

MRI 的安全與防護

Safety of MRI

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磁共振影像的安全與防護

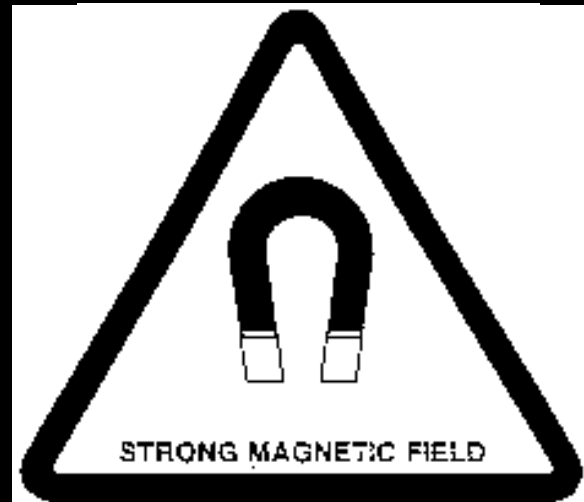
- MRI 不是沒有輻射性嗎？
- 既然 MRI 如此安全，那還需要什麼防護？

MRI 的安全性

- 正常操作下，根本毋須擔心
- 不正常操作可能 **極為危險!**

“危險！” 告示牌

WARNING !



**NO PACEMAKERS
NO METALLIC IMPLANTS
NO NEUROSTIMULATORS**

Persons with pacemakers, neurostimulators, or metallic implants must not enter this area. Serious injury may result.



NO LOOSE METAL OBJECTS

Iron, steel and other ferrous materials must not be taken into this area. Serious injury or property damage may result.

MRI 的強磁鐵

- 地球磁場：0.5 Gauss
- 小學生的吸鐵石：~ 50 Gauss
- MRI 主磁場：15,000 Gauss

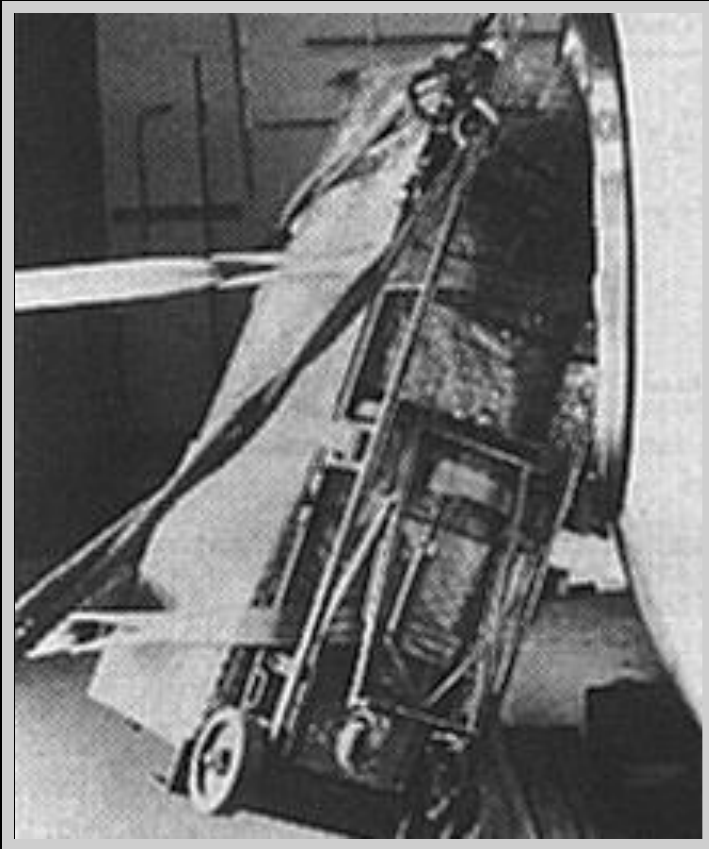
磁力的比較

- **0.5 Gauss** : 指南針偏轉
- **50 Gauss** : 吸引迴紋針
- **15,000 Gauss** : 吸引電視機 ?
- **MRI weight** : 4~9 tons

