Imaging: methodological issues for present day diagnosis of radiation damage..

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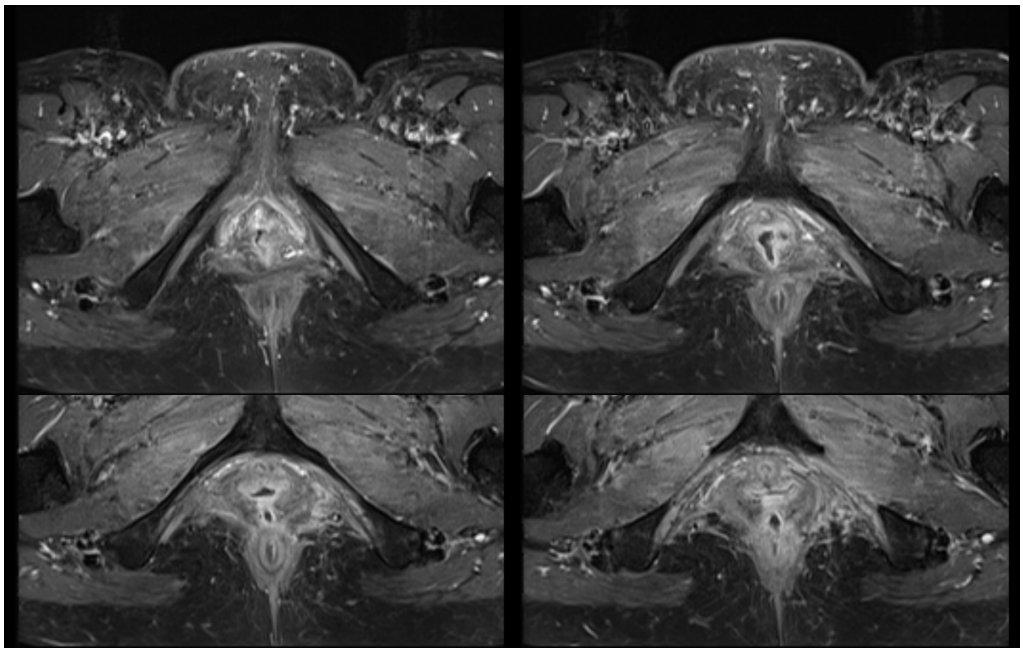
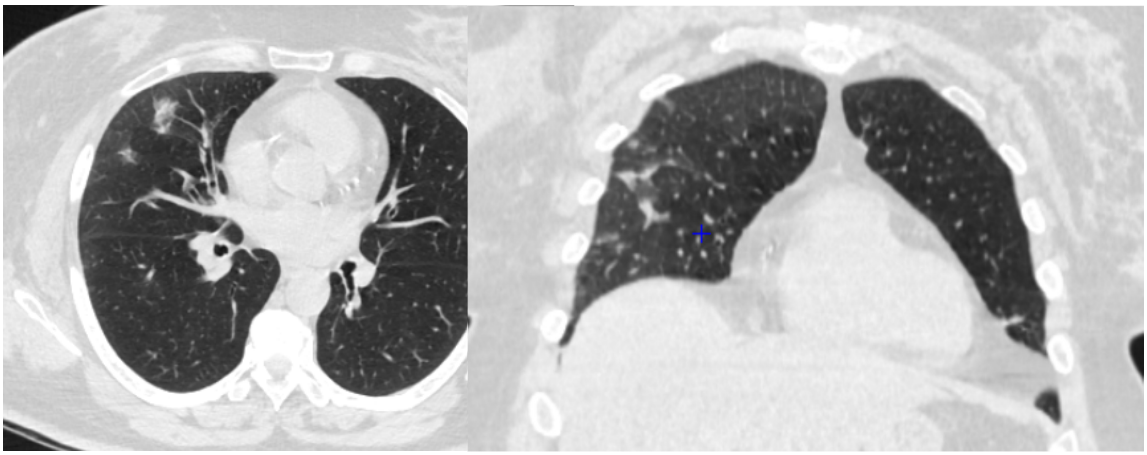
Treatment damage is nowadays rare, due to modern and selective techniques, but multimodal therapies can increase toxicity.



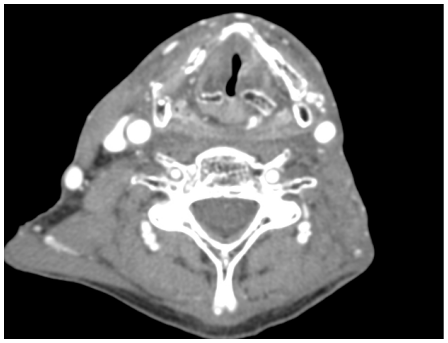
50 yrs old woman with rectovaginal fistula after Radio-Chemo-therapy for carcinoma of the posterior vaginal wall

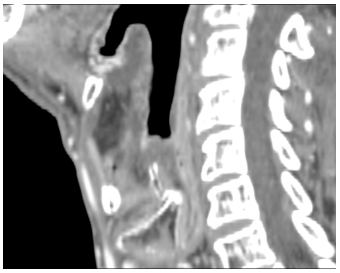
Symptoms and “conventional” imaging are usually able to obtain a correct diagnosis



66 yrs old woman with pneumonia after breast irradiation

62 yrs old man with lariyngeal SCC treated by RT and left lymphoadenectomy 1 yr ago

