Nuclear Powered Intensive Care

Radiation Exposure of Intensive Care Trauma Patients

Ross Freebairn

Intensive Care Services

Hawke’s Bay Hospital, Hastings, NZ

Rainbow Warrior, Auckland July 1985

HAWKE'S BAY
District Health Board

1985- Rainbow Warrior

- Greenpeace ship en route to Mururoa atoll to protest against French nuclear testing and the radiation damage in the Pacific.
- Sunk in Auckland Harbour – in the an act of State-sponsored terrorism by French agents.

HAWKE'S BAY District Health Board

COMPARISON OF RADIATION DOSES

(mSv per year)

Global natural background doses	
Typical range	1-10
Maximum	~100
Average	2.4
Mururoa and Fangataufa natural background dose	1.4 - 3
Current additional doses from remaining residual radioactive material at Mururoa and Fangataufa	
Maximum at Tureia	< 0.0001
Average at Mururoa and Fangataufa	< 0.01
Maximum at Kilo-Empereur region in Fangataufa	~ 0.25
Maximum additional dose at Tureia following a rock slide at Mururoa	0.007 (initial year)
IAEA recommended guidelines for remediation	10

HAWKE'S BAY
District Health Board

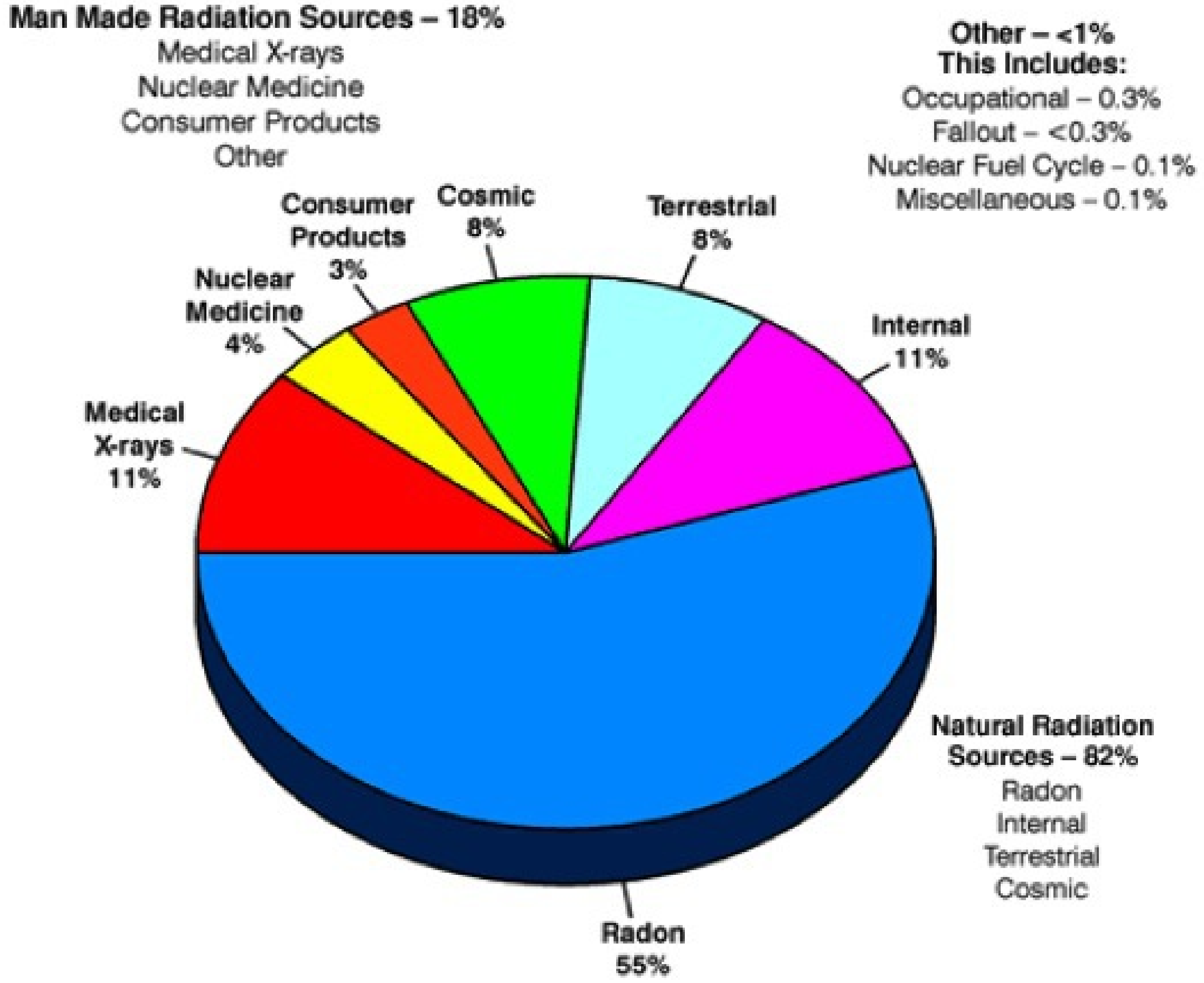
Risks of Radiation Damage in NZ

- People who received 100mSv or greater are at an increased risk of developing cancer
- 1 in 100 people exposed to 100mSv would develop solid organ cancer or leukaemia
- Current models suggest a linear relationship between dose and biological effect, with no ‘safe’ threshold

Board on Radiation Effects Research (BEIR VII) report, 2005

65% of Nagasaki & Hiroshima survivors exposed to < 100mSv

Ionizing Radiation Exposure to the Public



The above chart is taken from the National Council on Radiation Protection and Measurements (NCRP) Report No. 93, "Ionizing Radiation Exposure of the Population of the United States," 1987.

This chart shows that natural sources of radiation account for about 82% of all public exposure while man-made sources account for the remaining 18%.

Method	Conventional unit	SI unit
Radiation exposure	Roentgen (R)	Coulombs per kilogram (C/kg)
Radiation dose	Rad	Gray (Gy)
Equivalent dose	REM	Sievert (Sv)
Effective dose	Effective dose equivalent (Sv)	Sievert (Sv)
Computed tomography dose index	—	Milligray (mGy)