強磁鐵的危險性

- 以極大吸力快速吸引家電用品！
 - 鐵釘、剪刀、打火機、鑷子
 - 老虎鉗、鐵鎚、殺蟲劑、推車
 - 電腦、椅子、示波器、吸塵機

強磁場與鐵磁性物質的危險性



功率放大器



除濕機

強磁場與鐵磁性物質的危險性

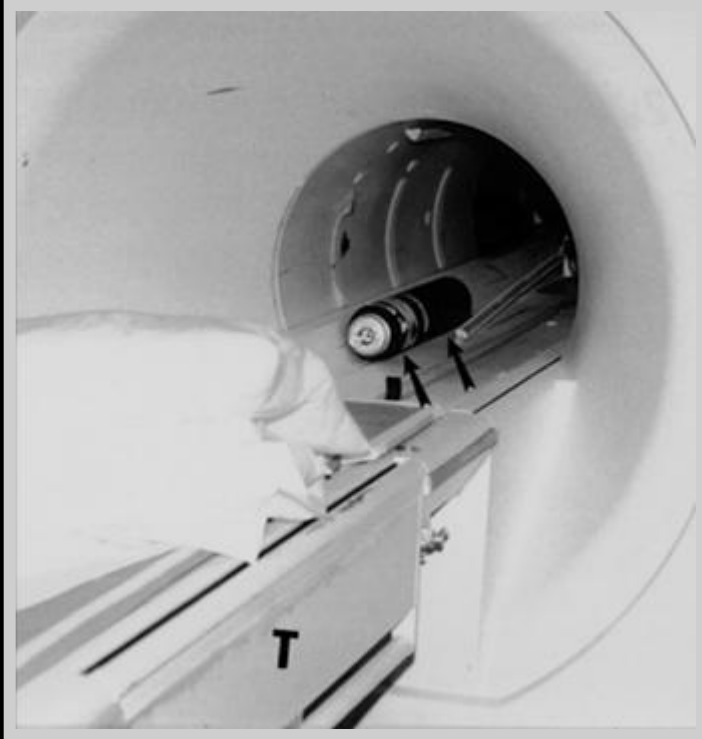


椅子

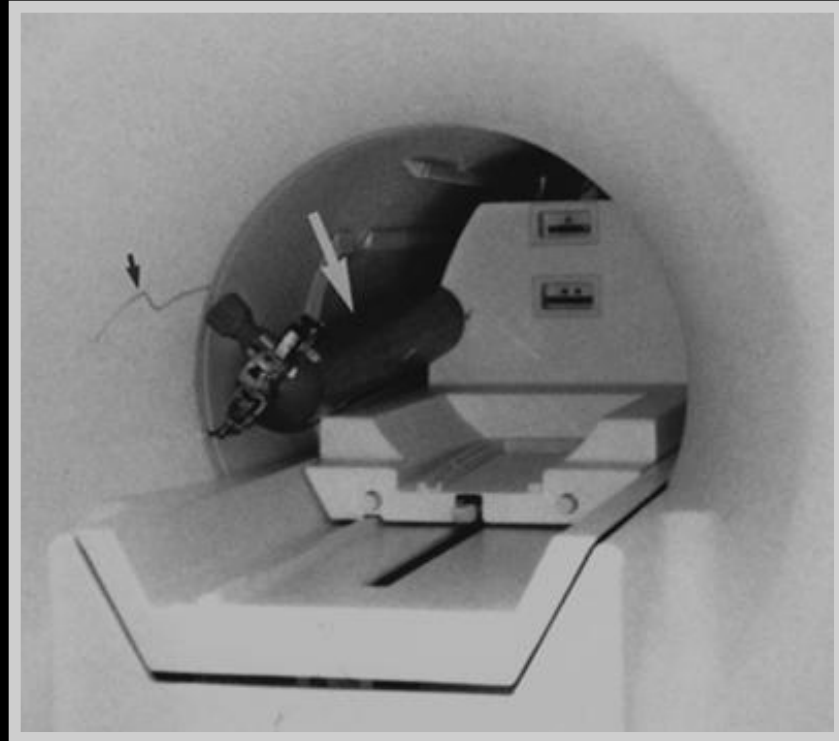


打蠟機

強磁場與鐵磁性物質的危險性



