SPECTRAL PHOTON-COUNTING CT MULTI-PHASE URINARY TRACT IMAGING USING DUAL CONTRAST

INITIAL EXPERIENCE

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SPECT
IMAGING ALL THE PHOTONS

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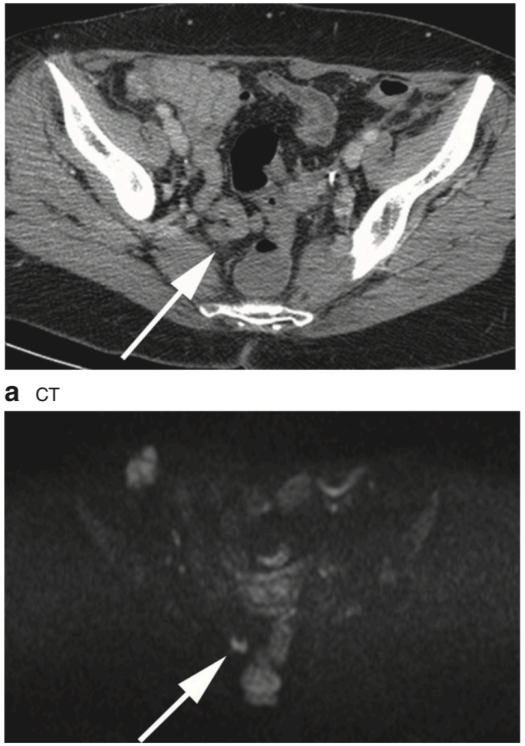
INTRODUCTION

- Peritoneal imaging
  - Crucial for the evaluation of peritoneal metastasis spread
  - Delay in diagnosis may alter the treatment management resulting in a life-threatening prognosis [1]

[(1)] *Jayne DG. Br. J. Surg. 2002*

- Computed tomography
  - First line in oncologic imaging
  - Intrinsic limitations resulting in underestimation of the peritoneal metastasis spread [2]



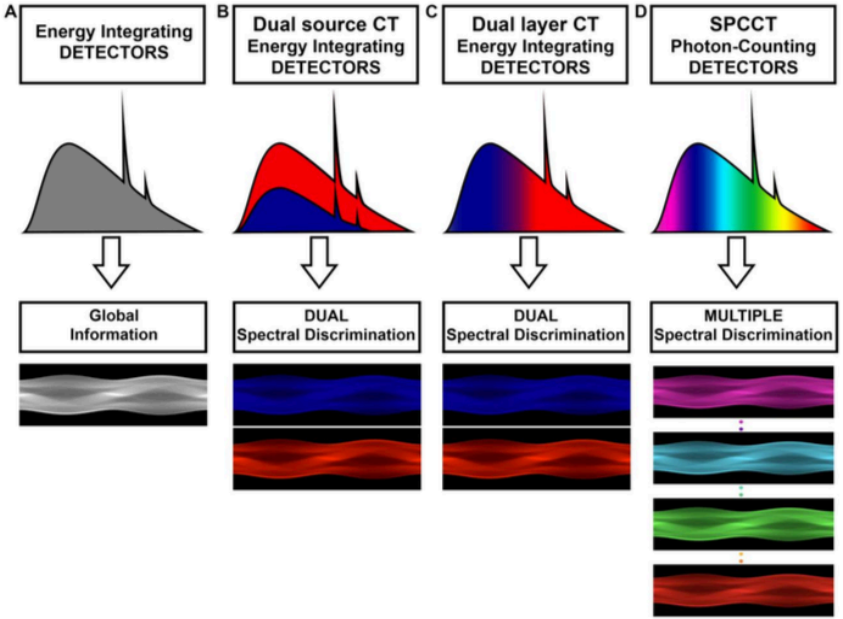
a CT

b Diffusion-weighted MRI

[(2)] *Dohan A et al. Br J Surg. 2017*

INTRODUCTION

- Spectral photon-counting computed tomography (SPCCT) technology
  - New and promising imaging modality
  - Development of energy resolving detectors called photon-counting detectors [1]
    - **K-edge imaging**
    - **Absolute quantification**
    - **Multiple contrast imaging**
  - Improved intrinsic spatial resolution [1]



[1] Si-mohamed et al. NIMAA. 2017

OBJECTIVE

To assess the feasibility of using a pre-clinical prototype spectral photon-counting computed tomography (SPCCT) to explore the peritoneal cavity in rats using two contrast agents simultaneously within the blood and peritoneal cavity compartments.

