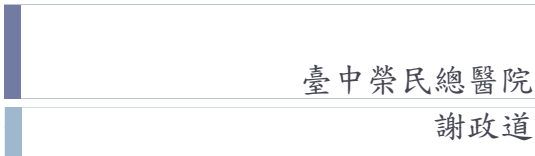# Myocardial perfusion scan

Image process

臺中榮民總醫院

謝政道

Outline

- Radiopharmaceutics
- Myocardial Perfusion Scan (Gated SPECT) - Acquisition Parameters
  - IQ SPECT
- Imaging Process
  - Compare with FBP & Iterative
  - Mask & Angle
- SPECT Image Quality Assurance
- Procedure Protocol

Radiopharmaceuticals

	Tc-99m	Tl-201
Activity (dose)	10–30 mCi	3.5–4.5 mCi
Collimator	High-resolution parallel-hole	Low-energy all-purpose parallel-hole
Matrix	64×64	
Peak	140 keV 20% centered	78 keV 30% centered
Gating	16 or 8 frames/cycle	8 frames/cycle
Number of projections	60–64, 32	32
Orbit & Orbit type	180 & Circular or noncircular	
Acquisition type	Step and shoot or continuous	
Pixel size	6.4±0.2mm	
Time/projection	25s-30s for low doses and 20s-25s for high doses	40s (at least) -60s
Attenuation correction	Sealed sources or CT	

Radiopharmaceuticals

Table 3. Absorbed doses

	Absorbed dose per unit activity administered (mGy/MBq) for adults			mGy/patient examination[a]		
	^{99m}Tc		^{201}Tl chloride	^{99m}Tc		^{201}Tl chloride
	Sestamibi[b]	Tetrofosmin[b]		Sestamibi	Tetrofosmin	
Bone surfaces	0.01	0.01	0.34	10	10	27
Gall-bladder	0.04 (0.03)	0.04 (0.03)	0.07	40	30	6
Small intestine	0.01	0.01	0.14	10	10	11
Colon	0.02	0.02	0.23	20	20	18
Kidneys	0.04 (0.03)	0.01	0.48	30	10	38
Urinary bladder	0.01	0.02 (0.03)	0.04	10	20	3
Heart	0.006 (0.007)	0.004 (0.005)	0.20	6	5	16
Ovaries	0.009 (0.008)	0.008	0.73	9	8	58
Testes	0.004	0.002 (0.003)	0.45	40	30	36
Effective dose[c]	0.0082 (mSv/MBq)	0.0073 (mSv/MBq)	0.22 (mSv/MBq)	8.1 mSv	7.2 mSv	17.6 mSv

The absorbed doses (mGy/MBq) are adopted from [20, 21]. The absorbed doses for ^{99m}Tc-labelled tracers are average doses for rest and stress studies. The effective doses are calculated according to the recommendations given by [22].

[a]The absorbed doses per patient examination are calculated with an average amount of activity for ^{99m}Tc-labelled tracers of 2×500 MBq (for a 2-day protocol) and for ^{201}Tl chloride as a single-injection examination of 80 MBq. The dose will increase with re-injection of ^{201}Tl chloride and with a 1-day ^{99m}Tc protocol, according to the increased activity administered, and it will be reduced correspondingly if only a single ^{99m}Tc study is performed.

[b]Data in brackets are values that are valid for stress studies. These values are only given when dose coefficients differed between rest and stress.

Radiopharmaceuticals

Radiation Dosimetry for Adults*

Radiopharmaceutical	Intravenously administered activity	Organ receiving the largest radiation dose	Effective dose
^{201}Tl-chloride[†]	74–148 MBq (2–4 mCi)	Kidneys, 0.46 mGy/MBq (1.7 rad/mCi)	0.23 mSv/MBq (0.85 rem/mCi) 25.53mSv
^{99m}Tc-sestamibi[‡]	740–1,480 MBq (20–40 mCi)	Gallbladder, 0.039 mGy/MBq (0.14 rad/mCi)	0.0085 mSv/MBq (0.031 rem/mCi) 14.15mSv
^{99m}Tc-tetrofosmin	740–1,480 MBq (20–40 mCi)	Gallbladder, 0.031 mGy/MBq (0.11 rad/mCi)	0.0067 mSv/MBq (0.025 rem/mCi)
^{82}Rb[§]	1,100–1,850 MBq (30–50 mCi)	Kidneys, 0.018 mGy/MBq (0.067 rad/mCi)	0.0048 mSv/MBq (0.018 rem/mCi)
^{13}N-ammonia	370–740 MBq (10–20 mCi)	Urinary bladder, 0.0069 mGy/MBq (0.026 rad/mCi)	0.0022 mSv/MBq (0.0081 rem/mCi)

*See package insert for full prescribing information and complete radiation dosimetry.
[†]ICRP 53, page 373.
[‡]ICRP 62, page 23.
[§]ICRP 53, page 162.