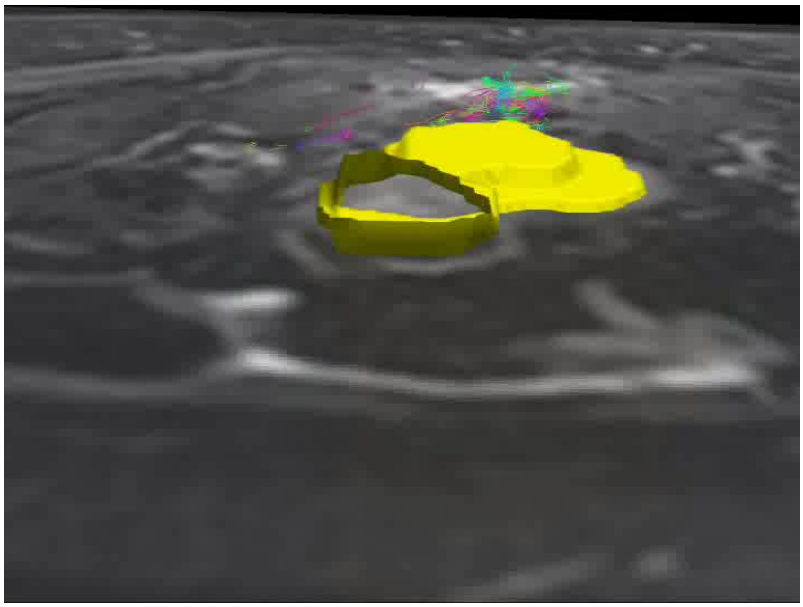




- *Epiglottis oedema and thickening of tracheo-oesophageal space*
- *Lack of solid bolus preparation and incoordination causing reflux*.

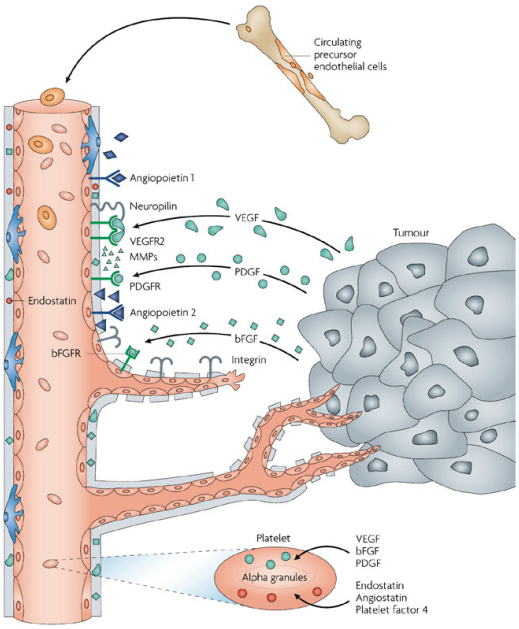
New diagnostic tools: «*non-conventional imaging*» :

- **Perfusion studies (CT or MR)**
- **MR Diffusion imaging**



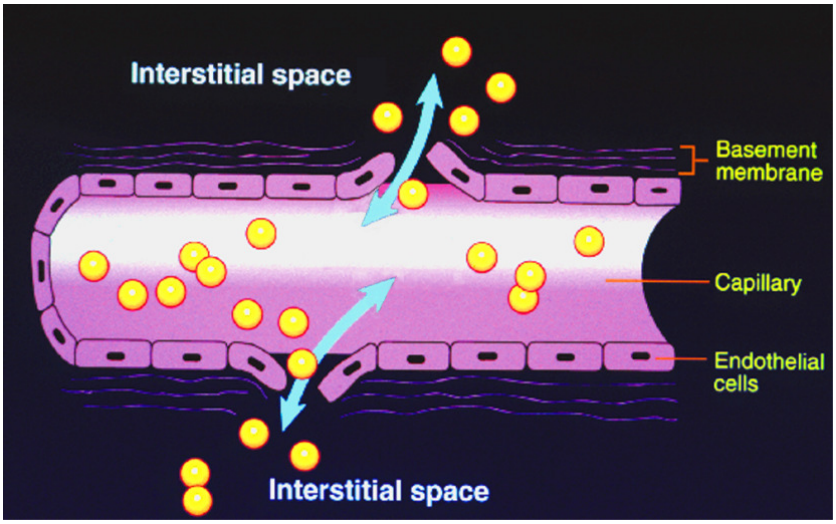
Imaging of perfusion in oncology

- “marker” of angiogenesis
- “ marker” of cells viability



Imaging of perfusion mirrors neoplastic neo-angiogenesis activity.

It is based on transit of contrast (and therefore of blood) from vascular to extravascular spaces

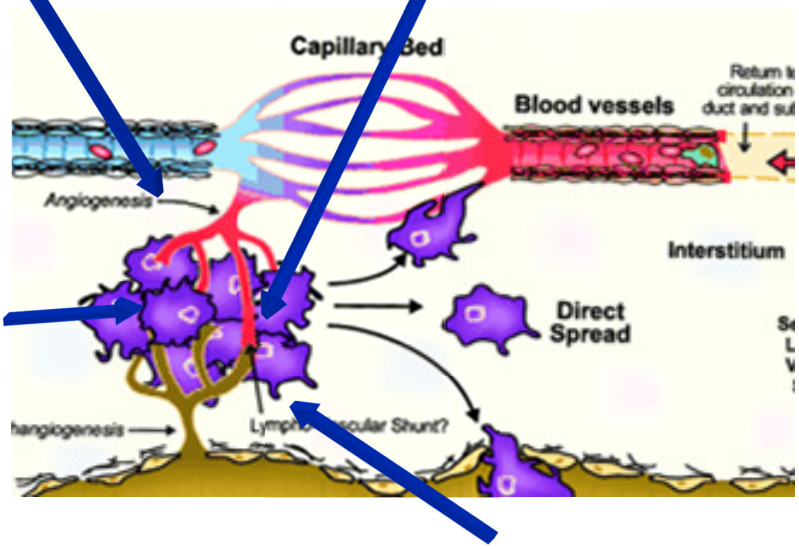


The perfusion can be measured both by CT or MRI:

- Relation between contrast and density is linear by CTp, while the effect of contrast on signal in MRI is complex.
- Perfusion software in CT are standard, widespread and tested, while in MR they differ from different centers, often beeing experimental.
- The need to identify tumor without contrast is easier by MRI
- Radiation

BF: *Contrast entering the tumor intravascular space*

PS: *Contrast leaking into extravascular space through defects in basement membrane*