Dose length product	—	Milligray centimetre (mGy.cm)

1 Gy = 1 J/kg.
1 rad = 100 Gy.
10 mSv = 1 REM (1 mSv = 100 mREM).

Terminology

Cumulative Effective Dose (CED)

= $\sum$ (Dose Length Product x Tissue weighting factor)

- Takes into account the different biological effects of absorbed radiation on different body organs
- Expressed as milli-Sieverts (mSv)

Tissue weighting factors

Tissue	Tissue weighting factor, w_T	Sum of w_T values
Bone-marrow (red), colon, lung, stomach, breast, remainder tissues[a]	0.12	0.72
Gonads	0.08	0.08
Bladder, oesophagus, liver, thyroid	0.04	0.16
Bone surface, brain, salivary glands, skin	0.01	0.04
Total		1.00

[a] Remainder tissues: Adrenals, extrathoracic (ET) region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate (♂), small intestine, spleen, thymus, uterus/cervix (♀).

Wrixon AD, New ICRP Recommendations, J Radiol Prot 28 (2008) 164

Routine CXR in ICU

- Of 645 CXRs performed in medical patients,
  - 127 (19.7%) led to one or more management changes.
- In the 66 surgical patients with ICU stay <48 hrs,
  - 15.4% of routine CXRs changed management.
- 35 surgical patients with an ICU stay > 48 hours,
  - 26% of 100 routine films changed management.
    - Chahine-Malus, N et al Crit Care **5:5, 271-5 (2001)**
- Of 74 mechanically ventilated ICU patients,
  - 13 (17.6%) new major findings discovered only by CXR.
    - Hall, JB, White, SR and Karrison, T Efficacy of daily routine chest radiographs in intubated, mechanically ventilated patients.Crit Care Med 19:5, 689-93 (1991)

Routine CXR

- Several studies have done a very limited cost accounting of the potential savings
  - The overall impact on patient outcome has not been investigated.
  - A true assessment of cost-effectiveness has yet to be determined.
- However
  - Radiation exposure (0.02mSv) is low.
- What about other radiological investigations?

Radiation Doses Equivalent

Procedure	Effective dose, mSv*	Chest radiograph equivalents, no.	Equivalent background radiation time	Increased risk of fatal cancer†
Chest radiograph (posteroanterior)	0.02	1	2.4 d	—
Chest/abdomen CT scan	10.00	500	3.3 yr	—
4-slice‡	4.55	228	1.5 yr	1/2197
40-slice‡	1.60	80	6 mo	1/6250
64-slice‡	1.52	76	6 mo	1/6579