Tc-99m Lower dose:15mCi(555MBq),

Large dose:30mCi(1110MBq)

Tl-201: ~3mCi(111MBq)

Procedure Guideline for Myocardial Perfusion Imaging

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Outline

- Radiopharmaceutics
- Myocardial Perfusion Scan (Gated SPECT) - Acquisition Parameters
  - IQ SPECT
- Imaging Process
  - Compare with FBP & Iterative
  - Mask & Angle & Zoom
- SPECT Image Quality Assurance
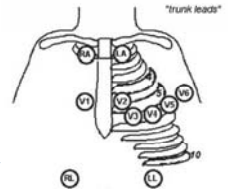- Procedure Protocol

Myocardial perfusion scan

RAO 45°
LPO 45°

Myocardial perfusion scan

0° 45° 90° 135° 180° — x-axis — y-axis — angle of rotation — A — B
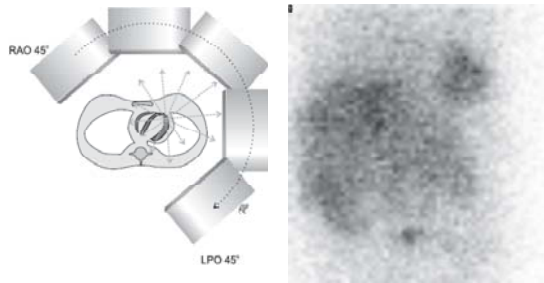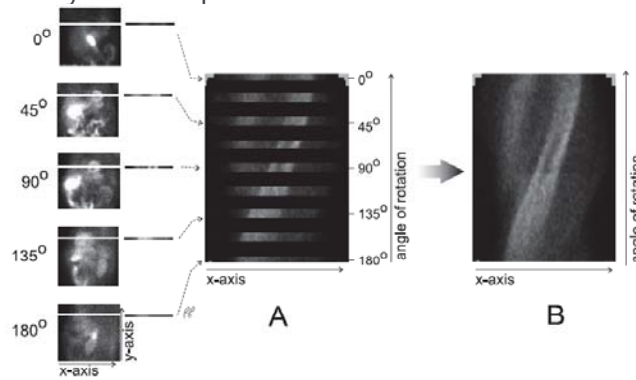
Acquisition parameter

- ▸ Matrix size
  - ▸ 64*64 (standard), or 128*128 (IQ SPECT)
- ▸ Pixel size
  - ▸ XCT: 6.4mm(Z=1.46), 5.0mm(Z=1.85), 4.3mm(Z=2.19)
  - ▸ ECAM: 6.6mm(Z=1.45), 5.4mm(Z=1.78), 4.8mm(Z=2)
  - ▸ ST IQSPECT: 3.9mm (Z=1.0)
- ▸ ECG gating
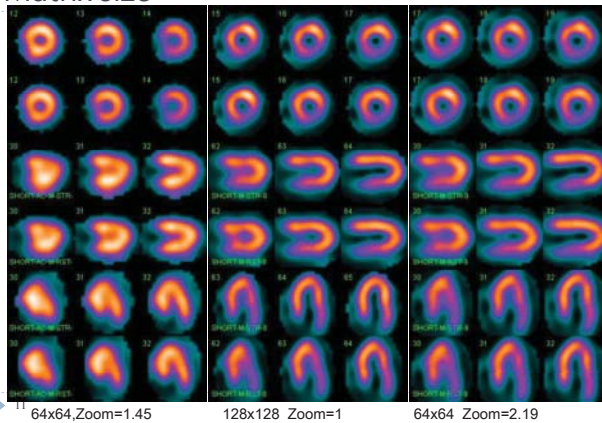 - ▸ R-R cycle
    - ▸ 16 frame/cycle
    - ▸ 8 frame/cycle

"trunk leads"

Matrix size

64x64,Zoom=1.45   128x128 Zoom=1   64x64 Zoom=2.19
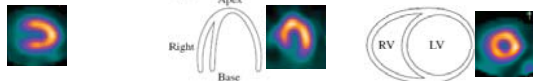
Acquisition parameter

- ▸ Number of projection
  - ▸ Tc99m MIBI : 60-64 projection
  - ▸ Tl-201 : 32 projection
- ▸ Orbit
  - ▸ Angle 90 or 76
- ▸ Acquisition mode
  - ▸ step-and-shoot ：Gated SPECT
  - ▸ continue mode：不建議用在Gated SPECT

Acquisition parameter

Parameters	^{201}Tl	^{99m}Tc
Collimators	LEGP	LEHP
Energy windows	20%	15% ~ 20%
No. of projections, 180° orbit	32 or 64	64 ~128
^{201}Tl: stress/rest	20/25 s (40~60s)	
^{99m}Tc 2-day protocol; 600 MBq		25s
^{99m}Tc 1-day protocol; 350 and 1,050 MBq		First scan: 25 s
		Second scan: 20 s
Total time 大約20 min		

Half time (combine Software) Astonish

56%
57%

61%
62%

64x64,Zoom=1.45 60s,40s   30s,20s

17
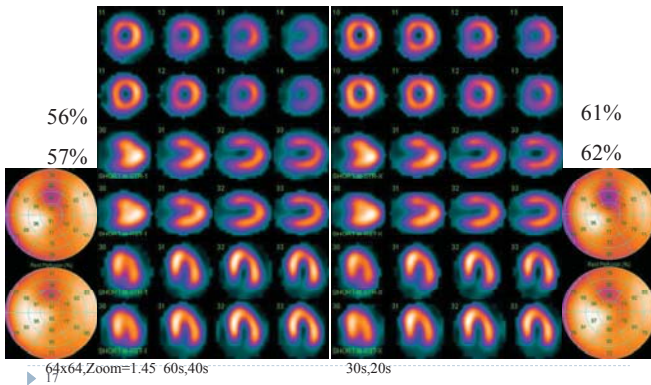
Techniques span the Microscopy, Satellite Imagery, Astronomy and Medical Imaging fields