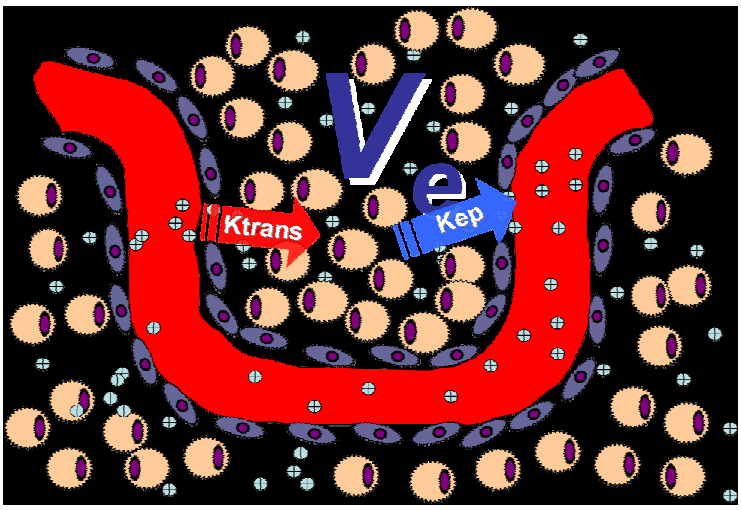
MTT: *Contrast transit through the tumor (shunts)*

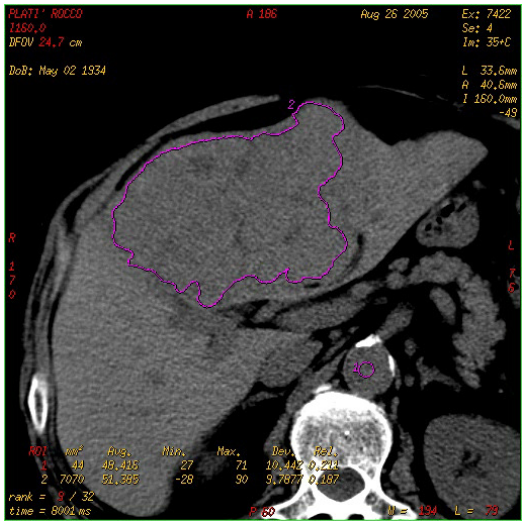
BV: *Contrast amount "feeding" the tumor*

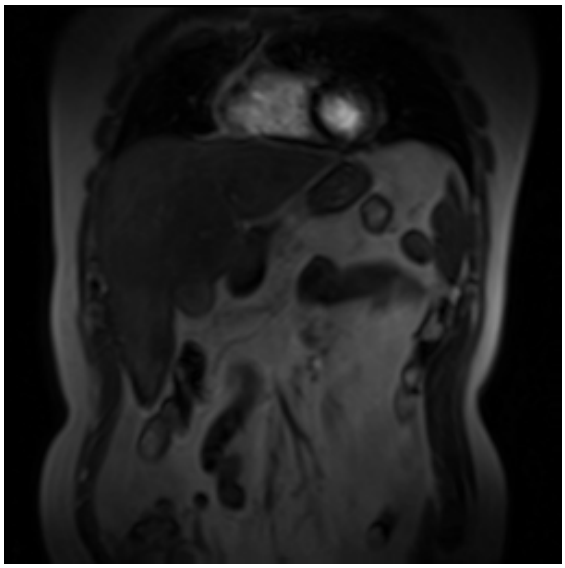
DCE-MRI: kinetic models

Compartimental (Tofts)

