



Hibrid tedavi ve görüntüleme sistemleri (PET/MR)

Radyoloji görüşü

Dr. Gülgün ENGİN

İstanbul Üniversitesi Onkoloji Enstitüsü

Sunu planı

- PET-MR
 - PET-BT'ye üstünlükleri
 - Teknik özellikleri
 - Klinik uygulama alanları
 - Tanı, evreleme, tedavi yanıtı
 - Pediatri, baş/boyun, pelvis, karaciğer
 - Radyoterapi planlama
 - Sınırlamaları



PET-BT sınırlamaları

- Radyasyon (x-ışını)
- Düşük yumuşak doku rezolüsyonu



Baş-boyun, pelvik kanserler,
kemik tm, yumuşak doku sarkomları,
karaciğer ve beyin met



Whole-Body PET/CT Scanning:

Estimation of Radiation Dose and
Cancer Risk¹

Radiology

Huang, Radiology 2009

Parameters of the Three CT Protocols

CT Protocol	Tube Potential (kV)	Rotation Time (sec)	Section Thickness (mm)	Pitch	Tube Current (mA)	Noise Level*
A	120	0.5	0.625	0.984	100–300	20
B	120	0.5	0.625	0.984	250	...
C	140	0.5	0.625	0.984	150–350	3.5

• Efektif dozlar

- PET → 6 mSv
- Protokol A → 14 mSv
- Protokol B → 25 mSv
- Protokol C → 32 mSv

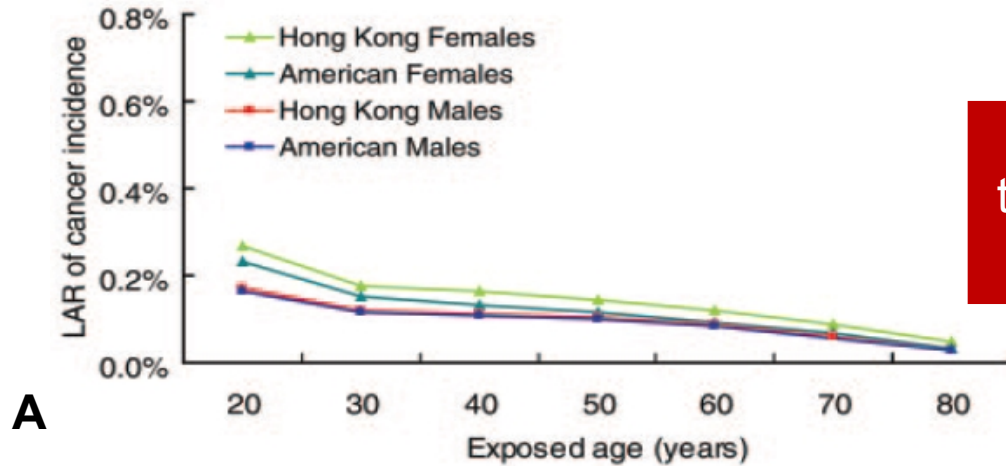
1 yıllık background
rad (2.4 mSv) X 5-
13

Parameters of the Three CT Protocols

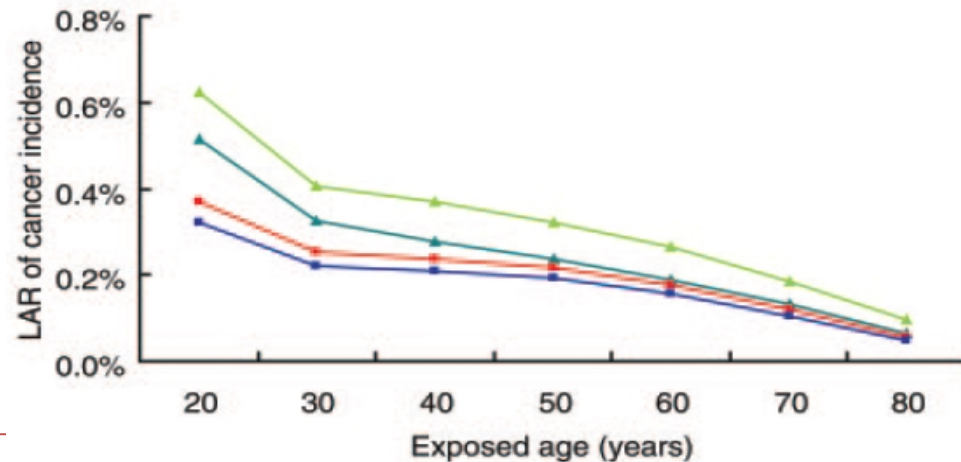
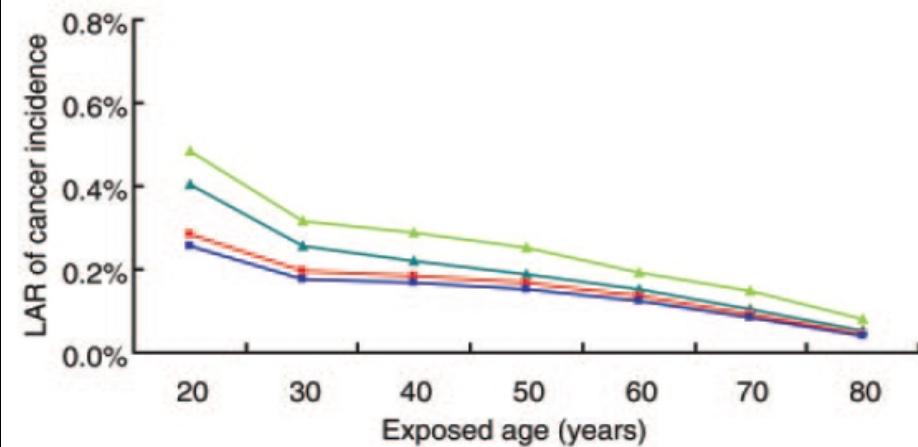
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Huang, Radiology 2009

Herhangi bir yaşta 1 kez uygulanan tüm vucüt 18F-FDG PET/CT sonrası Kanser riski



a.



c.

Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study



Mark S Pearce, Jane A Salotti, Mark P Little, Kieran McHugh, Choonsik Lee, Kwang Pyo Kim, Nicola L Howe, Cecile M Ronckers, Preetha Rajaraman, Sir Alan W Craft, Louise Parker, Amy Berrington de González

Lancet 2012; 380: 499–505

- Retrospektif cohort çalışma
- 1985-2002 yılları arasında, malignite (-),
- < 22 y BT çekimi yapılmış, 178.604 kişi
- Veriler 1985-2008 yılları arasında toplanmış
- Kümülatif (birikmiş) radyasyon dozu
 - > 50 mGy ➡ lösemi riski 3 kat fazla
 - > 60 mGy ➡ beyin tm riski 3 kat fazla



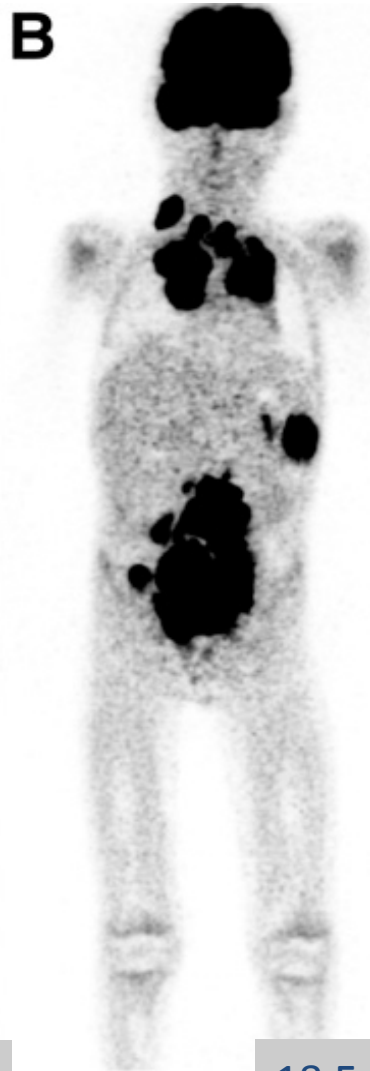
Diffüz B H'li lenfoma ve Hodgkin L



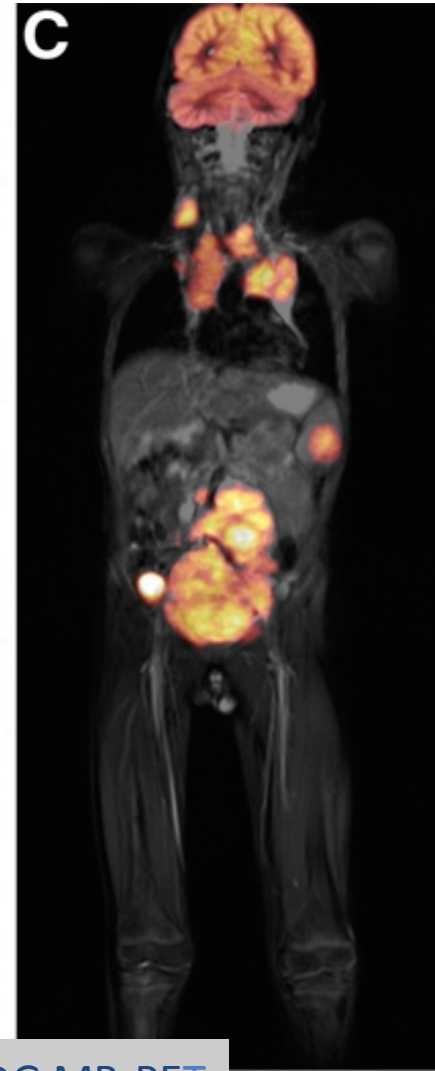
Tedavi öncesi Hodgkin Lenfoma (6 Y/E)



