

## Contraindications and test of equipment

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## Handling contraindications

How do we find out about them?



The clinician has written about it in the referral



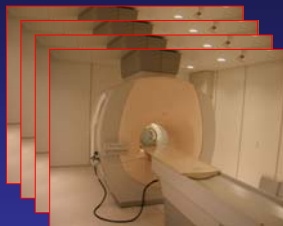
The patient calls according to instructions in received information and screening form



The hospital ward has completed a screening form

## MR-scanners in Lund

Several departments - various field strengths



MR-department (1.5T and 3T)  
Rtg 2 (1.5T)  
Landskrona (1.5T)



Neuro-rtg (3T)

## FRÅGEFORMULÄR

Inför magnetkameraundersökning

Namn: \_\_\_\_\_ Vikt: \_\_\_\_\_ kg Längd: \_\_\_\_\_ cm

Personnummer: \_\_\_\_\_

MR-undersökning kräver speciella förberedelser varför följande viktiga frågor måste besvaras innan vi kan ta ställning till om undersökningen kan genomföras. Om du svarar **JA** på någon fråga **MÅSTE** du ringa oss.

Har du opererats i hjärtat eller huvudet?  
- Vilken typ av operation? När och var?  
**Surgery?** JA  NEJ

Har du eller har du haft:  
Inopererad apparatur, t.ex. pacemaker  
aneurysmklipp (i huvudet)    
shunt (i huvudet för hydrocefalus) eller pump    
grandspår eller metallföroreningar i kroppen (t.ex. i ögonen)    
**Specific implants?**

- Om ja, vilken typ och var:  
**Metal or electrodes?**

Har du någon annan form av metall eller elektrod i kroppen?  
t.ex. ledtråror eller hjärtkatetrar?  
(Transferringar och lastbrygga är inget problem)

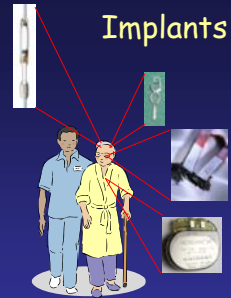
Om ja, vad och var?  
**Metal or electrodes?**

Har du någon njursjukdom?    
För kvinnlig patient: Är du gravid?

Följande skall tas bort före magnetkameraundersökningen:  
Alla metallföroreningar, smycken, piercing, färgade kontaktlinser, hörselhjälpmedel, insulinpump el dylikt.

Ring oss gärna om det är något ni undrar över.

## Implants



Active devices (e.g. pacemaker)  
Aneurysm-clips  
Shunt  
Foreign bodies

## Implants and equipment

Various patient groups – polyclinical, hospitalized, intensive care



## What will be a contraindication?



One has to know – do not guess!

May depend on the ability of the local MRI department to handle risks

Assessment of risk versus benefit and routines are then important

## To consider

### Available information about MR-safety

- Is there any information from the vendor?
- Is there any information at [www.mrisafety.com](http://www.mrisafety.com) (Shellock)?
- Are there scientific articles?

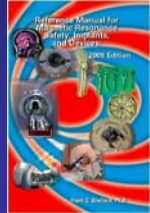
MR-safe



MR-conditional



MR-unsafe



## Local website

For each type of implant or external equipment there is:

- A report written by a medical physicist, ending up in recommendations regarding MR-safety
- Instructions approved by the radiologist in charge at the MR-department (and sometimes by clinicians)

## To consider

### Local routines in addition

- Local safety information and routines are used in Lund
- Medical physicists can assist in risk assessment

Estimation of risk is usually a cooperation between a **radiologist** with MRI-experience, a **physicist** and a **clinician** who knows about the implant and its use

## To consider

What are the risks ?