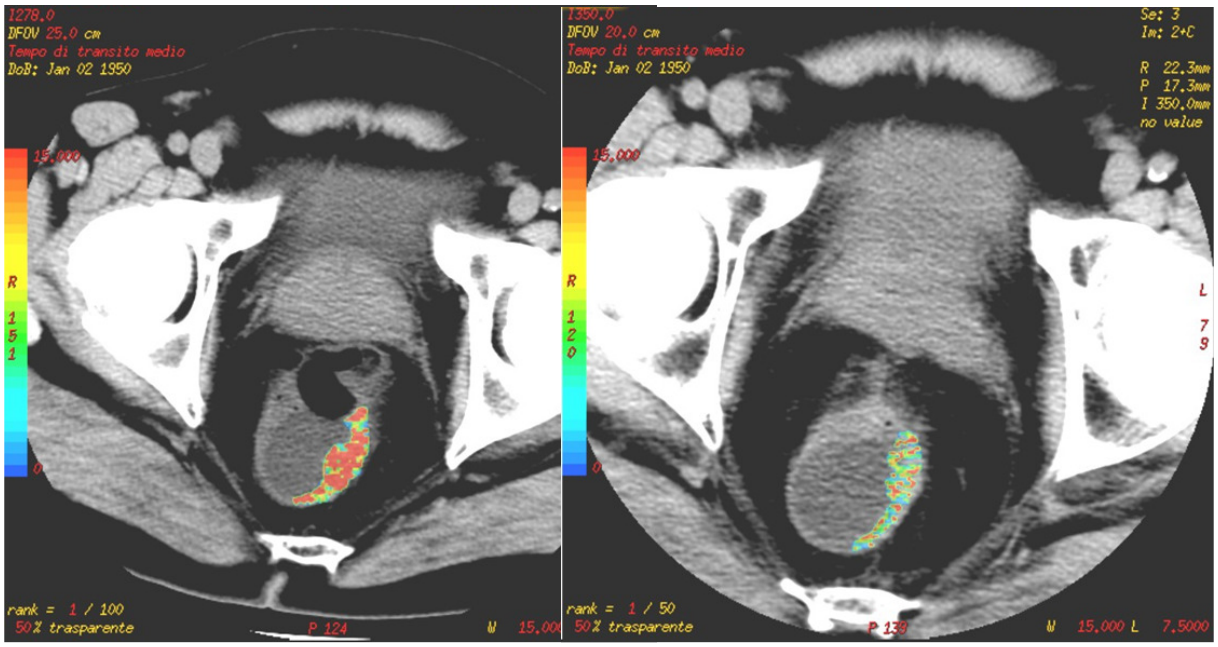
- Ktrans
- Kep
- Ve

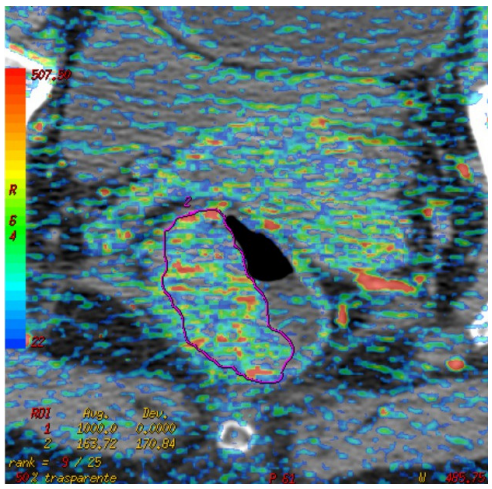


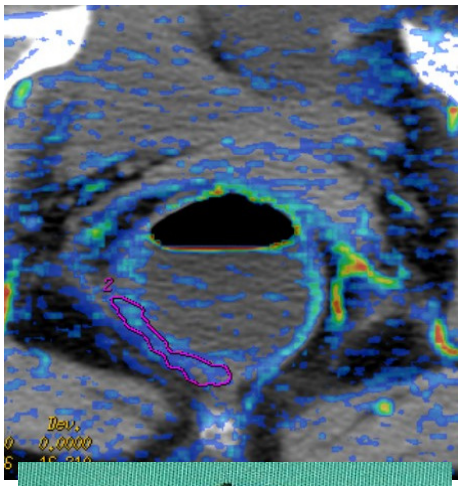

PLATI' ROCCO
A 186
Aug 26 2005
Ex: 7422
Se: 4
Im: 35+C
1150.0
DFOV 24.7 cm
DoB: May 02 1934
L 33.6mm
A 40.6mm
I 150.0mm
-49
2
R
L
1
7
0
1
0
ROI mm² Avg. Min. Max. Dev. Rel.
1 44 48.418 27 71 10.442 0.211
2 7070 51.395 -28 90 9.7877 0.187
rank = 8 / 32
time = 8001 ms
P 60
W = 134 L = 78

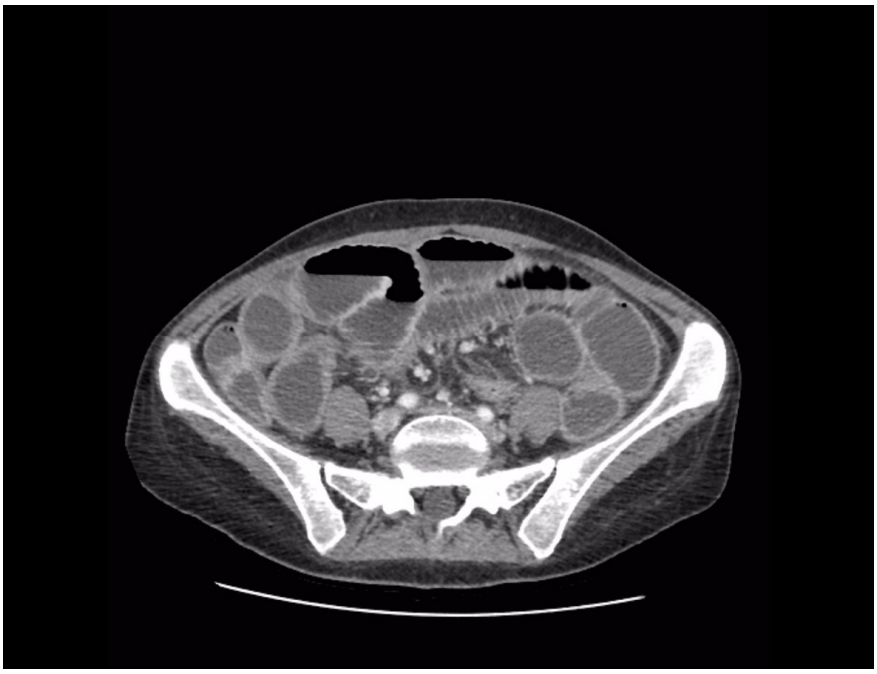


Rectal cancer response monitoring

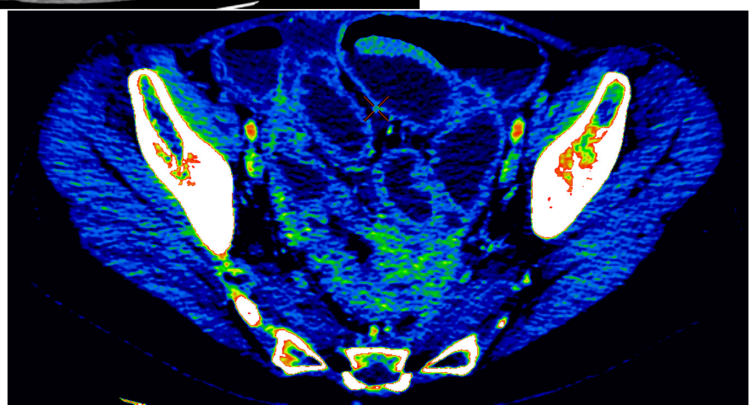








33 yrs old woman with abdominal pain and occasional ileus after RT for carcinoma of the cervix



DW-MRI in oncology: "marker" of cellularity

DW-MRI → "an extraordinary opportunity for DW-MRI to evolve into a clinically valuable imaging tool, potentially important for drug development."

Meeting Report

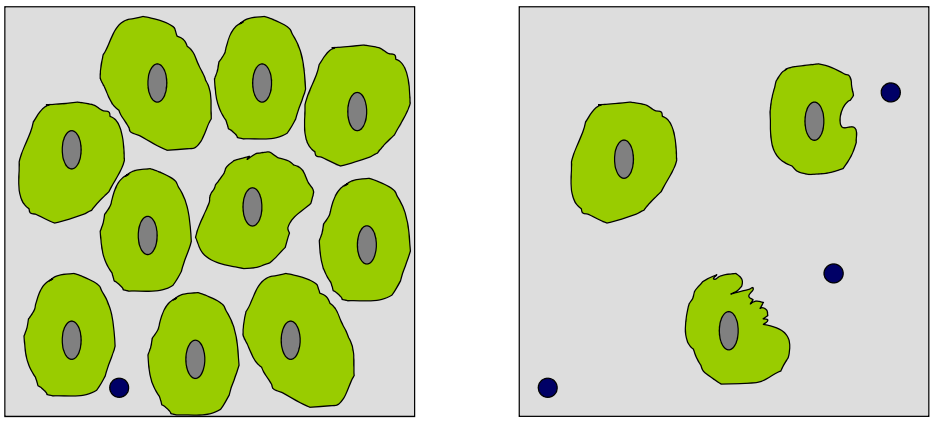
Diffusion-Weighted Magnetic Resonance Imaging as a Cancer Biomarker: Consensus and Recommendations

