The role of Hybrid Imaging in Paediatrics

Contributors: Ben Thurlow, Simon King, Dr. Lorenzo Biassoni
Travel and registration funded by the Society & College of Radiographers (UK)
Hybrid Imaging – Where are we Today?

• Hybrid imaging has now become firmly embedded into diagnostic imaging pathways

• Ability to undertake anatomical and functional imaging within one integrated environment.

• Use of dual-modality imaging technology, such as SPECT CT, PET CT and more recently, PET MR, SPECT-PET-CT.

• Data may be displayed independently of each other or as a *fused overlay*. *ie; high spatial resolution CT or MR imaging superimposed on functional imaging.*
Hybrid Imaging – Where are we Today?

• Ability to undertake anatomical and functional imaging in one environment
• Use of dual-modality integrated imaging systems, such as PET/CT and more recently, SPECT/CT
• The acquired data may be displayed independently of each other, or as a fused overlay of high spatial resolution CT images superimposed on functional images

Hybrid Imaging – Does it add anything new?

YES!

• The literature demonstrates the additional value of SPECT/CT, PET CT and PET MR
• Its use has resulted in a significant reduction in the number of equivocal reports.
• Problem solving tool – adding to the arsenal not replacing modalities as of yet

PET/MR imaging: technical aspects and potential clinical applications.

Toriqian DA¹, Zaidi H, Kwee TC, Saboury B, Udupa JK, Cho ZH, Alavi A.

Abstract

Instruments that combine positron emission tomography (PET) and magnetic resonance (MR) imaging have recently been assembled for use in humans, and may have diagnostic performance superior to that of PET/computed tomography (CT) for particular clinical and research applications. MR imaging has major strengths compared with CT, including superior soft tissue contrast resolution, multiphase image acquisition, and functional imaging capability through specialized techniques such as diffusion-tensor imaging, diffusion-weighted (DW) imaging, functional MR imaging, MR elastography, MR spectroscopy, perfusion-weighted imaging, MR imaging with very short echo times, and the availability of some targeted MR imaging contrast agents. Furthermore, the lack of ionizing radiation from MR imaging is highly appealing, particularly when pediatric, young adult, or pregnant patients are to be imaged, and the safety profile of MR imaging contrast agents compare very favorably with iodinated CT contrast agents. MR imaging also can be used to guide PET image reconstruction, partial volume correction, and motion compensation for more accurate disease quantification and can improve anatomic localization of sites of radiotracer uptake, improve diagnostic performance, and provide for comprehensive regional and global structural, functional, and molecular assessment of various clinical disorders. In this review, we discuss the historical development, software-based registration, instrumentation and design, quantification issues, potential clinical applications, potential clinical roles of image segmentation and global disease assessment, and challenges related to PET/MR imaging.
Hybrid Imaging – Where are we Today?

- Ability to undertake anatomical and functional imaging in one environment
- Use of dual-modality integrated imaging systems, such as PET/CT and more recently, SPECT/CT
- The acquired data may be displayed independently of each other, or as a fused overlay of high spatial resolution CT images superimposed on functional images

Versions of Hybrid Imaging

Software fusion of data from different systems has always been a possibility.

Potential issues relate to;
- Accurate co-registration of data
- Time delay between anatomical / functional datasets
- Operator dependency

Integrated hybrid imaging environments

The clinical use of dual-modality imaging began with the commercial introduction of;

- SPECT/CT in 1999
- PET/CT in 2001
Hybrid Imaging – Where are we Today?

- Ability to undertake anatomical and functional imaging in one environment
- Use of dual-modality integrated imaging systems, such as PET/CT and more recently, SPECT/CT
- The acquired data may be displayed independently of each other, or as a fused overlay of high spatial resolution CT images superimposed on functional images.