笑氣麻醉瓶



氧氣鋼瓶

強磁場與鐵磁性物質的危險性



吸塵器

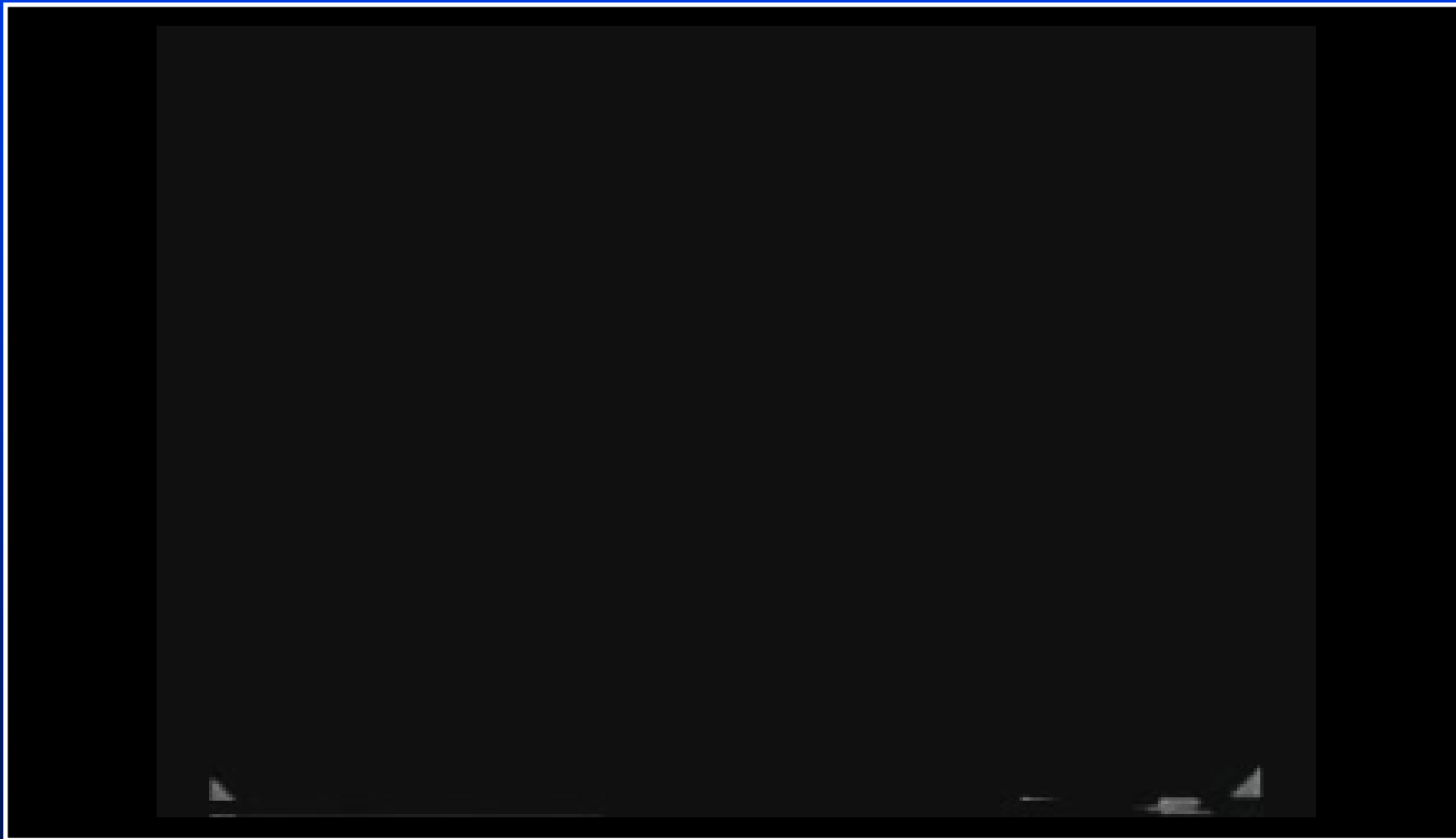


靜脈注射設備

MRI 強磁場影片

- 如果教室像電影院 ...
 - 取自 GE 公司教學影片
- 兒童在家請勿自行模仿

強磁場與鐵磁性物質的危險性



強磁鐵最大的危險性

- **MRI：數噸重的儀器**
- **愈重的物品，愈可能成為致命武器！**

其他危險物品 ...