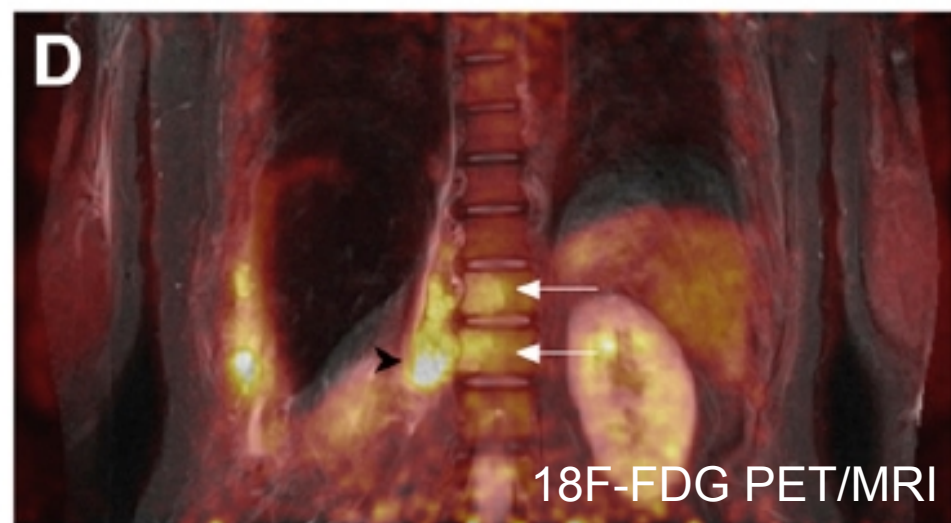
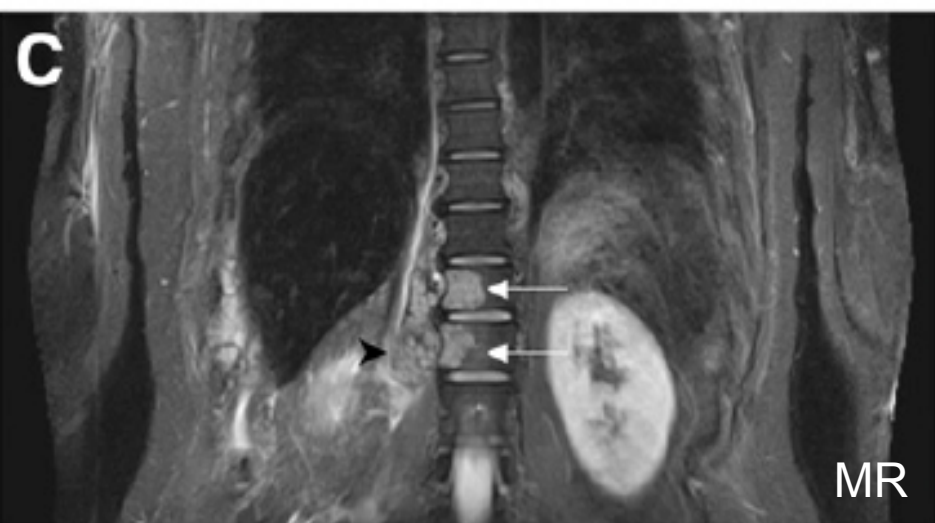
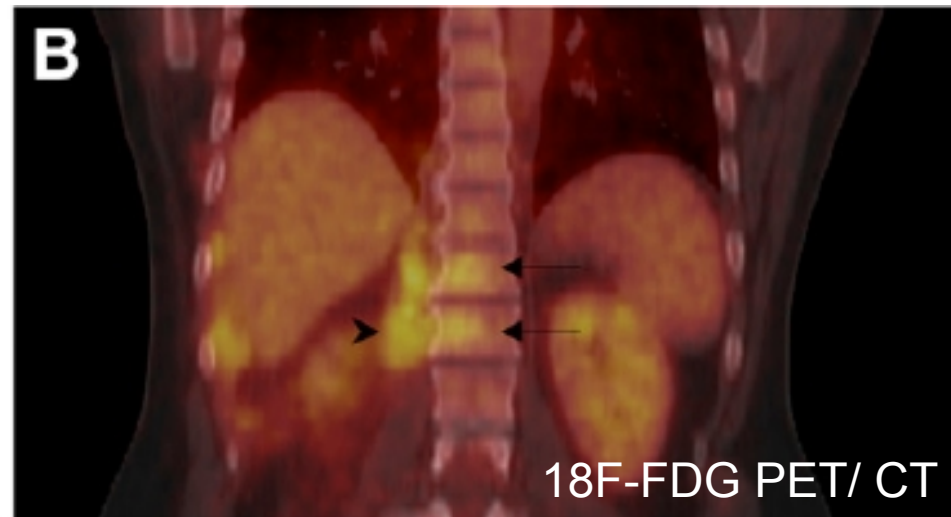
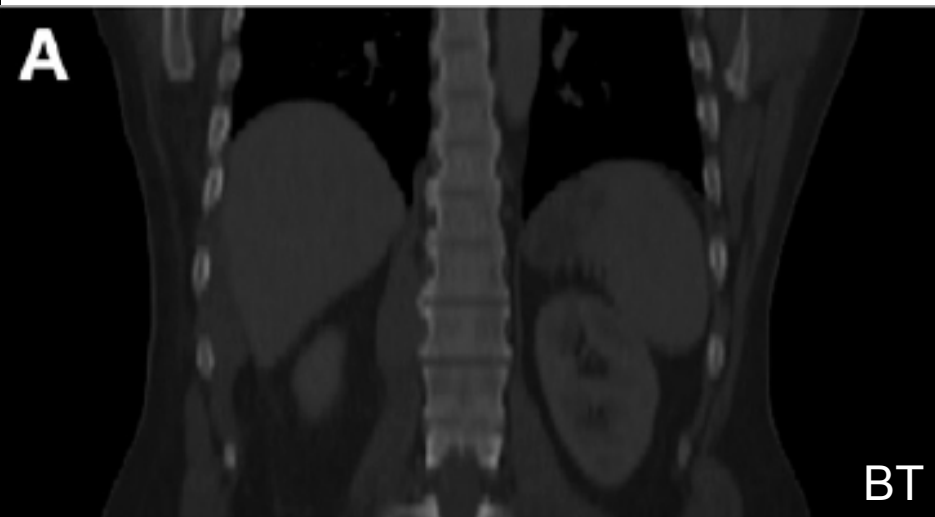
T2A tüm vücut MR



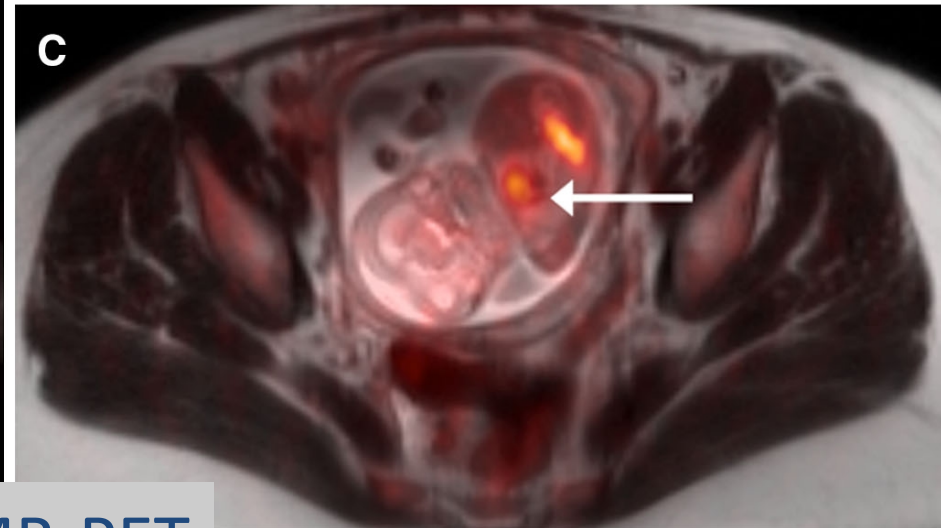
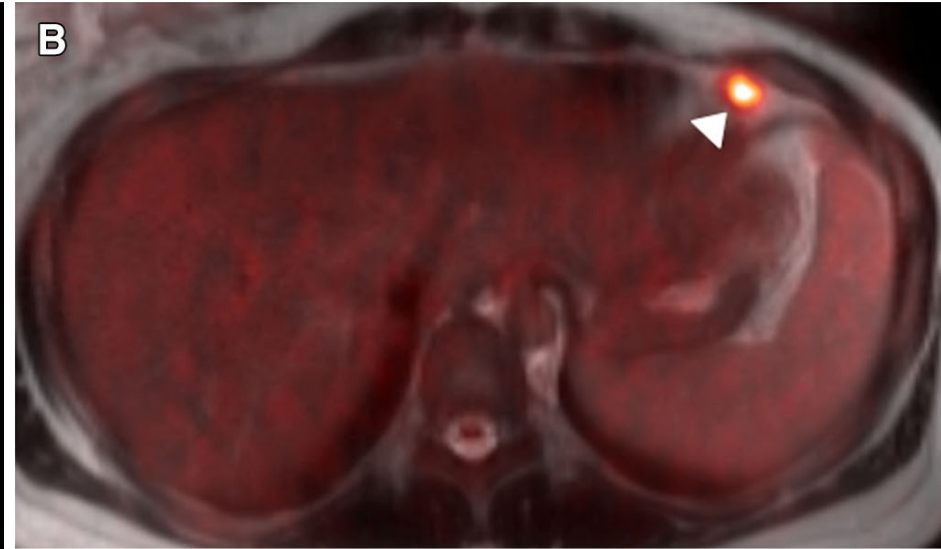
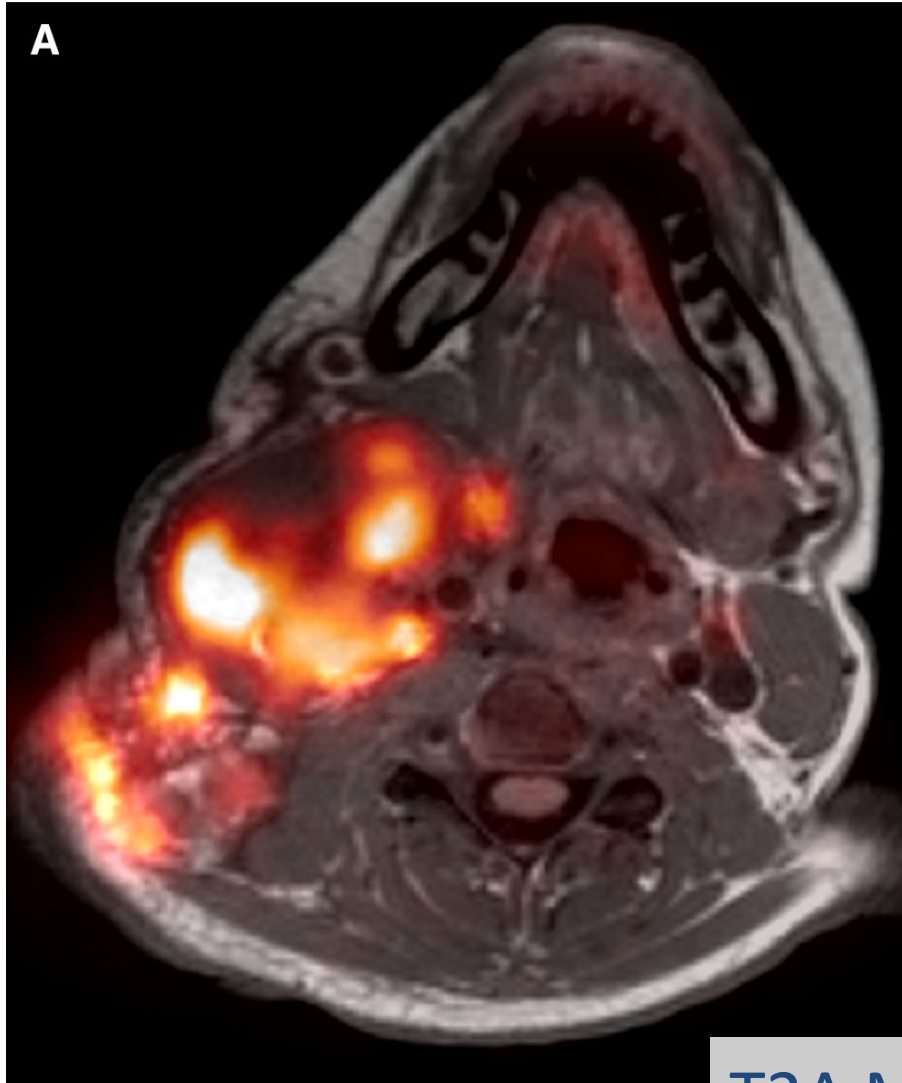
18 F-FDG MR-PET