Integrated Hybrid Environments

- PET CT
- PET MR
- SPECT CT
- SPECT CT
Hybrid systems worldwide

Over 1000 SPECT/CT systems currently in use worldwide

Over 2000 PET/CT systems currently in use worldwide

Approx 60 PET MRI systems currently in use worldwide
The use of hybrid imaging within paediatrics

Use of hybrid imaging within the paediatrics remains relatively limited, especially when compared to other cross sectional imaging modalities such as MR and CT.

Why is this?

- Limited experience of the radiographic staff;
- Lack of formal training or guidelines - uncertainty in how to achieve a successful study.
- Limited published data and evidence to support paediatric hybrid imaging
- Cost effectiveness / productivity
- Scan interpretation; difficulties in finding experienced reporters.
- Escalation of the radiation burden from the CT component in SPECT CT or PET CT.
Does hybrid imaging lend itself to paediatrics?

“Children are not small adults” - This is the classic mantra of paediatric healthcare providers.

Children are different from adults in terms of anatomy, physiology, body proportions, development and pathology. (ESR, 2015)

- Where conditions are found in both the adult and paediatric populations, it is reasonable to use hybrid imaging, where sufficient evidence exists.

- However, many conditions are limited to childhood, therefore it is can be difficult to justify its use, especially if evidence cannot be extrapolated from adults.

- In certain circumstances, hybrid imaging may be able to resolve clinical questions that are difficult to answer by anatomical imaging alone.
The GOSH experience...
The GOSH experience...

- Symbia SPECT CT system
- installed in 2008
- 2 slice CT
- 1-10 mm slice width
- 33-240 mA tube current capacity
- Care Dose 4D; mA dose modulation
- Image Fusion processing software
The majority of the referrals requiring hybrid imaging come from Oncology; however there has been unexpected expansion into new areas such Orthopaedics for spine SPECT CT, Urology for DMSA SPECT CT and Endocrinology for Parathyroid SPECT CT.
Breakdown of SPECT CT examinations at GOSH

The breakdown of the clinical workload from 2008-2015 at GOSH (*illustrated in the bar chart above*) demonstrates a year-on-year increase in the number of SPECT CT examinations undertaken within the nuclear medicine department.

This indicates hybrid imaging has been a growth area even within the paediatric population.
MIBG SPECT CT constitutes of the majority of the hybrid imaging examinations.

The bar chart above illustrates that there has been a net year-on-year growth in this examination type since the Siemens Symbia SPECT CT entered clinical use.
SPECT CT practice at GOSH

**MIBG SPECT CT**
- Used in Neuroblastoma or Phaeochromocytoma
- Low dose unenhanced CT for anatomical co-localisation

**Bone SPECT CT**
- Used in orthopaedic back pain and extremity pain, to identify and locate the pain generators
  *When plain film and MRI do not explain the symptoms*

**DMSA SPECT CT**
- Used in renal calculi for;
  - Assessment of function in the adjacent parenchyma
  - Assessment of stone location
Paediatric hybrid imaging – Some important prerequisites..

How is it going to happen?

• Un-sedated
• Feed and Wrap
• Sedation
• GA
CT optimisation

- Crucial that the CT component is optimised for paediatrics because the stochastic risks are greater

Larkin, 2011 has demonstrated how CT can escalate the effective dose

<table>
<thead>
<tr>
<th>Study type</th>
<th>Average radiopharmaceutical effective dose (mSv)</th>
<th>CT effective dose (mSv)</th>
<th>% increase in effective dose by the inclusion of the CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{67}$Ga</td>
<td>37.0</td>
<td>8.2</td>
<td>22%</td>
</tr>
<tr>
<td>$^{99m}$Tc-MDP</td>
<td>6.3</td>
<td>3.8</td>
<td>60%</td>
</tr>
<tr>
<td>$^{99m}$Tc-MIBI parathyroid</td>
<td>8.3</td>
<td>5.4</td>
<td>65%</td>
</tr>
</tbody>
</table>

- Many different approaches on how it is achieved...
Paediatric hybrid imaging – Some important prerequisites...

