CLINICAL INFORMATION ON RADIATION AND RADIATION PROTECTION SYMPOSIUM: FROM EVIDENCE TO ACTIONS

輻射防護及輻射臨床知識講座：從實證到行動

17 June 2011 (Friday)
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Hong Kong Convention & Exhibition Centre
香港會議展覽中心

International Radiology Quality Network

Hong Kong College of Radiologists

Hong Kong Association of Medical Physics

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Foreword
前言

Cardiovascular diseases is the foremost cause of death in nearly every corner of the world, claiming 17.1 million lives worldwide a year. Over the years, with the development of new and sophisticated technology, the important role of cardiovascular imaging in the management of these diseases has grown tremendously. As many imaging techniques involve the use of ionizing radiation, their proper and appropriate utilization to avoid unnecessary harm to patients cannot be over-emphasized.

In the course of preparing the 5th Congress of Asian Society of Cardiovascular Imaging (ASCI 2011), the Local Organizing Committee endeavoured to take this opportunity to enhance the awareness of medical professionals and healthcare workers on radiation protection. To this end, we have invited International Radiology Quality Network (IRQN), Hong Kong College of Radiologists (HKCR) and Hong Kong Association of Medical Physics (HKAMP) to jointly organize a symposium focusing on the medical use of radiation on the first half day of the Congress, i.e. 17 June 2011 (Friday). The title of symposium is "Clinical Information on Radiation and Radiation Protection Symposium: From Evidence to Actions". Renowned international and local experts have been invited to deliver important lectures focusing on the risks, benefits and safety of medical radiation in the Symposium. In addition, public concern on radiation protection has been driven up by the recent incident of the Fukushima nuclear power plant. For contributions to the public service, the Local Organising Committee provides a one-hour free Forum, to be conducted in Cantonese, to the professionals, healthcare workers, universities students as well as the media. The Forum aims at bringing together different walks of life into the symposium so that awareness of the society on radiation protection will be enhanced.

We would like to express our sincere appreciation for all participants for joining the symposium and the Forum. We wish you all fruitful, open and intellectually stimulating discussion in the arena of radiation.

心血管疾病乃現今世上之第一殺手。隨著科技進步，心血管造影術在該病防治方面的地位正與日俱增。然而此造影牽涉電離輻射的廣泛應用，正確的使用和適當的平衡利弊至為重要。

香港放射科醫學院及香港心臟專科學院在兩年多前開始籌備第五屆亞洲心臟血管影像國際學術研討會時已考慮到加強醫護人員對輻射知識及防護意識的重要性，並早已定下了首半天的學術會議加入上述的內容，由國際放射學質素聯網、香港放射科醫學院及香港醫學物理學會聯辦一個名為「輻射防護及輻射臨床知識講座：從實證到行動」。大會很榮幸邀請到來自世界各地知名學院的專家作專題演講，和與會者分享及交流有關「輻射防護」的新知和經驗。加上自日本福島核電廠事故發生，市民大眾對輻射防護知識日益增加，故本籌委會在該專題報告學術會議後，加入以粵語講述的一小時免費專家座談會，致力提升來自社會不同界別人士對「輻射防護」的認知。

希望大眾積極參與及各界人仕鼎力支持，將市民的輻射防護意識進一步提升。

Section I
第一章

Information on Radiation
輻射知識

Information on Radiation
輻射知識

1. What is radiation?
輻射是甚麼？

All matters are made up of tiny units called atoms. As radiation is mainly released from atoms, the first step to understand radiation is to know more about their structure and properties:

- Structure of an atom
- Unstable nuclei
- Decay

Radiation is everywhere in the universe. Since the inception of time, life on earth have been exposed to radiation in the natural environment.

Radiation embraces electromagnetic waves (such as light, radiowaves, x-rays, etc.), ultrasound and particles (such as alpha (α) particles, beta (β) particles, etc.) emitted by radioactive materials as they decay.

Radiation can be classified as non-ionizing and ionizing. In general, the energy of the non-ionizing radiation (such as light and radiowaves) is low and not sufficient to change the chemical properties of a substance. On the other hand, ionizing radiation (such as α and β particles) has energy high enough to remove electrons from an atom to create an electrically charged ion. This ionization process often results in chemical changes in living tissues, which can lead to injury in the organism. Ionizing radiation is generally referred as harmful radiation.

Radiation cannot be heard, seen, smelt nor tasted. Most of it cannot be felt. However, with the use of instruments, it can be detected and measured.

The unit to measure radiation dose to tissues is sievert (Sv). One millisievert (mSv) is one-thousandth of a sievert.