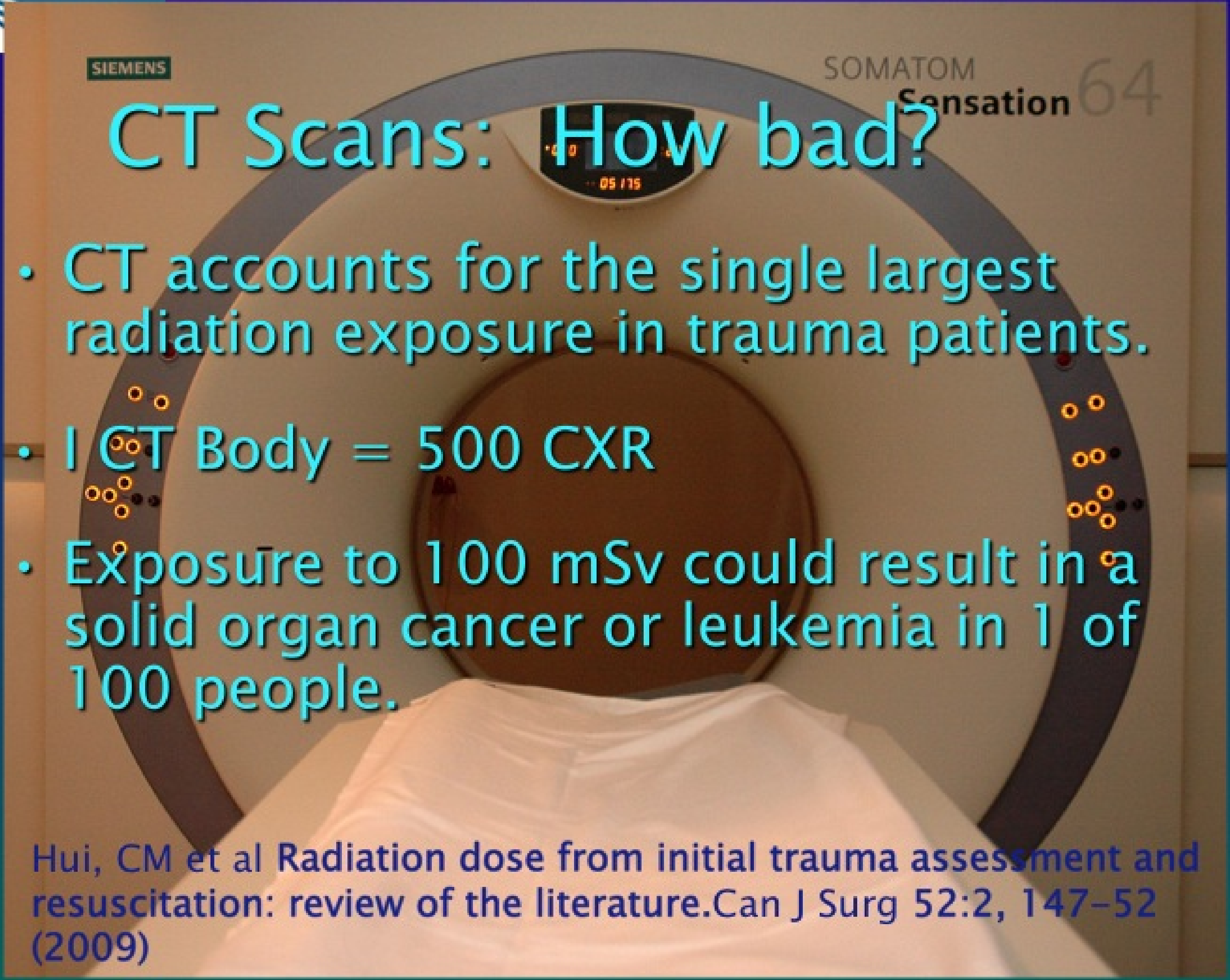
CT = computed tomography.

*Based on the assumption of an average effective dose from natural background radiation of 3 mSv/yr (US).

†Increased risk of fatal cancer = effective dose (Sv) × risk coefficient of fatal cancer in adults.

‡Newer CT technologies with automatic exposure control and multislice scanning.

Adapted from European Commission. *Radiation Protection Report 118. Referral guidelines for imaging.* Brussels (Belgium): Directorate-General for the Environment of the European Commission; 2001[20] and Powers J. *Assessment of patient doses from CT scanners used by the Calgary Health Region* [thesis]. Calgary (AB): University of Calgary; 2006.[4]



CT Scans: How bad?

- CT accounts for the single largest radiation exposure in trauma patients.
- I CT Body = 500 CXR
- Exposure to 100 mSv could result in a solid organ cancer or leukemia in 1 of 100 people.