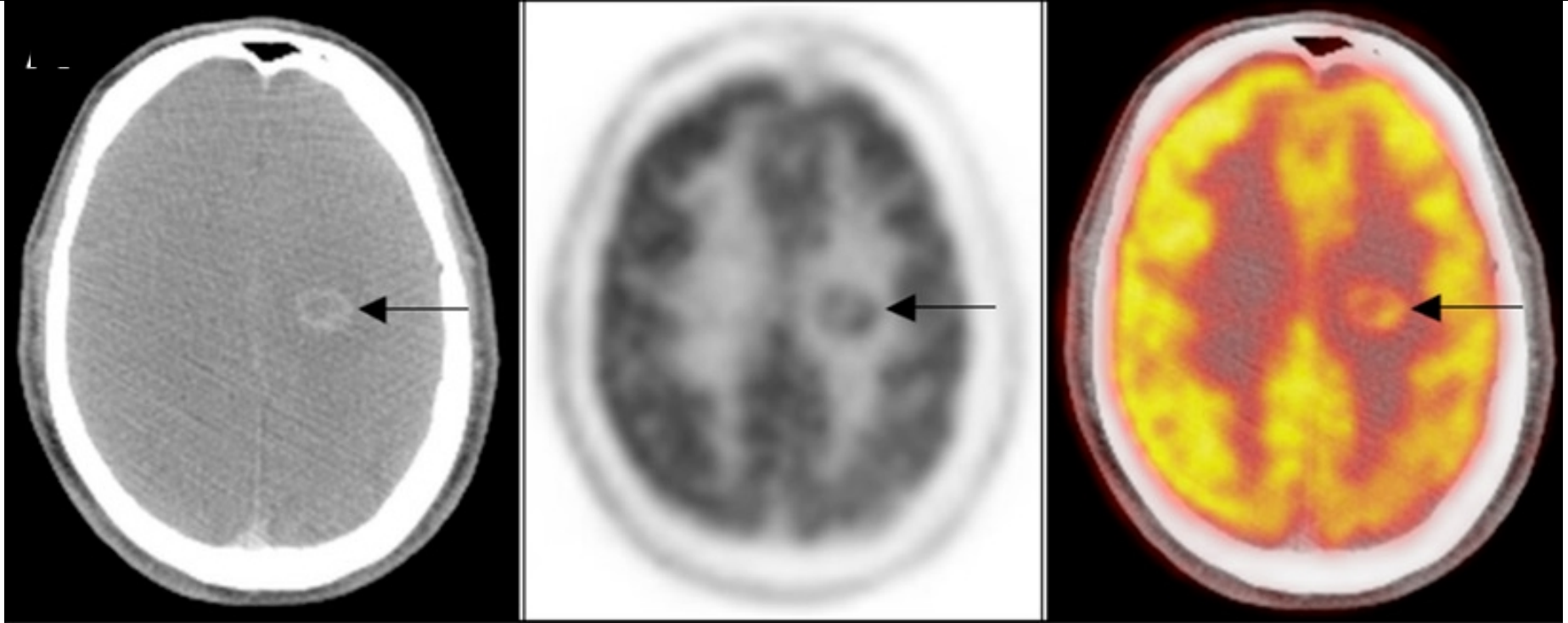
Hodgkin dışı lenfomada KI tutulumu

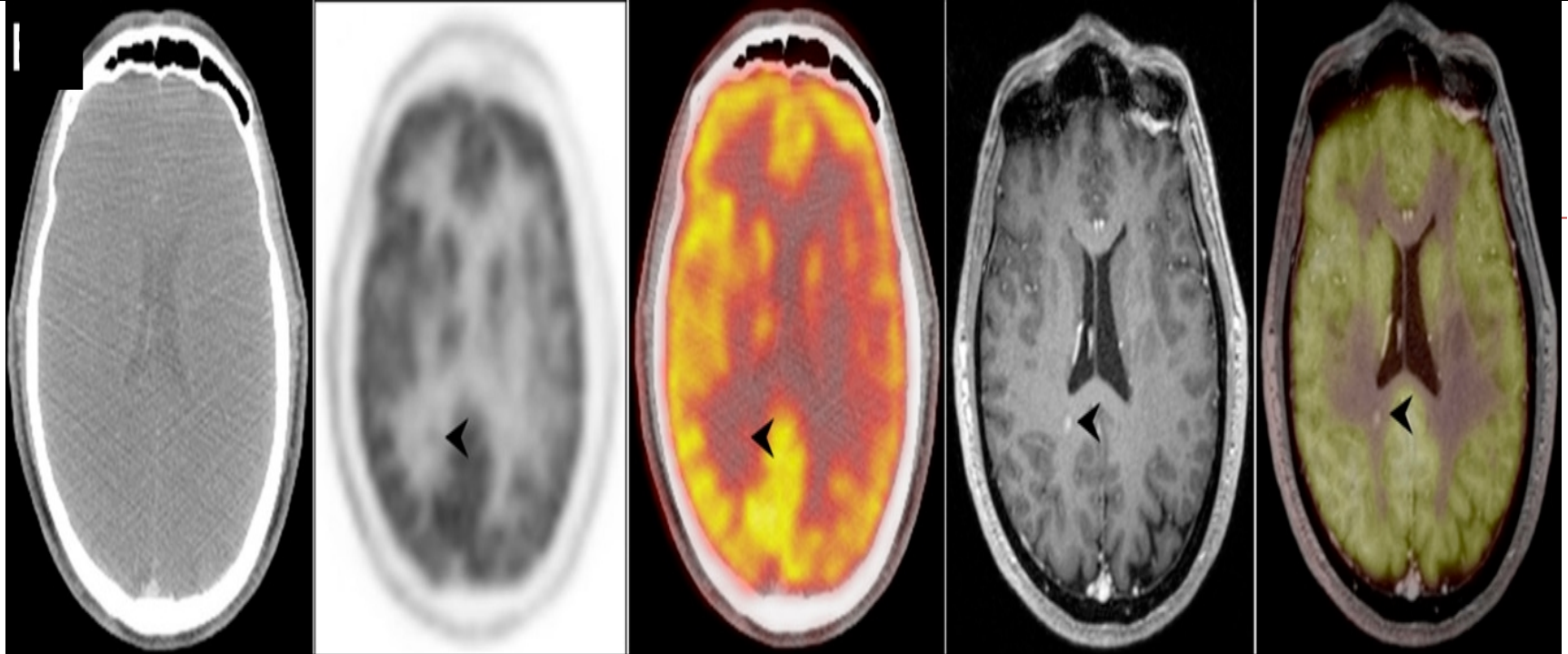


Nüks Hodgkin L (3 aylık gebe, 24 Y/K)