- 心律調節器 (pacemaker)
- 強磁場影響下功能可能喪失
- 全世界有一名死亡病例 (1990)
- 不單需注意病人，還要注意家屬

有關心律調節器

- 心律調節器的發展瞬息萬變，不同
工司磁場相容性不同
- **Circ '04: safe → Circ '05: 3 letters**
- **Follow new investigations!**
- 最好是謹慎一些

其他“不好”的物品

- 金屬或磁性物
 - 人工植入物
 - 隨身物品
- 可能引起不適或使影像扭曲

金屬或磁性人工植入物

- 外科手術夾
- 人工內耳
- 注射幫浦
- 義肢 ... 等等

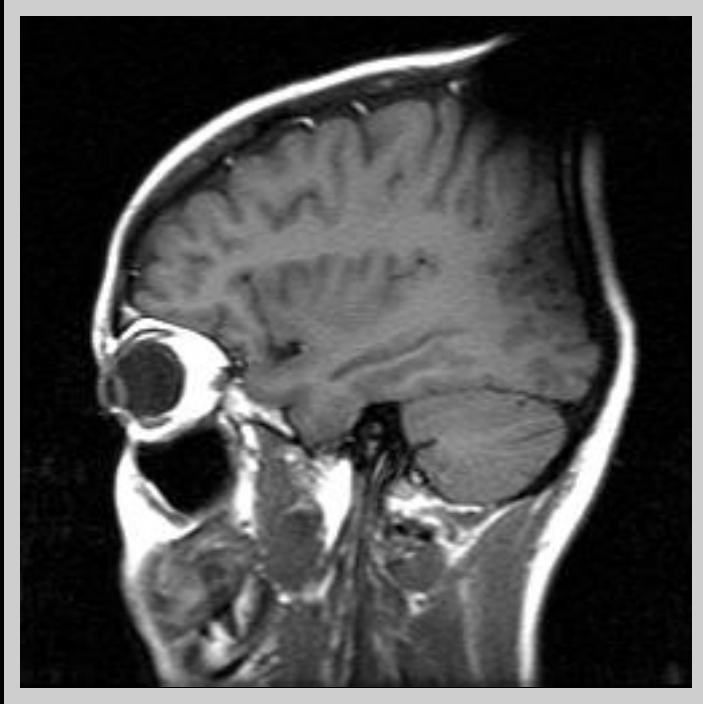
金屬或磁性隨身物品

- 假牙
- 皮帶環
- 含鐵化粧品
- 髮夾 ... 等等

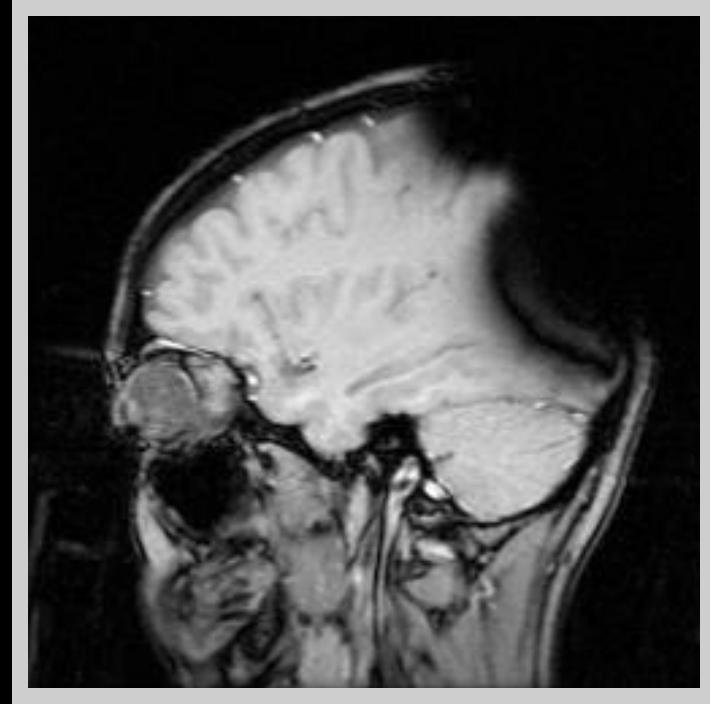
已知的「不好的東西」



鐵質髮夾的 MRI



Spin echo



Gradient echo

事前防範的重要性

- 儀器附近物品不可隨意放置
- 詢問病人有否裝設人工器官等
- 除去手錶、髮夾等物，更換病患衣
- 閒雜人等切勿進入！

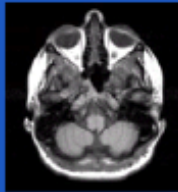
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Search THE LIST

Fill The Search Form

Object Name:

Result Status:

Hold the SHIFT key down
in order to make multiple
selections.

