

MR Safety

User Training



Dr. Meltem Karataş - January 2023



Contents



**MRI scanner is
ALWAYS ON!**

- Purpose of training
- Risk factors
 - MR environment
 - Static magnetic field (B_0)
 - Gradient fields (dB/dt)
 - Radiofrequency field (B_1)
 - Other issues
- Screening
- In case of emergency
- Warning and prohibition signs
- Further resources & References

Purpose

Why should you learn about MR safety?

- MRI is considered inherently safe — lack of **ionizing radiation**.
- Vast majority of MRI scans are performed without incidents — *millions* each year.
- There is *no evidence* of immediate or long-term adverse effects due to MRI procedure itself.
- MRI injuries result from **human errors**
 - ▶ Safety training of **all** staff
 - ▶ Protocols and regulations

Boy, 6, Killed in Freak MRI Accident

By ABC News



July 31, 2001 -- A 6-year-old boy died after undergoing an MRI exam at a New York-area hospital when the machine's powerful magnetic field jerked a metal oxygen tank across the room, crushing the child's head.

Purpose

Why should you learn about MR safety?

Elderly South Korean man dies after oxygen cylinder gets sucked into MRI machine

Anyone entering an MRI room should not have metal objects on or in their person as MRI machines utilise a powerful magnetic force

Alisha Rahaman Sarkar • Tuesday 19 October 2021 14:13 • [Comments](#)



Man dies after being sucked into MRI scanner at Indian hospital

Man was carrying oxygen cylinder which was pulled by machine's magnetic force and then thought to have punctured

Agence France-Presse

Tue 30 Jan 2018 01:28 GMT



An MRI scanner. An Indian man died in a freak accident in which an oxygen tank he was carrying was sucked into an MRI at a hospital in Mumbai, police said. Photograph: Gary Calton/The Observer

An Indian man died after being sucked into an MRI machine while visiting a relative at a hospital in Mumbai, police said Monday.



01/10/2019 06:00 | NEWS > AUSTRIA

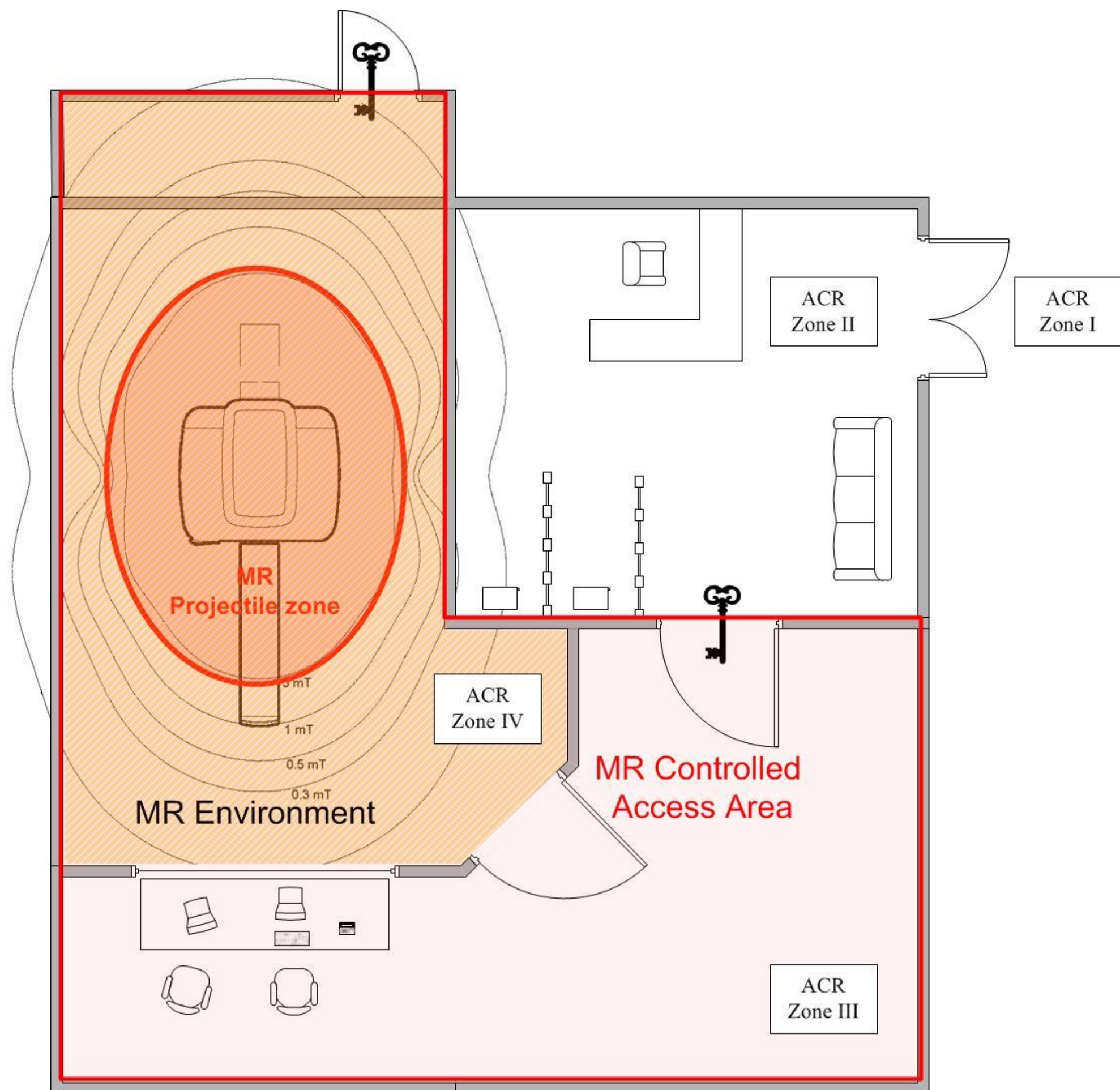
30,000 EUROS DAMAGE

Cleaning lady demolished MRI in the event of an accident in the hospital



(Image: laumat.at/Matthias Lauber, ZVG)

Risk factors



MR environment

- The 3D volume of space surrounding the MR magnet that contains both the Faraday shielded volume and the 0.50 mT field contour (5 gauss (G) line). — Exposure to the **electromagnetic fields** produced by the MR equipment and accessories.
- **Restricted access** — authorized personnel performs *safety screening*

Risk factors

MR environment

Exposure to the **electromagnetic fields** produced by the MR equipment and accessories.