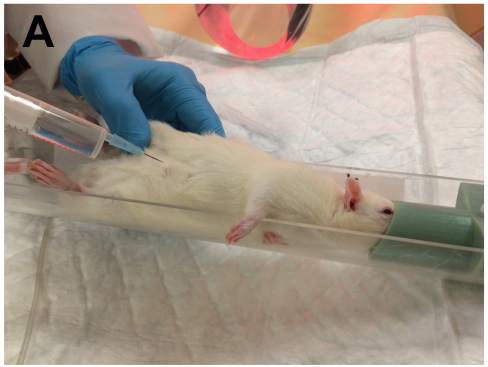
MATERIALS/METHODS

- Spectral photon-counting CT system (SPCCT)
  - 5 bins photon-counting detectors set as 30, 51, 64, 72, 85 keV
  - Conventional X ray tube
  - Limited field of vue of 160 mm
  - **Spatial resolution: 250 µm**
  - Parameters used:
    - Tube current of 100 mAs
    - Tube voltage of 120 kVp

Philips Spectral Photon Counting CT pre-clinical prototype UCBL, CERMEP, Lyon, France

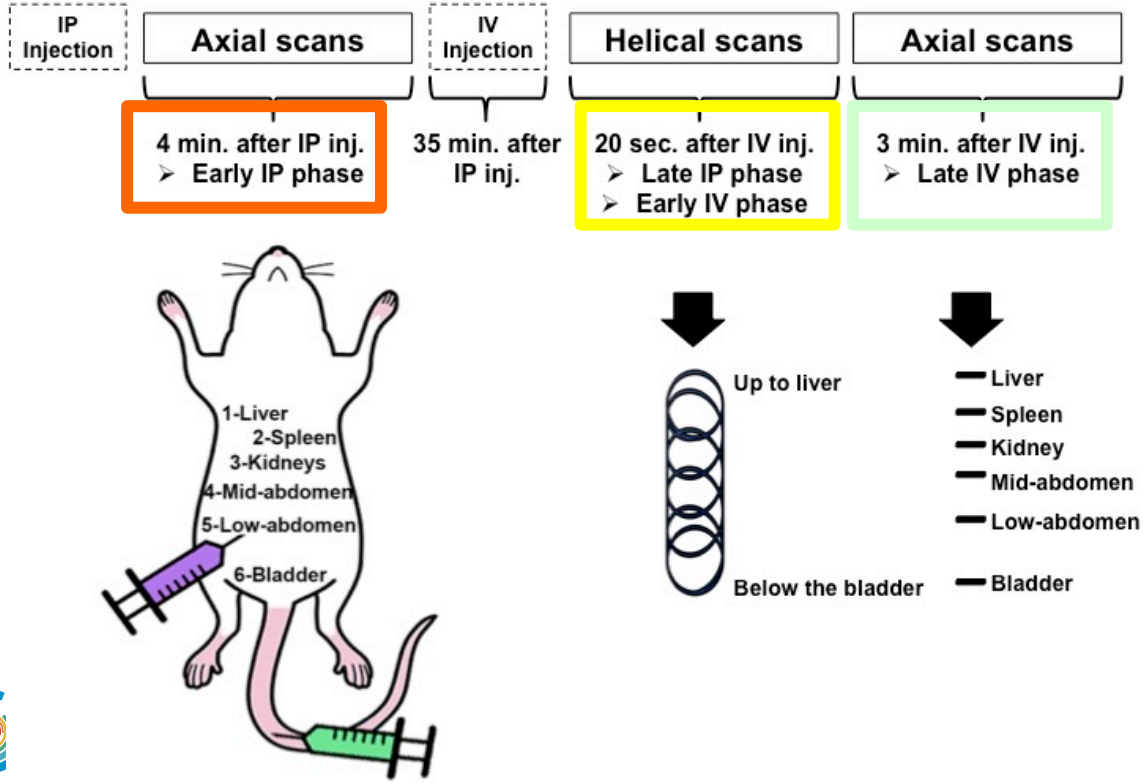
MATERIALS/METHODS

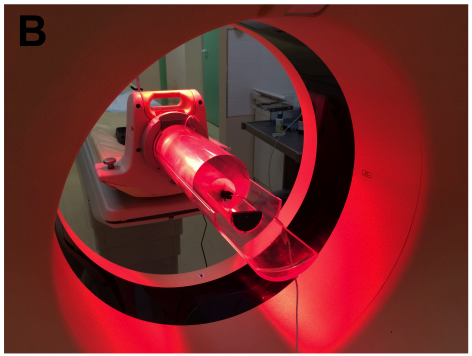
- Two groups of 3 Sprague Dawley rats (510±64 g)
- Two protocols:
  - Protocol A: IP gadolinium and IV iodine
  - Protocol B: IP iodine and IV gadolinium
- Contrast agents:
  - Macrocyclic gadolinium based contrast agent (Dotarem®, 0.5 M) 5 mL/kg for IV and 9 mL of a dilute solution (20%) for IP
  - Iodine based contrast agent (Xenetix®, 350 mg/mL): 2.1 mL/kg for IV injections and 9 mL of a dilute solution (5%) for IP
- Fasted for 3 hours and then gavage-fed with 2.5 mL of 20% Mannitol B. Braun®
- IV of antiperistaltic (0.1 mL of GlucaGen®, glucagon) 20±10 min before acquisition