- All
- Safe
- Unsafe 1
- Unsafe 2
- Conditional 1

**Manufacturer
Name:**

Object Category:

Hold the SHIFT key down
in order to make multiple
selections

- All
- AccuRx Constant Flow Implantable Pump
- Activa (Neurostimulation) System (Med
- Aneurysm Clips
- Bioeffects of RF Energy
- Biopsy Needles, Markers and Devices
- Bone Fusion Stimulator

Number of Hits per

萬一發生緊急事故

- 病人生命遭受威脅：
 - 身體不適：立刻讓病人離開 MRI
 - 已被夾住：緊急 quench
- 如無生命安全之虞，立刻電告廠商

緊急 Quench

- Quench：將超導磁性關除
- 耗費大量人力財力、磁鐵可能損壞
- 如無生命威脅或深仇大恨，切勿輕易使用！

Quench

- 液態氦、液態氮大量揮發
- 若無排除，室內氧氣將急劇減少
- 磁性消失，須重行充灌
- 時間 ~ 二週，金錢 ~ 數百萬元

Quench 場景 (NMR Spectrometer)

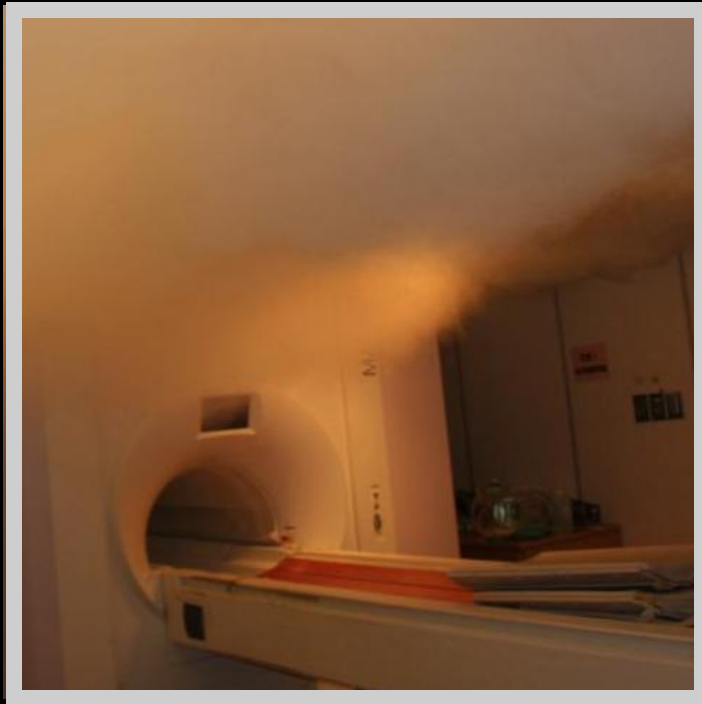


剛開始

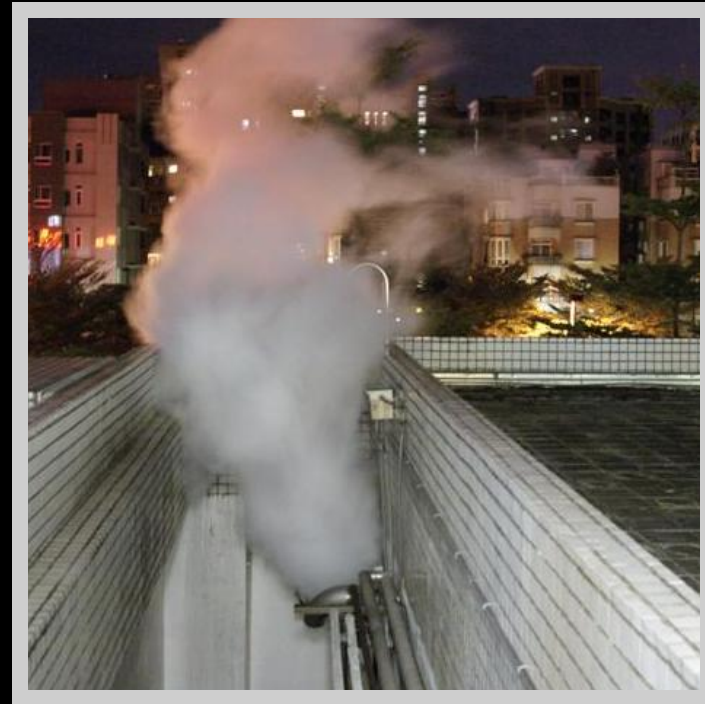


一陣子後

三總拆機的人工 Quench 場景



室內



室外

MRI Quench 影片實例

- 如果教室像電影院 ...
- 無版權，請勿告發

節錄自電影「救世主」 The One



射頻灼傷 (RF Burns)