- Ferromagnetism
- Effects on electronics or mechanics
- Nervstimulation [Gradients, dB/dt]
- Heating [RF, SAR]
- (Artefacts)

## Local website

MR - Avdelningen

MR-säkerhetssidorna, USIL

Information om implantat:

MR-vekselnet:

Utrustning som under glöms förhållningar kan användas i MR-rom:

Här meddelas uppdateringar:

- 20.2.2009 Ny anvisning för anestesipersonal
- 18.2.2009 FICCA-kalender
- 18.11.2009 Klipparspår
- 26.3.2009 Anvisningar för MR-undersökning av patienter med clipphälsningar
- 26.3.2009 Inomhus-säkerhetsplan för användning av MR-kameror
- 26.3.2009 Elektroteknisk kontrollplan (ETKA) OK om ljudproducer tas bort
- 18.3.2009 Analys av säkerhetsfall för användning av MR-kameror i en Circle-Zenith AAA
- 6.3.2009 Skuldundersökning av patienter med temporärer tillg. OK. Ta bort i övriga fall.
- 6.3.2009 Hjärtbevaknings an House och Fisch Agg alltså OK.
- 11.1.2009 Utvärderingsprotokoll om hur ett MR-rom och som kan användas utanför MR-rom, så länge...
- 6.8.2007 Kullen-fraktur
- 16.8.2007 Tättningar och permanenta kontakt
- 6.8.2007 Bortskrivning av patienter
- 6.8.2007 Användning av MR-kameror i MR-rom
- 6.8.2007 Användning av MR-kameror i MR-rom
- 6.8.2007 Hjärtbevaknings an House och Fisch Agg alltså OK.

## Example

### Hip prosthesis

Ferromagnetism:

- Material may be stainless steel – slightly ferromagnetic
- Fixed into bone and tolerates large forces

=> Very little risk



## Example Hip prosthesis

Effects on electronics or mechanics :

- Contains no electronics or mechanics

=> No risk

Compare for example with  
shunt valve



## Example Hip prosthesis - summary

- Ferromagnetism is a very small risk
- Effects on electronics or mechanics is no risk
- Nerve stimulation (Gradients, dB/dt) is a very small risk
- Heating (RF, SAR) is a small risk

Does not seem to be dangerous in general, but:  
Keep a continuous watchout for new information !

## Example Hip prosthesis

Nerve stimulation:

- Not connected to heart muscle or life important nerves
- Thick and solid, not pointed or thin like an electrode

=> Very little risk

Compare with pacemaker

Universitetssjukhuset i Lund

Bild- och funktionsdiagnostiskt centrum (BFC)  
MR-avdelningen



### Utlåtande

#### MR-säkerhet för implantat

Magnetfält: 1.5 T och 3 T

Typ av implantat: Ledproteser (t.ex. höft och knä)

Fabrikat / modell: -

- Patient får ej undersökas i denna MR-miljö  
 Patient får undersökas i denna MR-miljö under följande förutsättningar  
 Patient får undersökas i denna MR-miljö

#### Förutsättningar:

Undvik stora loopar, t.ex. genom att se till att benen ej har kontakt med varandra om patienten har höftledsprotes.

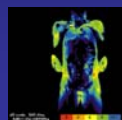
Be patienten meddela eventuellt obehag.

## Example Hip prosthesis

Heating (complex to predict):

- Not small compared to wavelength in vivo (20-40 cm)
- Thick and solid, not pointed or thin like an electrode
- Can form a loop together with surrounding tissue particularly when double prostheses

=> Some small risk exists

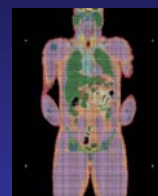


(Ho, JMRI, 2001)

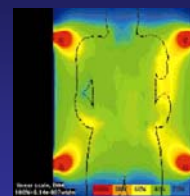
## RF - interaction in the body

Simulations

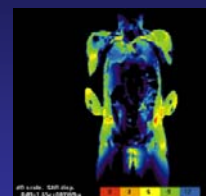
(Ho, JMRI, 2001)