Before   After
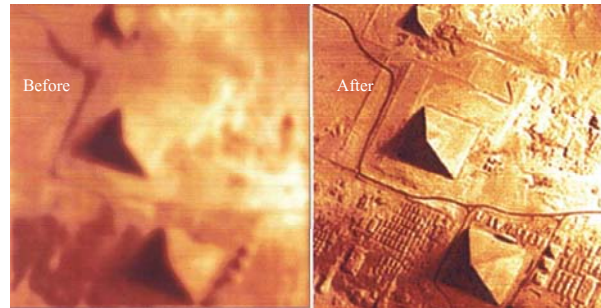
Satellite Imagery (Landsat Camera)

WB Bone   20 mCi MDP   18cm/min LEHR
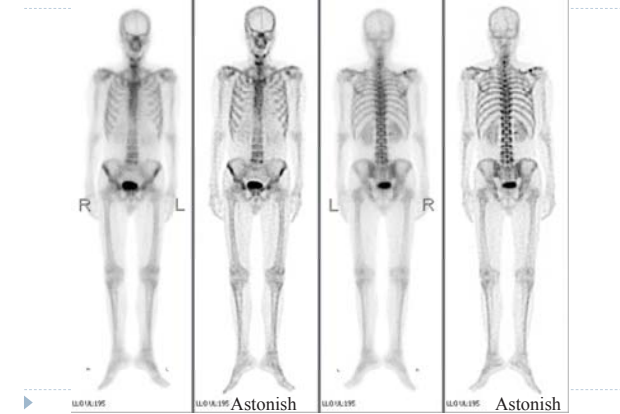
R   L   L   R

Astonish   Astonish

Outline

▸ Radiopharmaceutics
▸ Myocardial Perfusion Scan (Gated SPECT) - Acquisition Parameters
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▸ SPECT Image Quality Assurance
▸ Procedure Protocol

20

IQ SPECT

▸ Components:

1. Collimator :SMARTZOOM
2. Acquisition :Cardio-centric
3. Reconstruction :Flash 3D
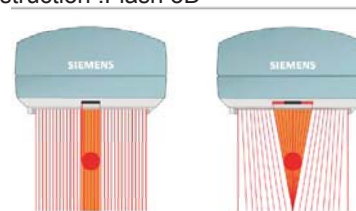
IQ SPECT

▸ For myocardial perfusion
▸ Sampling the most information: $<90°$ ($76°$)
▸ Acquisition $208°$ (17 view*2, $≒6°$/frame)

5cm   28cm   40cm
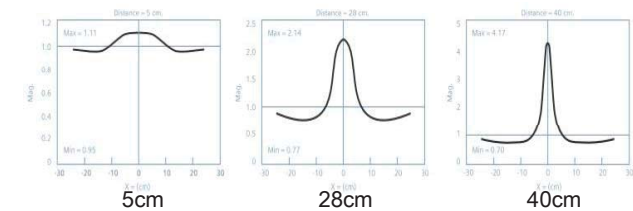
Magnifications at different distance to collimator

22

22

SMARTZOOM Collimator Design Principle
Magnification without truncation

SIEMENS

SMARTZOOM   LEHR

- Projection view of Data Spectrum Large Torso phantom w/ heart insert.
- Counts from ROI around heart:
  - SMARTZOOM → 9 seconds/view, 113K counts in ROI, 933 pixels
  - LEHR → 25 seconds/view, 71K counts in ROI, 177 pixels