- Work closely with medical physics to achieve CT dose reduction strategies

- GOSH approach has been;
  - Weight based protocols
  - kV and mAs reduction,
  - Aim for 80kV where possible
  - SPECT guided CT; no need for a topogram
  - Limiting the scan segment to the area required
  - Removal of Care Dose if not diagnostic CT

- Set up local DRL’s for SPECT CT and PET CT

- Do not rely on the manufacturer’s preset protocols

**Optimisation:**
A process that should take into account the condition being imaged, to which the CT parameters are adjusted to accordingly. Dose may in fact increase.
SPECT CT with $^{123}$ I MIBG
MIBG SPECT CT in Neuroblastoma

- Staging and workup
- Response assessment
- Biopsy site planning
- End of therapy
- Detection of possible recurrence

• Three possible strategies:
  1. MIBG SPECT + low-dose CT (anatomical localisation)
  2. MRI and MIBG SPECT fusion
  3. Fully diagnostic contrast enhanced CT (one-stop shop)

*(not currently possible at GOSH due to 2 slice scanner)*
### MIBG localisation – CT imaging protocol

<table>
<thead>
<tr>
<th>MIBG CT parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>mAs</td>
<td>33</td>
</tr>
<tr>
<td>kV</td>
<td>80</td>
</tr>
<tr>
<td>Tube rotation time</td>
<td>0.8 secs</td>
</tr>
<tr>
<td>Collimation</td>
<td>2 x 5.0mm</td>
</tr>
<tr>
<td>Pitch</td>
<td>2</td>
</tr>
<tr>
<td>Scan Slice Width</td>
<td>6.00mm</td>
</tr>
<tr>
<td>CTDI</td>
<td>0.93mGy</td>
</tr>
<tr>
<td>mA dose modulation</td>
<td>Not used</td>
</tr>
</tbody>
</table>
MIBG Case Study 1

12 year male
Stage 3 neuroblastoma
End of treatment scan

? Bowel activity
? Normal variant
? Another cause
MIBG Case Study 1

SPECT abdominal region
MIBG Case Study 1

SPECT CT abdomen

Small focal area of MIBG uptake below the site of the previously resected mass lesion

- Correlation with MRI needed
MIBG Case Study 1

Correlation of SPECT CT with MRI

T1 TSE SPAIR

Dotarem 6.6mls

Recurrent tumour visualised in lower abdomen between the aorta and indenting the IVC. Conclusion = relapse
5 year male
Swollen abdomen, palpable lump
U/S - bilateral renal masses
MRI used to further investigate
I-123-MIBG images at 24 hrs
**Biopsy → Histopathology:** RT and LT lesions are poorly differentiated. Neuroblastomas are cytogenetically and molecularly distinct.

**Plan:** High Dose Chemotherapy + Surgery (LT lesion resection, RT lesion resection and salvage RT adrenal)

**Trephine negative**
**MYCN non-amplified**

**Intermediate risk**
Bone SPECT CT of the Spine
Bone scan SPECT CT in orthopaedic back pain

- SPECT CT in orthopaedic back pain may be beneficial in:
  - Demonstration areas of mechanical stress
  - Identifying the source of the pain generator(s)
  - Highlighting previously undetected pathology
  - Correlate SPECT CT with the MRI findings.

➤ Diagnostic quality CT is needed.
### Bone Scan – Spine Over 8 – CT imaging protocol

<table>
<thead>
<tr>
<th>MIBG</th>
<th>CT parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>mAs</td>
<td>24</td>
</tr>
<tr>
<td>kV</td>
<td>110</td>
</tr>
<tr>
<td>Tube rotation time</td>
<td>0.8 secs</td>
</tr>
<tr>
<td>Collimation</td>
<td>2 x 1.0mm</td>
</tr>
<tr>
<td>Pitch</td>
<td>1.3</td>
</tr>
<tr>
<td>Scan Slice Width</td>
<td>1.25mm</td>
</tr>
<tr>
<td>CTDI</td>
<td>1.61mGy</td>
</tr>
<tr>
<td>mA dose modulation</td>
<td>Used</td>
</tr>
</tbody>
</table>
Spine Case Study 1

15 year old male. Persistent back pain. ? Scoliosis the cause. MRI used to investigate.