Fields	Most serious hazards
Static magnetic field	Attraction, alignment, and projectile-like acceleration of magnetizable objects Movement by implants and prostheses in the body
Gradient fields	Peripheral nerve stimulation
RF fields	Warming of body tissue

Risk factors

Static magnetic field (B_0)

- **Projectile effects - ferromagnetic objects**
 - The most serious consequences
 - Force of attraction proportional to — object's mass, susceptibility; field strength and gradients
 - *Anything* ferromagnetic will be pulled toward the bore of the MRI scanner with **dramatic acceleration.**



Risk factors

Static magnetic field (B_0)



Risk factors

Static magnetic field (B_0)



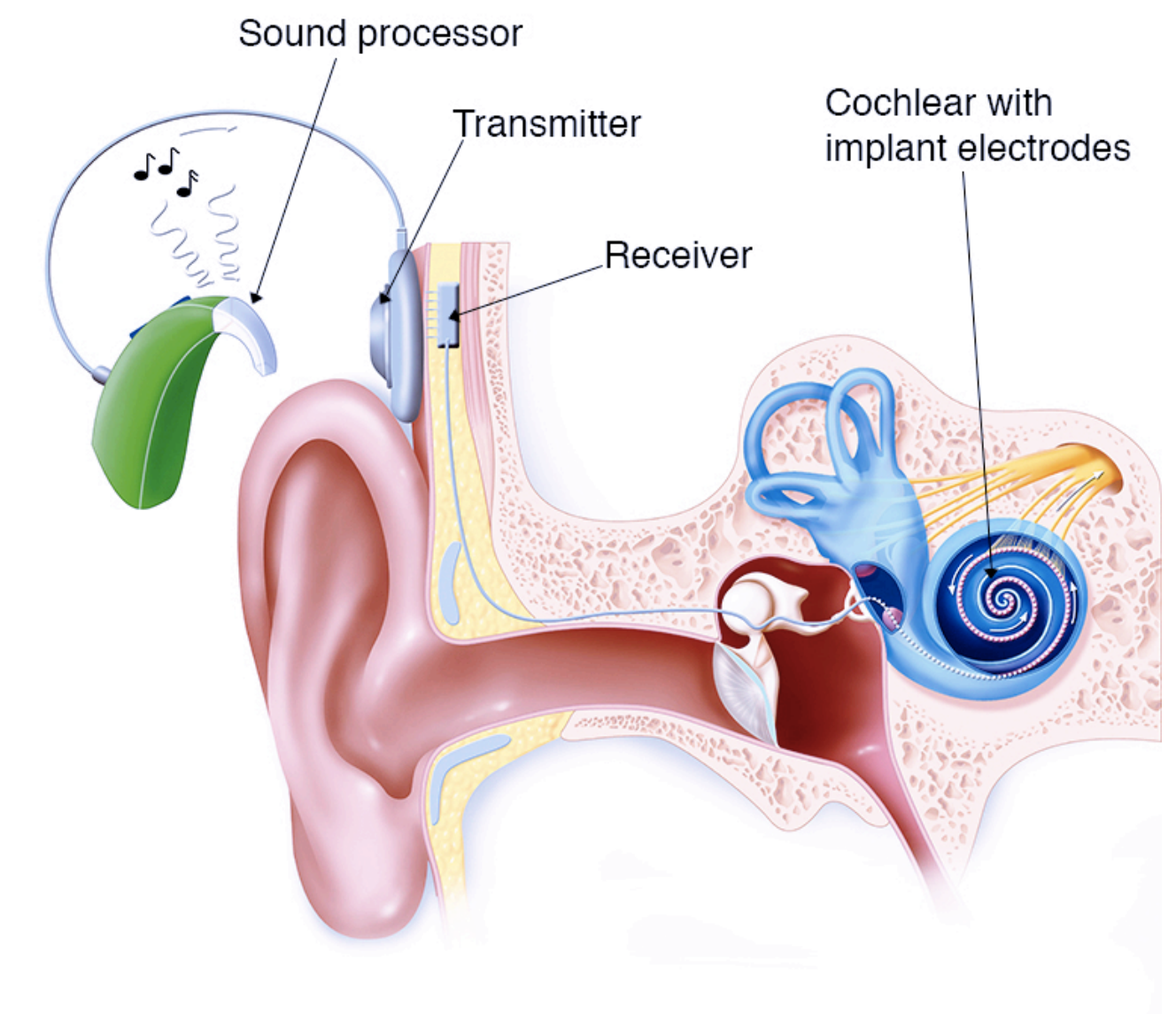
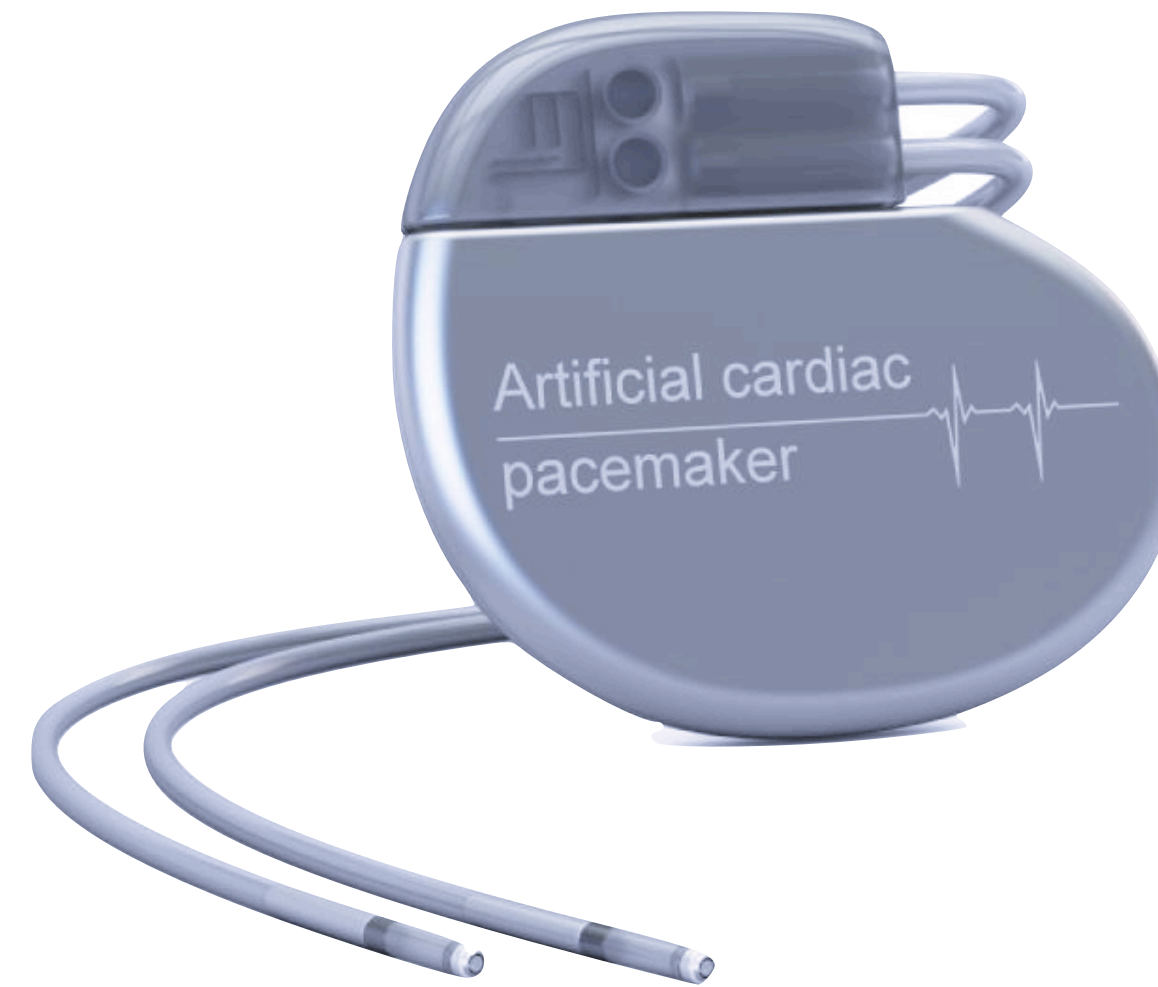
MR Unsafe