Acquisition Method: Cardio-centric

	Convention As close as possible	IQ SPECT:Cardiac Centric
	Det Angle:90 degree	76 degree
	Projection: 16/32/ 64	17 views
	Rotate angle:90	104
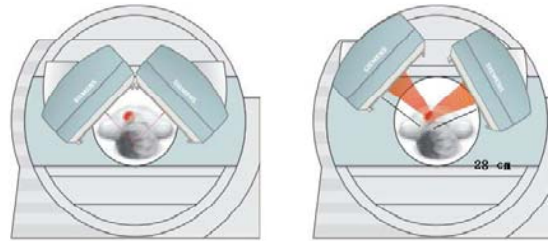
3.Reconstruntion Method –Flash 3D
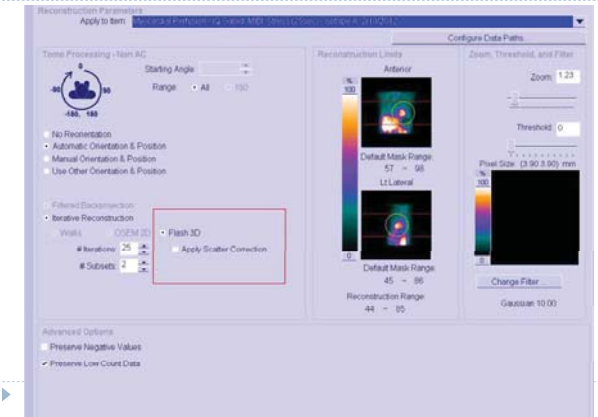
Fast, full count scans
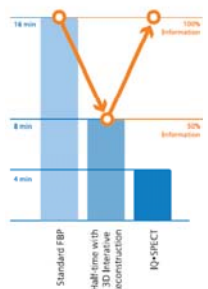
You can get more information from the heart in 5 minutes than you'd get with a conventional SPECT in 20 minutes.
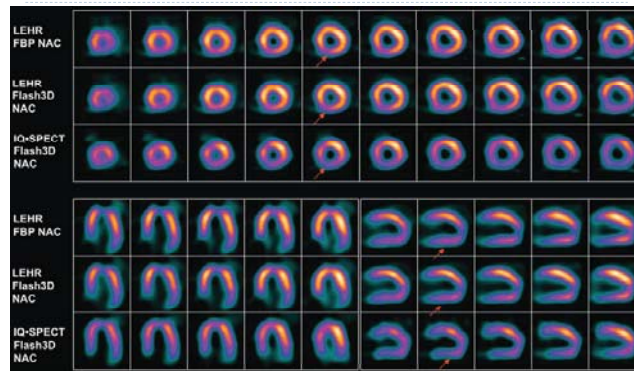
Tl vs MIBI
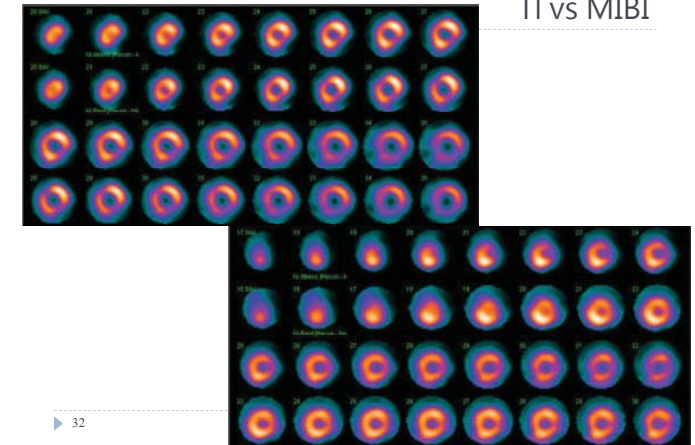
IQ SPECT Compare :11S/14S/19S/40S SA View
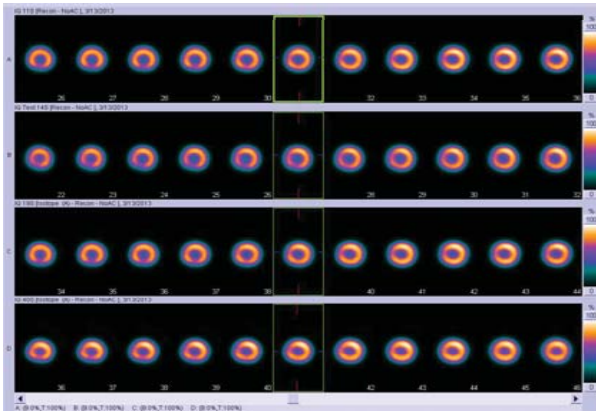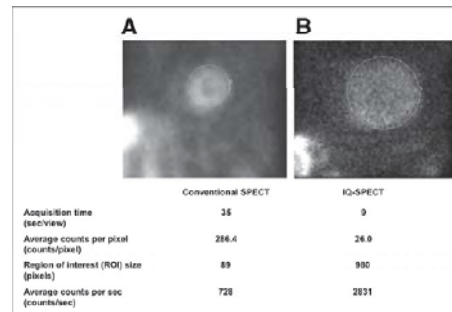
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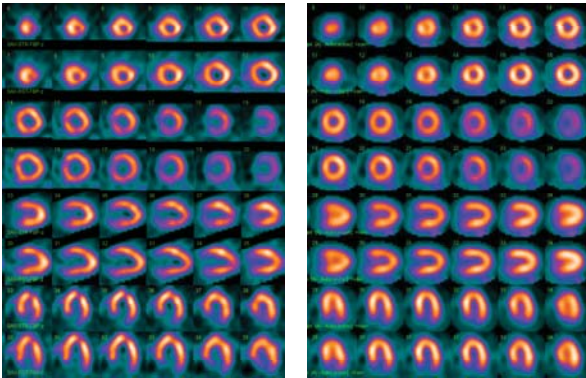- ▸ SPECT Image Quality Assurance
- ▸ Procedure Protocol
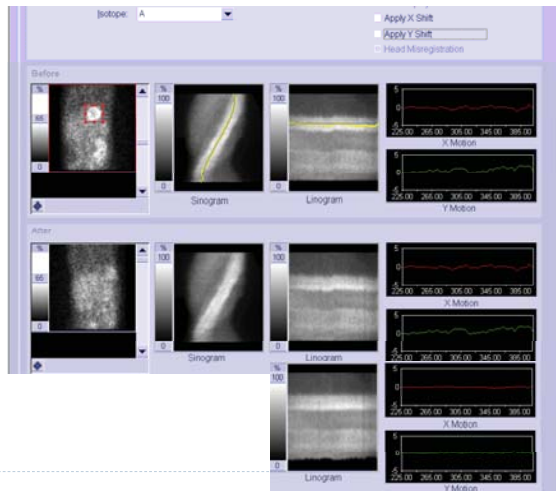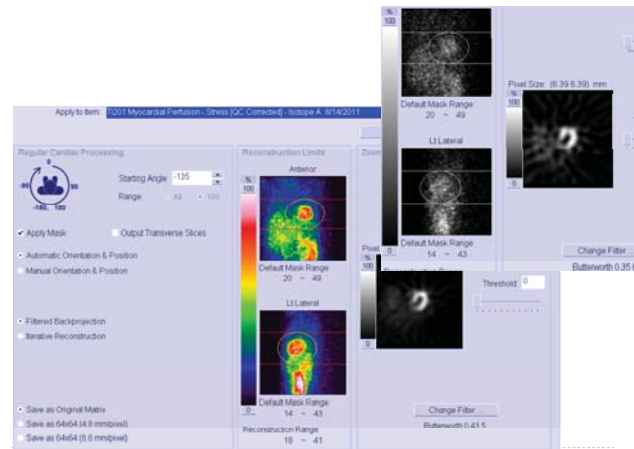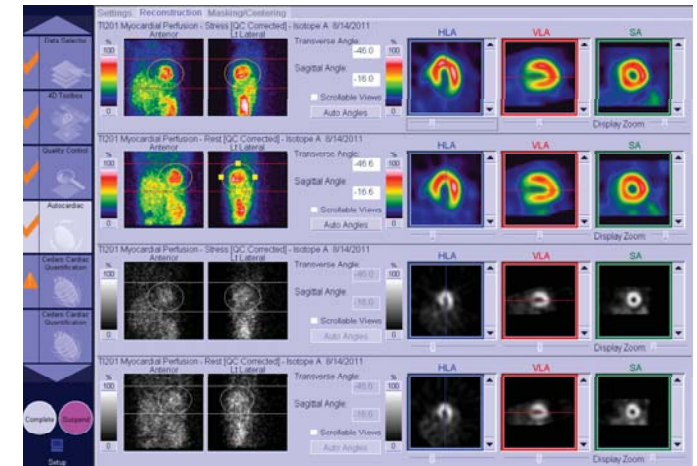
SPECT Image of Heart