Increased signal at T11 - Possible Osteoid osteoma or osteoblastoma

MRI unable to differentiate between the two conditions
Statics confirm abnormal focus of increased HDP uptake at the T11 pedicle.
Spine Case Study 1

SPECT CT demonstrates abnormal lucent calcification with surrounding sclerosis at T11 pedicle

Impression: Osteoid Osteoma
15 year old girl, athlete
3 year history of low back pain, aggravating by training
X-ray: minimal spondylolisthesis at L5.
MRI: Tarlov cyst at S2, cold on Bone SPECT
Bone SPECT CT: cold bilateral spondylolysis, unfused spinous process L5

Management: instrumentation and fixation with bone grafts
Increased uptake LT SIJ, probably due to altered distribution of mechanical forces

**Value of SPECT CT:**

- Established Cyst not the cause of pain
- Detected bilateral pars fractures, which did not feature in the MRI report
- Uptake at the LT SIJ is due to mechanical stress
- Unfused spinous process L5 is a normal anatomical variant
Extremity SPECT CT
-Elbow-
Bone scan SPECT CT in extremities

- Helpful in Elbow, Knee, Foot extremity pain
- Helpful to identify and locate the pain generators
- Demonstration areas of mechanical stress
- Localisation of erroneous uptake - *essential for preoperative planning, especially for tarsal coalition.*
## Bone Scan – Extremity – CT imaging protocol

<table>
<thead>
<tr>
<th>ELBOW  CT parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>mAs</td>
<td>40</td>
</tr>
<tr>
<td>kV</td>
<td>80</td>
</tr>
<tr>
<td>Tube rotation time</td>
<td>0.8 secs</td>
</tr>
<tr>
<td>Collimation</td>
<td>2 x 1.0mm</td>
</tr>
<tr>
<td>Pitch</td>
<td>1.3</td>
</tr>
<tr>
<td>Scan Slice Width</td>
<td>1.25mm</td>
</tr>
<tr>
<td>CTDI</td>
<td>1.41mGy</td>
</tr>
<tr>
<td>mA dose modulation</td>
<td>Not used</td>
</tr>
</tbody>
</table>

GOSH SPECT GUIDED CT SCAN for Elbow Extremity
Extremity Case Study 1

16 year old male, with a non-treatable AVM

Severe pain in right elbow.

? Epicondylitis

- SPECT CT to Pin-point source of pain.
Extremity Case Study 1

Extensive venous malformation of the right upper limb with numerous phleboliths
Fragmentation of the olecranon suggesting degenerative change.

**Added value of SPECT CT**

- this is likely represents the pain generator.

Plan = Steroid injection.
Extremity SPECT CT
-Foot-
Bone scan SPECT CT in foot pain

- Helpful in the underlying diagnosis of:
  - Tarsal coalition
  - Non-specific inflammation
  - Clubfeet Complex regional pain syndrome
  - Accessory navicular bone(s)
**Bone Scan – Extremity – CT imaging protocol**

<table>
<thead>
<tr>
<th>FEET CT parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>mAs</td>
<td>20</td>
</tr>
<tr>
<td>kV</td>
<td>110</td>
</tr>
<tr>
<td>Tube rotation time</td>
<td>0.8 secs</td>
</tr>
<tr>
<td>Collimation</td>
<td>2 x 1.0mm</td>
</tr>
<tr>
<td>Pitch</td>
<td>1.3</td>
</tr>
<tr>
<td>Scan Slice Width</td>
<td>1.25mm</td>
</tr>
<tr>
<td>CTDI</td>
<td>1.51mGy</td>
</tr>
<tr>
<td>mA dose modulation</td>
<td>Not used</td>
</tr>
</tbody>
</table>
Extremity Case Study 2

8 year female

Multifocal osteomyelitis

Acinetobacter growth from Bone biopsy

2 months treatment with antibiotics, but persisting pyrexia

? New site to biopsy
Extremity Case Study 2

Sclerosis of RT Calcaneum and Navicular

Developing Coalition, area of mechanical stress identified

Incidental finding; referral to orthopaedics
Focal area of increased HDP uptake at the distal end of the right tibia laterally.