Photograph of the intraperitoneal injection technique

MATERIALS/METHODS





Photograph of a rat positioned in the SPCCT scanner

MATERIAL/METHODS

- Image reconstruction
  - Conventional images (HU units)
  - Contrast material maps: K-edge gadolinium and iodine maps (mg/ml units)

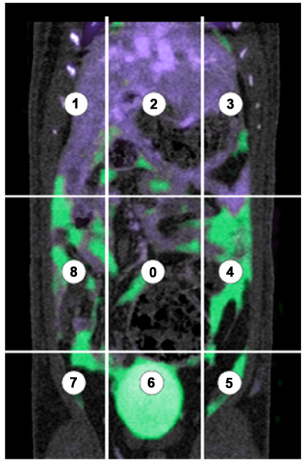
- Image analysis
  - Reconstruction of two spatial resolution images
    - with the spatial resolution standard CT-like at 600 µm
    - with the spatial resolution standard SPCCT at 250 µm
  - Qualitative scoring by three radiologists of **image noise, sharpness, diagnostic quality and small structures visualisation** based on a 4 point Likert scale (1: poor, 2: acceptable, 3: good, 4: excellent)

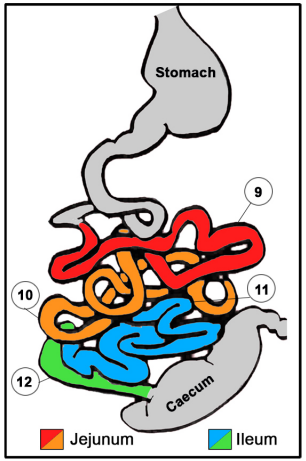
MATERIAL/METHODS

- Evaluation of the peritoneal opacification
  - on conventional maps
  - on contrast material maps

=> based on a modified peritoneal cancer index of Sugarbaker model for animal experiment [(1)]

[(1)] *Jacquet P, Sugarbaker PH. Clinical research methodologies in diagnosis and staging of patients with peritoneal carcinomatosis. Cancer Treat. Res. 1996;82:359–374.*