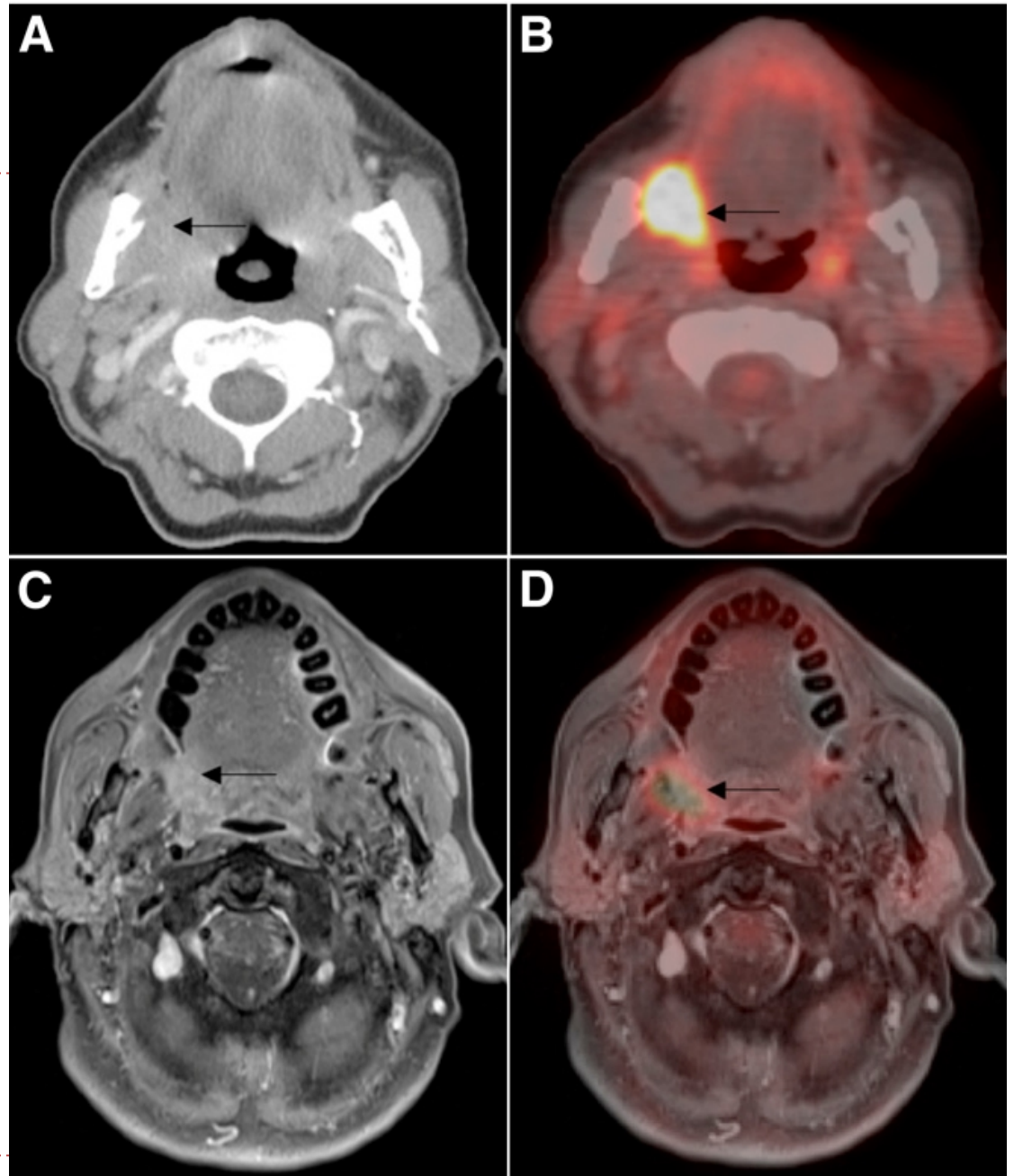


T2A MR-PET



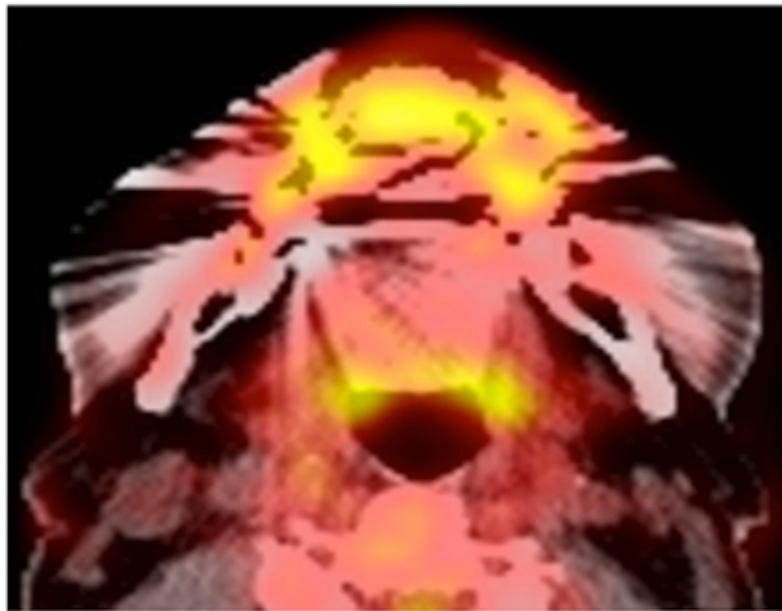


Boyun SCC



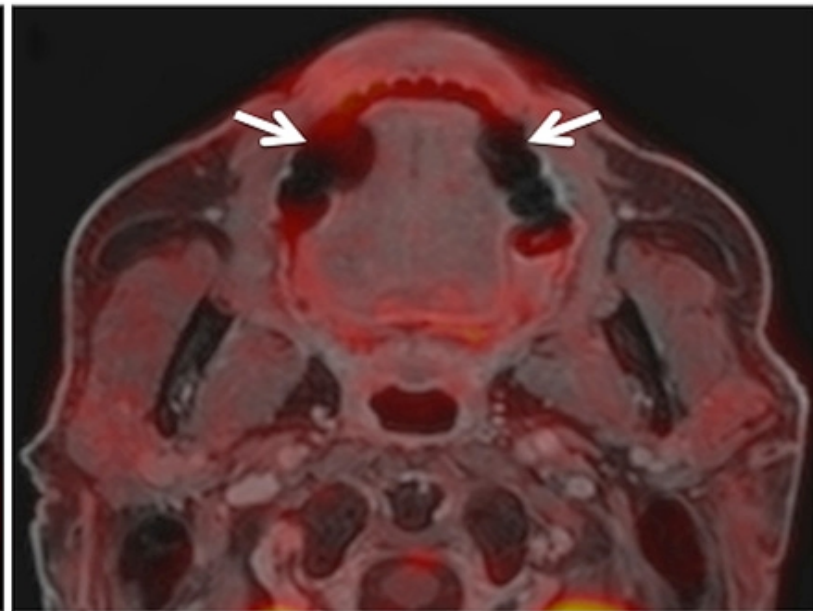
Baş-boyun SCC tedavi sonrası izlem

- Nüks
 - Lokal tm → Duyarlılık %92 (PET-BT %80)
 - MR yüksek yumuşak doku rezolüsyonu + PET yüksek NPV
- (Nakamoto, Mol Imag Biol 2009)



(a)

PET-BT



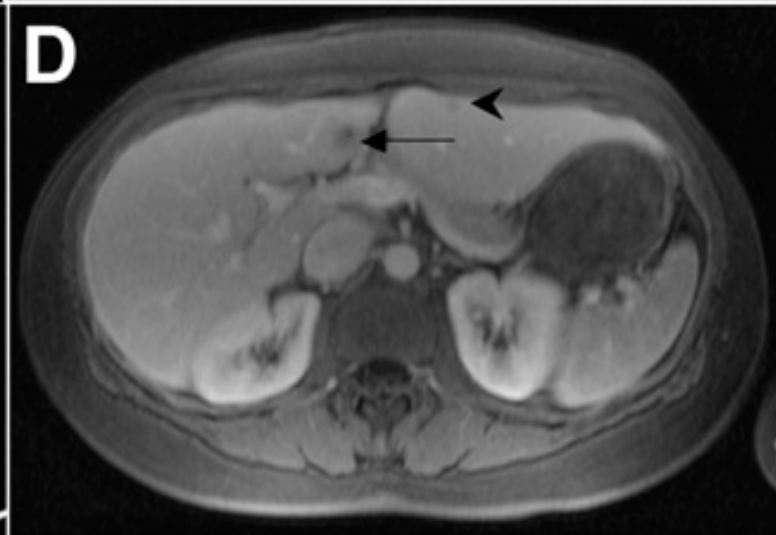
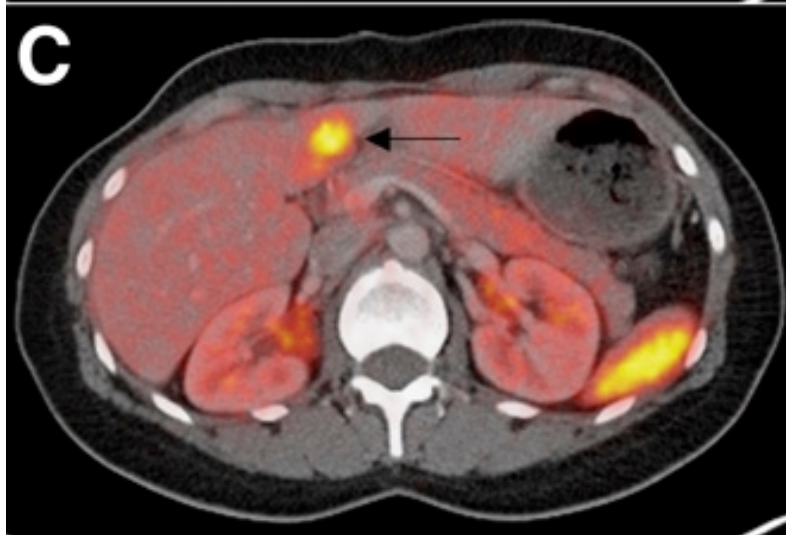
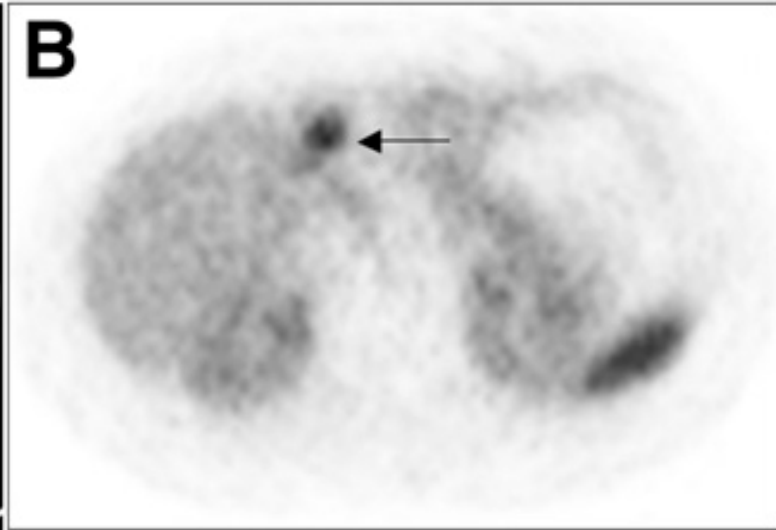
(b)