This is compatible with a persisting chronic osteomyelitis or a focal area of an inflammatory process such as CRMO.

As the area of HDP/MDP uptake is minimal, biopsy of this area unlikely to add further clinical value.
14 year old Male

Bilateral flat feet / Radiographs normal

? Tarsal coalition

? Accessory Navicular
Extremity Case Study 3

**Plan:**
Excision LT accessory navicular

**SPECT CT Both Feet**

High mechanical stress LT accessory navicular

Mild mechanical stress at the talo-navicular joint

**Plan:**
Excision LT accessory navicular
Parathyroid SPECT CT
Parathyroid SPECT CT in Parathyroid Adenoma

Parathyroid SPECT CT useful in;

- The localisation of abnormal parathyroid glands and demarcation of ectopic lesions
- Localisation of adenomas critical for preoperative planning.
- Difference between minimally invasive surgery or exploratory neck surgery

- Consequently improves clinical decision making.
### Parathyroid Localisation Protocol

<table>
<thead>
<tr>
<th>Parathyroid CT parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>mAs</td>
<td>20</td>
</tr>
<tr>
<td>kV</td>
<td>110</td>
</tr>
<tr>
<td>Tube rotation time</td>
<td>0.8 secs</td>
</tr>
<tr>
<td>Collimation</td>
<td>2 x 1.0mm</td>
</tr>
<tr>
<td>Pitch</td>
<td>1.6</td>
</tr>
<tr>
<td>Scan Slice Width</td>
<td>1.25mm</td>
</tr>
<tr>
<td>CTDI</td>
<td>1.34mGy</td>
</tr>
<tr>
<td>mA dose modulation</td>
<td>Not used</td>
</tr>
</tbody>
</table>
15 year old female. Persistently raised PTH. ? Hyperthyroidism or parathyroid adenoma

The SPECT CT demonstrated a large parathyroid adenoma below the lower pole of the right lobe of the thyroid. Plan = excision of adenoma.
DMSA SPECT CT
# GOSH SPECT GUIDED CT SCAN for DMSA

## DMSA Localisation Protocol

<table>
<thead>
<tr>
<th>DMSA CT parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>mAs</td>
<td>50</td>
</tr>
<tr>
<td>kV</td>
<td>80</td>
</tr>
<tr>
<td>Tube rotation time</td>
<td>0.8 secs</td>
</tr>
<tr>
<td>Collimation</td>
<td>2 x 1.0mm</td>
</tr>
<tr>
<td>Pitch</td>
<td>1.3</td>
</tr>
<tr>
<td>Scan Slice Width</td>
<td>1.25mm</td>
</tr>
<tr>
<td>CTDI</td>
<td>1.41mGy</td>
</tr>
<tr>
<td>mA dose modulation</td>
<td>Not used</td>
</tr>
</tbody>
</table>

* Breath Holding where possible
Hybrid Imaging – Where are we Today?

• Ability to undertake anatomical and functional imaging in one environment
• Use of dual-modality integrated imaging systems, such as PET/CT and more recently, SPECT/CT
• The acquired data may be displayed independently of each other, or as a fused overlay of high spatial resolution CT images superimposed on functional images

Reasons for DMSA SPECT CT in Renal Calculi

– Definition of parenchymal renal function, anatomy, and delineation of stones in relation to renal collecting system

– CT component:
  • Position of calculus (? Calyceal obstruction, ? Difficult to extract the stone)
  • Density of the stone
    – HU < 500: treated with lithotripsy (ESWL)
    – HU > 500: consideration of lithotomy (PCNL)
  • Exclude a ureteric stone
Preferred technique for treating large stones (over 2cm in diameter) within the kidney.

