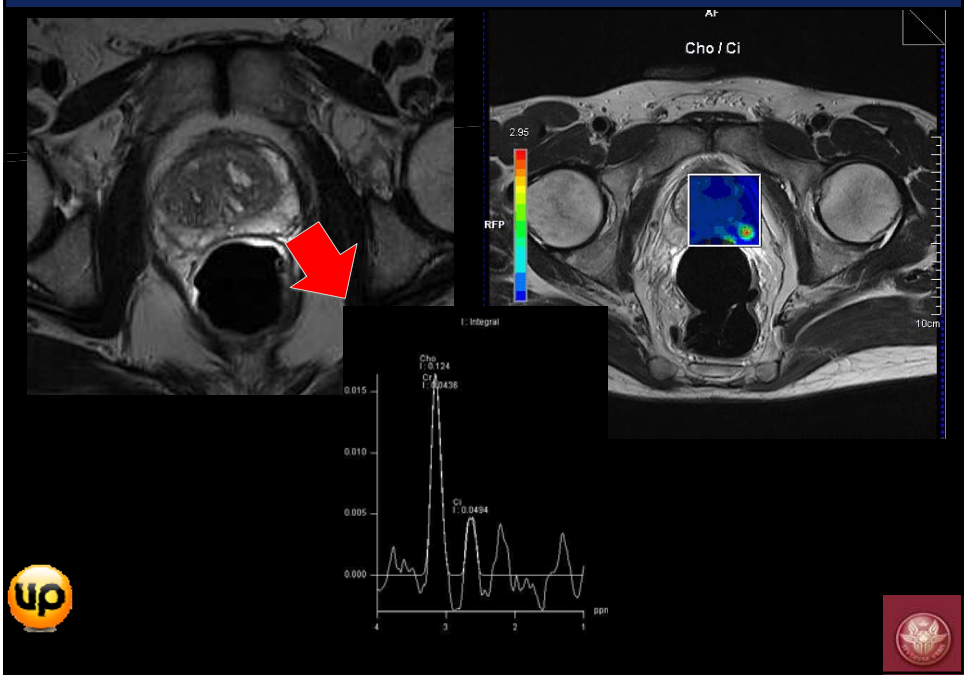
ER vs Bobina di superificie





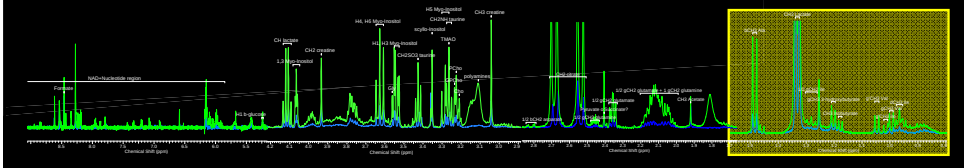


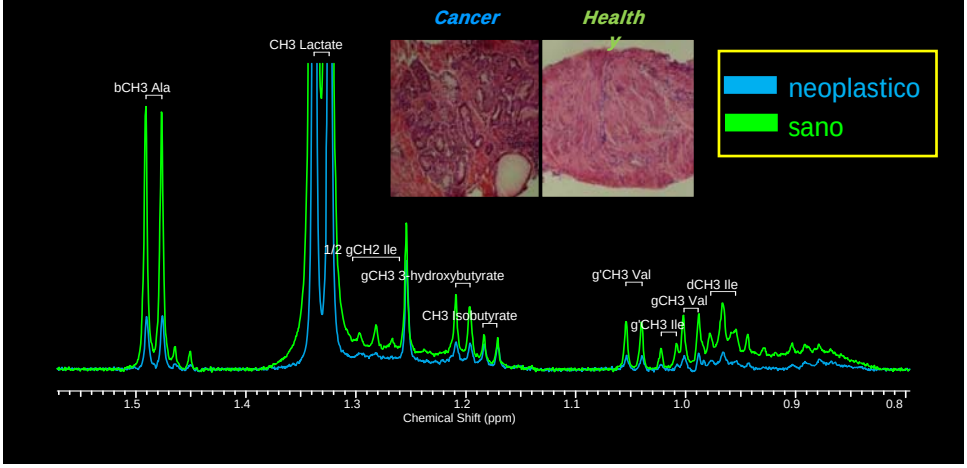
RISOLUZIONE SPETTRALE



RISOLUZIONE SPETTRALE

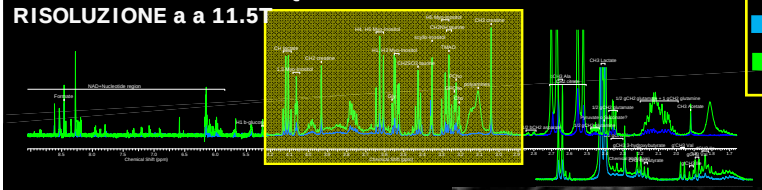
Profilo metabolico su frustolo (HRMR Magnete 11.7 T)



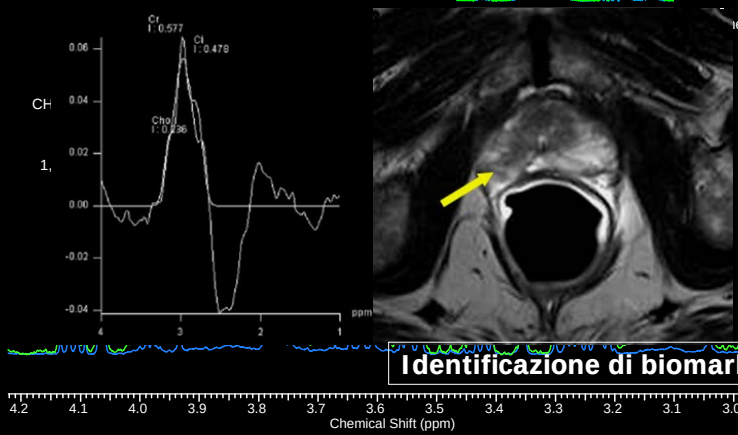


NUOVE PROSPETTIVE: APPROCCIO METABOLOMICO

CONFRONTO SPETTRI ACQUISITI IN VIVO A 1.5 E 3T ed EX VIVO AD ALTA RISOLUZIONE a a 11.5T



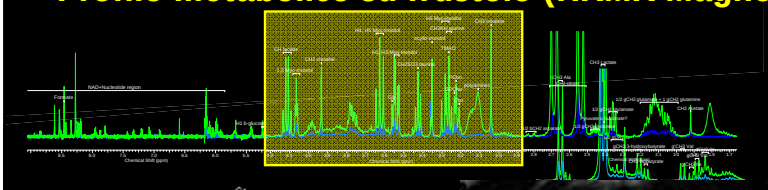
cancro
t. sano

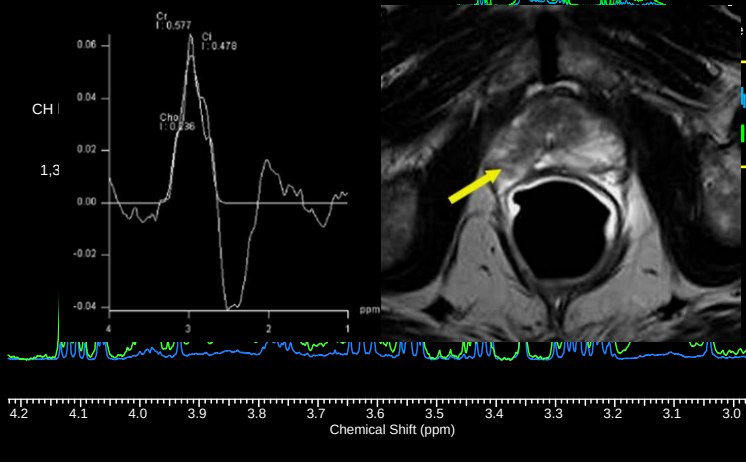


Identificazione di biomarkers)

RISOLUZIONE SPETTRALE

Profilo metabolico su frustolo (HRMR Magnete 11.7 T)

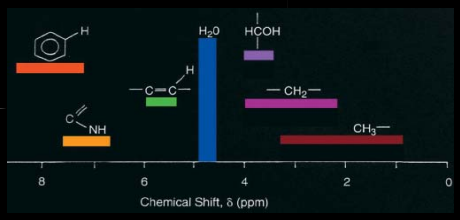




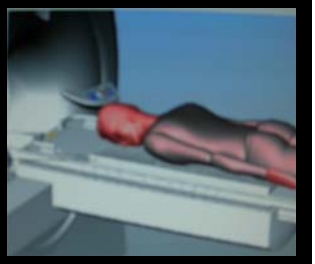
heoplastico
l sano

RISOLUZIONE SPETTRALE

Utilizzo di differenti nuclei



- **Idrogeno ($_{1}$H-MRS)**
- **Fosforo ($_{31}$P)**
- **Carbonio ($_{13}$C)**
- **Fluoro ($_{19}$F)**
- **Sodio ($_{23}$Na)**



La bobina cuore/fegato è dotata di "risonanza doppia", sia per frequenze $_{1}$H che $_{31}$ P
Eccitazione e ricezione dei nuclei 1H (63.6 MHz 1.5T)
Eccitazione dei nuclei 31P (25.7 MHz 1.5T)

ALTRI NUCLEI

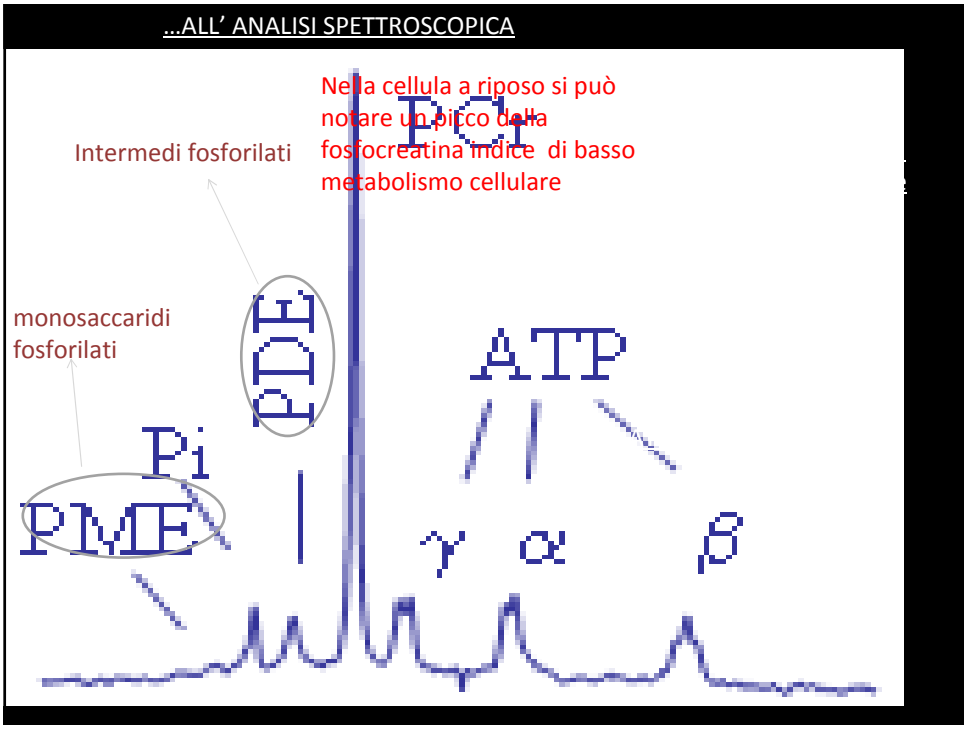
Fosforo ($_{31}$P)