PET-MR

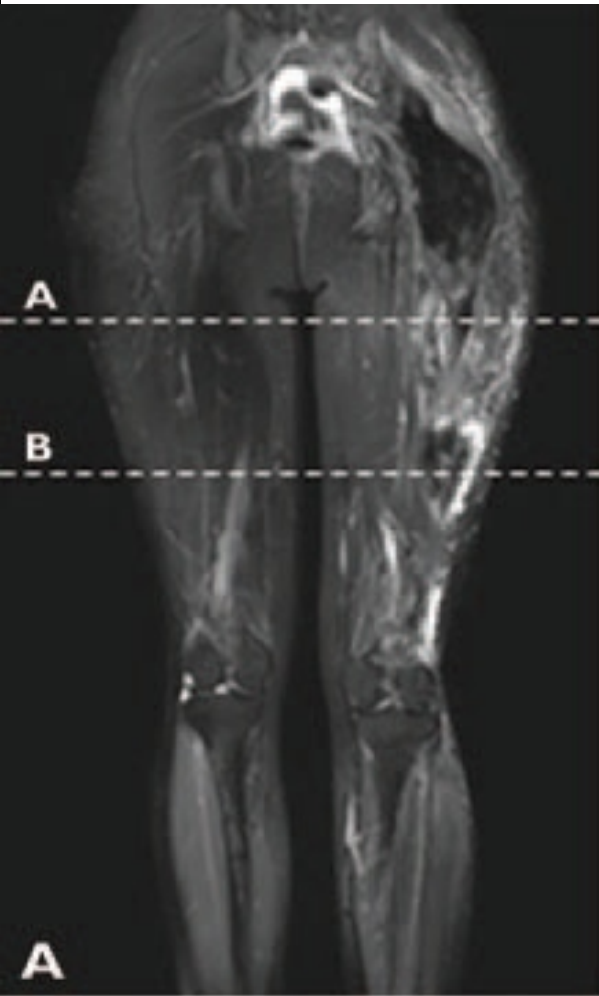
Karaciğer



51 Y, Nöroendokrin tm KC metastazı



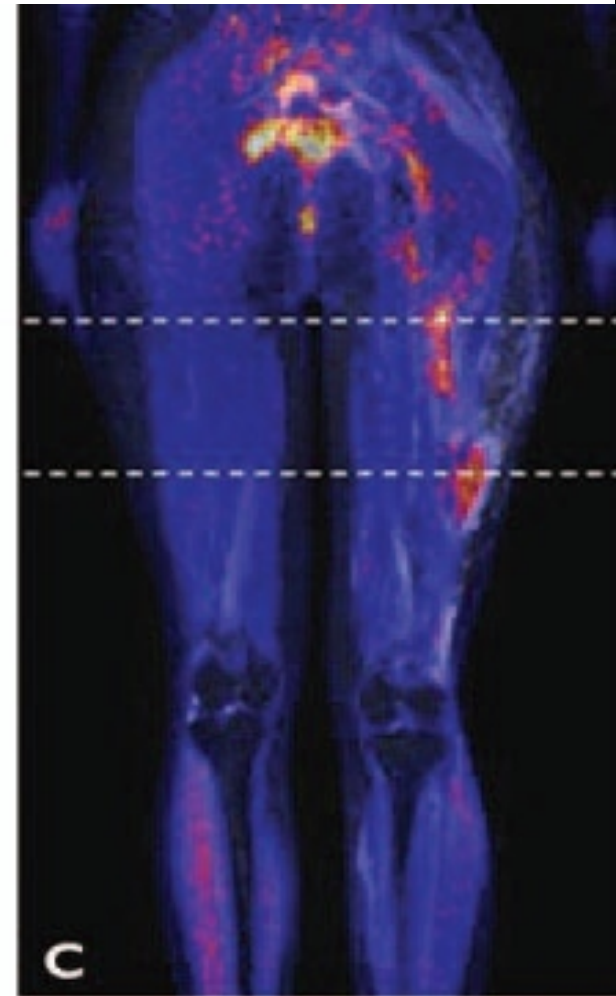
Agresif fibromatozis, 27 Y/K



T1A C+ MR



PET



PET-MR

Agresif fibromatozis, 27 Y/K

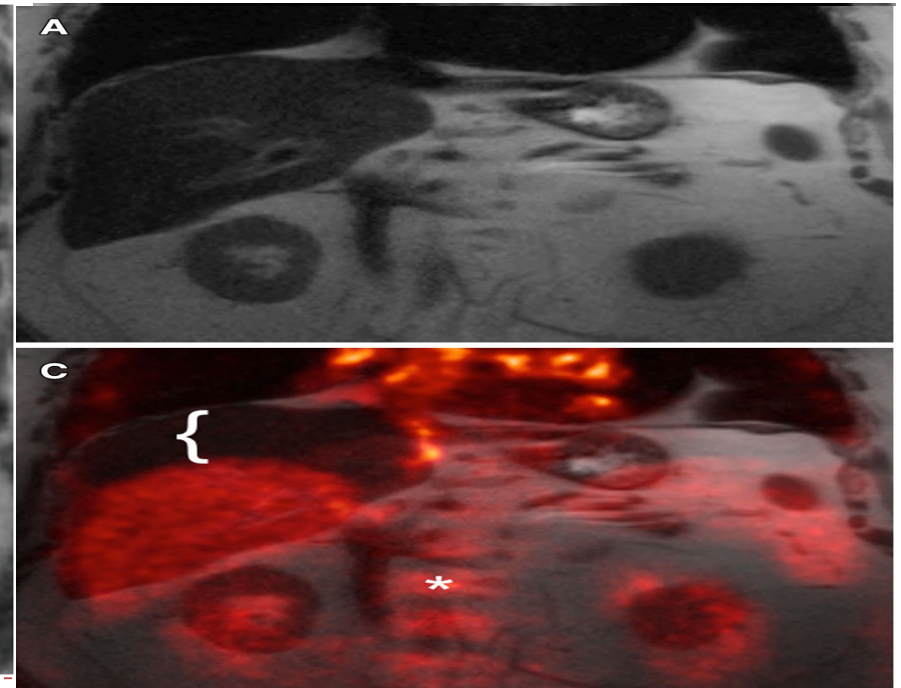
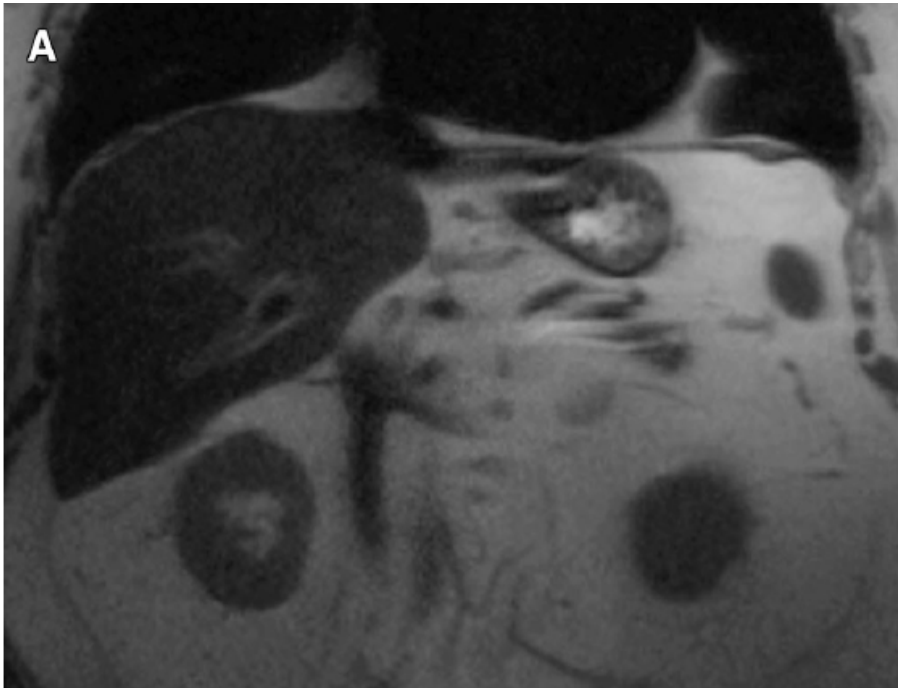
BT (C+)

MR (C+)

Werner, AJR 2012

PET-MR teknik

- PET ve MRG ayrı element, ortak masa
 - Bilgisayar donanımı ve yazılım sisteminde küçük değişiklik
 - Elektromanyetik etkileşim minimal
 - PET ve MR veri ayrışması ➡ yanlış kayıt (misregistration)



PET-MRG tek sistem

- PET dedektör ve elektronikleri MR cihazı içinde
- PET-MR verilerinin aynı anda eldesi
 - Yanlış kayıtların azalması
 - Kısa inceleme süresi
- PET-MR arası elektromanyetik etkileşim !!!
 - İleri teknik değişiklik
- Attenüasyon düzeltmesi !!!
 - SUV ölçümü için zorunlu



MR'a dayalı atenüasyon düzeltilmesi

- BT'de X ışını fotonları
 - PET atenüasyon düzeltilmesi için uygun
- MRG'de proton dansitesi ve doku T1/T2 özellikleri
 - PET için uygun değil
 - Segmentasyona dayalı AC (en yaygın)(Dixon metodu)
 - Dört doku: Hava, yumuşak doku, yağ ve akciğer
 - Kortikal kemik ihmal edilir
 - Kemiğe yakın alanlarda sinyal ve SUV ölçüm hataları !!!