Hui, CM et al Radiation dose from initial trauma assessment and resuscitation: review of the literature. Can J Surg 52:2, 147-52 (2009)

Trauma Resuscitation

- A = airway

- B= breathing

- C= circulation

The New Resuscitation

- A = airway
- B= breathing
- C= CT scan

HAWKE'S BAY District Health Board

Trauma guidelines: Abdo

	<u>HAEMODYNAMICALLY STABLE</u>	<u>HAEMODYNAMICALLY UNSTABLE</u>
Clear signs of abdominal injury.	CT	Laparotomy
No abdominal signs <u>or</u> signs unreliable due to: ▪ altered conscious level [GCS $\leq$ 13] ▪ paralysis ▪ significant pelvic or chest injury	CT	DPL <u>or</u> USS [FAST] <u>or</u> Laparotomy

Trauma guidelines: Abdo

	<u>HAEMODYNAMICALLY STABLE</u>	<u>HAEMODYNAMICALLY UNSTABLE</u>
Clear signs of abdominal injury.	CT	Laparotomy
No abdominal signs <u>or</u> signs unreliable due to: ▪ altered conscious level [GCS $\leq$ 13] ▪ paralysis ▪ significant pelvic or chest injury	CT	DPL <u>or</u> USS [FAST] <u>or</u> Laparotomy

Traumatic Resuscitation

- A = accuse
- B= blame
- C= criticize

The problem

- Multiple injured trauma patients receive a substantial dose of radiation.
- Radiation exposure is cumulative.
- The low individual risk of cancer becomes a greater public health issue when multiplied by a large number of examinations.
  - 29 000 cancers and 14500 deaths annually in the USA.
- Though CT scans are an invaluable resource and are becoming more easily accessible, they should not replace careful clinical examination and should be used only in appropriate patients.

Hui, CM et al **Radiation dose from initial trauma assessment and resuscitation: review of the literature.** Can J Surg 52:2, 147-52 (2009)
Berrington et al. Arch Intern Med/Vol 169 (No. 22), Dec 14/28,

Has CT usage increased in trauma ?

- Calculate the cumulative effective radiation dose received by ventilated trauma patients from admission to discharge from ICU.

- Compare 2 time periods
  - compare the number of CT's performed
  - cumulative effective dose

Yee M, Barron R, Knobloch T, Pandey U, Twyford C, Freebairn R. Changes over time in the Radiation Exposure of Intensive Care Patients receiving Ventilation following Admission with Trauma. Crit Care & Shock 2010. Vol 13, No.1, 35

Methods

- A retrospective analysis of patient clinical and radiological data
- 2 cohorts of 40 consecutive adult trauma admissions ventilated during ICU admission to Hawkes Bay ICU
- starting 1/1/04 and 1/1/09