- **-Acquisisce i più improtanti trasportatori di energia della cellula come l'ATP, Fosfocreatica e fosfato inorganico: stato energetico della cellula**

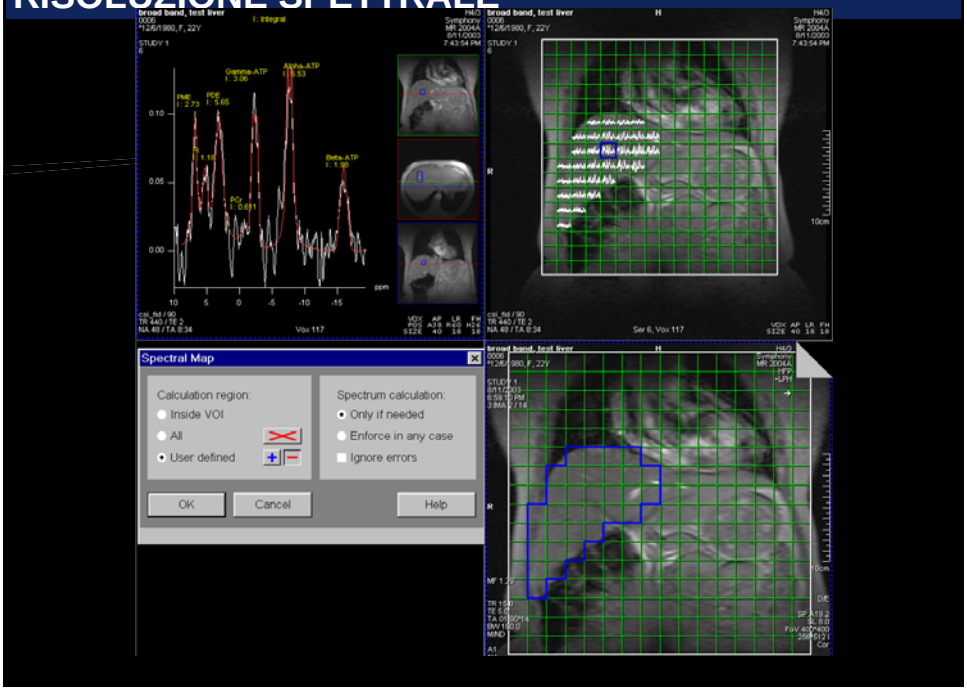
- **INDICAZIONI PRINCIPALI:**

-concentrazionia assolute di metaboliti fosforici specifici
-valori di pH
-rapidità di recupero da stress

…ALL' ANALISI SPETTROSCOPICA



RISOLUZIONE SPETTRALE



RISOLUZIONE SPETTRALE

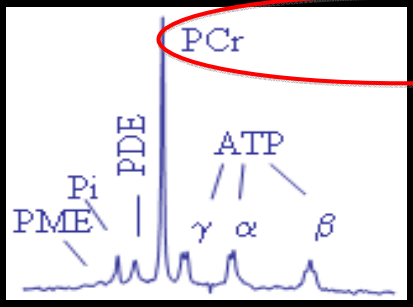
Spettroscopia 31P

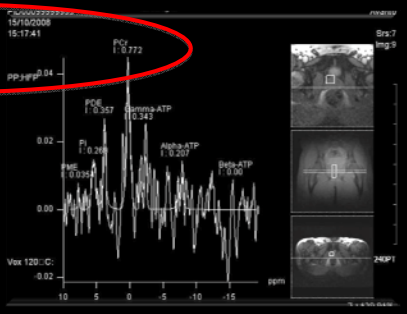
MARKERS:

-Metabolismo energetico

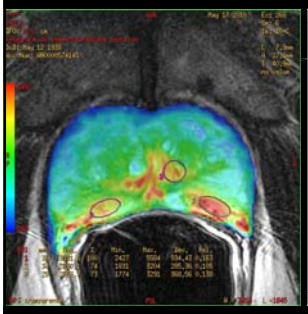
ATP, fosfocreatina, Pi, colina

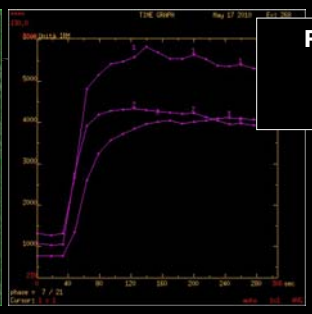
-PH intracellulare





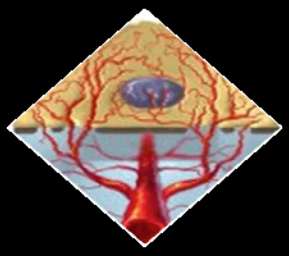
CARCINOGENESI: NEOANGIOGENESI (MRP)





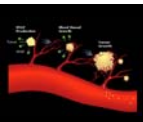
Rilascio fattore di crescita (VEGF)

NUOVA RETE CAPILLARE

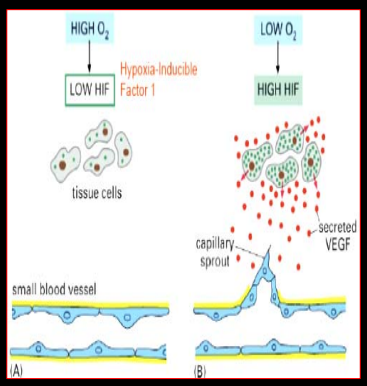


Padhani A., Radiology 2010

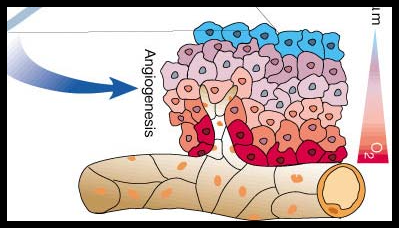
NEOANGIOGENESI



La neoangiogenesi è la formazione di nuovi capillari da vasi pre-esistenti



L'*ipossia* è tra i fattori più importanti nell'attivazione dell'angiogenesi



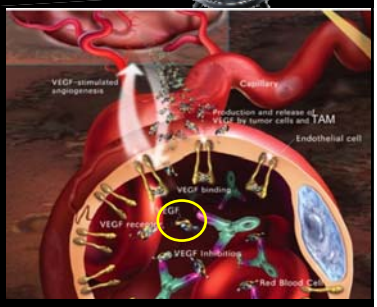
NEOANGIOGENESI

VEGF e VEGFR

VEGF (Vascular endothelial growth factor)
-prodotto dalle cellule tumorali in risposta a stimoli ipossici

-stimola la neoangiogenesi e la linfoangiogenesi

-aumenta inoltre la permeabilità dei vasi

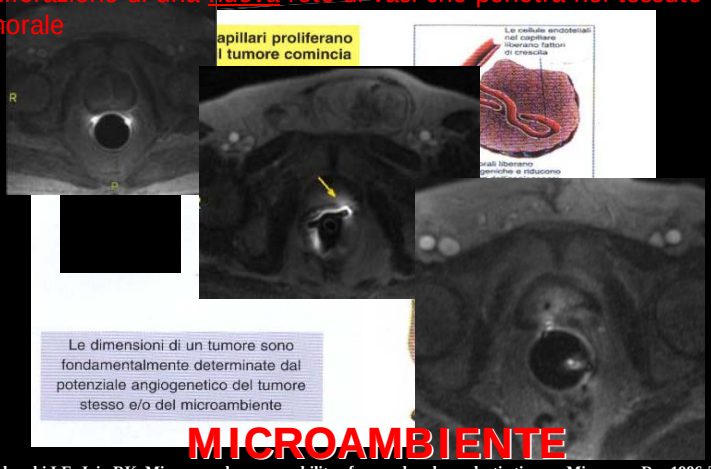


RECETTORI:
-VEGFR-1 e VEGFR-2 stimolano l'angiogenesi
-VEGFR-3 stimola l'angiogenesi e la linfogenesi

NEOANGIOGENESI

NEOANGIOGENESI TUMORALE

Proliferazione di una *nuova* rete di vasi che penetra nel tessuto tumorale



MICROAMBIENTE

- **Gerlowski LE, Jain RK. Microvascular permeability of normal and neoplastic tissues. Microvasc Res 1986;31:288–305.**
- **Tumor microenviroment is an indispensable participant in the neoplastic process, fostering tumor cell proliferation, survival and migration .Coussens LM and Werb Z Nature 2002**

PERFUSIONE RM

TRASPORTO DI SANGUE A UNA UNITA' DI VOLUME (tessuto) IN UNA UNITA' DI TEMPO

OSSIGENO E NUTRIENTI ALLE CELLULE

OTTIMIZZAZIONE DI SEQUENZE E SCANSIONI AD ALTA RISOLUZIONE TEMPORALE

PERFUSIONE RM

Intravoxel Incoherent Motion Perfusion MR Imaging: A Wake-Up Call[1]

Denis Le Bihan, MD, PhD

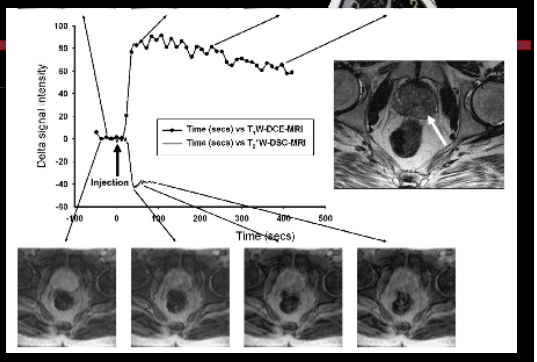
Radiology 2008; 249:748–752

colleagues, and at some point, they teased me with such aphorisms as "diffusion, perfusion,...confusion." Any-