Model of body  
Different electrical  
properties



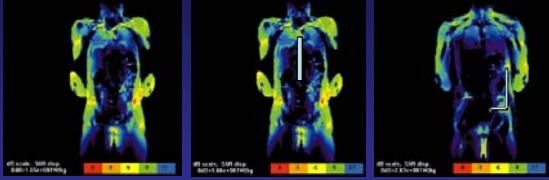
B1-distribution (x-z)



SAR-distribution

## RF - heating around implant

SAR – distribution, average for 1g tissue (Ho, JMIRI, 2001)



No implant

Metallic cylinder  
1 cm diameter  
8 or 24 cm length

L-shaped metallic wire  
1 mm diameter  
24 cm ver. 9 cm hor.

Note that a non-ferromagnetic metallic implant can still be heated – since it is electrically conductive

2.0 W/kg with implant  
1.8 W/kg without implant

26.3 W/kg with implant  
1.9 W/kg without implant (vertical part)

## Example

Pacemaker – **contraindication** – but some do it...

- MRI only if completely necessary for treatment  
Risk – benefit is assessed
- Informed consent is obtained
- Cardiologist present to program pacemaker and prepared for emergency
- Pre-specified short protocol, SAR and dB/dt minimized (Physicist)

Levine et al, Safety of Magnetic Resonance Imaging in Patients With Cardiovascular Devices, Circulation, 2007; 116:2878-2891

## Predicting heating is practically impossible But risk can be assessed and minimized

Biomed Eng Online, 2008, 7: 11  
Published online 2008 March 3. doi: 10.1186/1475-2875-7-11.  
© 2008 Mattei et al; licensee BioMed Central Ltd.

PMCID: PMC2292730

### Complexity of MRI induced heating on metallic leads: Experimental measurements of 374 configurations

Eugenio Mattei,<sup>1,2</sup> Michele Triventi,<sup>1</sup> Giovanni Calcagnini,<sup>1</sup> Federica Censi,<sup>1</sup> Wolfgang Kainz,<sup>2</sup> Gonzalo Mendoza,<sup>2</sup> Howard I Bassen,<sup>2</sup> and Pietro Bartolini<sup>1</sup>

<sup>1</sup>Dept. of Technologies and Health, Italian National Institute of Health, Roma, Italy

<sup>2</sup>Center for Devices and Radiological Health, Food and Drug Administration, Rockville, MD, USA

## Example

Vagus nerve stimulator

Therapy for treatment-resistant epilepsy



Stacey et al. nature, 2008

- Ferromagnetism not a big risk
- Effects on electronics or mechanics can occur
- Nerve stimulation (Gradients, dB/dt) can be dangerous
- Heating (RF, SAR) can cause fatal burns at the lead tips

## Example Pacemaker



Nordbeck et al, MRM, 2009  
 $\Delta T = 0.8^{\circ}\text{C} - 46^{\circ}\text{C}$

- Ferromagnetism not a big risk
- Effects on electronics or mechanics can be fatal
- Nerve stimulation (Gradients, dB/dt) can be fatal
- Heating (RF, SAR) can cause burns at the lead tips

Medtronic Receives European Approval for World's First Pacing System Designed, Tested and Approved for MRI  
EnRhythm MRI SureScan Pacemaker System Now Commercially Available in Europe

www.medtronic.com

## Example

Vagus nerve stimulator (and deep brain stimulator)

Strictly follow instructions from vendor. Procedure in Lund:

- Check and program stimulator before MRI
- Use transmit head coil only
- Special protocol, SAR and dB/dt minimized (Physicist)
- Monitor patient
- Check and program stimulator after MRI

Only for centers with necessary resources - be careful !  
Serious injuries have occurred (FDA)

## Example

Baclofen pump (Medtronic Synchromed)

- Ferromagnetism causes traction and large artefacts (3T)
- Effects on electronics or mechanics (pump stops)
- Nerve stimulation is reported to be a small risk
- Heating has not been reported to be a risk