- 射頻電磁波 + 導線接頭 ~ 尖端放電
 - 心電圖導線頭
 - 氧氣儀表指針 ... 等
- 線圈 “去耦合線路” 損壞亦可能灼傷

預防射頻灼傷

- 依照指示使用 MRI 專用之心電圖等儀表
- 愛惜線圈

MRI 與孕婦

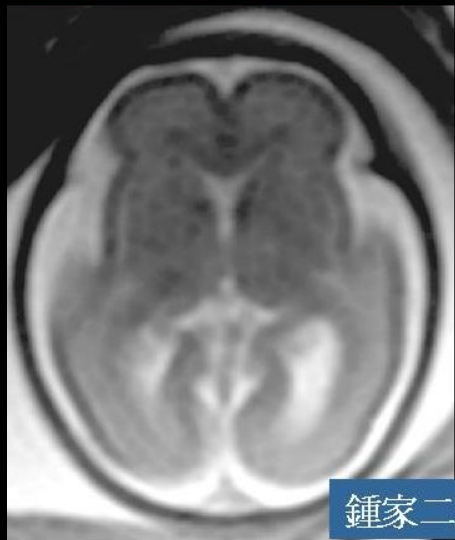
- 一般咸信理論上對胎兒無害
- 但沒有人敢冒然做此研究 ('95)
- 歐美已開始使用 (2~3 trimesters)
- 現在則愈來愈多了

包括我自己的兒子在內

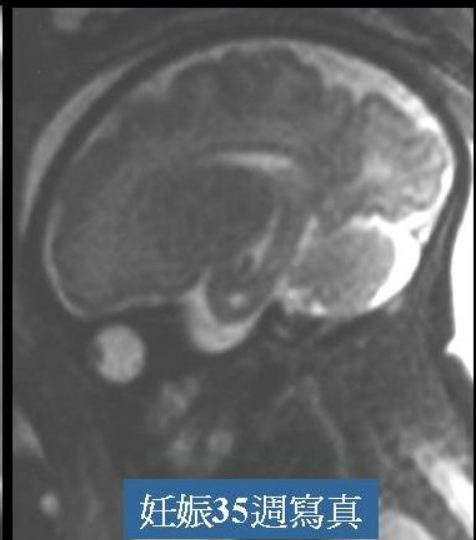
五個月寫真



回到未來



鍾家二少爺妊娠28週寫真



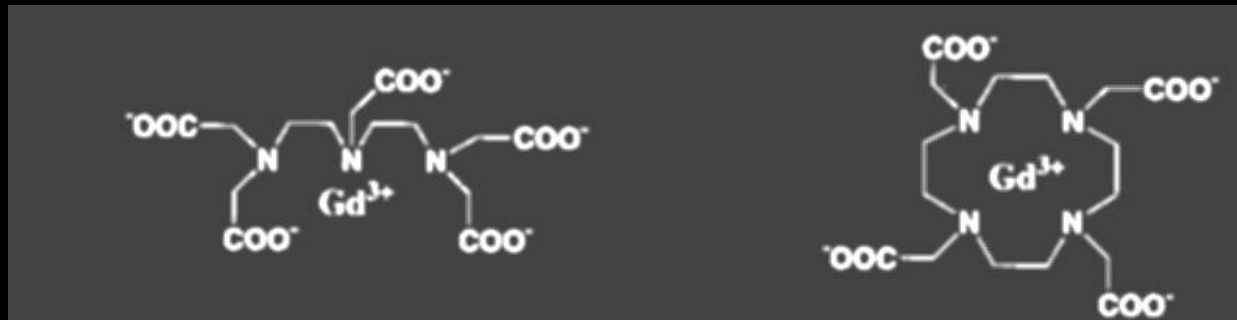
妊娠35週寫真

特別感謝三軍總醫院陳震宇主任熱情製作

MRI 的對比劑

- **Magnevist, Gadovist (Schering)**
- **ProHance (Bracco)**
- **OmniScan (Nycomed → GE)**
- **Dotarem (Guerbet)**
- **Optimark (Mallinckrodt) ...**