Regions 0 - 12	Score
0 - Central	…
1 - Right upper	…
2 - Epigastrium	…
3 - Left upper	…
4 - Left flank	…
5 - Left lower	…
6 - Pelvis	…
7 - Right lower	…
8 - Right flank	…
9 - Proximal jejunum	…
10 - Lower jejunum	…
11 - Upper ileum	…
12 - Lower ileum	…
TOTAL	… / 39

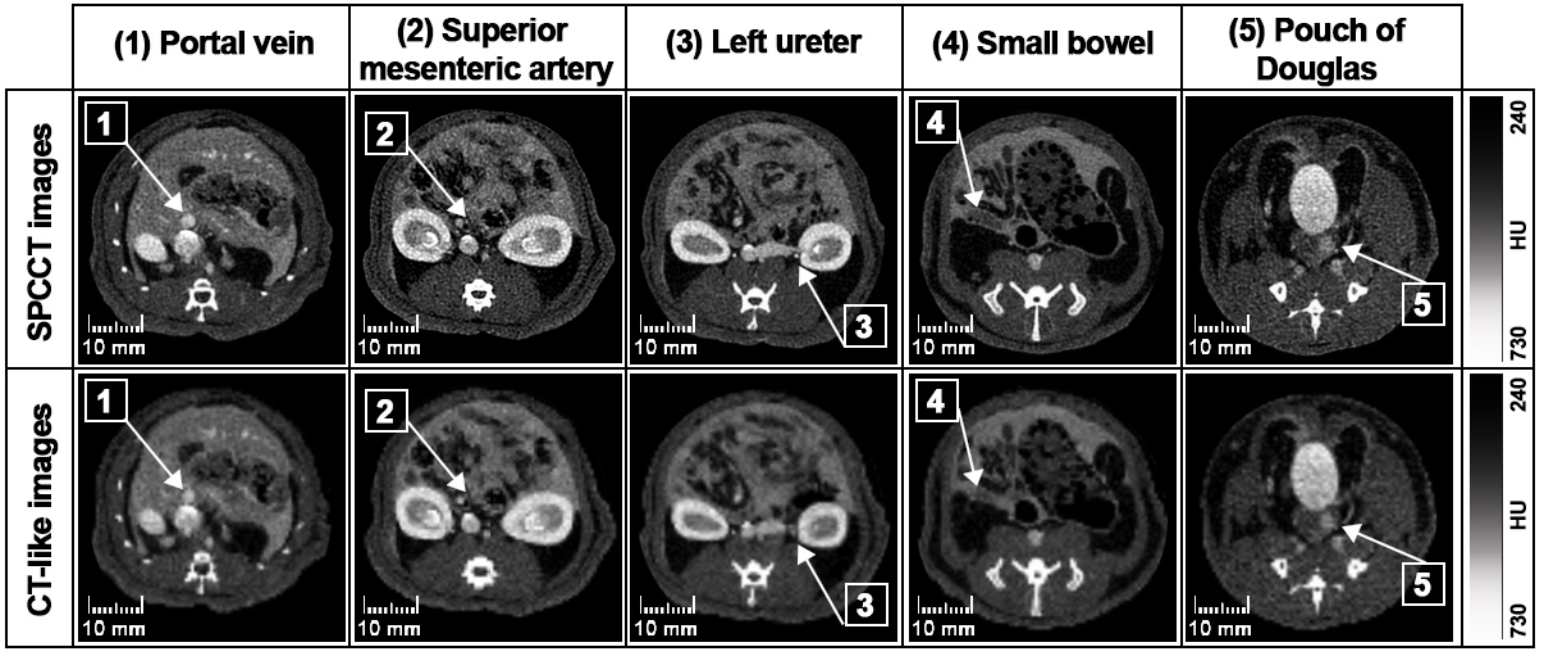
Opacification score for each region : 0=none, 1=few, 2=correct, 3=good

Schematic representation of the peritoneal opacification index (POI)