Risk factors

Static magnetic field (B_0)

- Ferromagnetic foreign bodies
 - Metal splinters in the eye
 - Bullets and shrapnel
 - Piercings
- **Implants and pacemakers**



- **Device malfunction**
- Cardiac pacemaker/defibrillators — as a *general rule*, exclude without exception.
- Cochlear implants, insulin pumps
- Stimulation devices

Risk factors

Static magnetic field (B_0)



MR Conditional

- **MR conditional materials** — items with demonstrated safety in the MR environment *within defined* conditions
 - American Society for Testing and Materials (ASTM)
 - Conditions — static magnetic field strength, spatial gradient, dB/dt (time varying magnetic fields), radio frequency (RF) fields, and specific absorption rate (SAR)
 - Implants and prostheses
 - Monitoring and support equipment for MR environment

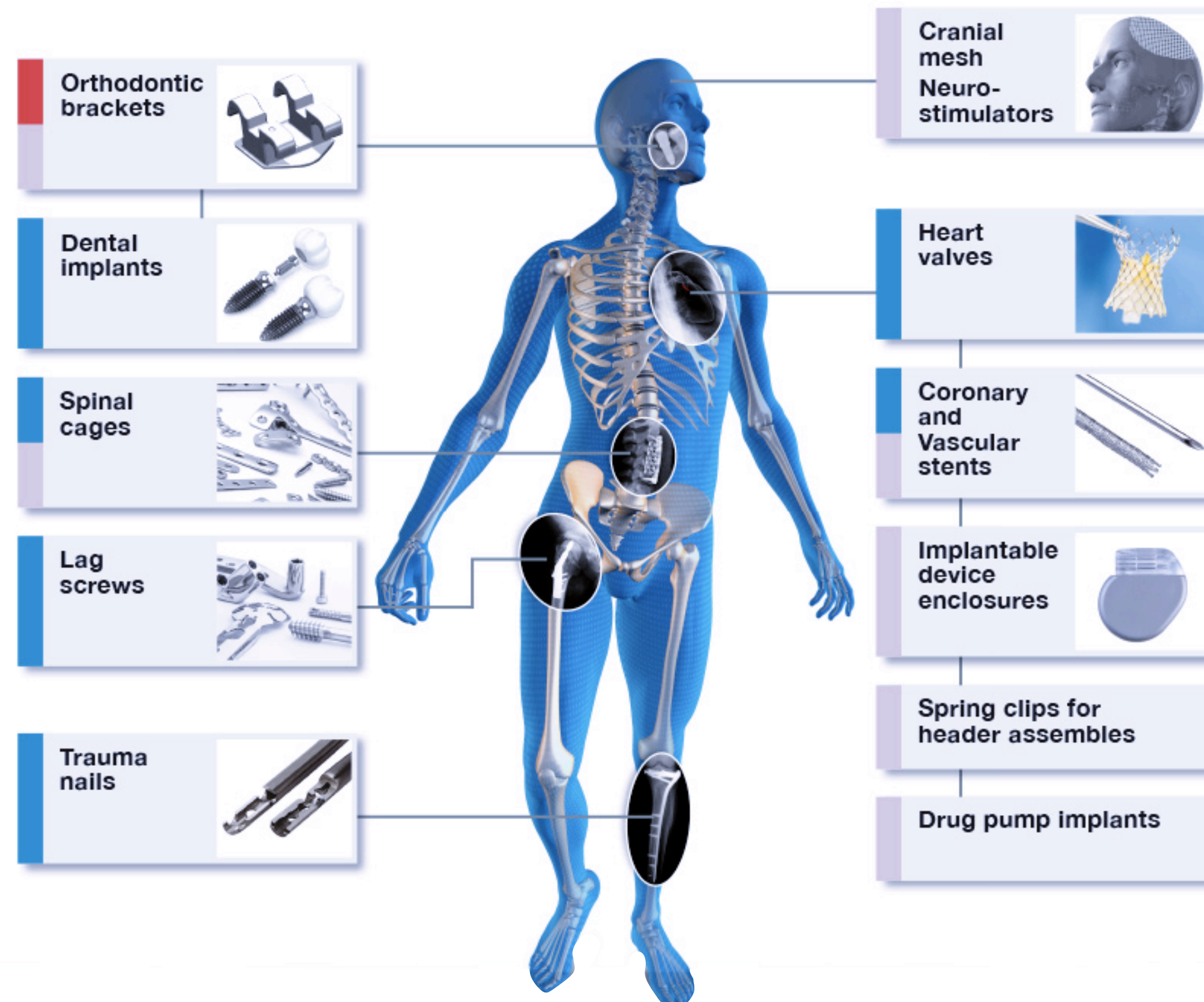
Risk factors

Static magnetic field (B_0)

- Implants and prostheses:



MR Conditional



Risk factors

Static magnetic field (B_0)

- Monitoring and support equipment for MR environment:
 - MR-compatible wheelchairs, stretchers, emergency trolleys, fire extinguishers



MR Conditional



Image source

Risk factors

Static magnetic field (B_0)



MR Safe

- **MR safe materials** —items that poses *no known hazards* resulting from exposure to any MR environment
 - electrically nonconductive
 - nonmetallic
 - nonmagnetic
 - **e.g.** plastic, silicone, glass — most nasogastric tubes, endotracheal tubes, IV catheters, IV tubing, drains, and wound dressings

Risk factors

MRIsafety.com

Research:

[The LIST](#)

[Safety Topics](#)

[Home](#)

[help](#)

search



(full/part words)