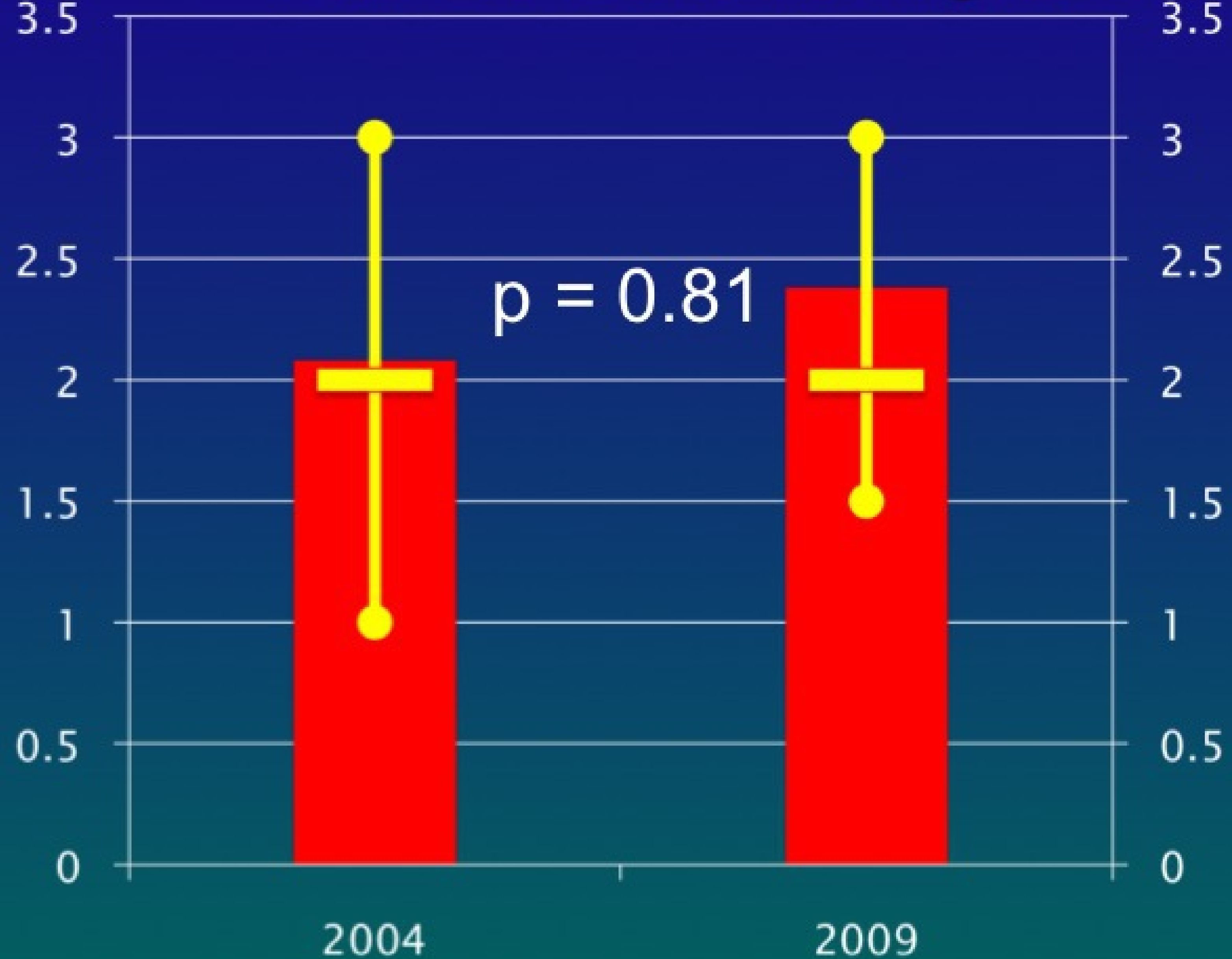
Yee M, Barron R, Knobloch T, Pandey U, Twyford C, Freebairn R. Changes over time in the Radiation Exposure of Intensive Care Patients receiving Ventilation following Admission with Trauma. Crit Care & Shock 2010. Vol 13, No.1, 35

Results: the 2 cohorts compared

	2004	2009	p-value
Median age	29.5	37	0.34
Sex (% M)	67.5	90.0	
APACHE II	19.5	17	0.56
SAPS2	43	34	0.37
Risk of Death	0.175	0.155	0.23

Yee M, Barron R, Knobloch T, Pandey U, Twyford C, Freebairn R. Changes over time in the Radiation Exposure of Intensive Care Patients receiving Ventilation following Admission with Trauma. Crit Care & Shock 2010. Vol 13, No.1, 35