SPCCT IMAGING ALL THE PHOTONS

RESULTS

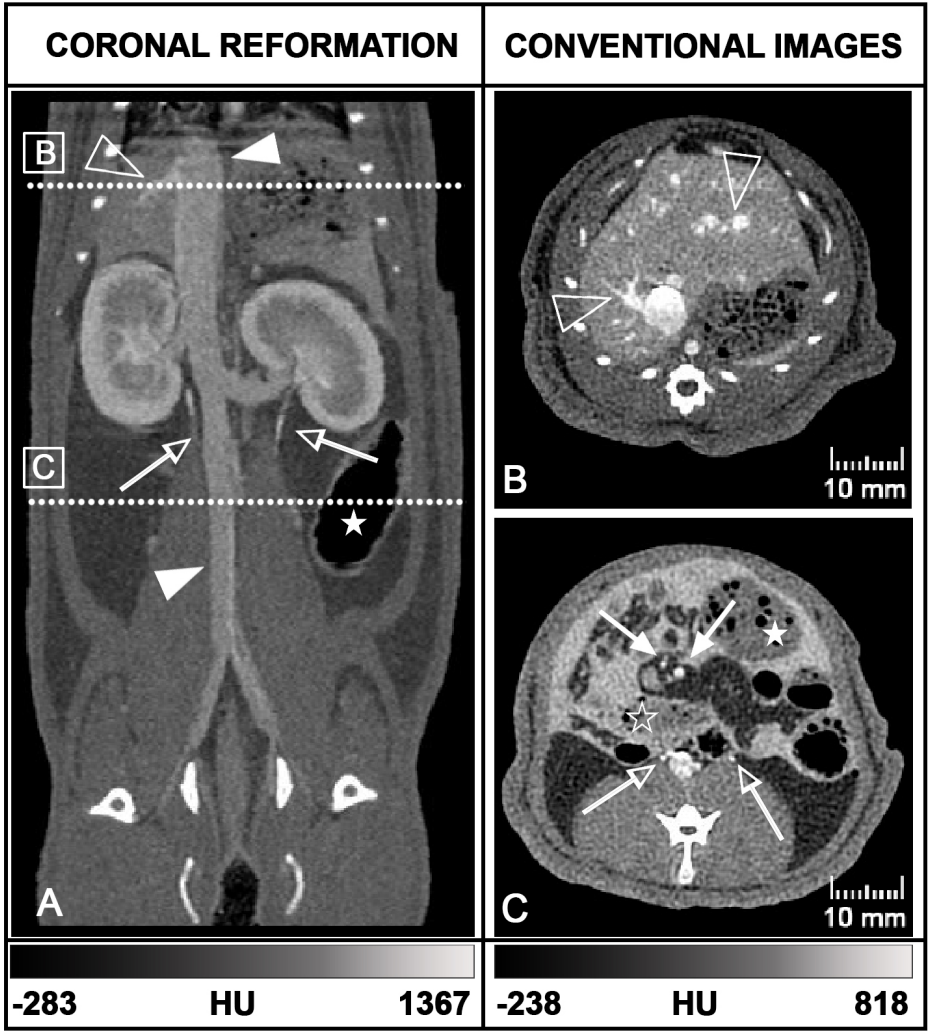
- Better diagnostic quality, image sharpness, depiction of small strutures of SPCCT images *vs* standard CT-like images
- Excellent and good interrater reliabilities (Kappa>0.6)