This site is Exclusively Sponsored by BRACCO



First Previous 11 12 13 14 15 16 17 18 19 20 Next Last

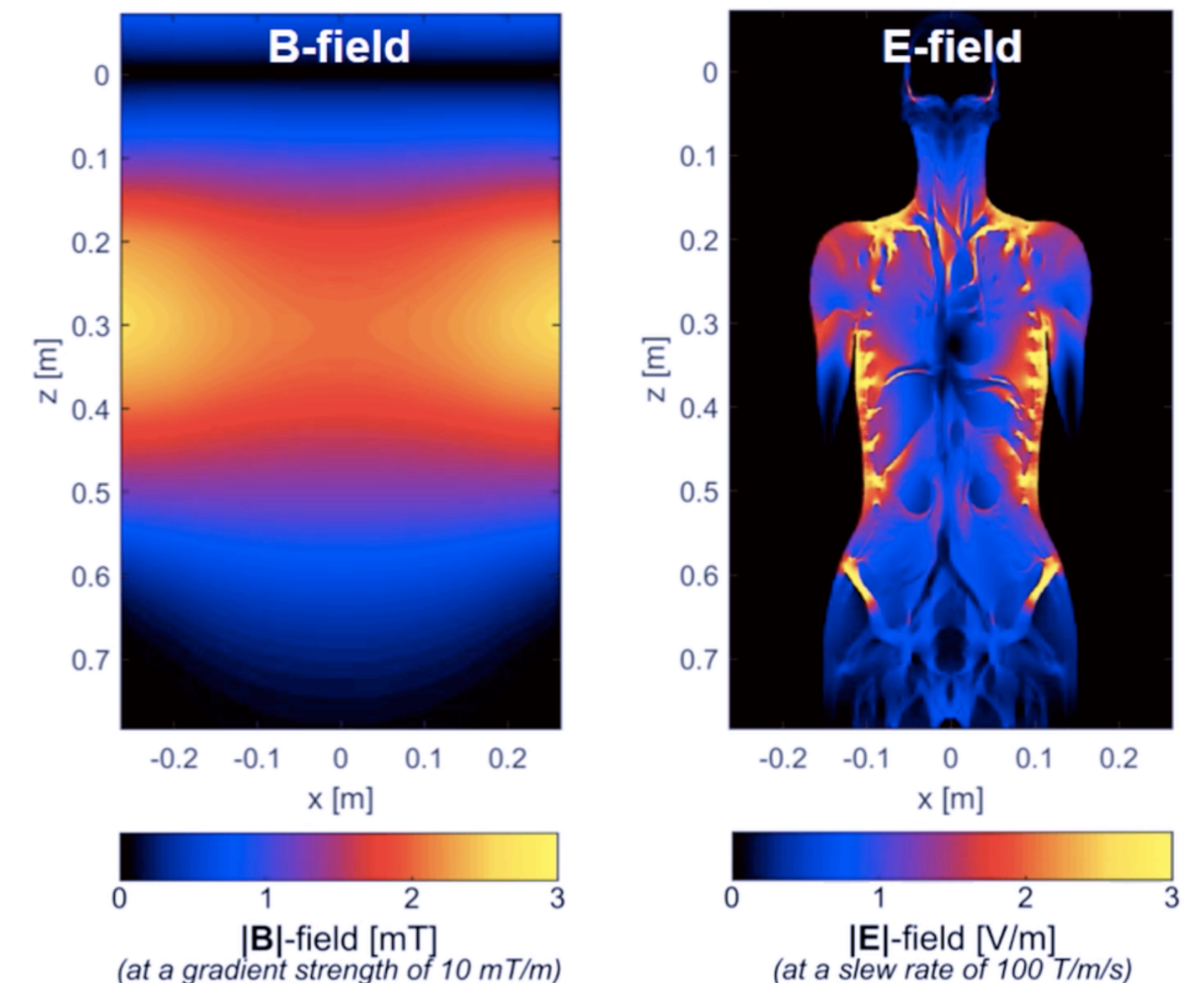
Displaying 301 - 320 of 4825 20

	<u>Object Description</u> ↑		<u>Object Status</u>	<u>Safety Topic / Subject</u>
Q	Arto Implant MVRx, Inc., www.mvrxinc.com	1.5, 3	Conditional 8 More...	Miscellaneous Implants and Devices More...
Q	ASAP 16, Automatic 16 G Core Biopsy System 19 cm length (304 SS)	1.5	Unsafe 1 More...	Biopsy Needles, Markers, and Devices More...
Q	Asept Drainage Catheter System PFM Medical, Inc.	3	Conditional 6 More...	Miscellaneous Implants and Devices More...
Q	Aspida Anterior Lumbar Plating System Alphatec Spine Inc., www.alphatecspine.com	1.5, 3	Conditional 8 More...	Orthopedic Implants, Materials, and Devices More...
Q	AspirationNeedle MRI MRI Devices Corporation Waukesha, WI	1.5	Safe More...	Biopsy Needles, Markers, and Devices More...
Q	ASpire Covered Stent 100 x 14 mm nitinol, nickel, titanium coil, stent, filter Vascular Architects	1.5	Safe More...	Coils, Filters, Stents, and Grafts More...

Risk factors

Time-varying magnetic field - gradient coils (dB/dt)

- Peripheral nerve stimulation: direct stimulation of peripheral nerves, experienced as *twitching* or *tingling*
 - Fast acquisitions *with* fast switching gradients — high-duty-cycle EPI, GE sequences with small FOV & short TR
 - Threshold of stimulation between 60-100 T/s — indicator of safety thresholds; **pain**
 - Cardiac stimulation/ventricular fibrillation — even faster gradients



Risk factors

Time-varying magnetic field - gradient coils (dB/dt)

- Acoustic noise: Consequence of the force exerted on the gradient coils due to the rapidly varying current within them in the presence of the main field.
 - Noise increases with *field strength* — varies considerably with the type of *pulse sequence*.
 - In addition to the noise levels, *duration* is important.
 - *Ear protection* necessary for patients and operators — <99 dB(A)
 - Associated with temporary and permanent **hearing loss**.



Source

Risk factors

Radiofrequency field (B_1)

- Heating: Energy deposited by repetitive RF pulses — **specific absorption rate (SAR)**
—joules *or* watts per kilogram of tissue
 - SAR values increase with field strength
 - Safe operating limits defined by FDA — *whole-body* average of <4 W/Kg over 15 minutes; <3 W/Kg over 10 minutes for *head*
 - IEC limits - $< 1^\circ\text{C}$ increase in body temperature
- Scanner manufacturer (*Siemens*) — set limits, real-time SAR monitoring
 - Acquisition parameter changes prevented — echo train lengths, number of slices or saturation pulses