Types of Ionizing Radiation

The various types of ionizing radiation include:

(a) Alpha particles, which are swiftly moving nuclei of helium atoms and carry positive charges. They have little power of penetration and can be easily stopped by a sheet of paper or the outer layer of the skin. However, alpha emitting materials are harmful to health if they enter the body by inhalation or along with food or water.

(b) Beta particles, which are high speed electrons and are more penetrating than alpha particles. A sheet of aluminum a few millimeter thick can stop beta particles.

(c) X-rays and gamma rays, which are both very penetrating and can pass right through the body. Dense materials such as lead or concrete are more effective in absorbing these rays.

(d) Neutrons, which do not carry any electric charge and are constituents of atomic nuclei. Hydrogen-rich materials, such as water or paraffin can shield against these highly penetrating particles.

世上所有物質都是由細小的原子組成。而輻射主要由原子釋放出來，因此要認識輻射，首先要了解原子的結構和特性：

- 原子的結構
- 不穩定的原子核
- 衰變

宇宙充滿輻射。自古以來，地球上的生命便暴露於自然環境的輻射中。

輻射包括不同能量的電磁波(例如光線、無線電波及X射線等)、超聲波，以及由放射性物質因衰變放出的粒子(例如 α 粒子及 β 粒子等)。

輻射大致可以分為非電離輻射及電離輻射兩類。一般來説，非電離輻射(例如光線及無線電波)的能量較低，不足以改變物質的化學性質。相反，電離輻射(例如 α 粒子及 β 粒子)有足夠的能量使原子中的電子游離而產生帶電離子。這個電離過程通常會引致生物組織產生化學變化，因而對生物構成傷害。一般所指可引起傷害的輻射，就是電離輻射。

輻射是無聲、無色、無臭、無味，大部份亦無法憑觸覺感覺其存在。不過，人們可以利用儀器探測和量度它們。

量度輻射劑量的單位是希沃特(Sv)。一毫希沃特(mSv)等於一千分之一希沃特。

電離輻射的種類

電離輻射包括以下各類：

(a) α 粒子是移動速度極高的氦原子核，帶正電荷，穿透能力極弱，一張紙或皮膚的外皮層已能把它們阻隔。不過，如果放射 α 粒子的核素隨呼吸或飲食進入體內，會損害健康。

(b) β 粒子是高速的電子，穿透能力比 α 粒子強。不過，一塊厚數毫米的鋁片便可阻隔這些粒子。

(c) X射線及 γ 射線的穿透力極強，能直透人體。高密度物質(如鉛或混凝土)對這些射線有較佳的阻隔效果。

(d) 中子不帶電荷，是組成原子核的粒子之一。水或石蠟這些含有大量氫的物質，可阻隔極具穿透力的中子。

Decay 衰變

An unstable (radioactive) nucleus can become stable by emitting particles and energy - a process called "decay". These particles or energy (in the form of electromagnetic waves) are collectively called radiation. The radiation emitted can either be alpha particles, beta particles, gamma rays or neutrons.

During the decay process of a radioactive material, the total number of that nuclei decreases with time. The time it takes the radioactive nuclei to decay to half of its original amount is called the half-life. Each radionuclide has a characteristic half-life. The half-lives of radionuclides may vary from millionths of a second to millions of years.

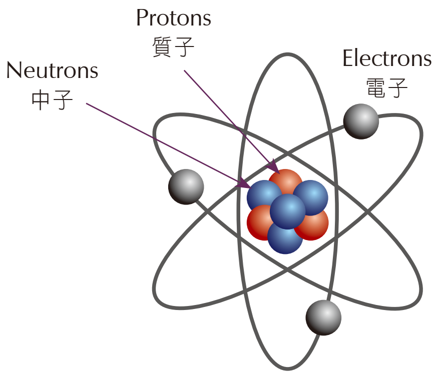
一顆不穩定(即具有放射性)的原子核在放射出粒子及能量後可變得較為穩定，這個過程稱為「衰變」。這些粒子或能量(後者以電磁波方式射出)統稱輻射。由不穩定原子核發射出來的輻射可以是 α 粒子、β 粒子、γ 射線或中子。

放射性核素在衰變過程中，該核素的原子核數目會逐漸減少。衰變至只剩下原來數目一半所需的時間稱為該核素的半衰期。每種放射性核素都有其特定的半衰期，由幾微秒到幾百萬年不等。