PERFUSION IMAGING

- **Flusso e Permeabilità vascolare**
- **Acquisizione durante somministrazione ev di mdc**
- **Valutazione quantitativa**
- **Post-processing**

TECNICA RM



-Sequenze T2* pesate

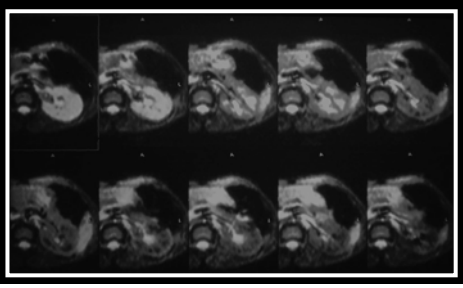
-Perfusione T1:

Metodo basato sulla suscettibilità
-MODELLO MONOCOMPARTIMENTALE
-FLUSSO – PERFUSIONE TISSUTALE
-AUMENTO DENSITA' VASALE – VOLUME SANGUE

European Journal of Radiology (2007) Roberto Alonzi , Anwar R. Padhani , Clare Allen

PERFUSIONE RM

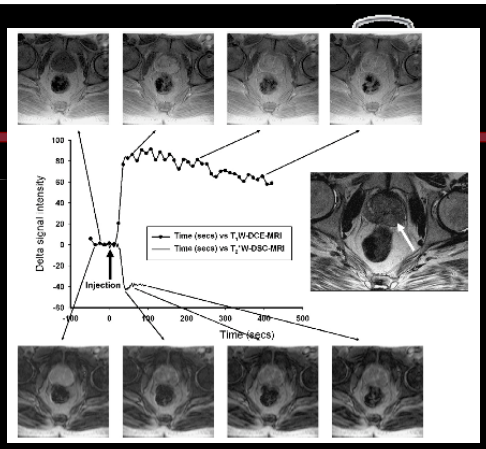
- **TECNICA DI STUDIO RM EPI T2**
  - Squenza dinamica GRE-EPI T2* (1000/40/30°), Risoluzione temporale 8 sez / 4” x 120”
  - Sequenza GRE-EPI T2*
  - Iniezione mdc paramagnetico in bolo (eff. T2, riduz. IS)
  - “quantizzazione” del flusso



Krestin, Functional MR of the kidney 1995
Lee, Genitourinary Radiology RSNA 2006

TECNICA RM

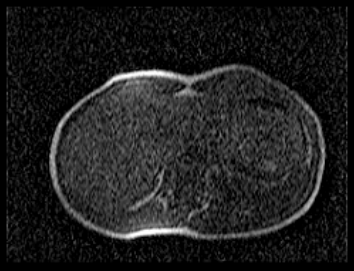
-Perfusione T1:



Metodo basato aumento relassività
-MODELLO BICOMPARTIMENTALE
-PERFUSIONE MICROCIRCOLO
-PERMEABILITA’
-LEGAME COMPARTIMENTO EXTRACELLULARE

European Journal of Radiology (2007) Roberto Alonzi , Anwar R. Padhani , Clare Allen

PERFUSIONE RM



Sequenze Ultraveloci GRE
T1 2D/3D
Risoluzione Temporale
Risoluzione Spaziale
2 minuti fino a 10 min

-Metodo basato aumento relassività
-MODELLO BICOMPARTIMENTALE
-PERFUSIONE MICROCIRCOLO
-PERMEABILITA' (piuttosto che flusso come in T2)
-LEGAME COMPARTIMENTO EXTRACELLULARE

European Journal of Radiology (2007) Roberto Alonzi , Anwar R. Padhani , Clare Allen

STUDIO DINAMICO

APPROCCIO DINAMICO – 2D GRE T1 pesata

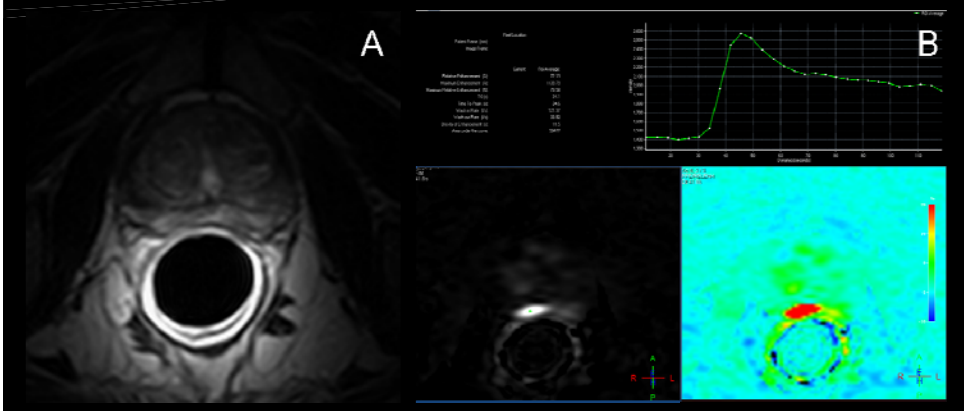
- **Identificazione e caratterizzazione della lesione in base alla vascolarizzazione**
- **Elaborazione curve dinamiche intensità / tempo (I/T)**

PARAMETRI SEQUENZA
- **TR:** 6.7 mSec
- **TE:** 4.1 mSec
- **Flip Angle:** 70°
- **Average:** 1
- **Thickness:** 4 mm
- **Section Gap:** 0
- **Matrix:** 256 x 128
- **Scan Time:** 2 min
- **8 sezioni in 4 sec**
- **30 acquisizioni**

Cortesia del dott. G. Cardone

STUDIO DINAMICO-PERFUSIONALE

APPROCCIO DINAMICO – 2D GRE T1 pesata



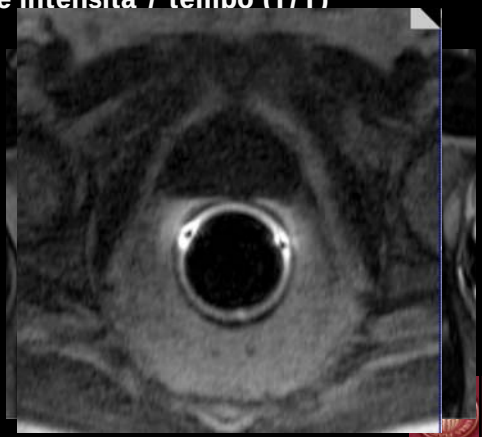
STUDIO PERFUSIONALE

APPROCCIO PERFUSIONALE – 3D GRE T1 pesata

- **Identificazione e caratterizzazione della lesione in base alla vascolarizzazione**
- **Elaborazione curve dinamiche intensità / tempo (I/T)**

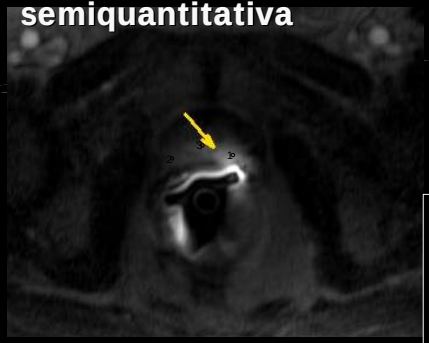
PARAMETRI SEQUENZA
- **TR:** 2,0 mSec
- **TE:** 1.0 mSec
- **Flip Angle:** 19°
- **Average:** 1
- **Thickness:** 4 mm
- **Section Gap:** 0
- **Time resolution: 12 sections/3 sec**
- **Matrix:** 256 x 256
- **Scan Time:** 3.50 min

-80 misurazioni



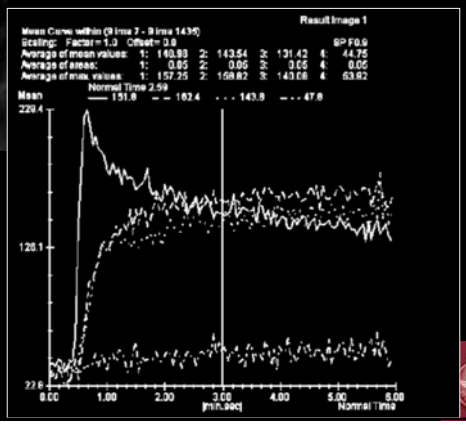
STUDIO DINAMICO-PERFUSIONALE

Valutazione semiquantitativa



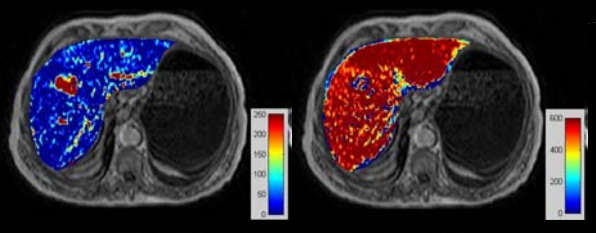
Posizionamento di 4 RoI

Onset-time (OT), ***tempo che intercorre tra somministrazione del m.d.c. e l'inizio della crescita della curva, (sec);***
Time to Peak (TTP)*, tempo impiegato affinché la curva raggiunga il suo picco massimo, (sec);
Peak enhancement (PE) ***la massima concentrazione del contrasto nella zona d'interesse, espresso i millimoli per chilogrammo (mmol/Kg).***

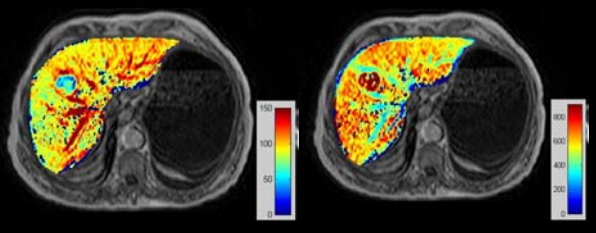


STUDIO DINAMICO-PERFUSIONALE

Valutazione quantitativa



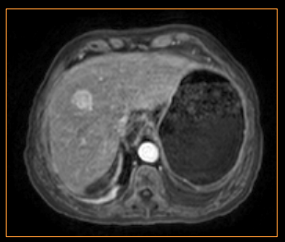
K^{trans} arterial



K^{trans} portal

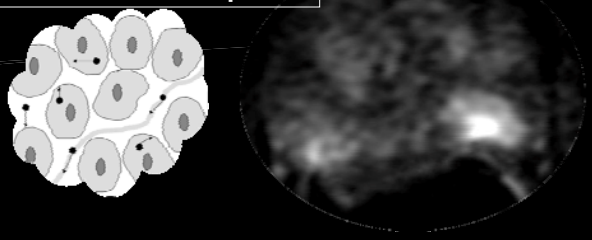
V_e

K_{ep}



CARCINOGENESI: DANNO CELLULRE (DWI)