Vertical Long Axis   **Horizontal Long Axis**   **Short Axis**
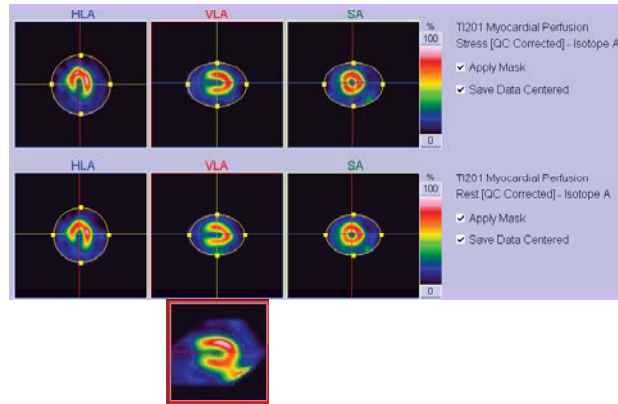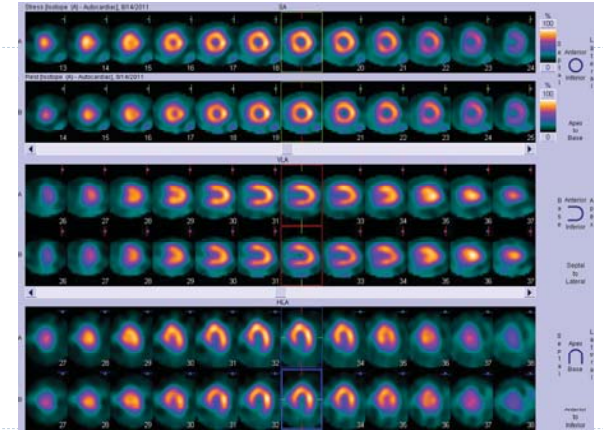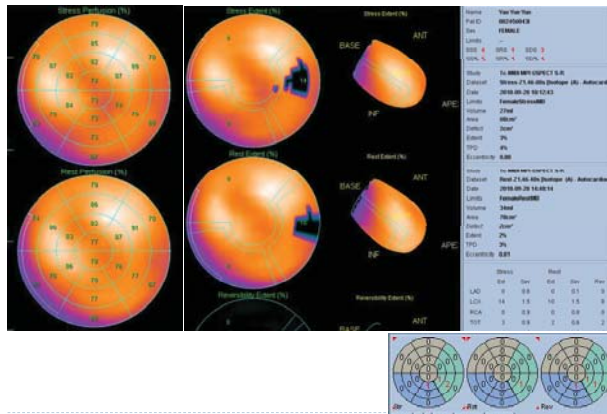
Gated MPS (8 phase)
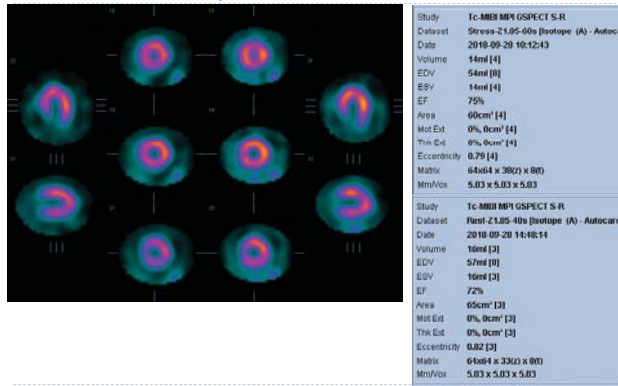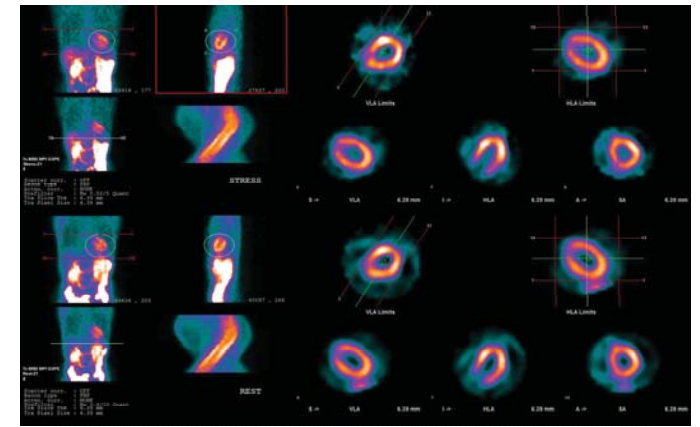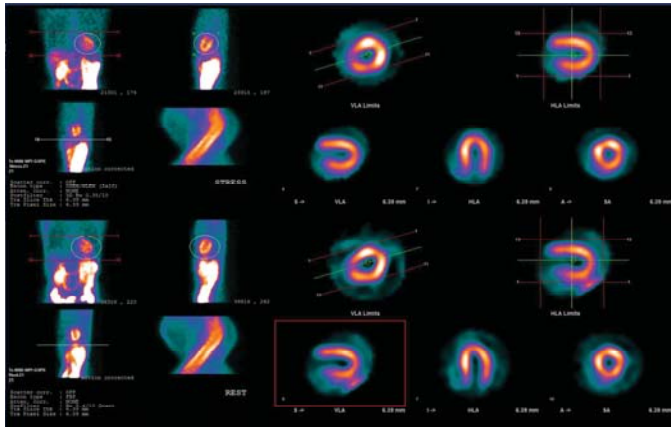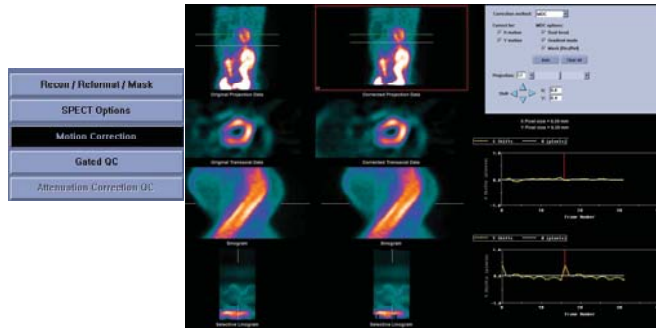
FBP V.S. Iterative
1.Counts
2.Smooth vs sharp
3.EF