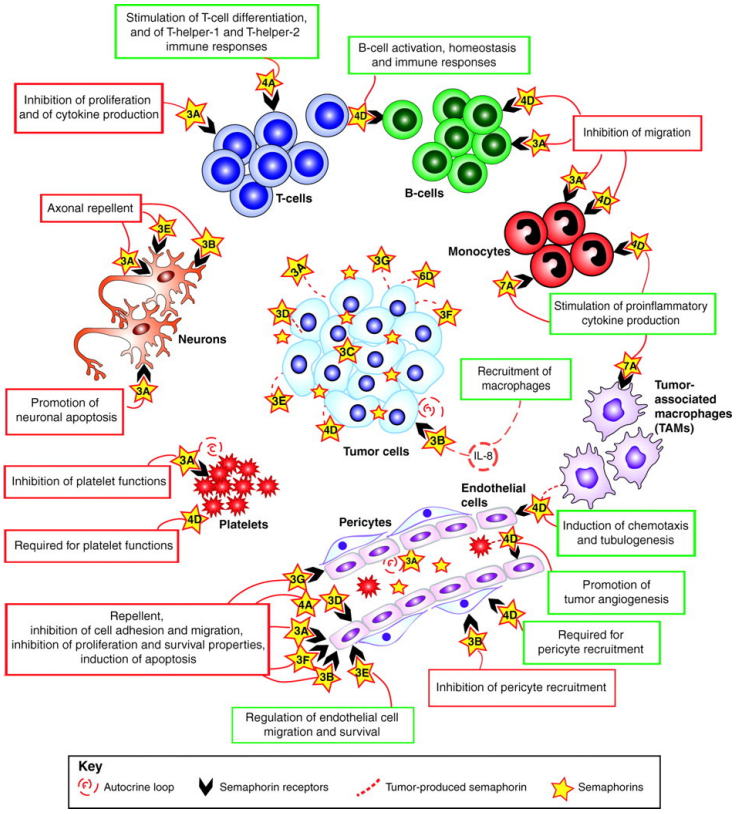
Anwar R. Padhani[*], Guoying Liu[†], Dow Mu-Koh[‡], Thomas L. Chenevert[§], Harriet C. Thoeny[¶], Taro Takahara[#], Andrew Dzik-Jurasz[**], Brian D. Ross[§], Marc Van Cauteren[††], David Collins[‡], Dima A. Hammoud[‡‡], Gordon J.S. Rustin[*], Bachir Taouli[§§] and Peter L. Choyke[†]

[*]Mount Vernon Cancer Centre, London, UK; [†]National Cancer Institute, Bethesda, MD, USA; [‡]Royal Marsden Hospital and Institute of Cancer Research, London, UK; [§]Center for Molecular Imaging, Ann Arbor, MI, USA; [¶]University Hospital of Bern, Bern, Switzerland; [#]University Medical Center, Utrecht, The Netherlands; [**]Novartis Pharmaceuticals Corporation, East Hanover, NJ, USA; [††]Philips Healthcare BU-MR Asia Pacific, Tokyo, Japan; [‡‡]Clinical Center, NIH, Bethesda, MD, USA; [§§]NYU Medical Center, New York, NY, USA