MR'da atenuasyon düzeltmesi (AC)(Dixon yöntemi)

Rekonst. algoritmaları



Performance of Whole-Body Integrated ^{18}F -FDG PET/MR in Comparison to PET/CT for Evaluation of Malignant Bone Lesions

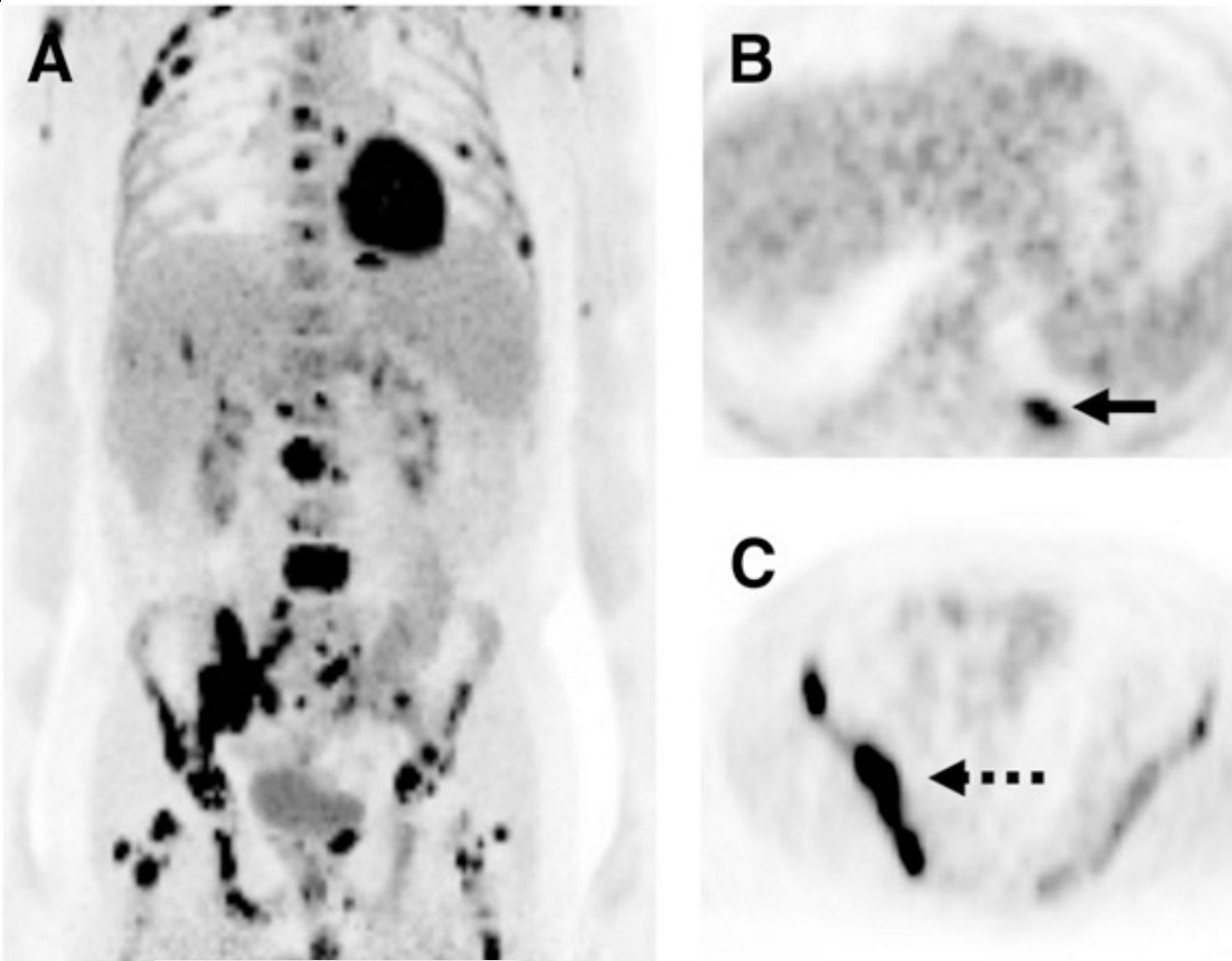
Matthias Eiber*¹, Toshiki Takei*², Michael Souvatzoglou², Marius E. Mayerl³, Denys J. Loeffelbein⁴, Ernst J. Rummeny¹, Sibylle I. Ziegler², Markus Schwab², J Nucl Med 2014; 55:191–197 Jaertner²,

¹Department of Radiology, Technische Universität München, Klinikum rechts der Isar, Munich, Germany; ²Department of Nuclear Medicine, Technische Universität München, Klinikum rechts der Isar, Munich, Germany; ³Department of Radiology and Nuclear Medicine, Medical University of Vienna, Vienna, Austria; and ⁴Department of Oral and Maxillofacial Surgery, Technische Universität München, Klinikum rechts der Isar, Munich, Germany

- 119 hasta, retrospektif
- PET-MR atenüasyon düzeltmesi etkisi ???
 - PET-MR ➡ Kemik lezyon tanısı, sınırları ve SUV değeri
 - PET-MR vs PET-BT
- PET-MR sekansları
 - T1A Dixon (Atenüasyon düzeltmesi için)
 - T1A TSE (kontrastsız) (Kemik analizi için)

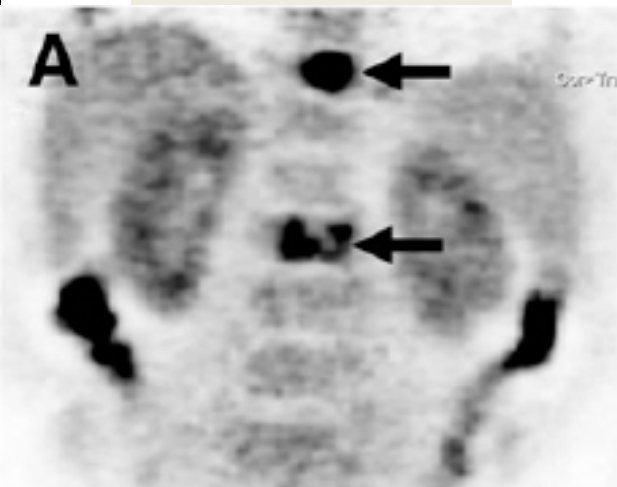


Hodgkin dışı lenfoma-yaygın kemik tutulumu

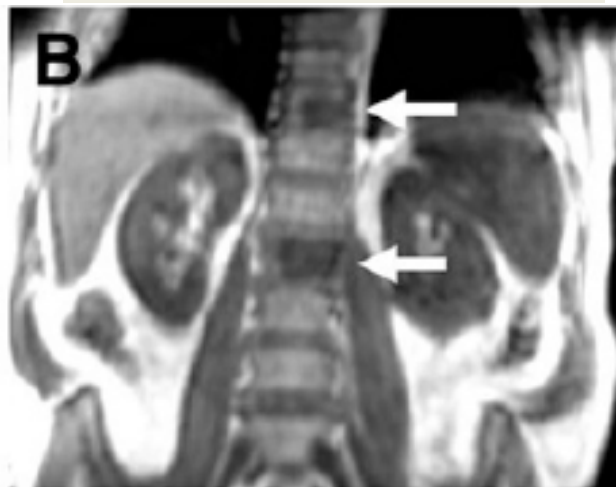


Koronal PET-MR

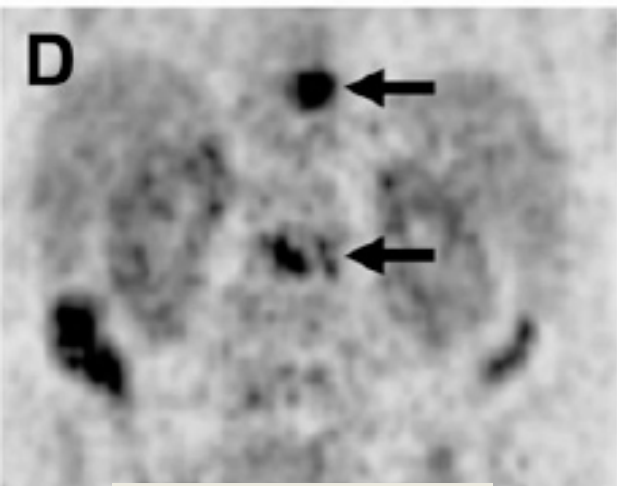
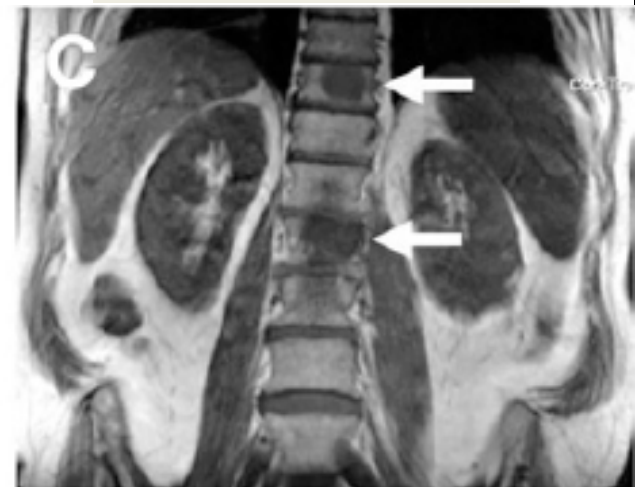
Koronal PET MR