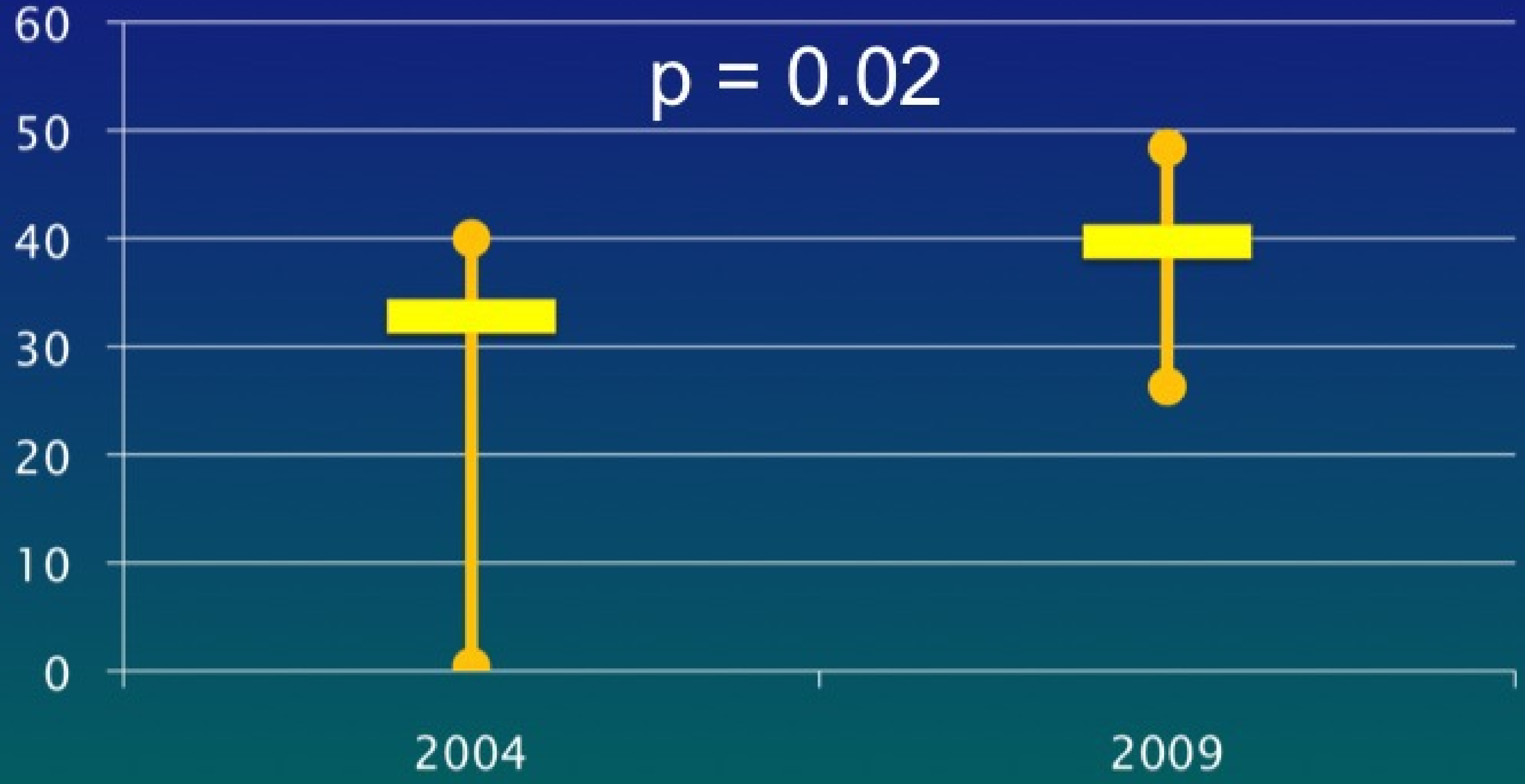
Total CT scans during ICU stay



Yee M, Barron R, Knobloch T, Pandey U, Twyford C, Freebairn R. Changes over time in the Radiation Exposure of Intensive Care Patients receiving Ventilation following Admission with Trauma. Crit Care & Shock 2010. Vol 13, No.1, 35

Total Radiation in ICU (mSv)