Reference Database
1.Tc-99m MIBI vsTI-201
2.Female vs Male
3.Stress vs Rest
4. FBP & Iterative

Zoom: 1.46

Zoom: 1.85

▶ 54

Zoom=1.46   Stress/Rest

▶ 55

Zoom=1.85   Stress/Rest

▶ 56

FBP   Iterative

▶ 59

FBP
Stress:73%
Rest:73%

STRESS_FBP(G)
EF: 73%
EDV: 61ml
ESV: 16ml
Perf. Vol.: 55ml

REST_FBP(G)
EF: 73%
EDV: 60ml
ESV: 16ml
Perf. Vol.: 49ml

Iterative
Stress:68%
Rest:66%

STRESS_IRNC(G)
EF: 68%
EDV: 73ml
ESV: 23ml
Perf. Vol.: 56ml

REST_IRNC(G)
EF: 66%
EDV: 70ml
ESV: 24ml
Perf. Vol.: 55ml

▶ 60
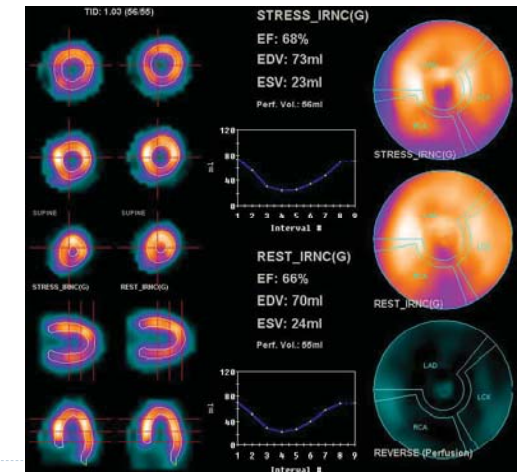
Mask & Angle & Zoom

- Mask
  - Reconstruction Marge => relation motion correction
  - Display range => Quantification
- Angle
  - HLA, VLA, SA => Quantification contour range
- Zoom
  - Acquisition => Quantification EF value
  - Display Size