Keyhole surgery performed through a 1cm incision in the skin overlying the kidney.
Extracorporeal Shock Wave Lithotripsy

Non-invasive treatment using high energy acoustic pulse
Hybrid Imaging – Where are we Today?

• Ability to undertake anatomical and functional imaging in one environment
• Use of dual-modality integrated imaging systems, such as PET/CT and more recently, SPECT/CT
• The acquired data may be displayed independently of each other, or as a fused overlay of high spatial resolution CT images superimposed on functional images

Two Techniques

GOSH Siemens FORCE CT scanner (384 slices)  Siemens Symbia T2 SPECT CT scanner
DMSA SPECT CT Technique 1

- Static images (POST, LPO, RPO views)
- SPECT followed by a low dose CT on SPECT CT gamma camera
  - 2 slice CT - installed in May 2008
  - CT acquired immediately after SPECT
  - Patient to be still during SPECT and CT
  - Slow acquisition of CT images (40-60 secs)
  - Possible motion artefacts due to free breathing
  - Motion artefacts may lead to an inaccurate position of stone(s) on the fused SPECT CT images,
Since May 2015, CT acquisition performed on the new Siemens FORCE CT scanner (384 slices).

CT images then co-registered to DMSA SPECT study using Hermes workstation.

CT acquisition time approximately 1.47s.

Avoids artefacts from patient’s movement and breathing.

CT protocol on Siemens FORCE scanner:

- Low dose non-contrast enhanced CT KUB.
Dose

- Mean effective dose equivalent (EDE) administered by the CT component of Symbia T2 = 0.35 mSv (range 0.056 – 0.75)

- EDE much lower when the FORCE CT is used (0.05 – 0.1 mSv)
15 year old Male
Left Duplex Kidney
UTI at 3 yrs
Infective stones in lower moiety of LT Kidney
July 2015: LT sided renal colic

Retrograde contrast study confirms LT incomplete duplex with obstruction of the lower moiety
CT acquired on FORCE 128 slice CT scanner

LK 51%         RK 49%

DMSA
LT duplex kidney with slightly reduced function

CT
Stone partially obstructing LT lower moiety collecting system

HU = 993

Plan: proceed to PCNL
PCNL: All stones removed, one small fleck of calcification remaining

Plan: Follow up CT KUB to reassess stone burden in 4 months

✓ DMSA SPECT CT was helpful

- LT lower moiety still good function
- CT showed exact location of the stone, thus making possible to proceed to PCNL
- PCNL was successful
PET CT hybrid imaging

**Ga68 DOTATATE**
- Octreotide → Somatostatin receptors
- Non-Avid MIBG Neuroblastoma
- Prior to Lu$^{177}$ DOTATATE Therapy

**F18 FDG**
- Uptake of glucose → Correlates to tissue metabolism
- Hodgkins and Non-Hodgkins Lymphoma
- Rhabdomyosarcoma

**Theranostics / Radionuclide Therapy**

**I131 MIBG**
- Radioiodine (364 KeV) labeled to MIBG
- Evaluation of MIBG radionuclide therapy
PET CT hybrid imaging

7 year old male

Stage 4
Neuroblastoma

Not weight bearing left leg

MIBG Scan
Demonstrates non-avid uptake

MIBG negative recurrent disease cannot be excluded.
PET CT hybrid imaging

MRI T2 STIR

Abnormal signal and enhancement

Possible metastatic deposit or possible infection

MRI not able to discriminate between either, and unable to fully answer clinical question
PET CT hybrid imaging

**Ga68 DOTATATE**

Extensive and intense gallium DOTATATE uptake in LT distal femur. Destruction of the cortex near the distal epiphysis