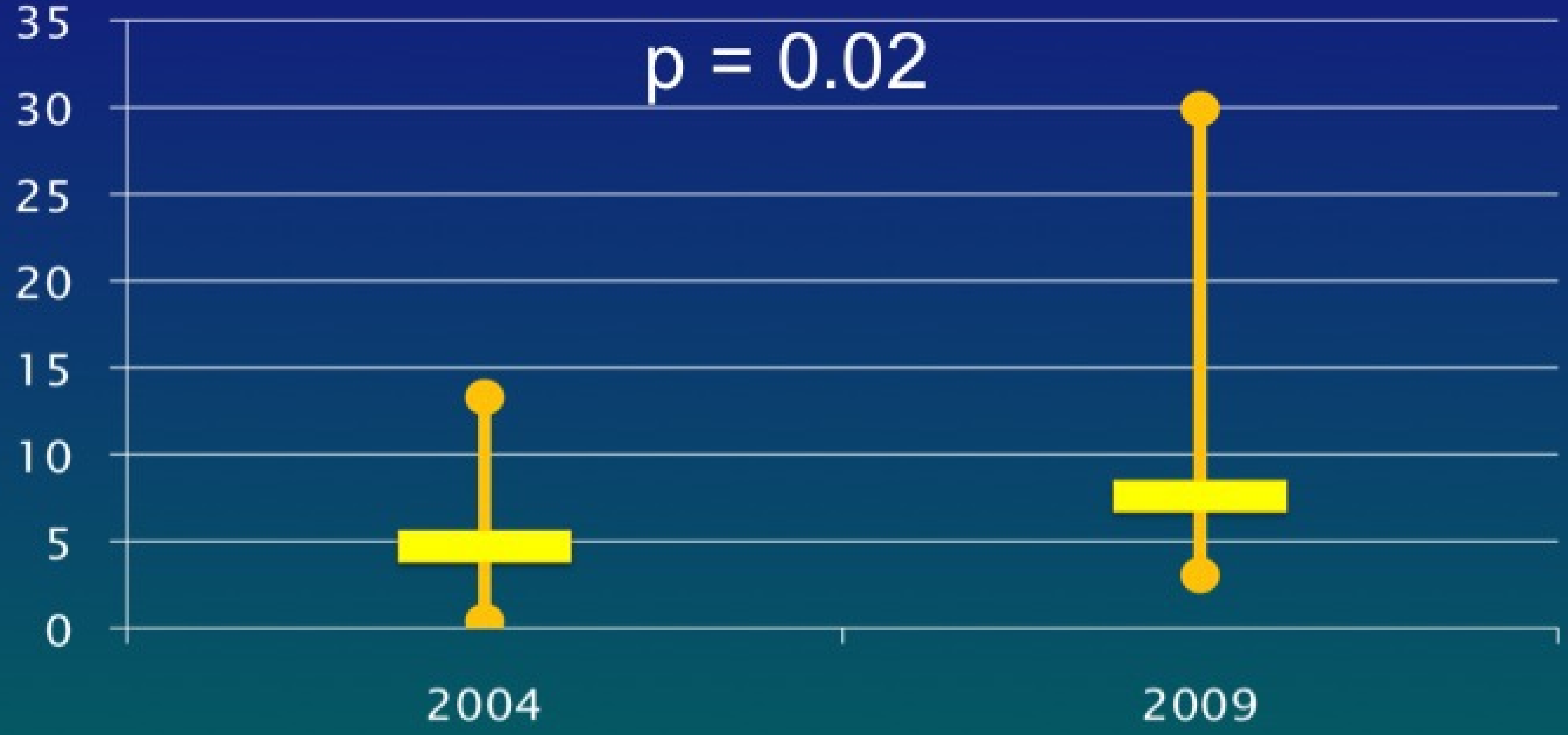
Median and Quartiles



Yee M, Barron R, Knobloch T, Pandey U, Twyford C, Freebairn R. Changes over time in the Radiation Exposure of Intensive Care Patients receiving Ventilation following Admission with Trauma. Crit Care & Shock 2010. Vol 13, No.1, 35

Daily Radiation in ICU (mSv)

Median and Quartiles



Yee M, Barron R, Knobloch T, Pandey U, Twyford C, Freebairn R. Changes over time in the Radiation Exposure of Intensive Care Patients receiving Ventilation following Admission with Trauma. Crit Care & Shock 2010. Vol 13, No.1, 35

So what does this mean?

- There has been an increase in the radiation dose exposure of ICU trauma patients in recent years, largely due to complexity of the CT scans.
- Increased radiation exposure is consistent with other studies.
- What evidence is there of benefit?

Similar studies

- CT accounts for the single largest radiation exposure in trauma patients

Hui, CM et al. Can J Surg 2009; 52:147-152

- Increase in the mean number of CT exams per patient in 2007 compared with 2003 (4.41 v 3.44)

Salottolo, K et al. Crit Care Med 2009; 37: 1336-1340

Alternatives

- MRI:
  - Access (timeliness)
  - Access (monitoring & resuscitation)
- FAST/ US scan:
  - Reliability & reproducibility
  - Only detects presence of fluid.
-

Alternatives

- MRI:
  - Access (timeliness)
  - Access (monitoring & resuscitation)
- FAST/ US scan:
  - Reliability & reproducibility
  - Only detects presence of fluid.
- Sequential Clinical Examination

Avoid routine repeat scans

Of 692 patients

- In no patient without clinical deterioration did a change in management arise from a repeat routine Head CT

- A Glasgow Coma Scale score less than 15 (13 or 14),
- age higher than 65 years,
- multiple traumatic lesions found on first head CT,
- interval <90 minutes from arrival to first head CT

–predicted independently a worse RRHCT.

Routine repeat Head CT is unnecessary in MHI.

Velmahos, G et al Routine repeat head CT for minimal head injury is unnecessary. J Trauma (2006) 60:3, 494-9;

But -repeat routine CT scans are being advocated

- Routine follow-up CT scans
  - beneficial in those patients with MBI
  - worsening CT findings may lead to
    - higher levels of medical management
    - neurosurgical intervention.
    - Some patients may be asymptomatic
- a prospectively randomized multi-centered trial would be beneficial.
    - Bee, TK, et al Necessity of repeat head CT and ICU monitoring in patients with minimal brain injury.Trauma 66:4, 1015-8 (2009)