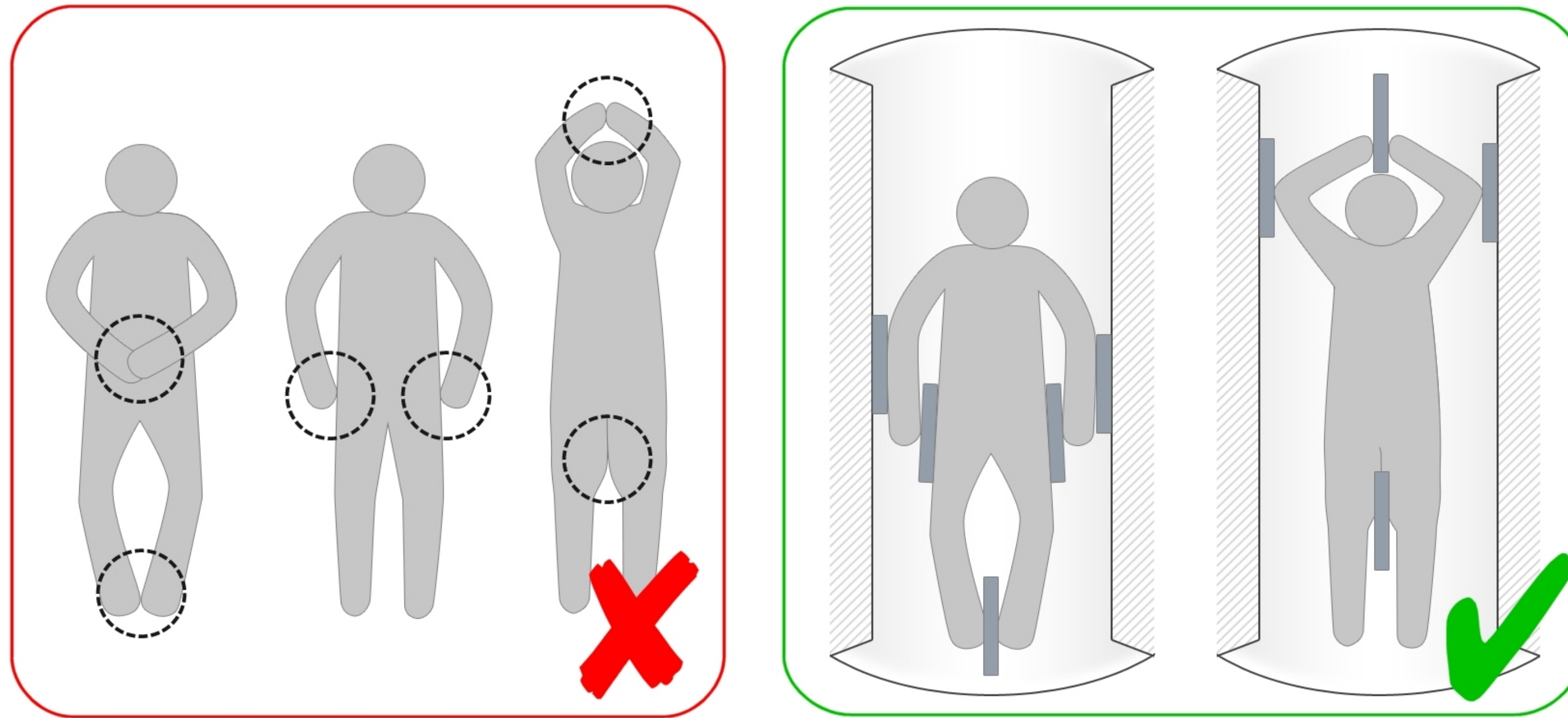
Risk factors

Radiofrequency field (B_1)

- Burns:
 - RF-related burns are **unrelated to SAR** — may happen with low SAR acquisitions
 - Near-field burns — contact with the *bore wall*
 - Resonant circuitry burns — *conductive metals* within the volume of the RF transmit coil
 - Large caliber loops — *skin-skin contact*
- **Padding** is necessary to avoid contact between the subject and the bore *or* skin-skin contact.

Risk factors

Radiofrequency field (B_1)

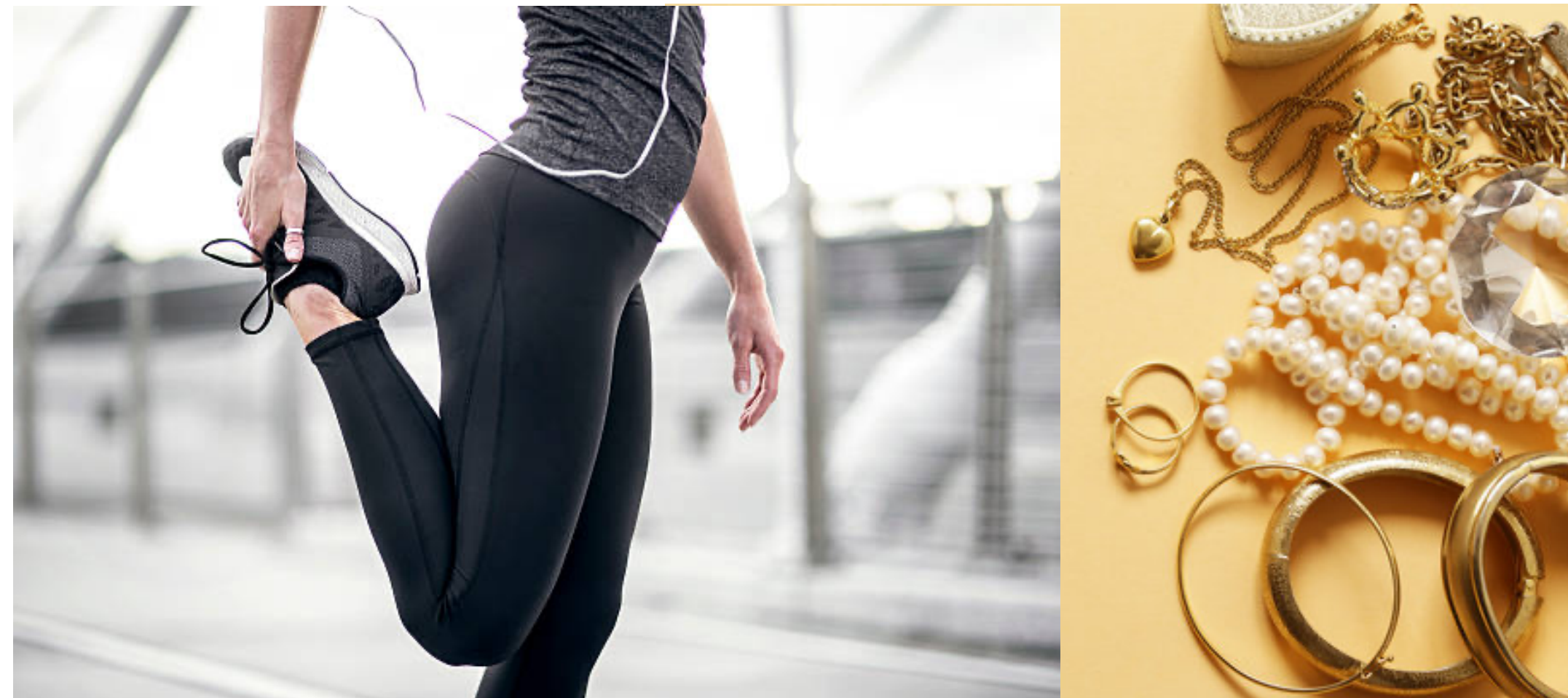


Proper positioning inside the scanner

Risk factors

Radiofrequency field (B_1)

- Remove *any metallic/conductive* objects — jewelry, hair accessories, brassieres with support wires, metallic appliqués on clothing
- Certain eyeliners and tattoos may cause skin irritation
- **Ideally** - out of street clothes, patient gowns



Risk factors

Radiofrequency field (B_1)

Invisible Metallic Microfiber in Clothing Presents Unrecognized MRI Risk for Cutaneous Burn

J.A. Pietryga, M.A. Fonder, J.M. Rogg, D.L. North, and L.G. Bercovitch



FIG 1. A linear erythematous blistering eruption is noted on the patient's right flank minutes after completion of the MR imaging of her brain and spine.



FIG 2. The patient wore a Boston Silver T shirt beneath a conventional cotton tee shirt during her imaging study. It was not until after the scan that it was realized that the undershirt, recommended for wear beneath her back brace, contained antimicrobial silver microfibers.