Padhani AR, Liu G, Koh DM, et al. Neoplasia 2009

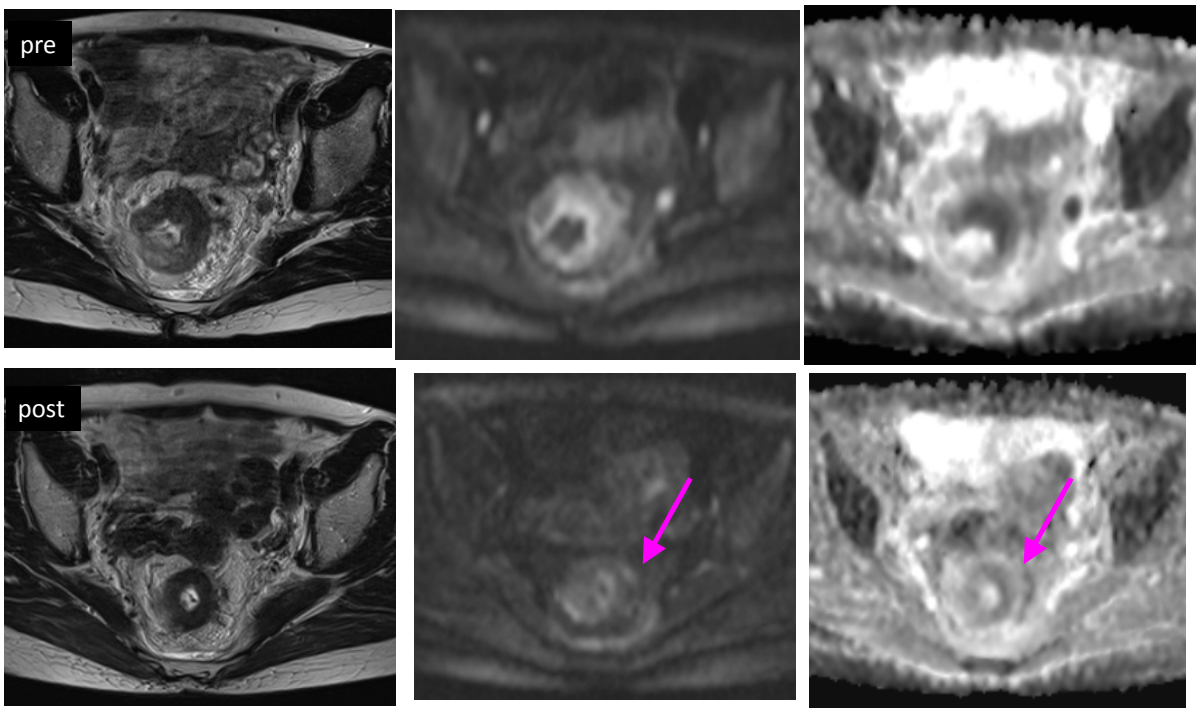
Factors influencing DWI are many…



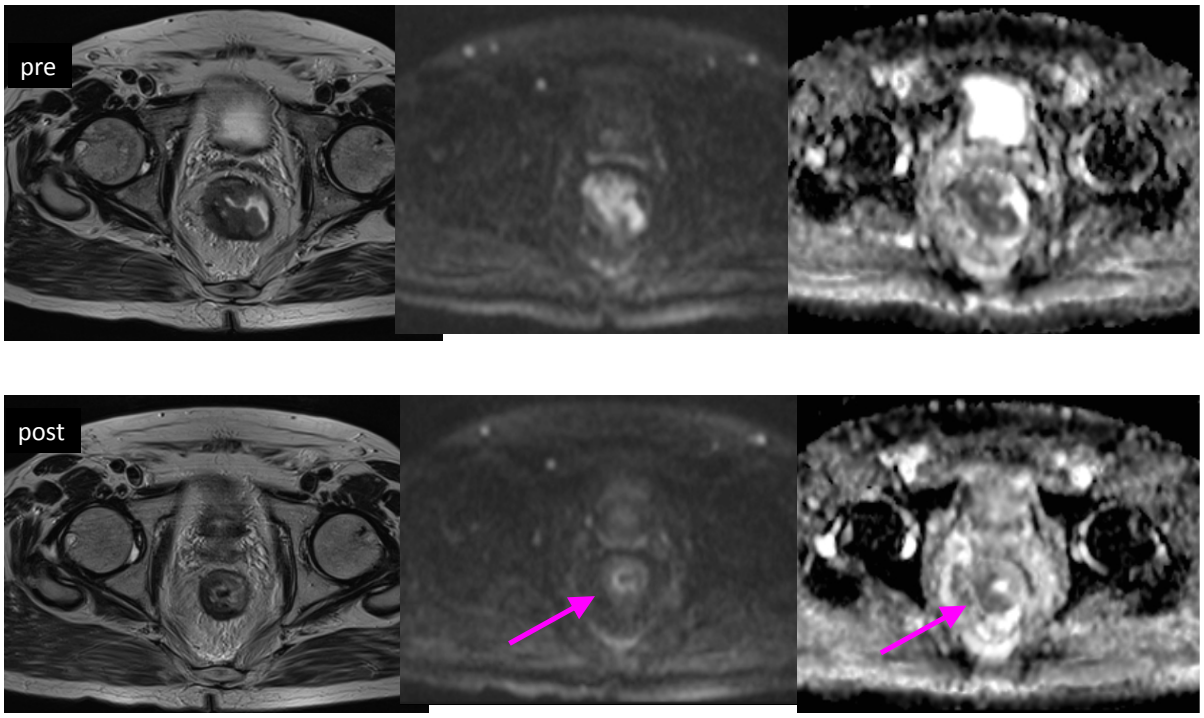


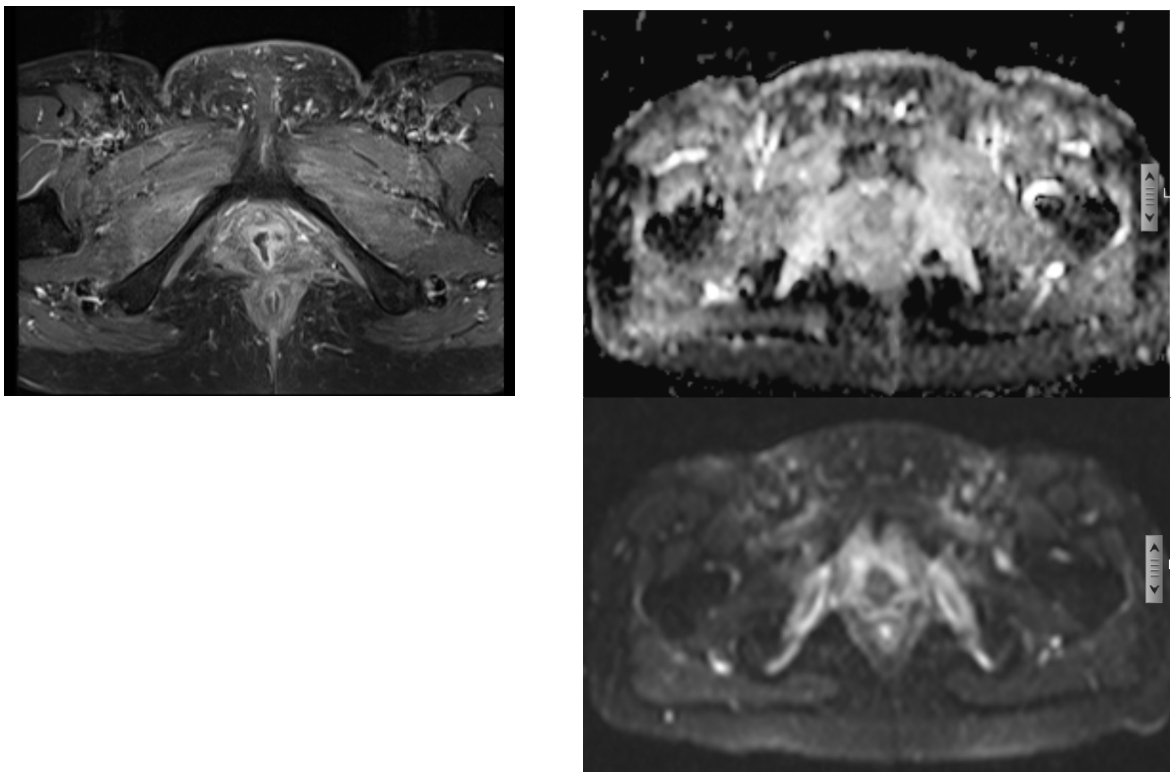
Capparuccia L , and Tamagnone L J Cell Sci 2009;122:1723-1736