Restrizione movimento molecole di acqua

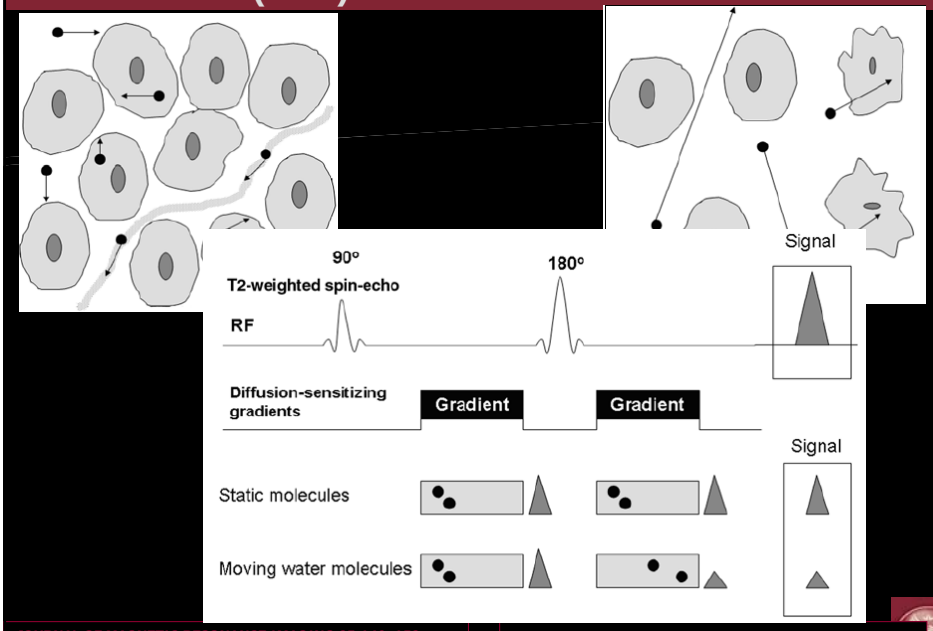


-Nell'imaging RM di diffusione (DWI) il contrasto delle immagini si basa sull'intensità dei movimenti microscopici delle molecole d'acqua.

-L'attenuazione del segnale nelle immagini RM di diffusione dipende dal fattore di diffusione b e dal coefficiente apparente di diffusione (ADC) tissutale.

Padhani A., Radiology 2010

DIFFUSIONE (DWI)

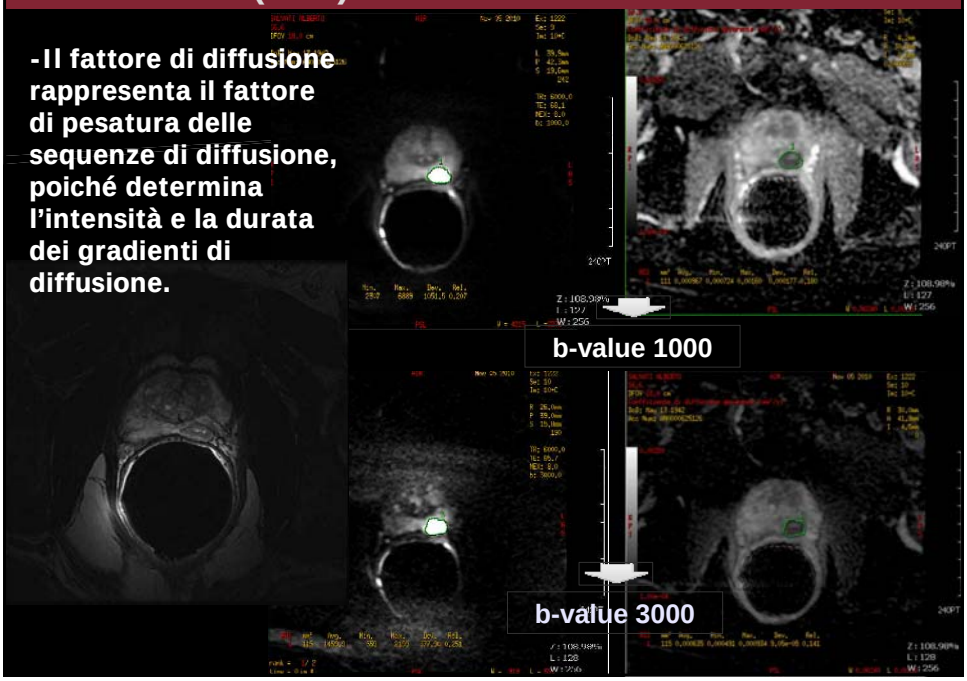


JOURNAL OF MAGNETIC RESONANCE IMAGING 25:146–152 (2007)

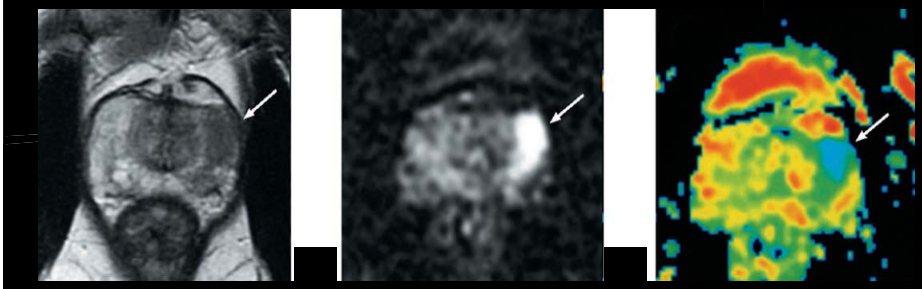
Invest Radiol. 2007 Jun;42(6):412-9

DIFFUSIONE (DWI)

-Il fattore di diffusione rappresenta il fattore di pesatura delle sequenze di diffusione, poiché determina l'intensità e la durata dei gradienti di diffusione.



DIFFUSIONE (DWI)



-Le immagini in diffusione, ottenute con tempi di eco lunghi, contengono tuttavia anche una quota di contrasto T2, che può simulare quadri di riduzione della diffusione (effetto "T2 shine through")

-Mappe ADC a partire da immagini in diffusione ottenute con almeno due diversi valori di b, in grado di evidenziare voxel per voxel dei coefficienti di diffusione puri.

DIFFUSIONE (DWI)

-Nelle mappe ADC le aree di ridotta diffusione mostrano segnale basso. Il parametro analitico fondamentale ottenuto dalle sequenze pesate in diffusione è il coefficiente di diffusione (ADC).

-Il tumore tende ad avere una diffusione generalmente ristretta (isotropica) rispetto ai tessuti non cancerosi a causa dell'elevata densità cellulare.

Punteggio	Alto b-value immagine DWI	Mappa ADC	Caratterizzazione Tessuto
5	ipersegnale	iposegnale	maligno
4	segnale intermedio	iposegnale	probabile maligno
3	nessun altro pattern	nessuno altro pattern	indeterminato
2	intermedio, iposegnale	intermedio	tessuto flogistico tumore di basso grado
1	iposegnale	ipersegnale	tessuto normale

DIFFUSIONE

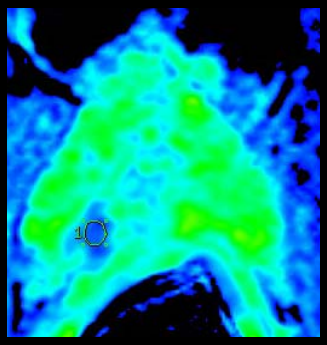
Sequenze EPI ed imaging parallelo *(Single Shot Spin Echo echo-planar)*
Fat Suppression

SS-EPI DWI
TE: Minimum
TR: 5000
FOV 18
Slice Thikness: 3mm
Pixel size: 1.4 x 1.4 x 3 mm²
Parallel Imaging ASSET
DWI b-value: 1000 s/ mm²
DTI directions: 16

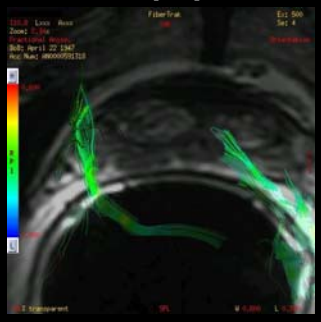
Almeno 3 b value: 0-100-800 s/mm2.....1000.....

DIFFUSIONE

1. Coefficiente Diffusione Apparente (ADC) quantificato per fornire informazioni sul grado di restrizione movimento molecole di acqua



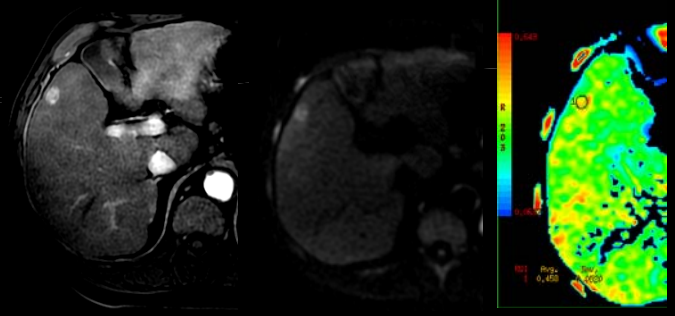
2.Grado della mobilità direzionale della diffusione molecole d'acqua in un tessuto quantificato da un indice: Anisotropia Frazionata (FA)



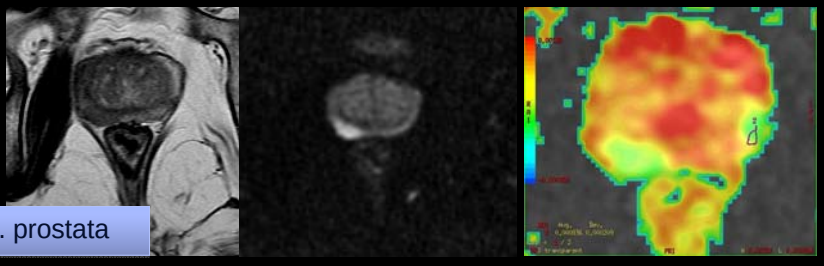
2. Tracciato orientamento spaziale in dipendenza del processo di diffusione Tensore di diffusione (DTI)