幾種 FDA 已批准準的 Gd 螯合物



Gd-DTPA (Magnevist) Gd-DOTA (Dotarem)



Gd-DTPA-BMA (Omniscan) Gd-HP-DO3A (Prohance)

類似的 multi-arm organic ligand 結構

MRI 對比劑的安全性

- 穩定性：螯合物不應在人體中分解
- 分解前即已排泄出體外 (尿液)
- 上市前的 LD₅₀ study
 - 50% 的老鼠會致死的劑量

LD₅₀ Study

一半老鼠死亡劑量 (mmol/Kg)

| | | |
|------------------------------|------------------|----------------|
| Gd-DTPA | Magnevist | 10 |
| Gd-DOPA | Dotarem | >10 |
| Gd-DTPA-BMA | Omniscan | 34 |
| Gd-HP-DO₃A | ProHance | 12 |
| GdCl₃ | | 0.2~0.5 |
| Gd(OH)₃ | | 0.1 |

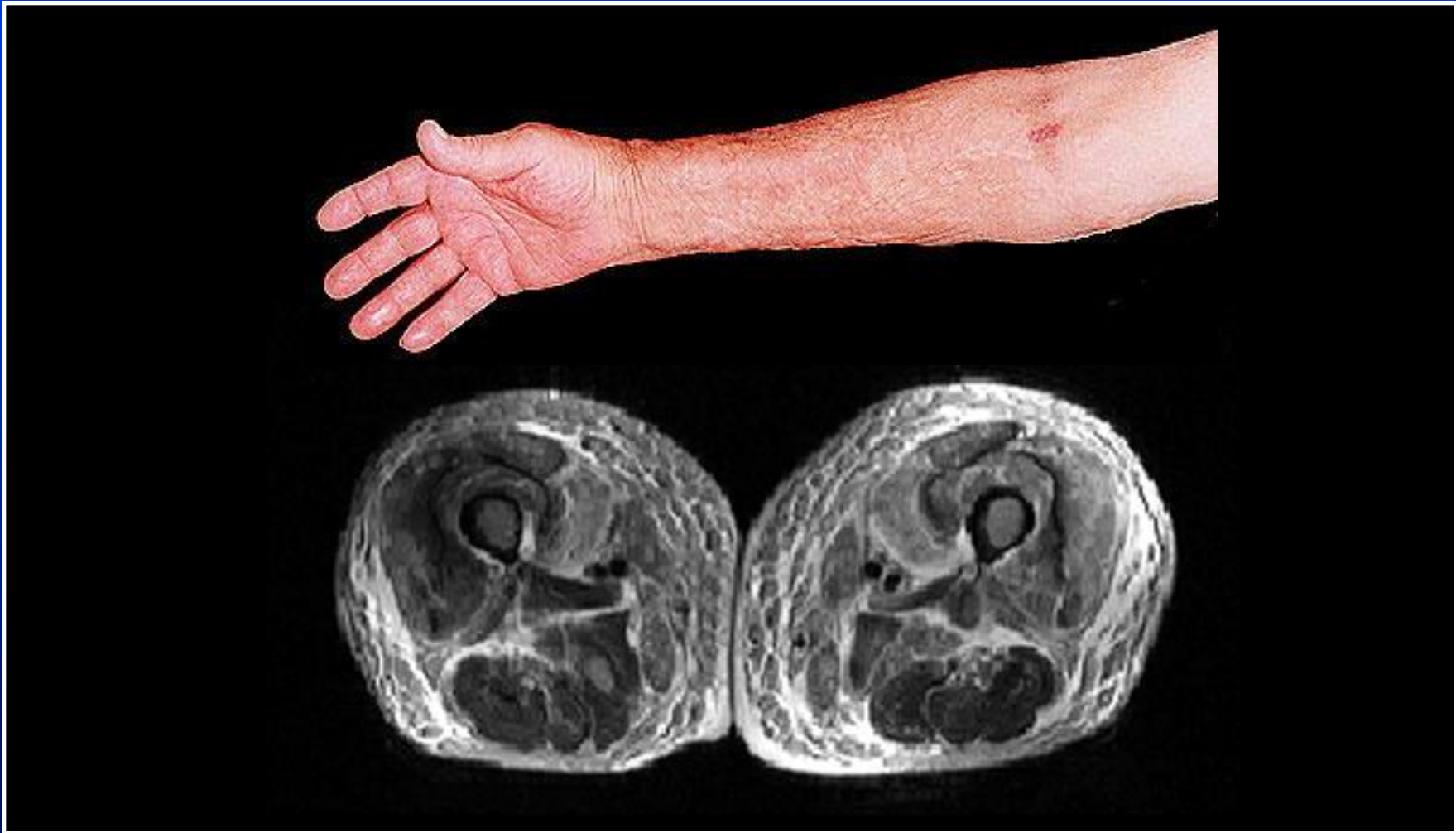
都是血管內注射

- 安全性很高
- 使用的過敏病例 (1994) :
 - Magnevist : 13 in 5,900,000
 - 一名死亡、一名 coma
 - 六名死亡病例無法證實是顯影劑造成

對比劑安全性的考量

- LD₅₀ 只是顯影劑的整體毒性
- 腎功能異常者就未必了
- 最新範例：OmniScan 與 NSF
 - 腎因性全身纖維化病變

Nephrogenic Systemic Fibrosis



原因推測

- NSF 患者都做過 CE-MR，並且都有腎功能異常 (反之不成立)
 - 腎功能異常者無法排出顯影劑
 - 病患皮膚 biopsy 中找到 Gd

原因推測

- 無法證明是 Gd 引起 (螯合物?)
- 但是證據已經指向與顯影劑有關
- 向全球發出警示 (RSNA, ISMRM, FDA, 衛生署 ...)
- 持續密切注意

MRI 的噪音

- 起因：梯度線圈的磁場變化
- 成像愈快，通常聲音愈大
- 給予病人耳塞

閉塞空間恐懼症

- Claustrophobia (心理因素)
- 病人害怕進入 MRI 內
- 解釋 MRI 無害
- 儘可能安撫情緒，亦不勉強

摘要：MRI 的安全防護

- 防止強磁鐵吸入外物
- 防止射頻灼傷
- 注意病人的身心舒適
- 不危言聳聽，亦不大意行事

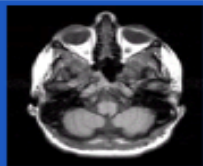
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- ▶ 3.0-Tesla MR Safety Information for Implants and Devices
- ▶ Accessories and Equipment For the MR Environment
- ▶ AccuRx Constant Flow Implantable Pump and Duracath Intraspinal Catheter
- ▶ Acoustic Noise and MR Procedures
- ▶ Activa (Neurostimulation) System (Medtronic, Inc., Minneapolis, MN)
- ▶ Aneurysm Clips
- ▶ Bioeffects of Gradient Magnetic Fields
- ▶ Bioeffects of RF Energy