Pietryga et al., 2013

Case report

MRI induced fourth-degree burn in an extremity, leading to amputation

Josef Haik^a, Simon Daniel^{b,*}, Ariel Tessone^a, Arie Orenstein^a, Eyal Winkler^a

^aDepartment of Plastic & Reconstructive Surgery and Burn Unit, The Chaim Sheba Medical Center at Tel HaShomer 52600, Israel

^bSackler School of Medicine, Tel Aviv University, Israel

ARTICLE INFO

Article history:

Accepted 13 November 2007

Haik et al., 2009

Risk factors

Other issues

- **Psychological distress** — claustrophobia, anxiety and restlessness
 - Put subjects at ease, provide *detailed* information — purpose of scan, duration
 - Verbal contact, mirrors to see outside the scanner
 - Music or video during acquisitions
 - Oral anxiolytic medications
 - Sedation and anesthesia

Risk factors

Other issues

- **Pregnancy** — There is no evidence that suggests MRI can be harmful to the fetus.
 - Prudent to avoid MRI during vulnerable periods of fetal development (1st trimester).
 - No contraindication, MRI is favored for *fetal imaging*.
 - Gadolinium-based contrast agents should be avoided — cross the placenta
- **Contrast agents**
 - Patients with kidney failure
 - Pregnancy
 - Basal ganglia accumulation with older medications

Screening

<https://www.turkrad.org.tr/assets/DernektenHaberler-Pdf/Ek-A-Hastalar-icin-MR-Guvenlik-Formu.pdf>

HASTALAR İÇİN MANYETİK REZONANS BİLGİLENDİRME ve ONAM FORMU

Tarih ____/____/____ Hasta Numarası _____
Adı/Soyadı _____ Yaşı _____ Boy _____ Kilo _____

Doğum tarihi ____/____/____ Erkek Kadın Tetkik adı _____
Adres _____ Telefon (____) _____ - _____

Hastanın şikayetleri _____
Gönderen Doktor _____ Doktorun telefonu (____) _____ - _____

1. Herhangi bir ameliyat ya da operasyon geçirdiniz mi (Artroskopi, endoskopi vb) ? Evet Hayır

Eğer evet ise belirtiniz: _____

Tarih: ____/____/____ Ameliyat tipi: _____
Tarih: ____/____/____ Ameliyat tipi: _____

2. Herhangi bir Görüntüleme yöntemi (MR, Tomografi, Röntgen US) yapıldı mı ? Evet Hayır

Eğer evet ise belirtiniz: _____

MR _____
BT _____
Röntgen _____
US _____
Nükleer Tıp _____
Diğer _____

3. Daha önce çektiğiniz MR işleminde herhangi bir sorun yaşadınız mı? Evet Hayır

Eğer evet ise belirtiniz: _____

4. Gözünüzde herhangi bir metalik cisim ile ya da yabancı cisim ile yaralanma oldu mu? Evet Hayır

Eğer evet ise belirtiniz: _____

5. Metalik bir cisim ya da yabancı cisim ile yaralandınız mı (mermi, şarapnel vb) ? Evet Hayır

Eğer evet ise belirtiniz: _____

6. Sürekli kullandığınız ya da yakın zamanda kullandığınız bir ilaç tedavisi var mı? Evet Hayır

Eğer evet ise belirtiniz: _____

7. Herhangi bir ilaca karşı alerjik durumunuz var mı? Evet Hayır

Eğer evet ise belirtiniz: _____

8. Astım, alerjik reaksiyon, solunum sıkıntısı öyküsü ya da, MR'da, tomografide, röntgende kullanılan kontrastlı ilaçlara karşı alerjik reaksiyon oldu mu? Evet Hayır

Eğer evet ise belirtiniz: _____

9. Kansızlık, anemi, böbrek hastalığı, böbrek nakli, yüksek tansiyon, karaciğer hastalığı, şeker ya da epilepsi gibi hastalığınız var mı? Evet Hayır

Eğer evet ise belirtiniz: _____

Bayan Hastalar İçin:

10. Son adet tarihi : _____ Postmenapozal? Evet Hayır

11. Gebelik var mı, ya da adet gecikmesi mevcut mu? Evet Hayır

Eğer evet ise belirtiniz: _____

12. Doğum kontrol ilaçları ya da hormon tedavisi alıyorsunuz mu? Evet Hayır

Eğer evet ise belirtiniz: _____

11. Kısırlık tedavisi görüyor musunuz? Evet Hayır

Eğer evet ise belirtiniz: _____

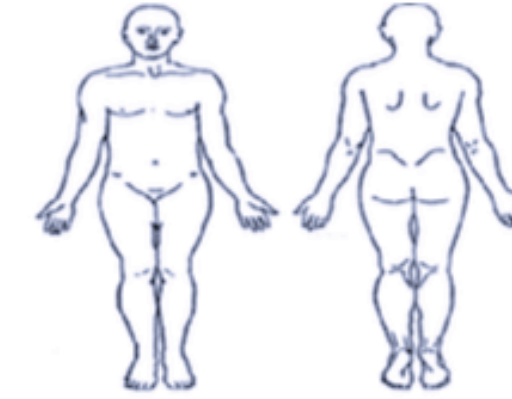
14. Emziriyor musunuz? Evet Hayır

UYARI: Bazı Metalik İmplantlar ve Objeler MR ortamında zararlı olabilir. Bu tür implant ve objeler ile ilgili şüpheli bir durumunuz var ise MR ortamına girmeyiniz. MR odasına girmeden önce MR teknisyenine ya da Radyolog'a başvurunuz. MR ortamında sürekli manyetik alan mevcuttur.

Aşağıdakilerden size uygun seçeneği işaretleyiniz

<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Anevrizma klipsi
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Kalp pili
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	İmplant kardiyoverter defibrilatör (ICD)
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Elektronik implant ya da obje
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Manyetik olarak aktif implant ya da obje
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Nörostimülasyon sistemleri
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Spinal kord stimülatörleri
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	İnternal elektrotlar ya da kablo
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Kemik büyüme/füzyon stimülatörleri
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Koklear otoljik ya da diğer kulak implantları
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	İnsülin ya da diğer infüzyon pompaları
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	İmplant ilaç infüzyon aletleri
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Protez tipleri (Göz, penis, vb)
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Kalp kapak protezi
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Göz kapaklığı teli ya da kablosu
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Suni ya da protezik ekstremitte proteziniz var mı
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Metalik stent, filtre ya da koil
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Shunt (spinal ya da intraventrüküler)
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Vasküler girişim port ya da kateter
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Radyasyon seeds ya da implant var mı
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Swan-Ganz ya da termodilasyon kateteri var mı
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	İlaç patch (yama) (Nikotin, nitroglicerine)
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Herhangi bir metalik parça ya da yabancı cisim
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Tel mesh implant var mı
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Cerrahi klip, staples, metalik sütür
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Doku genişleticisi var mı (meme)
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Eklem protezi (Kalça, diz vb)
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Kemik Eklem Vidası (Çivi, tel, plaka vb)
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Spiral, diyafram
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Diş protezi
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Piercing, takı malzemesi
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	İşitme cihazı (girmeden önce çıkartınız)
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Diğer implantlar
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Solunum sıkıntısı ya da hareket sıkıntısı
<input type="checkbox"/> Evet	<input type="checkbox"/> Hayır	Kloströfobi (kapalı alan korkusu)

Vücudunuzda bulunan implant ya da metali resime işaretleyiniz



ÖNEMLİ BİLGİLENDİRME

Metalik objeleri, işitme cihazlarını, diş protezlerini, anahtarları, cep telefonlarını, gözlükleri, toka, saç tokası, takıları, piercingi, saat, kağıt ataç, kredi kartları, banka kartları bozuk paraları, kalem, cep bıçağı, tırnak makası, pantolon kemeri gibi malzemeleri çıkartmadan MR odasına girilmez. Herhangi bir sorunuz varsa MR teknisyenine ya da radyoloji uzmanına başvurunuz.

Not: MR tetkiki esnasındaki gürültüye bağlı olası işitme problemlerini önlemek için kulak tıkacı ya da diğer koruma cihazlarının kullanılması önerilir ve gereklidir.