Imaging in diffusione

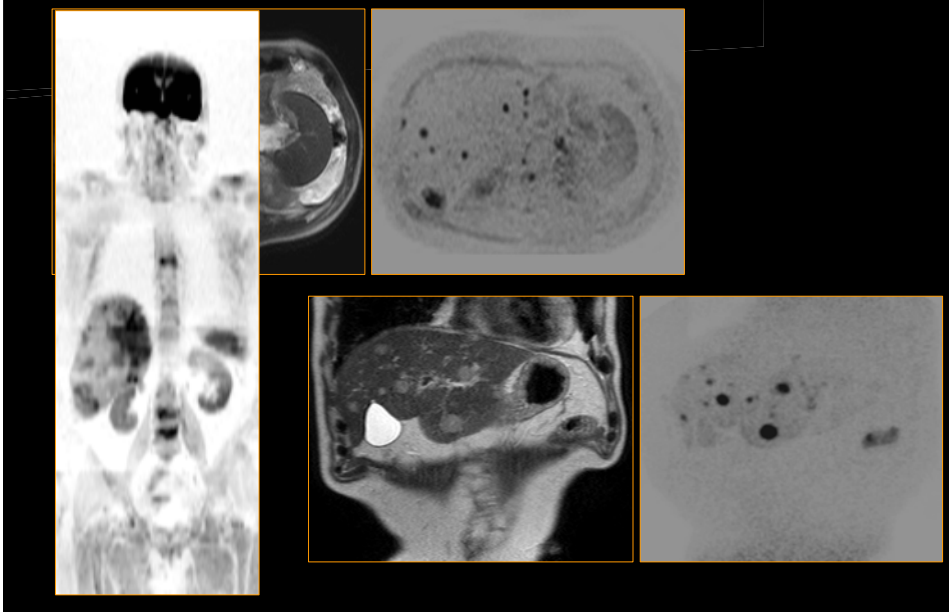
HCC



Ca. prostata



Imaging in diffusione



PHYSICAL REASONS

Precession frequency

$$\omega = \gamma B_0$$

Eq. di Larmor

42 MHz 1 T

63.9

T

127.8

B_0

Coils

64 MHz 1.5T ⟷ 128 MHz 3T

ADVANTAGES

SIGNAL to NOISE
S/N

- SPATIAL RESOLUTION (SNR)
- CONTRAST RESOLUTION (CNR)
- TEMPORAL RESOLUTION

INCREASED EFFECT OF GADOLINIUM
HIGHER SPECTRAL RESOLUTION

Mara M. Barth et al. , Radiographics 2007
Soher BJ et al, Magn Reson Imaging Clin N Am 2007
Christiane K. Kuh et al, Radiology 2008

OBIETTIVI DELL'IMAGING

DIAGNOSI INIZIALE
IDENTIFICAZIONE
(localizzazione, volume e morfologia)
Caratterizzazione/aggressività

BILANCIO DI MALATTIA
STADIAZIONE
PLANNING TERAPEUTICO

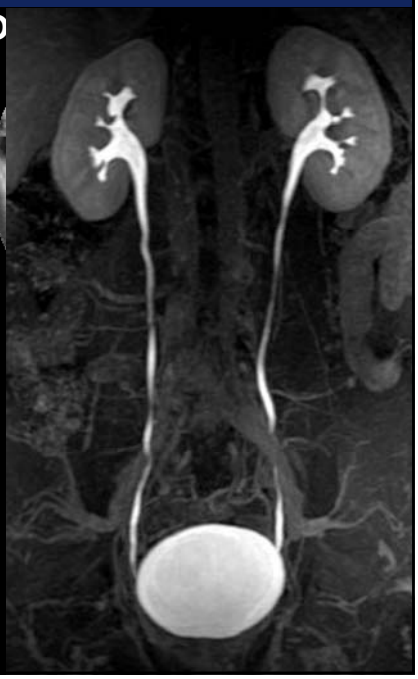
FOLLOW UP
RISPOSTA ALLA TERAPIA
EFFICACIA TERAPEUTICA

CNR – SNR

Thinner slices,
higher matrices
smaller voxels

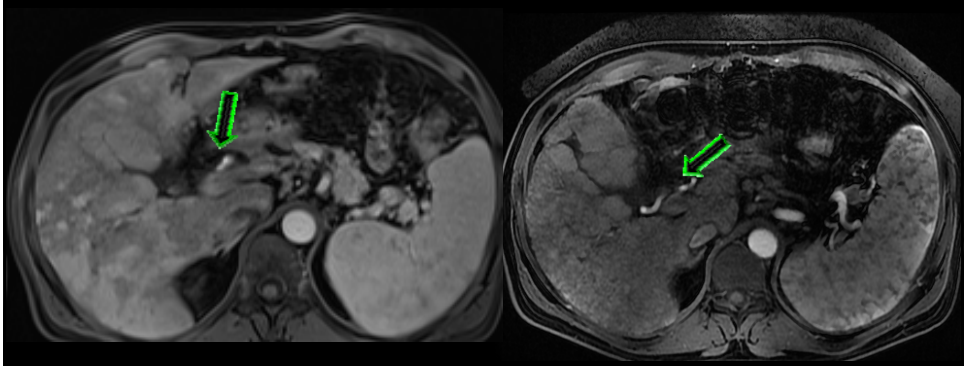
SMALLER LESION DETECTION
BETTER IMAGE RESOLUTION

MR as CT
MULTIPARAMETRIC VIEW
ACQUISITION OF LARGE VOLUME
BETTER 3D RECONSTRUCTIONS
PARALLEL IMAGING
LOWER TA



DETECTION

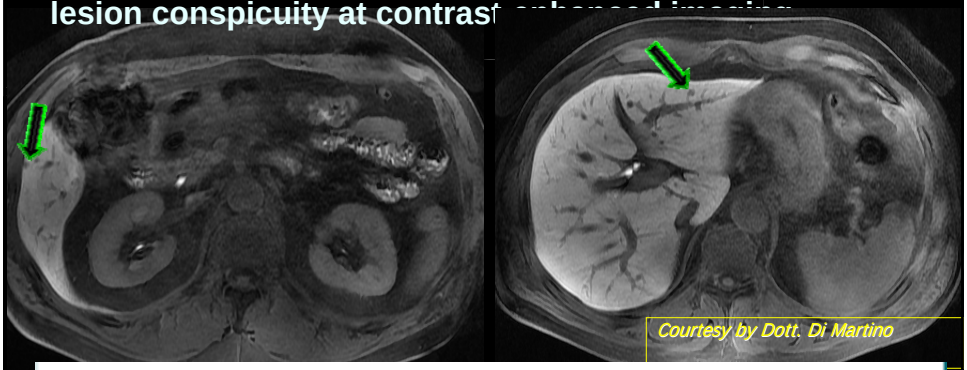
- An increase of signal-to-noise ratio (SNR) can be used to achieve a better spatial resolution



Courtesy by Dott. Di Martino

DETECTION

- A higher contrast-to-noise ratio (CNR) improves lesion conspicuity at contrast-enhanced imaging



Courtesy by Dott. Di Martino

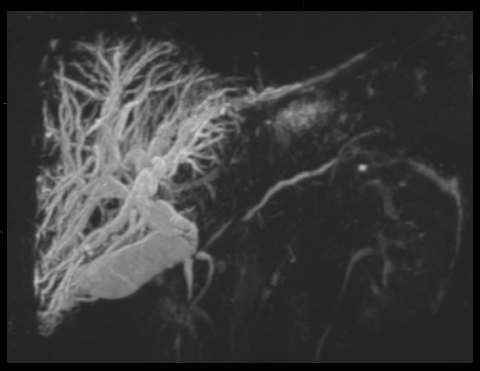
High-Field-Strength MR Imaging of the Liver at 3.0 T: Intraindividual Comparative Study with MR Imaging at 1.5 T

Von Falkenhausen MM, Radiology 2006

3T MRI is equivalent to 1.5T in terms of detection and characterization of focal liver lesions

CNR – SNR

MRCP



MR cholangiopancreatography at 3.0 T is readily achievable and offers improvements in image quality and signal characteristics over MR cholangiopancreatography at 1.5 T.

Patel, Radiographics 2009

The results suggest that 3.0 T may allow higher spatial resolution and offer promise for improved diagnosis in MRCP, although further investigations using optimize scan parameters will be needed before its full potential can be achieved.

Onishi H, Invest Radiol, 2009

SNR

MSK

T2 and T2* mapping can help assess the microstructural composition of cartilage overlying osteochondral lesions

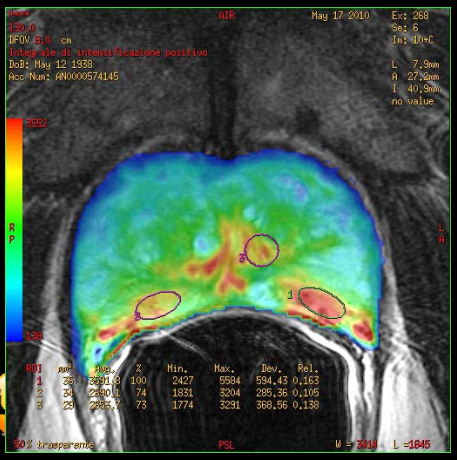
The clinical impact of this technology remains uncertain because no published controlled clinical trial has evaluated the impact of 3T MR imaging on diagnostic outcomes*

MOSHER TJ. Magn Reson Imaging Clin N Am, 2006 *
Marlk W., Eur J of Rad, 2011

TIME RESOLUTION + SNR - CNR

- **Faster acquisitions**
- **Faster MRA and Perfusion Imaging**

Better characterization of the lesion



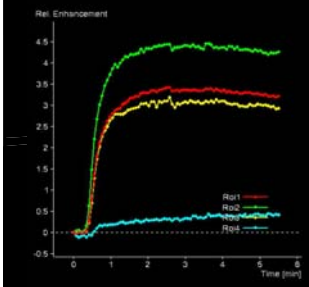
TR = almeno 10 sec

< 3 sec

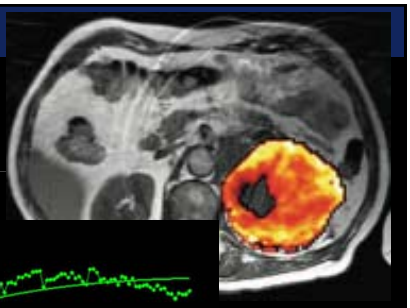
Consensus Document Dynamic Contrast Enhanced MR imaging, 2010

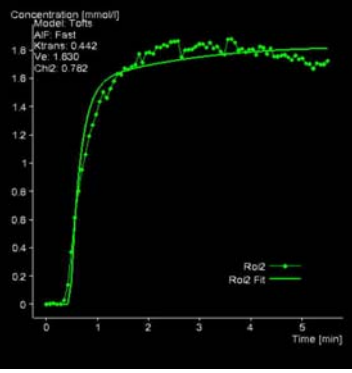
Christiane K. Kuh et al, Radiology 2008
Hambrock T et al., Invest Radiol 2008

CHARACTARIZATION



SEMI-QUANTITATIVE EVALUATION





QUANTITATIVE EVALUATION

K trans map:
Stima del volume di mdc estratto dal plasma allo spazio extravascolare espresso in min

Imaging angiogenesis of genitourinary tumors

Ying-Klat Zee, James P. B. O'Connor, Geoff J. M. Parker, Alan Jackson, Andrew R. Clamp, M. Ben Taylor, Noel W. Clarke and Gordon C. Jayson

Zee, Y.-K. et al. Nat. Rev. Urol. 7, 69–82 (2010); published online 19 January 2010; doi:10.1038/nrurol.2009.262

INCREASED EFFECT OF GADOLINIUM

"Gad is good."