Monitoring Use

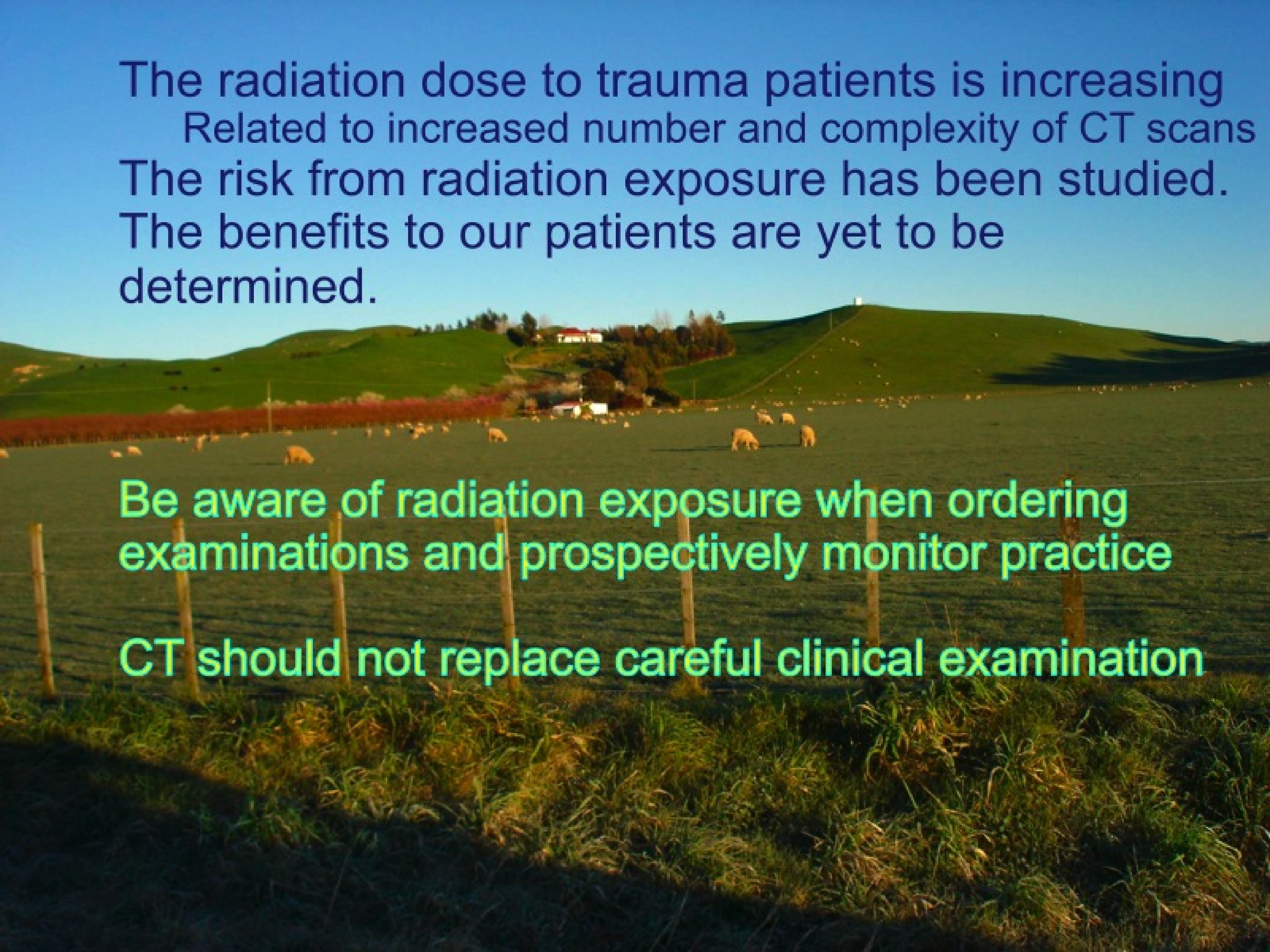
- Prospectively monitor CT requests:
  - What is expected to be found
  - What intervention / management change will result from scan
  - Audit the scan indications , scan results, and interventions that arise .

Marie Curie

- 1903, awarded Nobel prize in Physics
  - with Pierre Curie, and Henri Becquerel
- 1911 awarded Nobel prize in Chemistry

- 1934 died from aplastic anaemia almost certainly contracted from exposure to radiation.

- Much of her work had been carried out in a shed, without taking any safety measures.
- She had carried test tubes containing radioactive isotopes in her pocket remarking on the pretty blue-green light that the substances gave off in the dark.


The radiation dose to trauma patients is increasing
Related to increased number and complexity of CT scans
The risk from radiation exposure has been studied.
The benefits to our patients are yet to be determined.
Be aware of radiation exposure when ordering examinations and prospectively monitor practice
CT should not replace careful clinical examination


Thanks to Michaela, Rochelle, Tom, Catherine and Umesh