RESULTS

- Peritoneal opacification
  - Protocol A: 37±1.7
  - Protocol B: 35.3±1.5

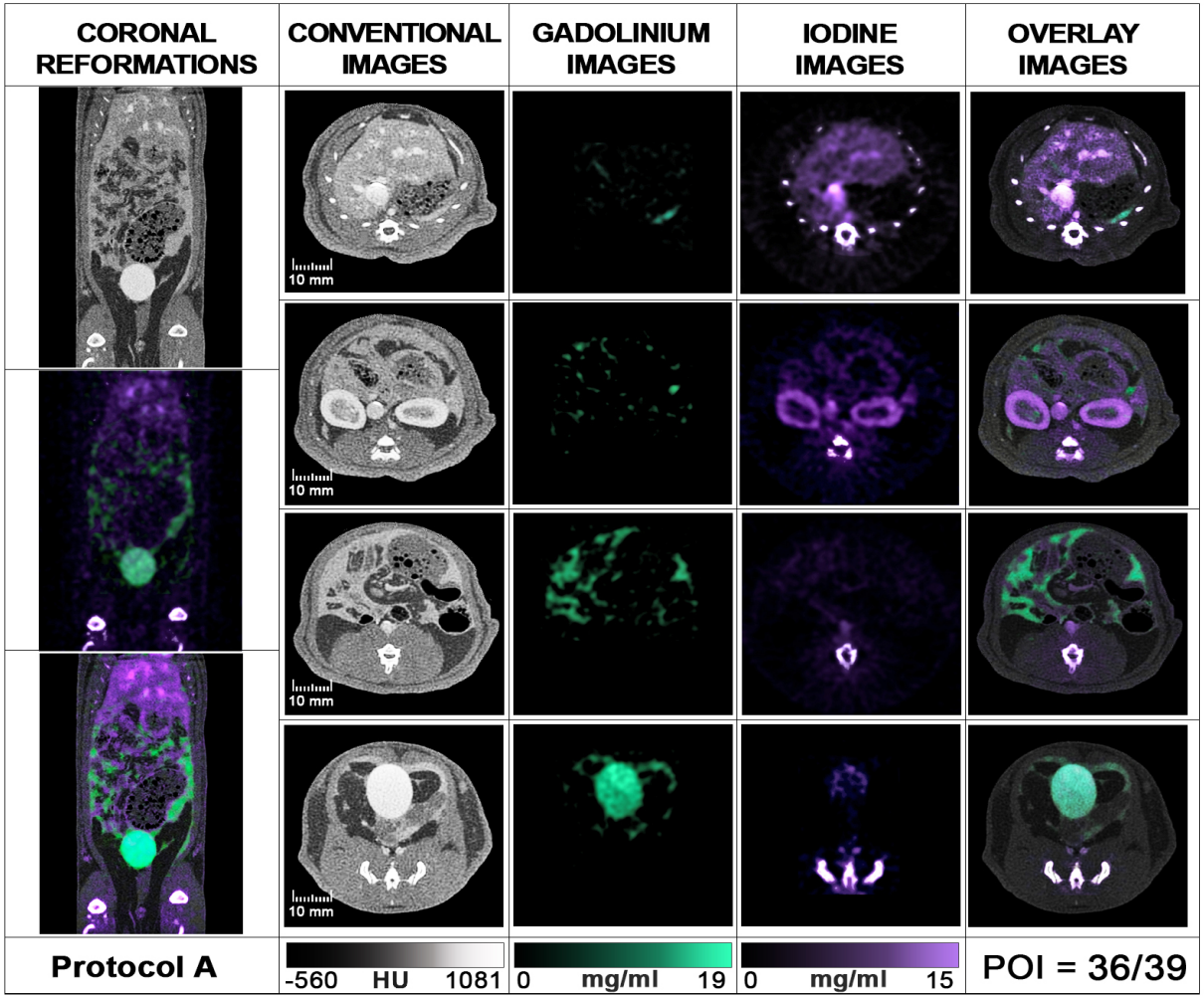
- Small structures depiction



SPCCT
IMAGING ALL THE PHOTONS

RESULTS

- Clear visual separation of the contrast agents
- Peritoneal opacification
  - similar score between HU and material maps