T1 relaxation times of gadolinium containing contrast agents decrease on the order of 5 to 10% at 3.0 T

T1 relaxation times of the tissues prolong on the order of 40% or more at 3.0 T

$$\Delta T1 = T1_{(sangue)} - T1_{(sangue+mdc)}$$

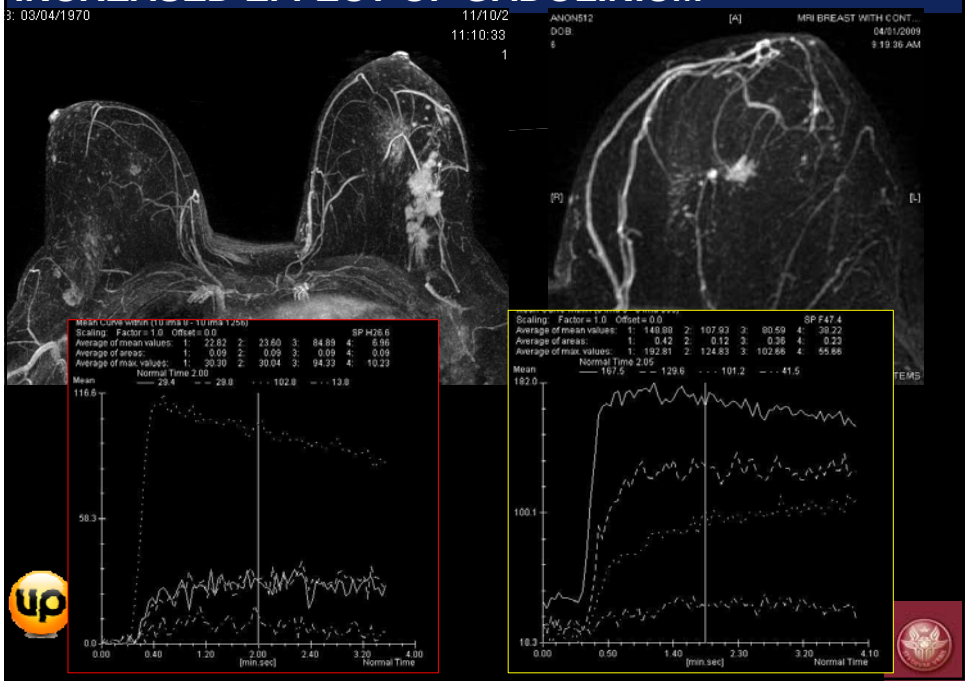
An equivalent dose of gadolinium containing contrast agent causes an increased contrast difference at 3.0T

- **Higher signal-to-noise ratio**
- **Higher contrast-to-noise ratio**

DOSE REDUCTION

Soher BJ, Dale E[illegible]
vs 1.5T Magn Reson Imaging Clin N Am 2007

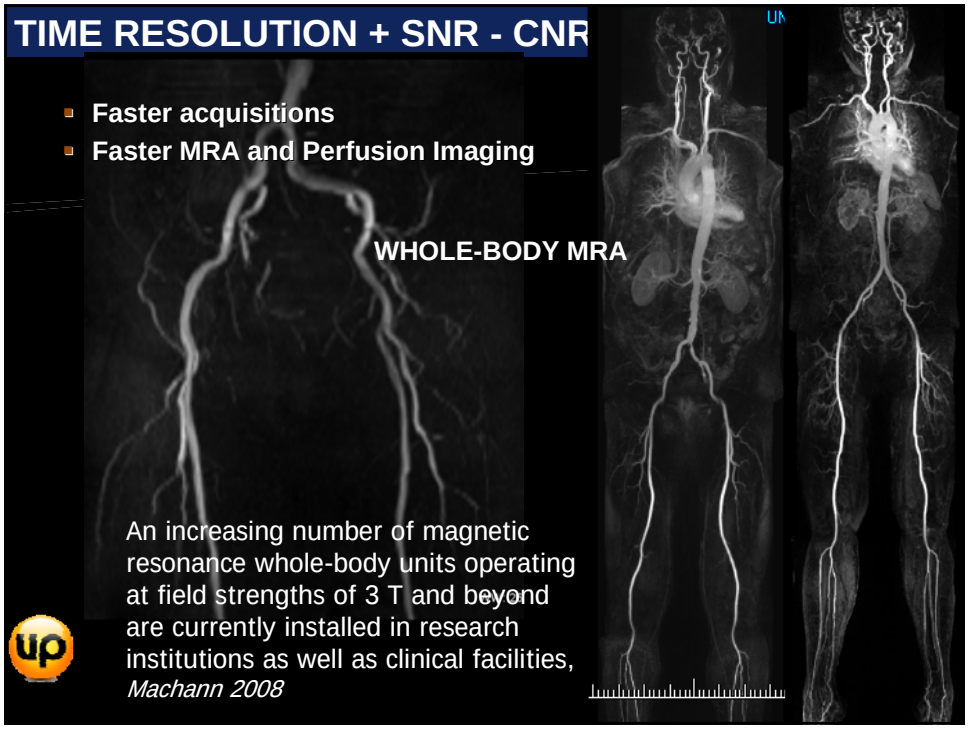
INCREASED EFFECT OF GADOLINIUM



TIME RESOLUTION + SNR - CNR

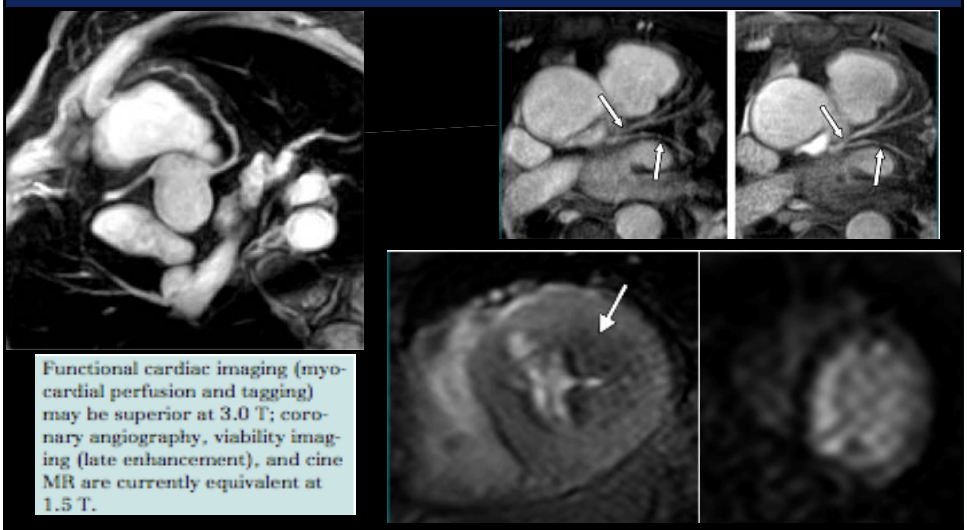
- **Faster acquisitions**
- **Faster MRA and Perfusion Imaging**

WHOLE-BODY MRA



An increasing number of magnetic resonance whole-body units operating at field strengths of 3 T and beyond are currently installed in research institutions as well as clinical facilities, *Machann 2008*

TIME RESOLUTION + SNR - CNR



Functional cardiac imaging (myocardial perfusion and tagging) may be superior at 3.0 T; coronary angiography, viability imaging (late enhancement), and cine MR are currently equivalent at 1.5 T.

Christiane K. Kuhl, MD
Frank Träber, MD
Jürgen Gieseke, MD
Wolfgang Drahanowsky, MD
Nuschin Morakkabati-Spitz, MD
Winfried Willinek, MD
Marcus von Falkenhausen, MD
Christoph Manka, MD
Hans H. Schild, MD

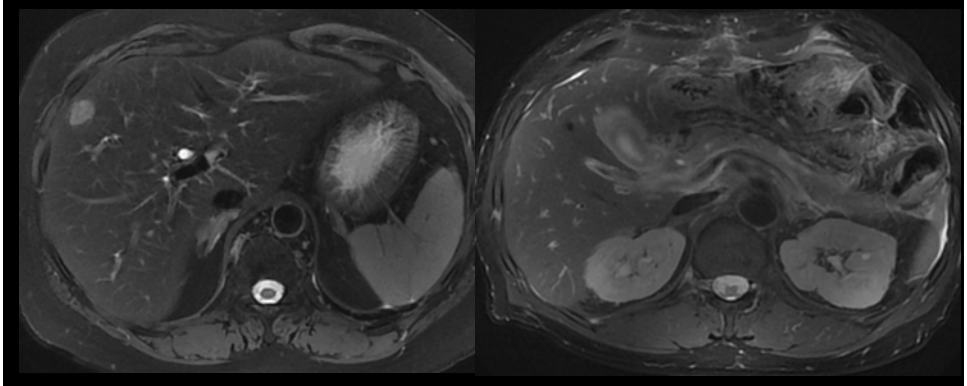
Whole-Body High-Field-Strength (3.0-T) MR Imaging in Clinical Practice
Part II. Technical Considerations and Clinical Applications[1]