Rectal ca after NACRT - pCR

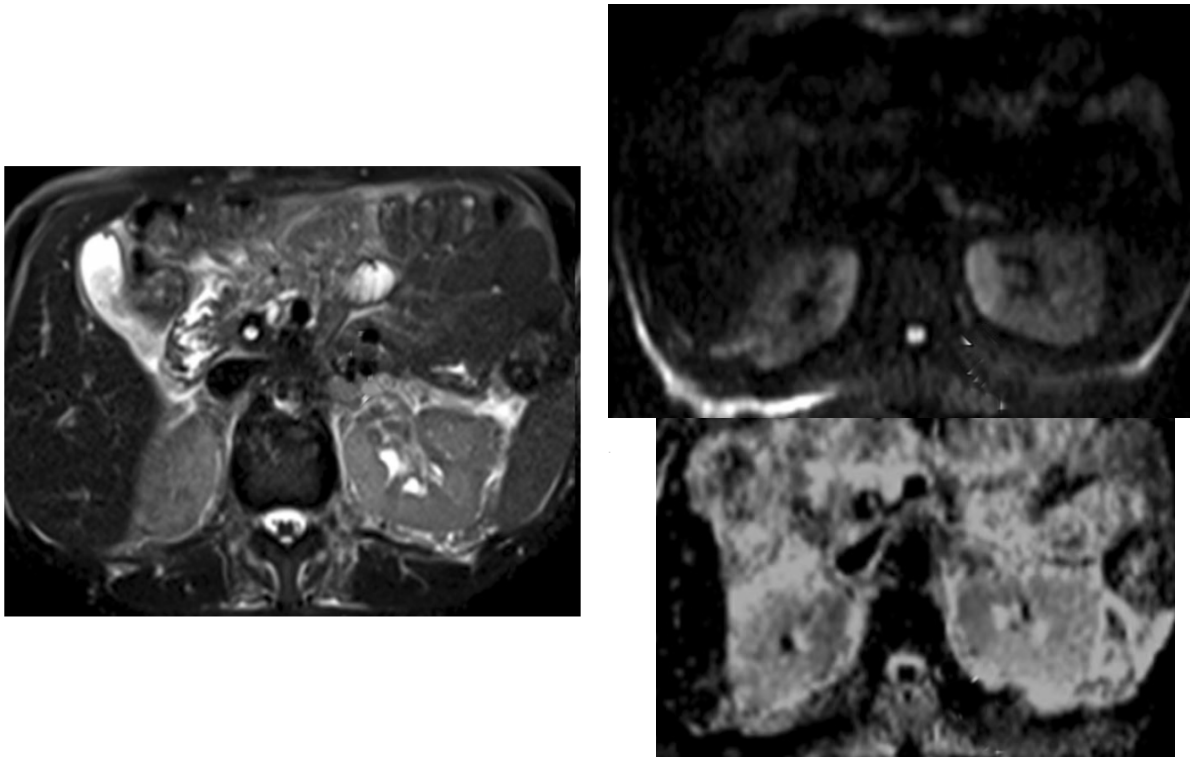


Rectal ca after NACRT – resid.





50 yrs old woman with rectovaginal fistula after Radio-Chemo-therapy for carcinoma of the posterior vaginal wall

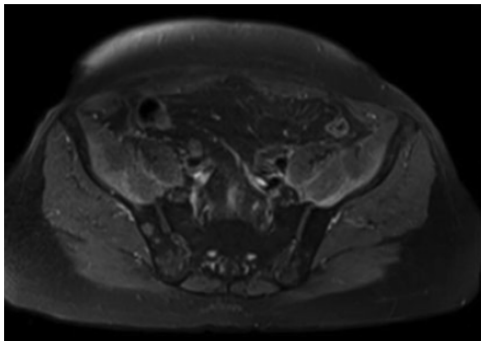


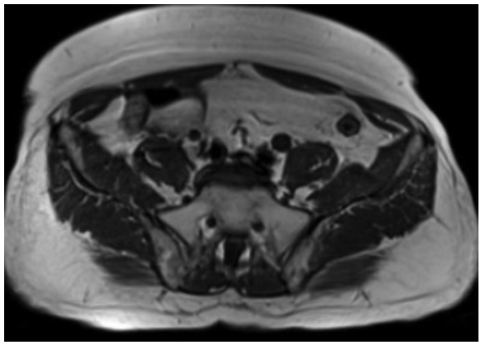
50-year-old man treated for L2 met. from pancreatic carcinoma. 9 months later: increased T2 signal intensity in the medial upper pole renal cortex, with restricted diffusion and low signal intensity on ADC map: acute radiation nephropathy.

…the clinical and forensic consequences of a wrong conclusion and the need for a new semeiotic.

FIRST

the radiologist must be aware of the variety of appearances of tissue in patients who have undergone radiation therapy.