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SPECT Image Quality Assurance

- **Counts –** 計數要足夠
- **Motion –** 注意病患在攝影過程中是否有明顯的移動
- **Attenuation Correction –** 體厚造成放射活度衰減需校正
- **Alignment –** 壓力及休息影像的相對切面排列要一致
- **Normalization --** 壓力及休息影像均要以心肌上的最高攝取點為準，作為色階的標準化
- **Extra-Cardiac Activity –** 減少心臟外圍高活度器官的干擾

Counts

CHR Z=1.46 VS 1.85 Stress:40s Rest: 45s 心臟太小，加Zoom，出現空洞
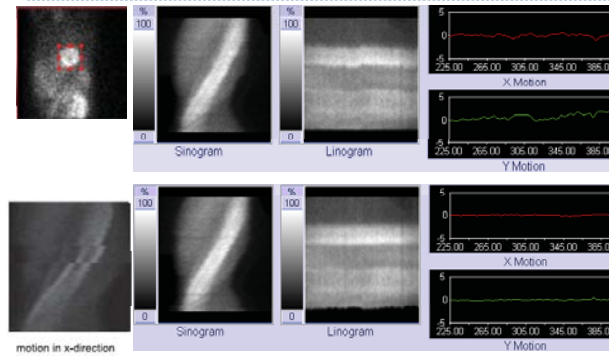
Data Sheet

Collimator Specification comparison

Count Rate Comparison

Unit : cpm/uCi @ 10cm

Relative Sensitivity	Siemens Symbia T Series	GE Discovery NM/CT 670	Philips Precedence Series
LEAP	330	320	277
LEHR	202	160	168
ME	275	144	212
HE	135	97	106

Motion

motion in x-direction
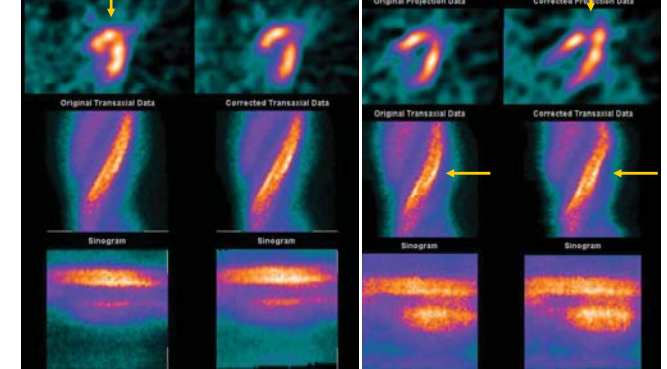
Motion correction

Y motion correction   Y +X motion correction

Reconstruction + orientation
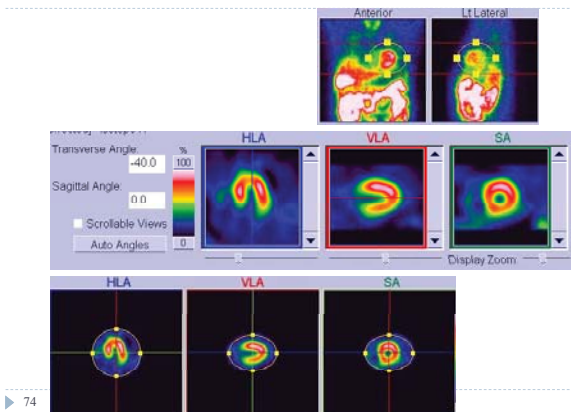
## Reconstruction + orientation
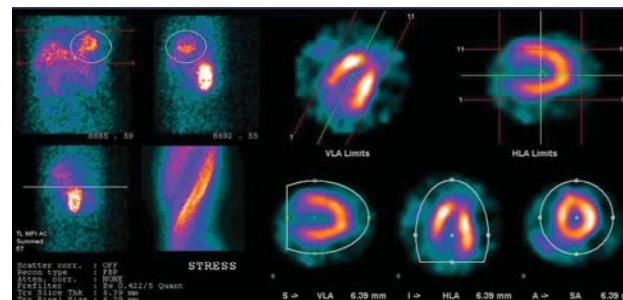
Reconstruction + orientation
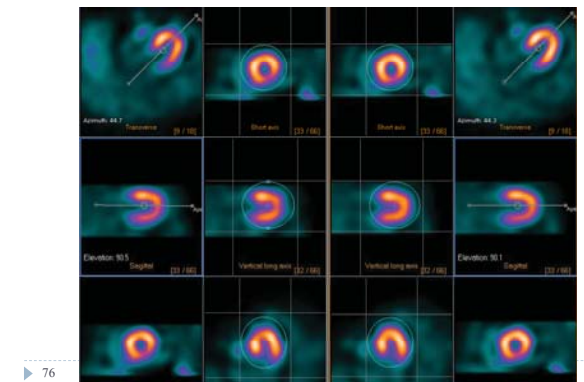
衰減校正
（Attenuation Correction）