Yukardaki soruları doğru şekilde cevaplandırdım. Bu formun içeriğini okudum anladım ve formdaki konular ile ilgili yeterli şekilde soru sorma imkanım oldu. Uygulanacak olan tetkiki bilincim yerinde olarak kabul ediyorum

Formu dolduranın imzası: _____ Tarih: _____

Form dolduran kişi: Hasta Hasta yakını: Hemşire Adı/Soyadı _____ Yakınlık Derecesi _____

Formu kontrol eden kişi Adı/Soyadı _____ İmza _____

MR teknisyeni Hemşire Radyolog Diğer

Screening

<https://www.turkrad.org.tr/assets/DernektenHaberler-Pdf/Ek-B-Hasta-Disi-Kisiler-icin-MR-Guvenlik-Formu.pdf>

HASTA DIŐI KİŐİLER İÇİN MANYETİK REZONANS BİLGİLENDİRME ve ONAM FORMU

UYARI: MR görüntüleme sistemi çok kuvvetli manyetik alan içermesi nedeni ile eğer üzerinizde metalik elektronik manyetik mekanik implant malzemeler varsa zarar oluşturabilir. Bu nedenle MR ortamına ya da odasına girmeden önce bu form doldurulmalıdır. Ortamda manyetik alanın sürekli bulunduđu unutulmamalıdır.

Not: Eğer hasta olarak MR işlemi yapılacaksa başka bir form doldurmanız gerekir.

Tarih ___/___/___ Adı/Soyadı _____ Yaşı _____

Adres _____ Telefon (____) _____ - _____

1. Daha önce herhangi bir operasyon geçirdiniz mi (Artroskopi, endoskopi vb) ? Evet Hayır

Eğer evet ise belirtiniz: _____

Tarih: ___/___/___ Cerrahinin tipi: _____

2. Gözünüze herhangi bir metalik cisim ile ya da yabancı cisim ile yaralanma oldu mu? Evet Hayır

Eğer evet ise belirtiniz: _____

3. Herhangi bir metalik cisim ya da yabancı cisim ile yaralandınız mı (mermi, şarapnel vb) ? Evet Hayır

Eğer evet ise belirtiniz: _____

4. Gebelik ya da gebelik şüphesi var mı? Evet Hayır



UYARI: Bazı implantlar, malzemeler ve objeler MR ortamına veya MR odasına girişte zarar meydana getirebilir. MR ortamı ya da MR odasına girişteki malzemeler ile ilgili şüpheniz varsa kesinlikle girmeyiniz.

Vücudunuzda aşağıda belirtilenlerden biri var mı?

<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Anevrizma klipsi
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Kalp pili
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Implante kardiyoverter defibrillatör (ICD)
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Elektronik implant ya da obje
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Manyetik olarak aktif implant ya da obje
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Nörostimülasyon sistemleri
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Spinal kord stimulatörleri
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Koklear otolitik ya da diğer kulak implantları
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	İnsülin ya da diğer infüzyon pompaları
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Implante ilaç infüzyon aletleri
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Protez tipleri (Göz, penil, vb)
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Suni ya da prostetik ekstremitte proteziniz varmı
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Eksternal/internal metalik cisim
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	İşitme cihazı (girmeden önce çıkartınız)
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Diğer implantlar
<input type="checkbox"/>	Evet	<input type="checkbox"/>	Hayır	Diğer objeler



ÖNEMLİ BİLGİLENDİRME

Metalik objeleri, işitme cihazlarını, diş protezlerini, anahtarları, cep telefonlarını, gözlükleri, toka, saç tokası, takıları, piercingi, saat, kağıt ataç, kredi kartları, banka kartları bozuk paraları, kalem, cep bıçağı, tırnak makası, pantolon kemeri gibi malzemeleri çıkartmadan MR odasını girilmez. Herhangi bir sorunuz varsa MR teknisyenine ya da Radyoloji Uzmanına başvurunuz.

Yukardaki soruları doğru şekilde cevaplandırdım. Bu formun içeriğini okudum anladım ve formdaki konular ile ilgili yeterli şekilde soru sorma imkanım oldu.

Formu dolduranın imzası: _____ Tarih: _____

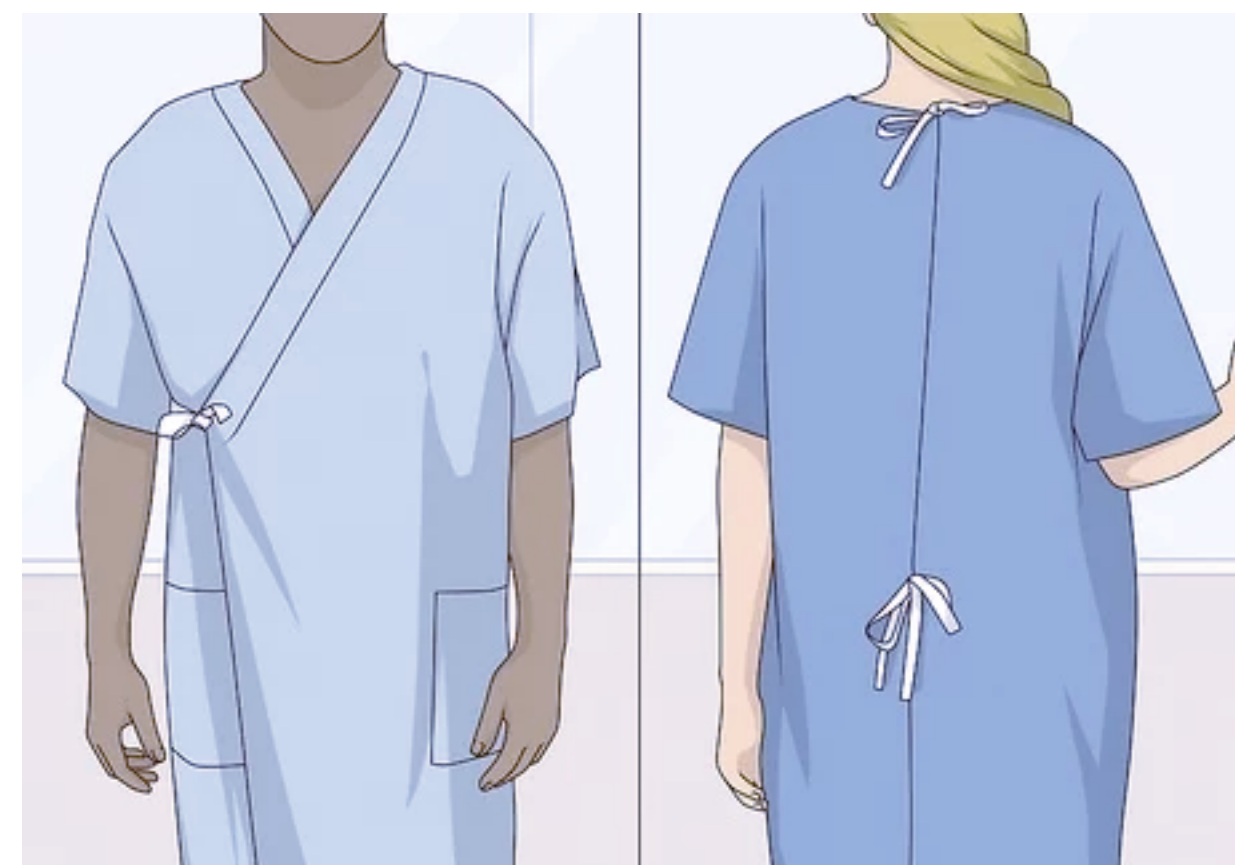
Formu kontrol eden kişi Adı/Soyadı _____ İmza _____