Radiology

GREATER SPECTRAL SEPARATION

Better fat suppression*

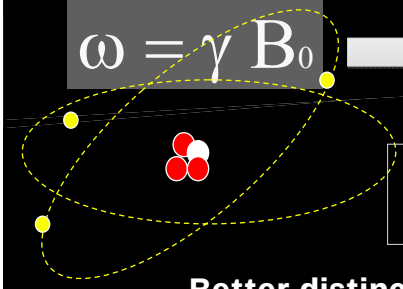
- **Spectral fat saturation**
- **Water excitation (WE)**



*Lee VS, Hecht EM, Taouli B, et al. Body and Cardiovascular MR Imaging at 3.0 T. Radiology 2007; 244:659-705.
Alkan E, Semelka RC, Dale BM, et al. Water Excitation MPRAGE: An Alternative Sequence For Postcontrast Imaging of the Abdomen in Noncooperative Patients at 1.5 T and 3.0 T. J Magn Reson Imaging 2008

SPECTRAL RESOLUTION

$$\omega = \gamma B_0 \rightarrow \omega = \gamma B_0 (1-\sigma)$$



More efficient MR spectroscopy

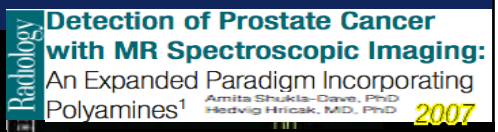
Better distinction of the metabolites compared to background

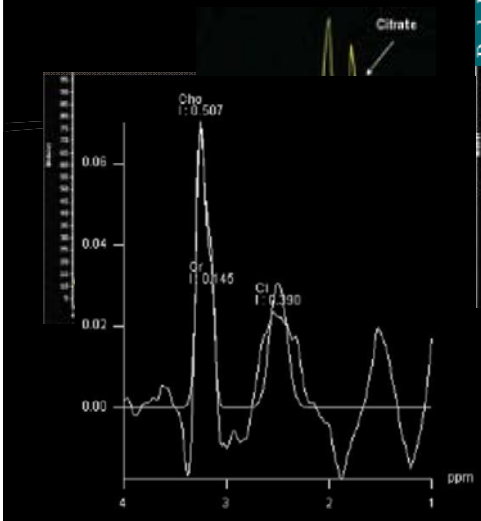
Peaks improvement

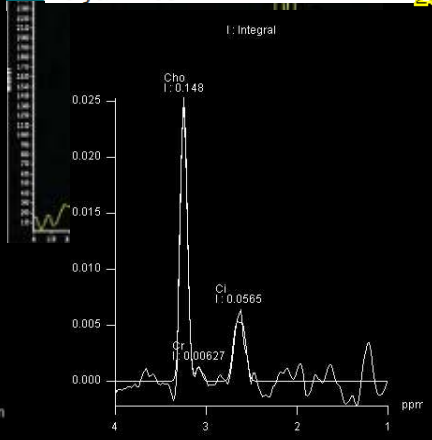
Size voxel reduction

TA reduction

SPECTRAL RESOLUTION



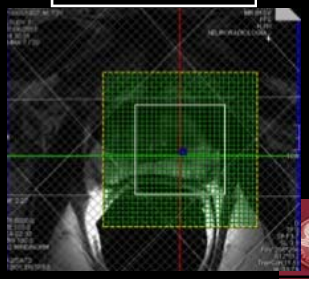




3D CSI multivoxel

INTERPOLAZIONE VOXEL

3.4 mm 1.5T
2.5 mm 3T

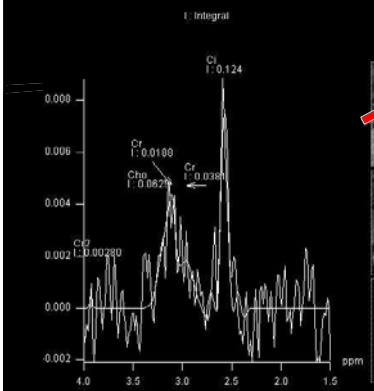


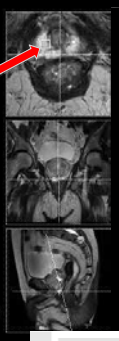
T A

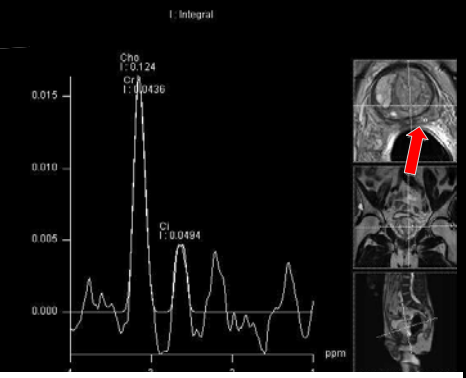
9.27'1.5T | 6.44' 3T

SPECTRAL RESOLUTION

ER vs Phaced-array coil







ECMRI – STAGING
3T accuracy 94%,
sens 88%
spec 96/98%

Radiology

Tamar Sella, MD
Lawrence H. Schwartz, MD
Peter W. Swindle, MD, MS, FRACS
Chinyere N. Onyebuchi, MPH
Peter T. Scardino, MD
Howard I. Scher, MD
Hedvig Hricak, MD, PhD

Suspected Local Recurrence after Radical Prostatectomy: Endorectal Coil MR Imaging[1]

100% sens 100% spec

1) Mazaheri Y, Shukla-Dave A, Muellner A, Hricak H. MR imaging of the prostate in clinical practice. MAGMA. 2008 Nov;21(6):379-92.

1) Cornfeld DM, Weinreb JC. MR imaging of the prostate:1,5T versus 3T. Magn Reson Imaging Clin N Am. 2007; 15: 433-448

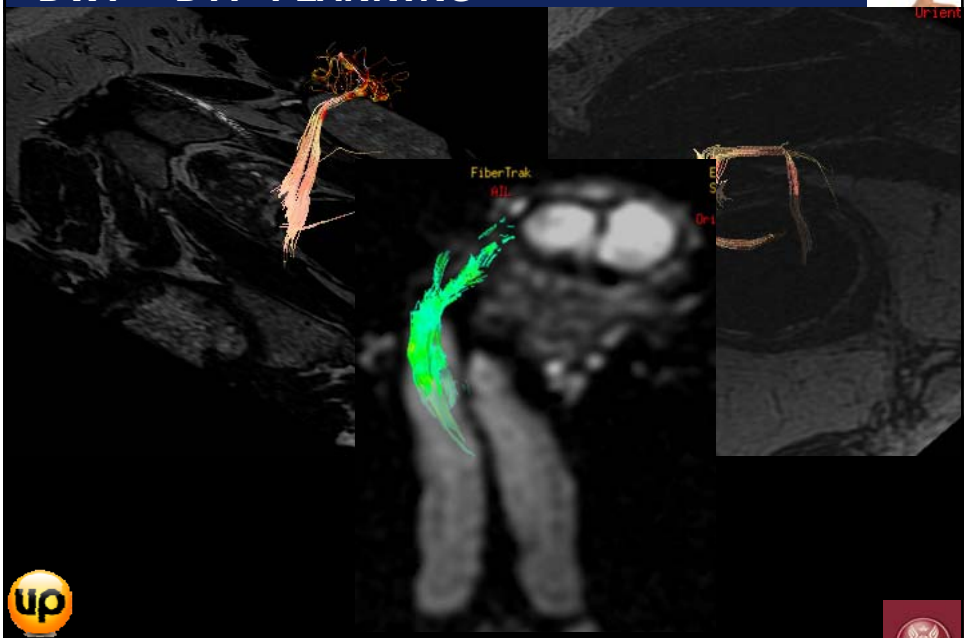
Caratterizzazione / Aggressività

PERFUSIONE *
DIFFUSIONE **
SPETTROSCOPIA***

Pattern e cut-off :
Cho + Cr / Ci < 0.5 = tessuto sano
Cho + Cr / Ci > 0.5 but < 1 = probabilità di tumore
Cho + Cr / Ci > 1 = certezza di tumore

H. Hricak, Radiology 2005
J. Barentsz, RSNA 2009

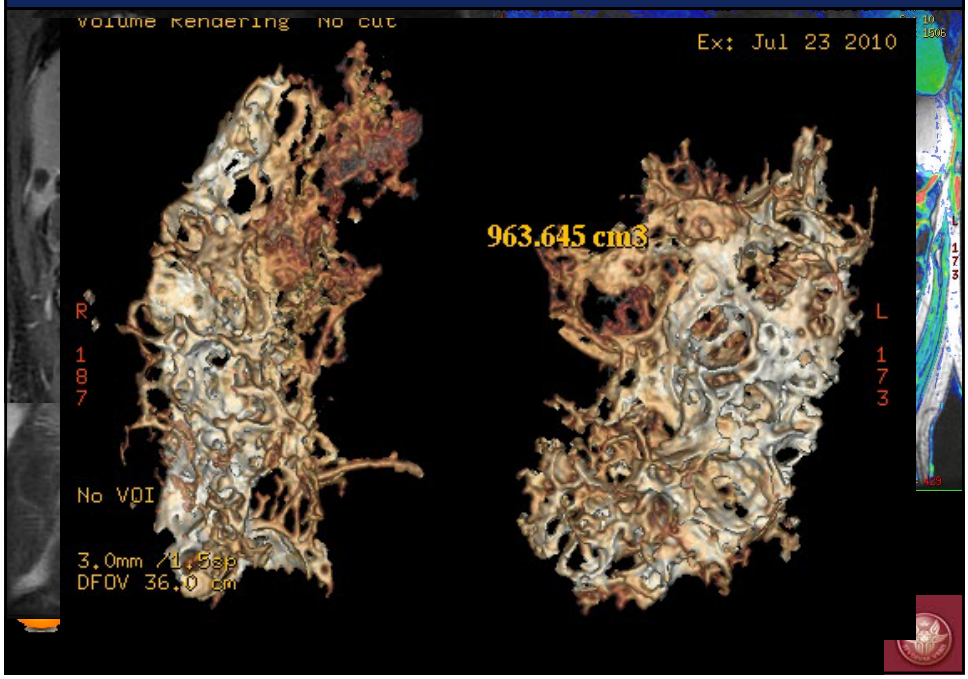
DWI + DTI -PLANNING



Panebianco ESUR, 2010

Notohamiprodjo M, Invest Radiol. 2010

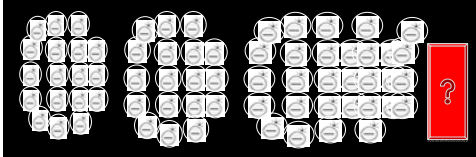
SNR- GAD EFF – TIME RESOLUTION -PLANNING



PLANNING

Theoretically the biological follow up in oncology is based on evaluation of *cells number variation over time …*

…practically, according to dimensional criteria, tumor size is associated to the number of tumor cells…!!!