- linear attenuation coefficient for ^{99m}Tc in tissue = 0.15/cm
  - every centimeter of tissue between the source and camera will absorb or scatter approximately 15% of entering photons.
  - attenuation coefficient: 0.13/cm for the head
  - 0.12/cm for the abdomen
- Attenuation correction methods may be categorized as:
  - constant μ, or the Chang method
  - variable μ, or transmission source method

Attenuation Correction
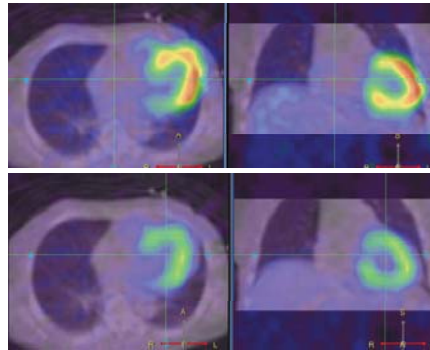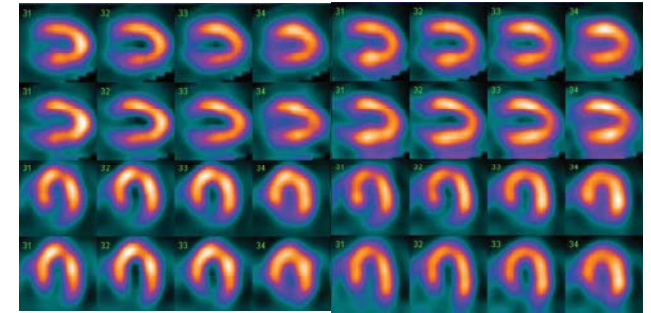
Attenuation Correction

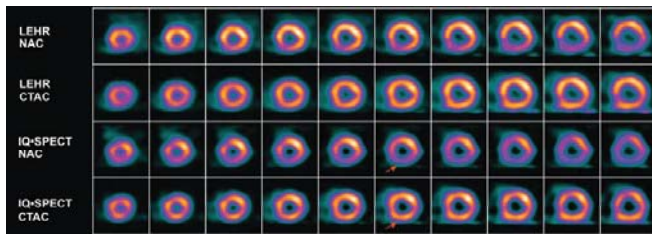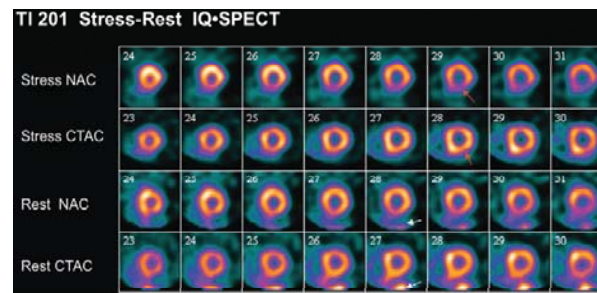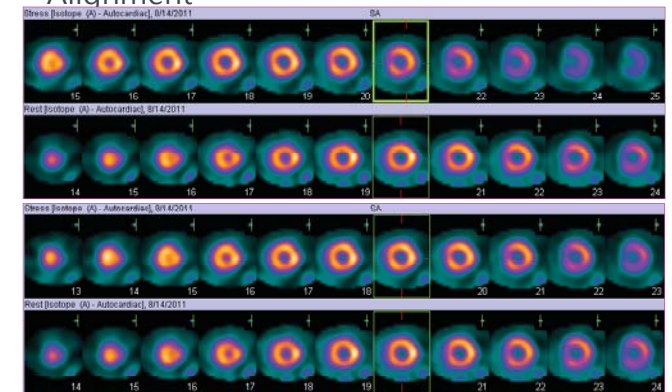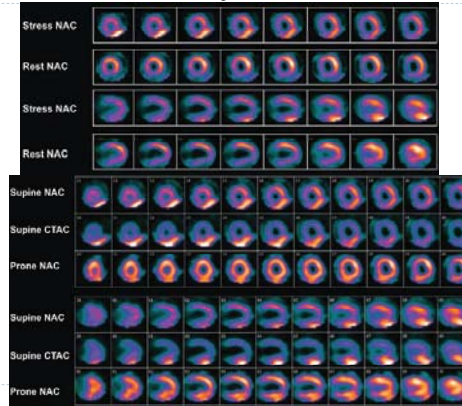## Attenuation Correction

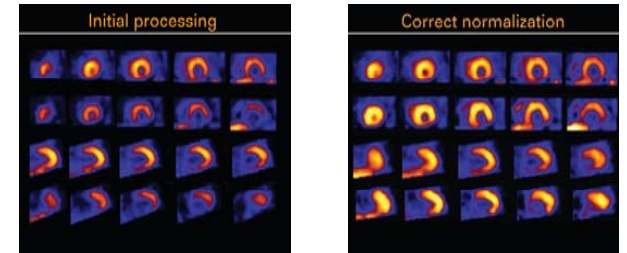## Attenuation Correction

Alignment

Extra-Cardiac Activity

Extra-Cardiac Activity

Normalization (scaling)

Thanks~~