MR teknisyeni Radyolog Diğer

Screening

Pre-scan interview with volunteer/patient & positioning

- Do not depend on the consent form entirely – **ask** about medical history and implants
- **Explain** the scanning procedure, length of the examination, hazards and safety measures – *noise, heating, twitching muscles*
- **Make sure** that the subject removes any jewelry/ferromagnetic objects; give patient gowns if possible



Screening

Pre-scan interview with volunteer/patient & positioning

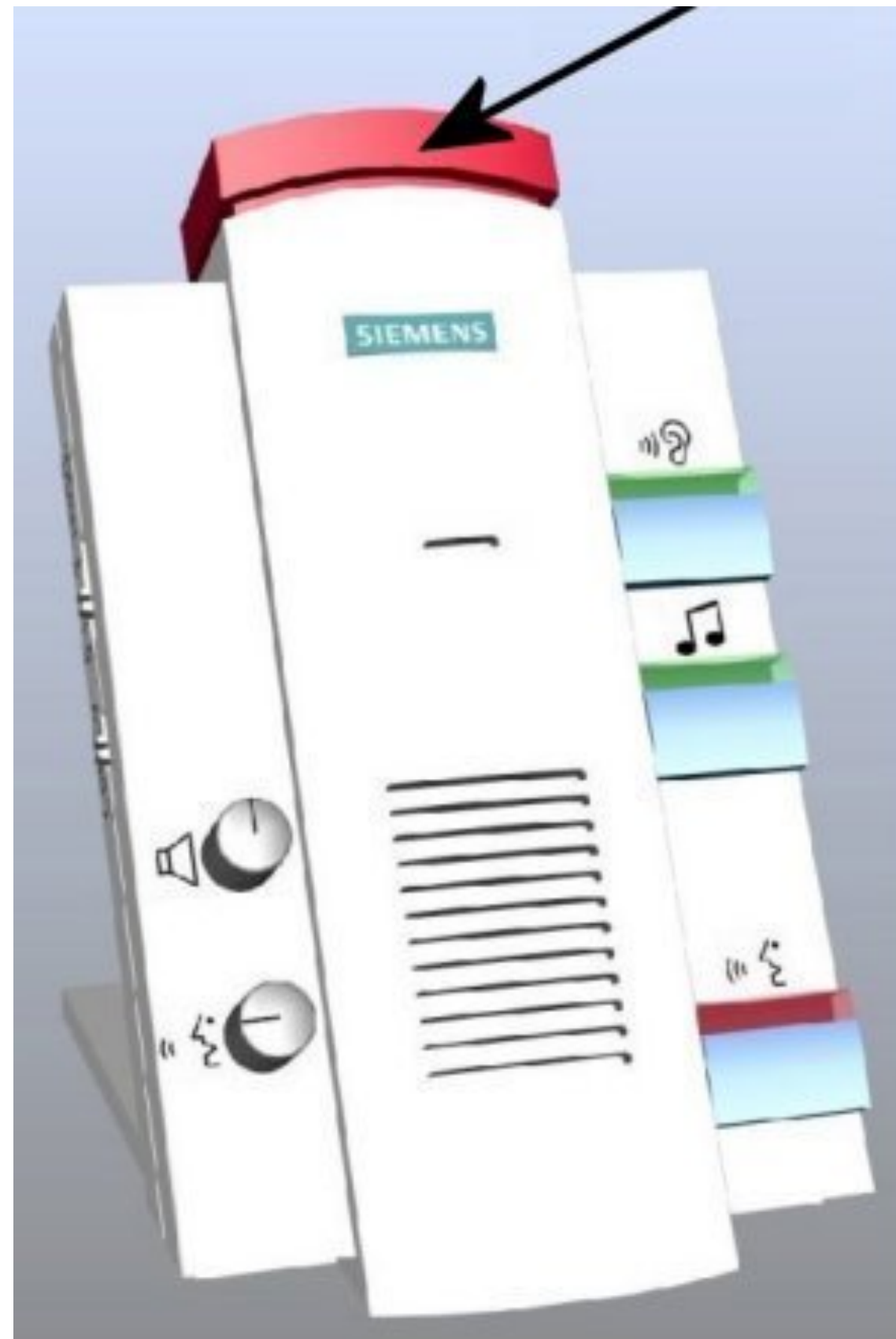
- **Provide** hearing protection - earplugs, headphones
- **Inform** them about the communication equipment — *squeeze ball, intercom*
- **Position** the patients comfortably and properly, **place padding** where necessary



In case of emergency

Medical emergency during MR measurements

- **Terminate** the measurement



In case of emergency

Medical emergency during MR measurements

- **Terminate** the measurement
- **Remove** patients from the examination room for first aid
 - Call for **help** – colleagues & **112**
 - Do not enter the MR room with *ferromagnetic objects*
 - Do not operate oxygen bottles, defibrillators, or other resuscitation tools *in the examination room*
 - MR-conditional medical equipment

In case of emergency

Medical emergency during MR measurements

- **Terminate** the measurement
- **Remove** patients from the examination room for first aid
 - Call for **help** – colleagues & **112**

Fire

- Only **non-magnetic** CO₂ extinguishers can be used
- Call the **responsible person** for MRI facility & **112**



Warning signs



Magnetic field



RF field



Observe operator manual



Mandatory hearing protection



Potential injury to persons



Risk of injury



Risk of breaking



Prohibition signs



Implants susceptible to electromagnetic effects



Open flames, no smoking



Metallic implants and other metallic objects inside the body



Mechanical watches



Fire extinguishers with magnetizable metal housing



Metal parts, e.g. tools



Electronic data carriers

Further resources

National and international guides

- Food and Drug Administration (FDA)
- American Society for Testing and Materials (ASTM)
- American College of Radiologists (ACR)
- International Electrotechnical Commission (IEC)
- Medicines and Healthcare Products Regulatory Agency (MHRA, UK)
- Türk Radyoloji Derneği (TRD)
- mrisafety.com – ‘The List’
- <https://www.ismrm.org/mr-safety-links/>

References

- Dale, B. M., Brown, M. A., Semelka, R. C., & Brown, M. A. (2015). *MRI: Basic principles and applications* (Fifth edition). John Wiley & Sons, Ltd.
- Elmaoğlu, M., & Çelik, A. (2012). *MRI Handbook*. Springer US. <https://doi.org/10.1007/978-1-4614-1096-6>
- Liney, G. (2006). *MRI in clinical practice*. Springer-Verlag.
- Lipton, M. L. (2008). *Totally Accessible MRI*. Springer New York. <https://doi.org/10.1007/978-0-387-48896-7>
- Medicines and Healthcare Products Regulatory Agency (2021). *Safety Guidelines for Magnetic Resonance Imaging Equipment in Clinical Use*.
- *MRI Questions & Answers; MR imaging physics & technology*. (n.d.). Questions and Answers in MRI. Retrieved January 2, 2023, from <http://mriquestions.com/>
- Siemens Healthcare GmbH (2017). *MAGNETOM Family Operator Manual—MR System*.