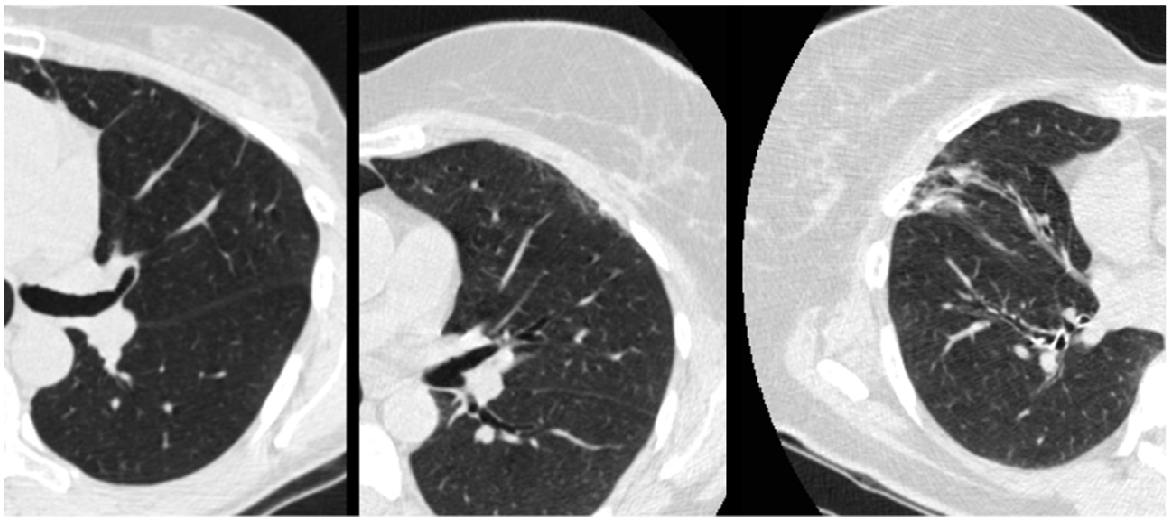




Bilateral focal red bone marrow changes in iliac bones in 60-year-old woman who received radiation therapy for bladder cancer. (Axial fat-suppressed T1-weighted post-contrast image shows no contrast enhancement.

SECOND

In the majority of cases in which radiation-induced changes are noted, patients are asymptomatic and the abnormal findings represent physiologic reactions to radiation therapy.
When the radiologist analyzes the images and is aware of the radiation ports, dose, and time frame since therapy, he or she is most likely to avoid misdiagnosis.

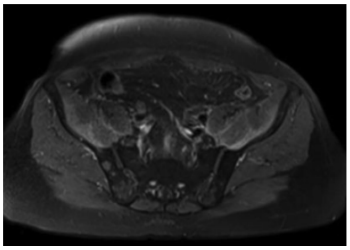


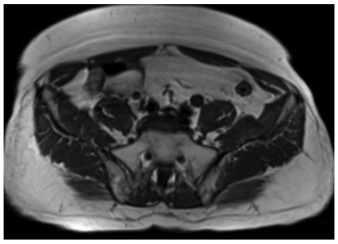
THIRD

Speak to the patient ! (*and listen to him*)

Whether used as a primary therapeutic modality or in combination with chemotherapy or surgery, radiation therapy remains a mainstay in the treatment of a wide variety of neoplasms. Depending on the area irradiated (target tissue), radiation dose, and dose fractionation, a variety of complications may occur. Although most patients remain asymptomatic, significant morbidity may result from the therapeutic regimen. In recent years, the frequency of radiation-induced complications has decreased with more pinpoint therapeutic beam control, the introduction of three-dimensional radiation therapy planning, and better understanding of tissue response.

Radiation-induced pelvic bone complications are not uncommon after radiation therapy. As radiation therapy is a curative treatment for many cancer patients, these effects and imaging characteristics need careful attention. Patients must be carefully assessed when pelvic pain appears, and pelvic bone complications must be considered in the differential diagnosis. Knowledge of characteristic imaging patterns of bone complications is essential in order to rule out bone metastases and to avoid inaccurate or excessive treatment.





Bilateral focal red bone marrow changes in iliac bones in 60-year-old woman who received radiation therapy for bladder cancer. (Axial fat-suppressed T1-weighted post-contrast image shows no contrast enhancement.

While most
serious complications related to radiotherapy
are relatively uncommon, given the number of
patients that are treated
and the relatively long latency period for
development of radiation changes, follow-up
imaging studies frequently
have findings that should be recognized as
radiation related.

techniques such as IMRT and proton therapy
are
specifically designed to decrease dose and
injury to
tissues surrounding malignant tumors.
However some
patients treated with definitive radiation
therapy over
the past several decades continue to survive
and present
for surveillance. Evaluation of imaging studies
in these
patients requires an understanding of the
expected
changes post therapy.
References

Radiation-induced malignancies such as invasive ductal carcinoma, lymphoma and angiosarcoma are infrequent and late complications (11). Radiation-induced angiosarcomas are very rare tumors of endovascular origin. Primary angiosarcoma accounts for only 0.04% of breast tumors and affects patients of younger age (20-40 years). Secondary angiosarcoma induced by radiotherapy occurs in older aged patients, with a mean age of 68 years. Secondary angiosarcoma is difficult to diagnose due to its rarity, benign appearance and difficulty in differentiation from radiation-induced changes in the skin (12) (Fig. 13). Therefore, it is very important that radiologists are aware of the possible presence of an angiosarcoma.

three criteria characteristic of cancers caused by radiation therapy: 1) histologic features of first cancer and secondary cancer are different, 2) secondary cancer is within the area previously treated with radiation, and 3) the secondary cancer has a latency period of 5 years – that is, the secondary cancer develops five years or later after the first. These criteria are not set in stone, but stand as a good general reference when trying to deduce whether a cancer was likely secondary to radiation.

and older with cancers originating at 15 anatomic sites throughout the body. Both patients treated without and with radiation therapy were included in the analysis. Among all patients, 60,271 (9%) developed a second solid cancer, of which 3,266 were estimated to be related to radiotherapy, corresponding to a risk of five excess cancers per 1,000 patients treated with radiotherapy at 15 years after diagnosis. The authors appropriately concluded that a relatively small proportion of second cancers are related to radiotherapy in adults, suggesting that most are due to other factors such as lifestyle, carcinogenic exposures, and genetics. Highlighting the differences in risk across cancer sites, only 4% of second cancers originating in or around the eye were related to radiation therapy, yet 24% of second cancers following treatment of primary testicular cancer in men were related to radiation therapy. Of note, it is relatively uncommon nowadays to undergo radiation therapy for testicular cancer – surgery and chemotherapy are the most common forms of current treatment.

Generally, the risk of developing a radiation induced malignancy after treatment of cancer is very small, though certainly a scary thought. Remarkably though, radiotherapy related cancers account for a small minority of second cancers which develop in patients after treatment for a first cancer. In the Lancet study above, nearly 10% of cancer patients developed second cancers, but only 0.5% of patients developed cancers which seemed likely to be radiotherapy related. In discussion with cancer patients, radiation oncologists strive to balance the often highly effective cancer controlling benefit of radiation with the risk of secondary malignancy, as well as other possible side effects of treatment. Thankfully, with modern radiation techniques, the risk of causing a secondary malignancy is less than that demonstrated in historical studies, due to higher precision radiation targeting.