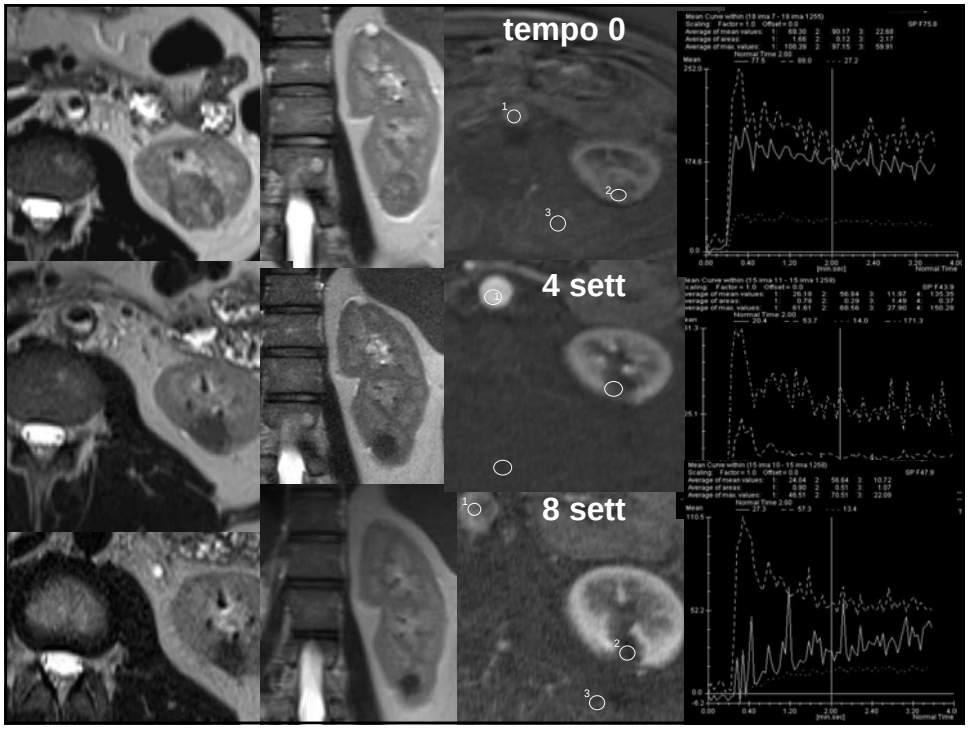


-tumors cannot be measured
-poor measurement reproducibility
-mass lesions of unknown activity persist following therapy
(Padhani Radiology 2010)

EVIDENCE

"…Adding DW MR to T2-weighted imaging can significantly improve the accuracy of prostate PZ tumor volume measurement"
Mazaheri Y, Hricak H, Radiology 2009

"…significant increase in the risk of PSA failure in men with eMRI-defined TV progression during nAST"
D'Amico, Int. J. Radiation Omcology Biol. Phys., 2008



PEDIATRIC

Breath-hold technique at1.5

Pediatric patients are the one who will probably profit most from higher magnetic fields.

line SNR. Fast imaging is also very helpful in young children who may not stay still throughout a long pulse sequence and in toddlers who do not respond to sedation

Free-breathing resiratory-triggered at 3T

Frank Träber, MD
Jürgen Gieseke, MD
Wolfgang Drahanowsky, MD
Nuschin Morakkabati-Spitz, MD
Winfried Willinek, MD
Marcus von Falkenhausen, MD
Christoph Manka, MD
Hans H. Schild, MD

Whole-Body High-Field-Strength (3.0-T) MR Imaging in Clinical Practice
Part II. Technical Considerations and Clinical Applications[1]

Radiology

DISADVANTAGES

BIG MAGNET BIG PROBLEM!

SAR (specific absorption rate, Watt/Kg)

T1 Relaxation times

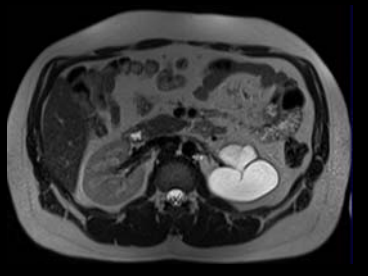
Artifacts
-shadow
-chemical shift
-susceptibility

DISADVANTAGES "solvable"

SAR (specific absorption rate, Watt/Kg)

Energy transfer related to radiofrequency pulses
"IL QUADRUPLO"

Effect on T2: quality comparable to 1.5T*



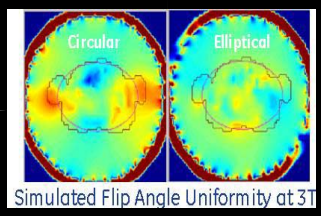
FLIP ANGLE MODIFICATIONS **
(VERSE, Hyperechoes, TRAPS)

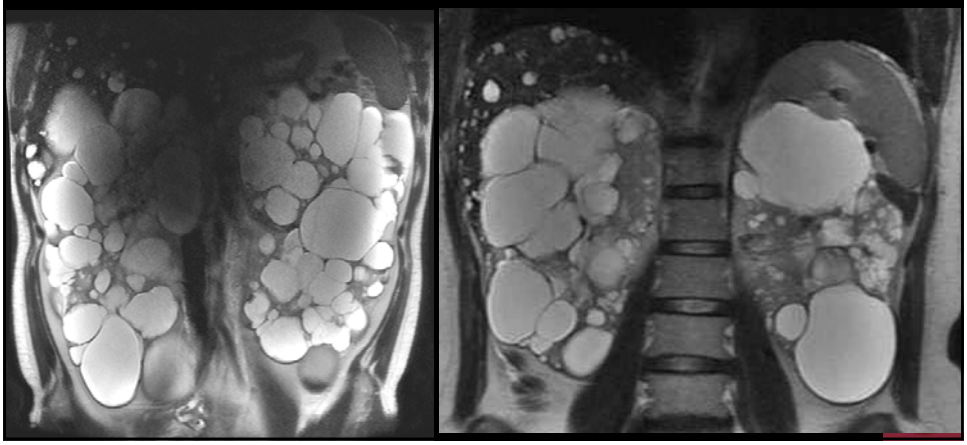
GOOD QUALITY , NO EXCESS SAR

Lee VS, Hecht EM, Taouli B, et al. Body and Cardiovascular MR Imaging at 3.0 T. Radiology 2007
Merkle EM, Dale BM. Abdominal MRI at 3.0 T: The Basics Revisited AJR 2006
**Zapparoli M, Semelka RC, Altun E et al. 3.0 T 2008*

DISADVANTAGES “solvable”

SHADOW
-Dielectric Pad





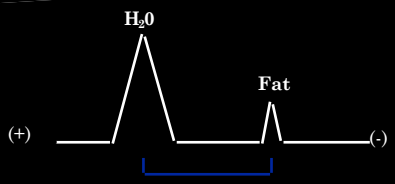
DISADVANTAGES “solvable”

CHEMICAL SHIFT artifacts

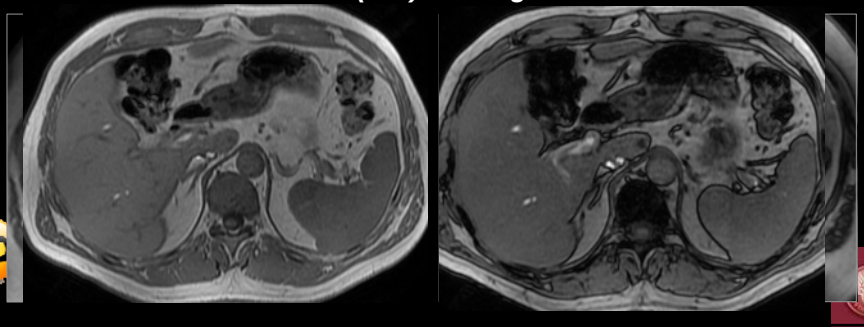
Disvantage:
- **Increase interface water/fat**

Advantages:
- **Spectral resolution improvement**
- **Fat saturation improvement**

1.5T---223 hertz
3.0T---447 hertz



CS: Use of bands (BW) with higher matrix



FINAL CONSIDERATIONS

VS

The advantages overcome the disadvantages

Some are solvable

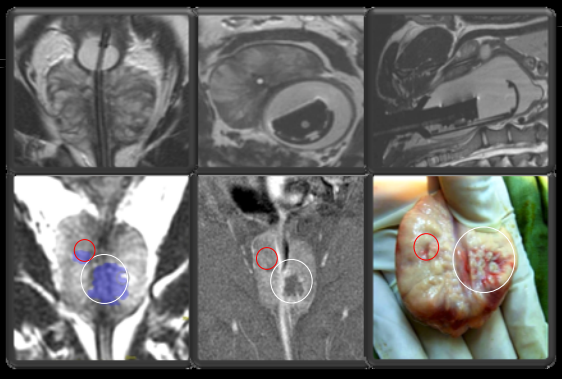
HIGHER IMAGE QUALITY ’

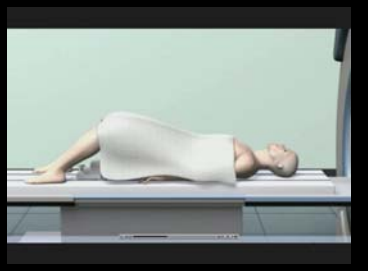
BETTER RESULTS USING MULTIPARAMETRIC IMAGING

1.5 REMAINS VALID FOR CLINICAL USE

GUIDA ALLA TERAPIA: MRgFUS

MRgFUS… ultrasound focused MR-guided

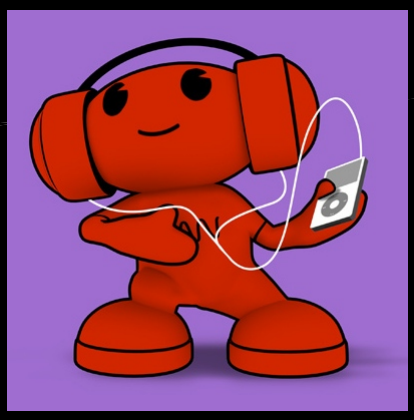




Ablazione focale

Terapia di salvataggio

Terapia Alternativa



GRAZIE