- ▶ Bioeffects of Static Magnetic Fields
- ▶ Biopsy Needles, Markers and Devices
- ▶ Body Piercing Jewelry and MRI Safety
- ▶ Bone (Spinal) Fusion Stimulator
- ▶ Breast Tissue Expanders and
- ▶ IsoMed Implantable Infusion Pump (Medtronic, Inc., Minneapolis, MN)
- ▶ Kinetra Dual Program Neurostimulator for Deep Brain Stimulation, Model 7428
- ▶ M2A Capsule Endoscopy Device
- ▶ Magnetically Activated Implants and Devices
- ▶ Medical Devices and Accessories for the MR Environment
- ▶ Medtronic MiniMed 2007 Implantable Insulin Pump System
- ▶ Metallic Foreign Bodies and Screening
- ▶ Miscellaneous Implants and Devices
- ▶ "Missile Effect" Accidents and Prevention
- ▶ Monitoring Patients in the MR Environment
- ▶ MR Procedures: Implants and

http://www.stmichaelshospital.com/content/programs/medical_imaging/mri/mri_safety.asp


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Serving with Compassion

Medical Imaging
MRI

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A teaching hospital affiliated with the University of Toronto

MRI: MRI Safety

Prior to booking an MRI examination, please ensure that the MRI Screening Questionnaire is completely filled out and sent to the MRI Department. The following represents a list of contraindicated and MRI compatible devices. Please note, this is not a complete list but should serve as a guideline. If you require more information, please check with the MRI staff at 416 360-4000 Ext. 2134 or visit the following website:
www.mrisafety.com

摘要：MRI 的安全防護

- 正常操作下，根本毋須擔心
- 可是一定要確保正常操作！

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