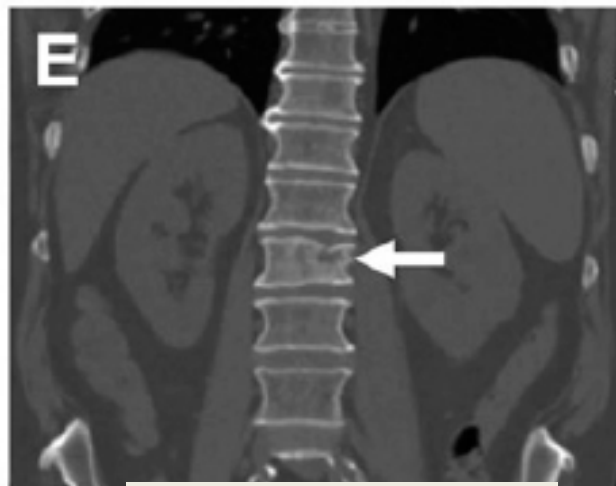
Koronal T1A Dixon MR



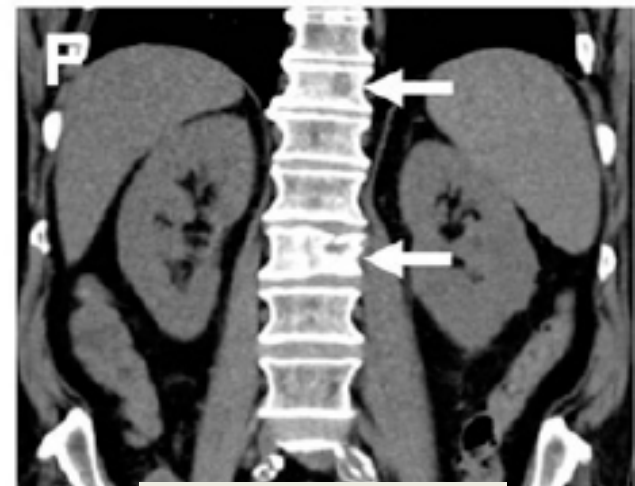
Koronal T1A MR



Koronal PET-BT



Kemik pencere BT

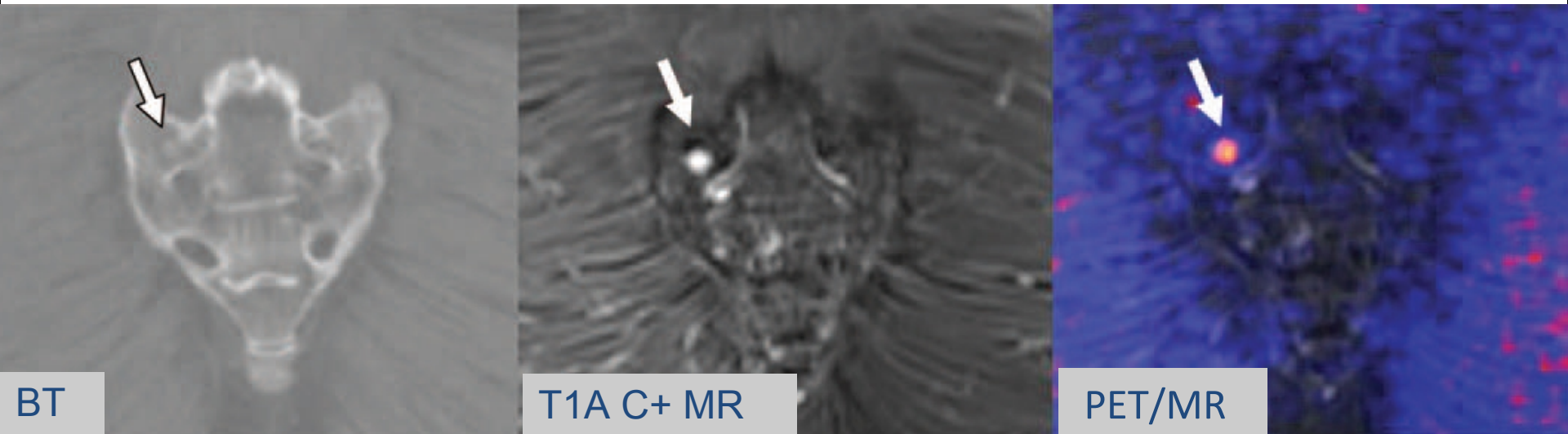


Yd pencere BT



Kemik met tanısı

- Diffüz küçük volümlü metastaz
 - PET-BT ile atlanabilir.
- Saptanabilen en küçük lezyon (Schmidt, Eur Radiol 2007)
 - MR ile 2mm
 - PET-BT ile 5mm



PET-MR sınırlamaları (BT'ye göre)

- Küçük pulmoner lezyon saptanması
 - En önemli sınırlaması
- Uzun inceleme süresi (45-70 dk)
- Gantry açıklığı 60 cm
- Artefaktlar
 - **Atenüasyon düzeltme artefaktları**

Klostrofobi



Akciğer

- MR duyarlılığı < BT

- Tüm vucüt MR vs PET-BT → 139 vs 170 nodül



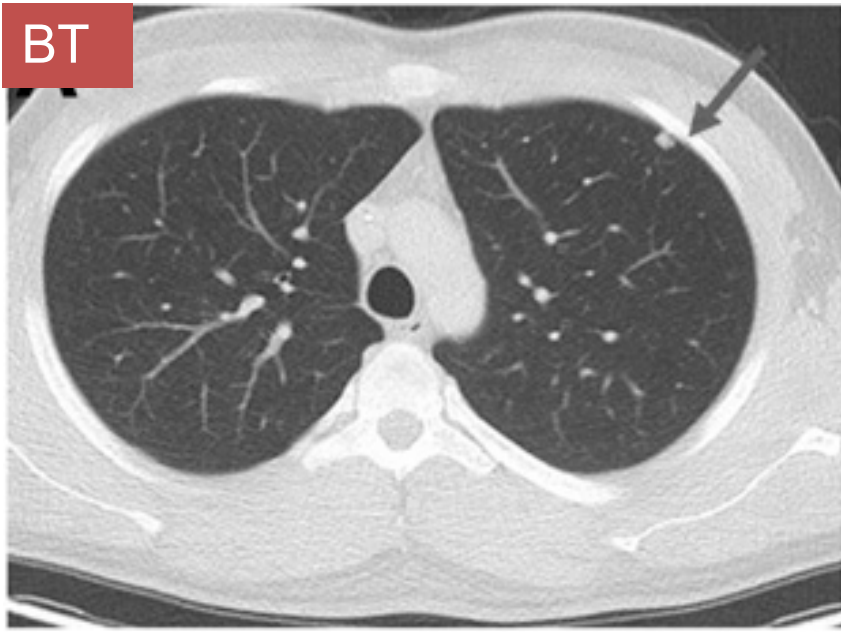
BT kontrast rezolüsyonu
yüksek

(Schmidt , Invest Radiol 2005)

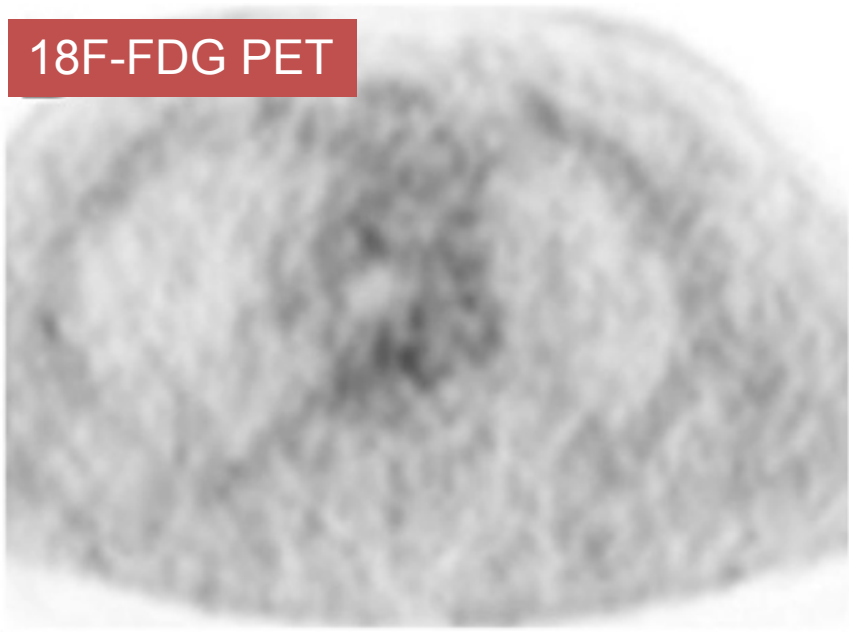
- Küçük lezyon tanısında duyarlılığı → PET-MR < PET-BT