*SUV max = 24.9 (25)*
PET CT hybrid imaging

Repeat Ga68 DOTATATE

External beam radiotherapy

Disease reassessment scan

SUV max = 6.7

New periosteal bone formation left distal femur
However, increased number and size of DOTATATE avid lymph nodes. Now extends from the left inguinal station to the left common iliac station.
What might be the future for hybrid imaging in paediatrics?
The future of hybrid imaging in paediatrics

• SPECT CT
  - Widespread globally, relatively low cost and clinically effective.
  - If CT is optimised, patients can receive a low dose from the CT component
  - This form of hybrid imaging will likely remain and will compliment the other hybrids.

• PET CT
  - Higher radiation dose, which is not as ideal for paediatrics
  - This form of hybrid imaging is a proven technology and will not disappear
  - However, its use may focus on adults and its use in children may possibly diminish as we move into the future.
The future of hybrid imaging in paediatrics

• PET MRI
  - It is highly likely that PET/MRI will become established as a standard method of hybrid imaging in children.

“The relatively higher costs and the longer examination time of PET/MRI will be accepted in order to gain the huge benefit of low radiation exposure in children”

- Now located in a few children hospitals in the U.S.

- Research is on-going. Although this form of imaging is currently in its infancy, there will undoubtedly be further refinement, and advances in PET/MRI in the future.
Why might PET MRI be so advantageous in Paediatrics

✓ MRI provides more detailed anatomical data than CT – without the radiation.

✓ MRI provides greater spatial resolution compared with CT.

✓ Improved prognostic powers, treatment planning and response monitoring are envisaged.

✓ Potential one-stop examination for those requiring PET and MRI. Beneficial to the patient and greater efficiency in the workplace.

✓ Reduction in the radiation burden, especially those requiring multiple scans.

✓ Gatidis et al (2016): PET/MRI scans can lead to potential changes in patient management, compared with PET/CT.
The future of hybrid imaging in paediatrics

PET MRI practice...

More Questions than answers..

? Are we teaching the MRI radiographers to undertake PET

? Are we teaching the NM radiographers to undertake MRI

? Are we seeing an emergence of a completely new workforce “Hybrid Imaging Practitioner”

? Would a “HIP” practitioner need to be multi-skilled; in NM / CT / PET / MRI
The emergence of the Hybrid Imaging practitioner (HIP)

✓ Changing Work Dynamics

HI Practitioner will need a new level of awareness in;

• Radiation Protection, dose limits and MR safety

• Cross sectional anatomy

• Artefacts in SPECT CT, PET/CT, PET MRI imaging
  Such as; Metallic implants, Contrast Media, Respiratory motion
Moving towards true Hybrid Practice

- Diagnostic CT & Contrast
- MRI & Gadolinium Contrast
- PET Tracer administration
- NM radiopharmaceutical administration for SPECT
The future of hybrid imaging in paediatrics

King S., & Dawson G., 2012

Knowledge of Nuclear Medicine
- What Pharmaceuticals to use
- How to much to inject
- Scan parameters
- Radiation protection

Knowledge of CT
- Knowledge of cross sectional anatomy
- CT acquisition parameters
- Dose limits
- Radiation protection

Knowledge of MRI
- Knowledge of cross sectional anatomy
- Knowledge of pathological appearance, in order to apply the most appropriate sequences as necessary
- MR safety

Hybrid Imaging Environment
The future of hybrid imaging in paediatrics

We’ve already experienced increased pressure on the existing imaging workforce to embed new hybrid techniques

- Anxiety
- Fear
- Uncertainty

- Career Development
- Engagement
- Involvement

King S., & Dawson G., 2012
The future of hybrid imaging in paediatrics

What does this mean for us as imaging healthcare professionals...

- In order to improve patient care and outcomes, imaging professionals need to be adapt and embrace these new emerging technologies.

Lifelong learning is essential

- This is imperative if we are to deliver high quality patient centred care and remain relevant within the modern evolving healthcare environment.