SPCCT
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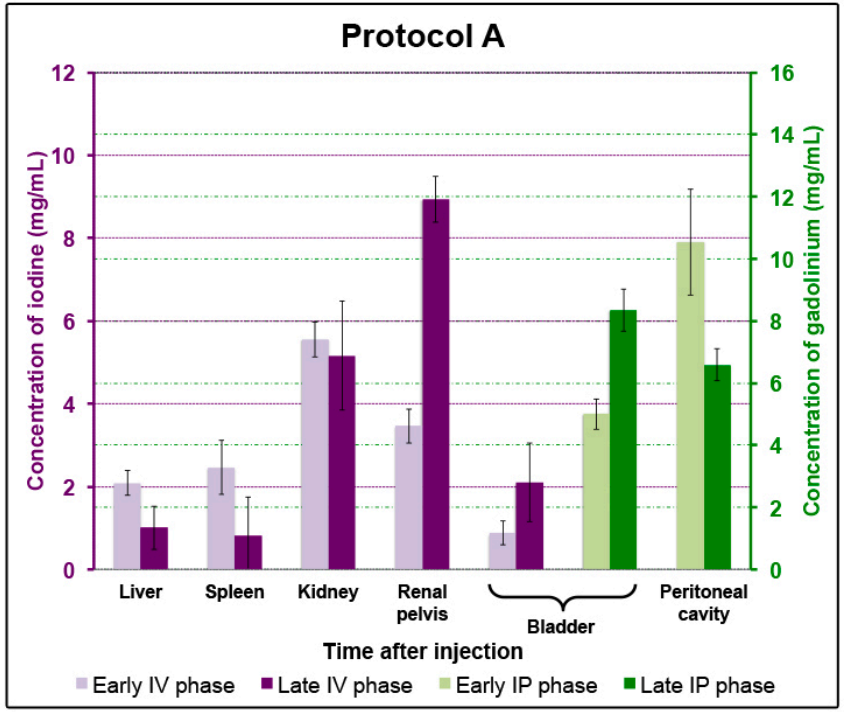
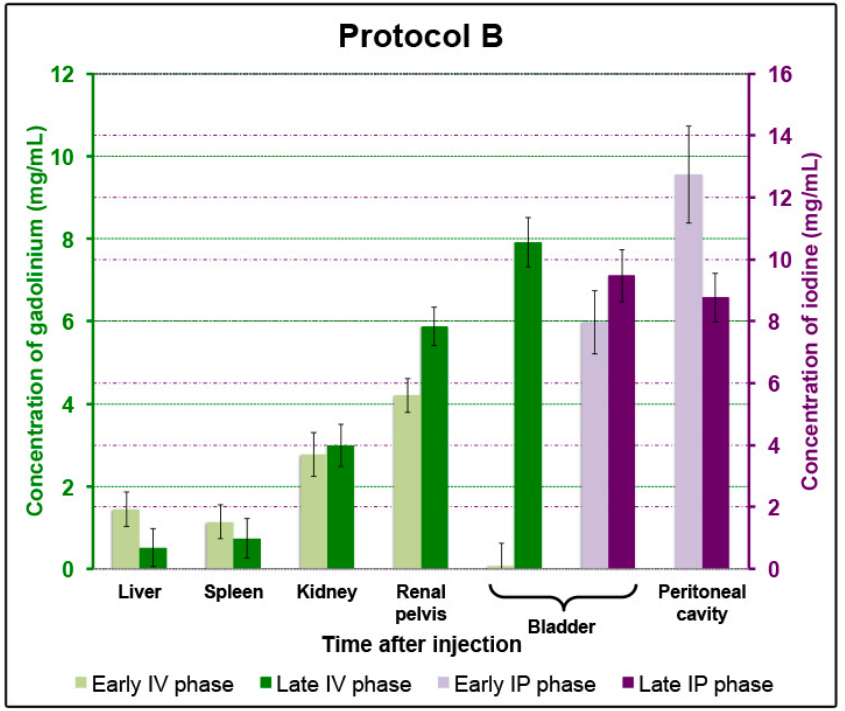
RESULTS