(Rauscher, J Nuc Med

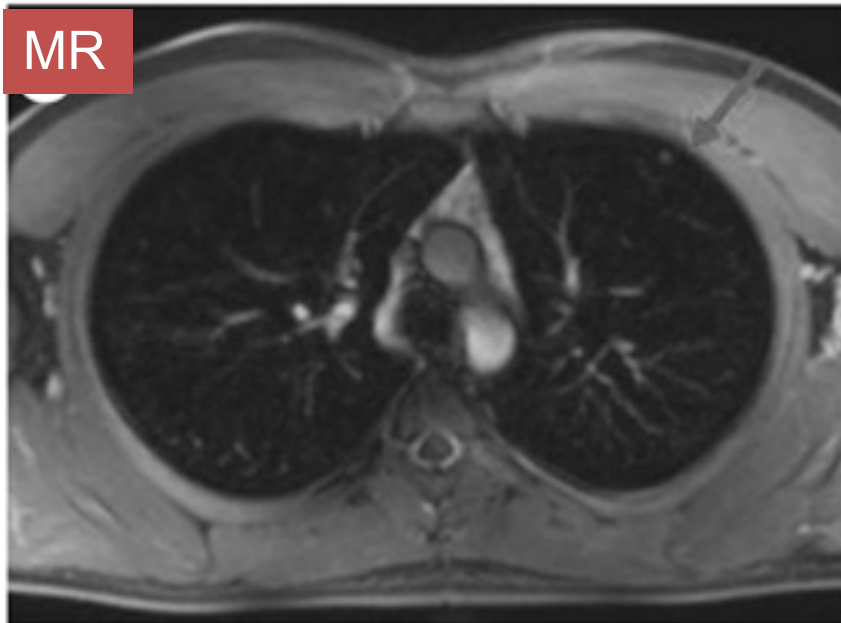
BT



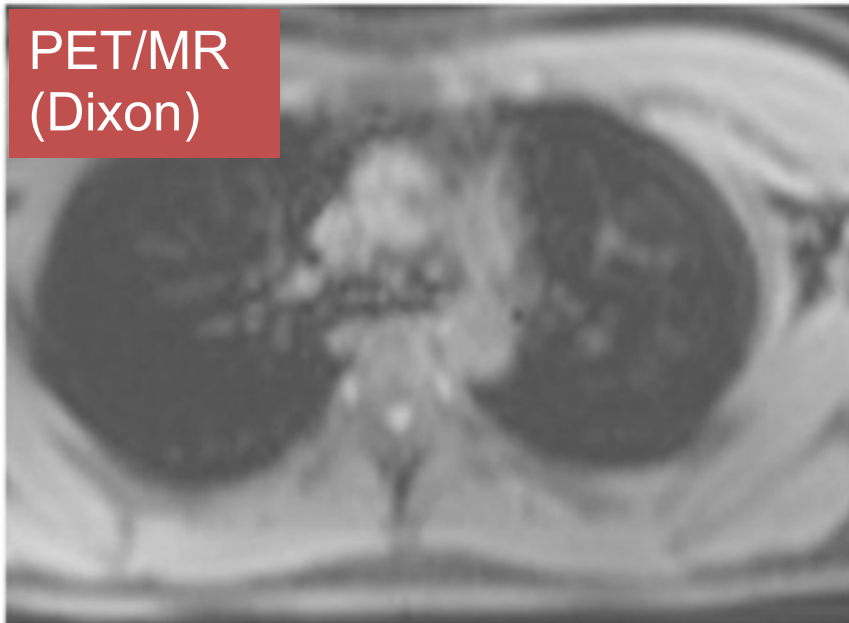
^{18}F -FDG PET



MR



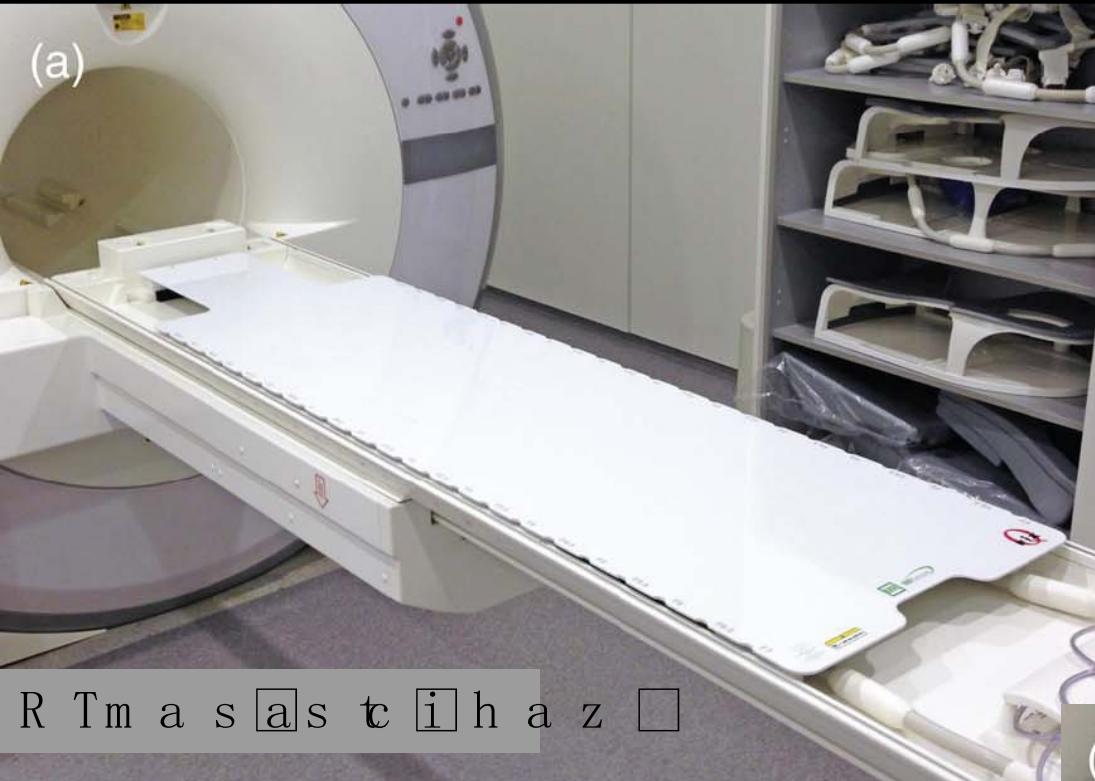
PET/MR
(Dixon)



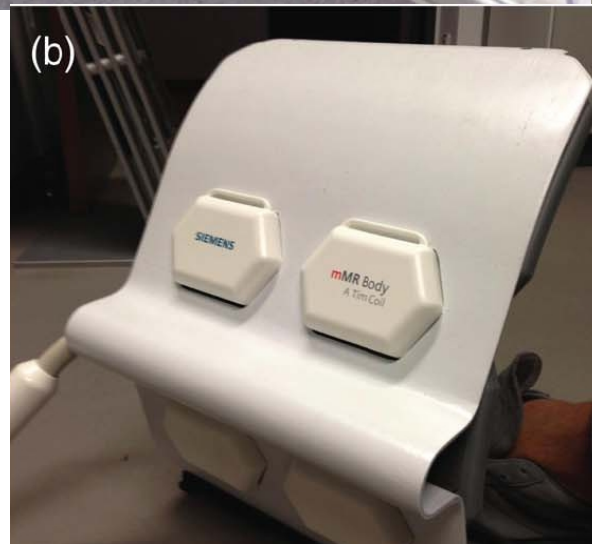
RT planlamada PET-MR

- Hibrid PET-MR ile uyumlu masa üstü ve pozisyonlama cihazları
 - Prototip düz RT masası
 - Plastik sandviç yapı + köpük kor (Varian Exact Style Indexing system)
 - Baş-boyun RT görüntülemesi için fleksibl body koili
 - Standart MR koillere göre daha geniş
 - Sabit (2 adet radyofrekans coil tutturacı)

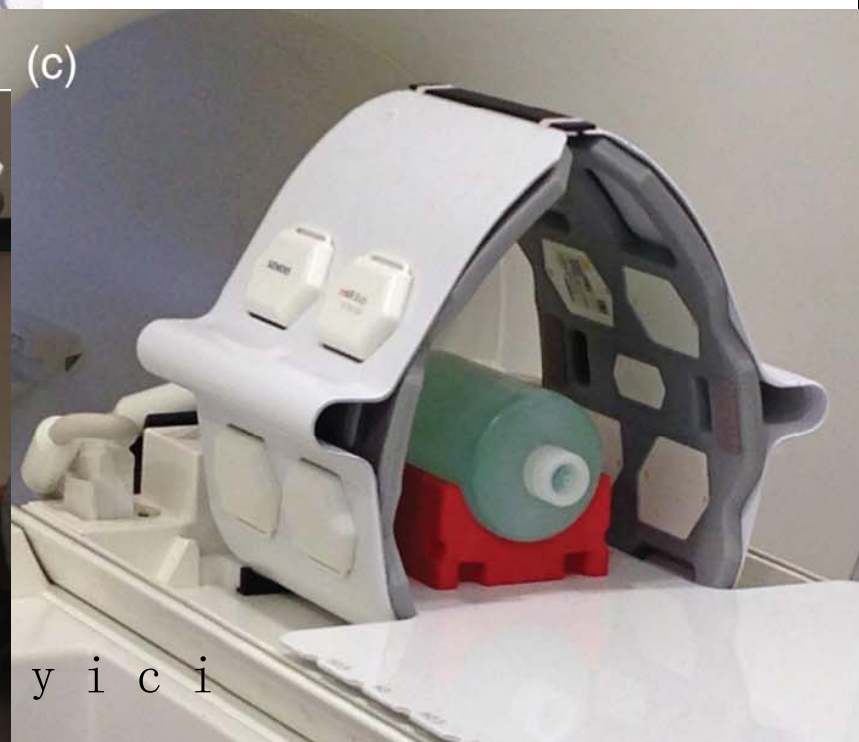




R T m a s a s t i h a z



F l e k s i b l e d e v i c e i s a b i t l e y i c i



Sonuç