Treatment of spasticity  
Surgically implanted beneath skin

www.medtronic.com

## Example

Foley catheter with temperature sensor

Follow instructions from vendor. Procedure in Lund:

- Only MRI of the head, otherwise remove catheter
- Disconnect monitor and any extra cables
- Position catheter in a straight configuration. No loops. Avoid skin contact.
- Ask patient to (if possible) tell if any inconvenience

## Example

Baclofen pump

Strictly follow instructions from vendor. Procedure in Lund:

- Maximum 1.5T
- Pump is switched off and emptied before MRI
- Inform patient about traction
- Reduce dB/dt if nerve stimulation occurs

## External equipment

Clinical and research

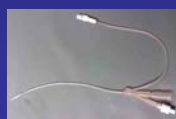


- Tested and marked
- Conditions for safe use must be known by all users

## Example

Foley catheter with temperature sensor

- Ferromagnetism is not a risk
- Effects on electronics or mechanics is not a risk (But monitor must be disconnected)
- Nerve stimulation (Gradients, dB/dt) is a very small risk
- Heating (RF, SAR) may cause burns at the lead tip



## Markings and lines in floor

MR-safe



MR-conditional



MR-unsafe



Max 2mT

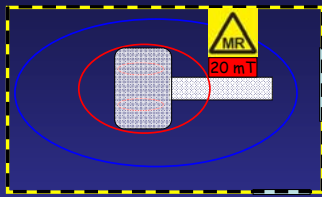
Max 20mT

2 mT

20 mT

(Lines in floor is no standard – local routines in Lund)

## Approved external equipment

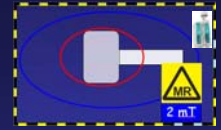


Remember!

MR-conditional equipment may become unsafe and dangerous if conditions are not followed

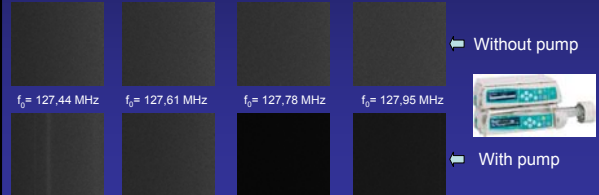
Do you know what happens to your external equipment if it gets close to the magnet?

## RF-artefacts in MR images? Service sequence in MR-scanner



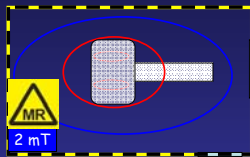
Psviq spurious t15 180hz (Philips)

180 Hz/pixel, 1024-matrix, BW = 184 kHz (x4)



## Research equipment

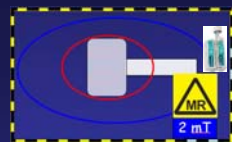
Some equipment has to be inside the room



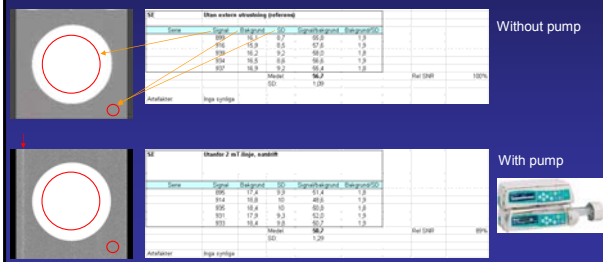
Some equipment can stay outside



## RF-artefacts in MR images? Measure SNR



Images obtained with high bandwidth and resolution



## Testing of equipment

- Ferromagnetism  
Test with permanent magnet outside MR-room
- Function of the equipment – consult technical expertise  
Test equipment before, during and after exposure (B0, RF, gradients)
- Effects on MR image quality  
Evaluate with and without equipment (MR-Physicist)

## Still - probably most importantly

Keep up routines that minimize the risk of getting ferromagnetic objects inside the scanner room



Magnus Olsson, Röntgenavdelningen, Helsingborgs Lasarett, 2009-02-27