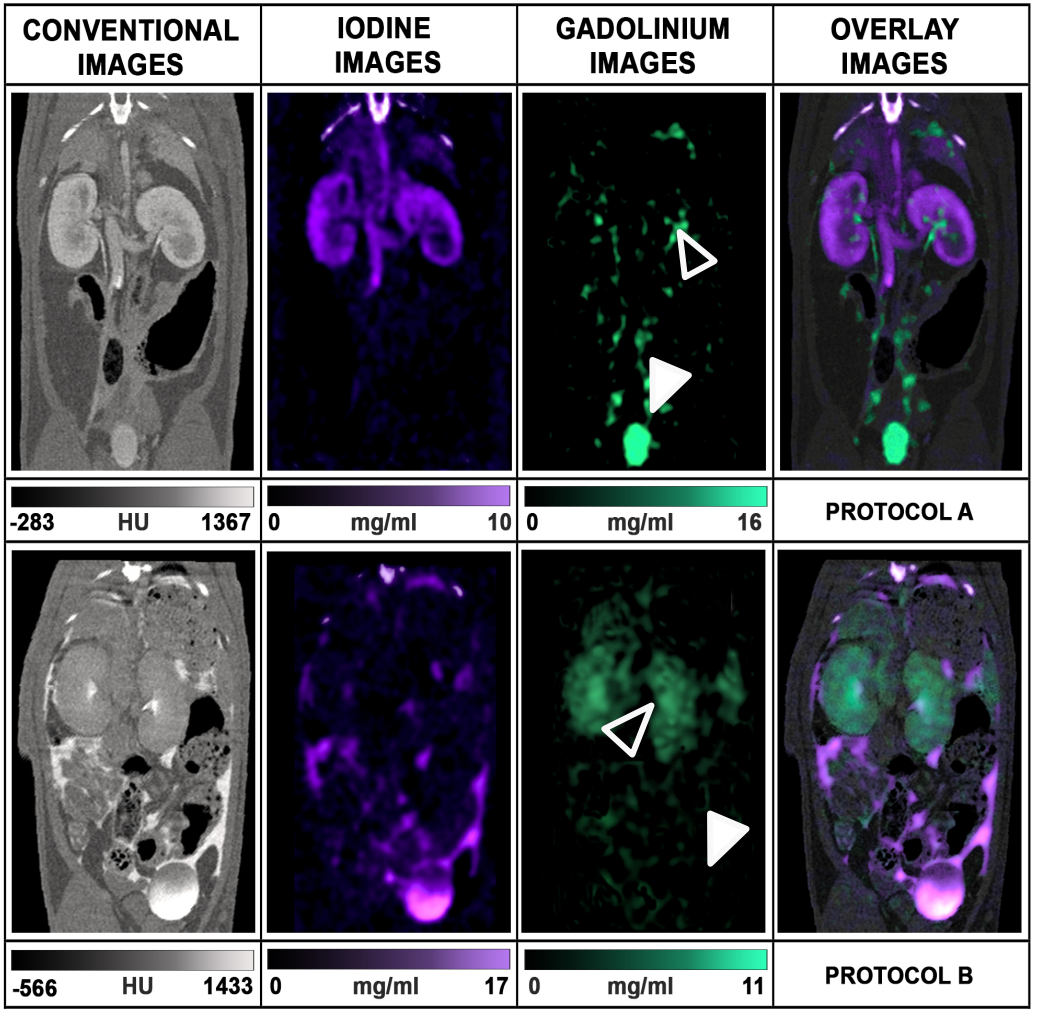
– Concentration pharmacokinetics in mg/mL of the contrast agents





RESULTS

- Discrimination of a late renal excretion of the IP agent
  - Blood diffusion



SPCCT
IMAGING ALL THE PHOTONS

DISCUSSION

- Ability of a dedicated prototype spectral photon-counting CT system to perform *in vivo* **high spatial and multicolor** dynamic peritoneal imaging

- Combination of a negative contrast strategy to potentially enhance normal tissue surrounding the tumor, with the conventional approach of enhancing the tumor, highlighting **the spectral capabilities of the system**, with **differentiation and quantification of two contrast agents**

  => Functional approach of peritoneal CT imaging

PERSPECTIVES

- Evaluation of physiopathologic process of the peritoneal tumors, such as the **quantification of the vascular bed relative to the neoangiogenesis that could be marker of treatment response.**

- Using a candidate for K-edge imaging would be an additional value for **radiosensization of peritoneal lesions using theranostic agents such as nanoparticles based on candidate for K-edge imaging, e.g. gold, or gadolinium**

THANK YOU FOR ATTENTION