Half-lives of radionuclides
放射性核素半衰期表

Radionuclide 放射性核素	Half-life 半衰期
Radon-219 氡 -219	4 seconds
Potassium-38 鉀 -38	7.6 min
Selenium-73 硒 -73	7.2 hours
Iodine-131 碘 -131	8 days
Cobalt-60 鈷 -60	5.26 years
Caesium-137 銫 -137	30 years
Carbon-14 碳 -14	5,730 years
Iodine-129 碘 -129	15,700,000 years
Uranium-235 鈾 -235	703,800,000 years
Potassium-40 鉀 -40	1,277,000,000 years

每經過一個半衰期，放射性物質的放射性便會剩下一半，經過二個半衰期，放射性便會剩下原先的四分之一，如此類推。



Structure of an atom
原子的結構

Radiation is everywhere in the universe
宇宙充滿輻射

2. Where does radiation come from?
輻 射 從 何 而 來 ?

In general, there are two kinds of radiation according to its origin: natural radiation and artificial radiation.

Natural radiation

Natural radiation comes from cosmic rays from outer space and naturally occurring radioactive materials that exist in food, air and our natural habitat.

Artificial radiation

Exposure in medical practice, mostly due to diagnostic x-rays, probably contributes the largest fraction of human's exposure to artificial radiation. Fallout of radioactive substances from nuclear weapon tests, radioactive substances released from nuclear power plants, radioactive materials used in consumer products such as luminous watches and smoke detectors, etc. make up the balance.

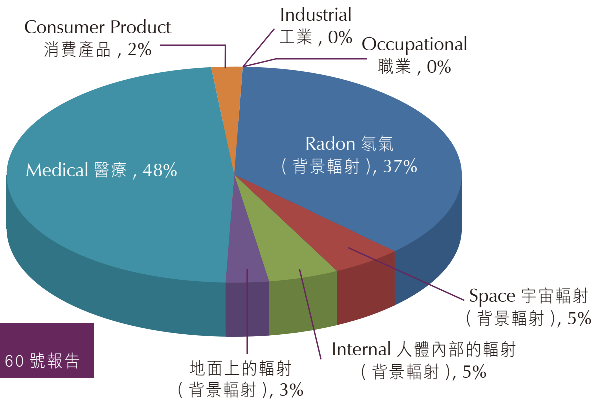
一般來說，輻射按其來源可以分為兩大類：天然輻射和人工輻射。

天然輻射

我們接觸到的天然輻射包括來自外太空的宇宙射線及存在於食物、空氣及居住環境的天然放射性物質等。

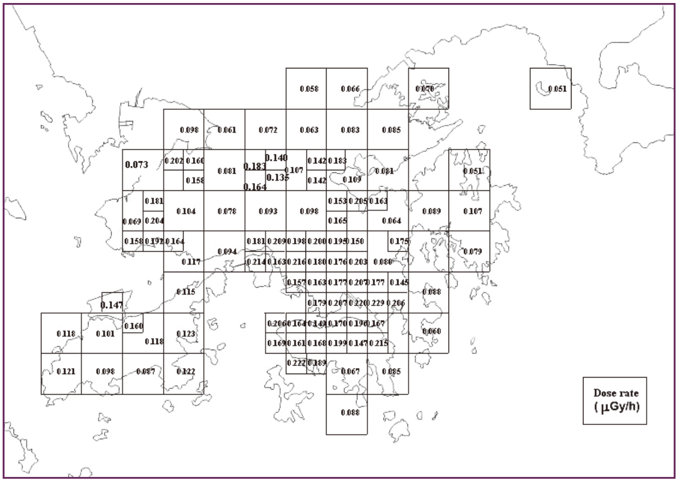
人工輻射

我們接觸到的人工輻射以用於醫療診斷的 X 射線所佔比例最多。其餘的來源包括從核武器試驗產生的輻射性微塵、核電廠釋放出的放射性物質、用於消費產品的放射性物質如夜光手錶和煙霧感應器等。



Source: NCRP 160
美國輻射防護委員會第 160 號報告

Percentage of different types of radiation dose in daily life
我們日常吸收到輻射劑量的比例



Spatial distribution of environmental gamma absorbed dose rates in air in Hong Kong in 1999
一九九九年在香港所測得的伽馬空氣吸收劑量率地域分佈

3. What are the uses of radiation?
輻 射 有 甚 麼 用 途 ?

Radiation is part of our daily life. We benefit from it without noticing its presence. Common examples are electricity generation, medical and industrial applications. With proper use, radiation can be beneficial to the society.

- Electricity generation
- Medical applications
- Industrial and agricultural applications
- Applications in consumer products
- Archaeological applications

輻射與我們息息相關，很多時我們不知不覺間已經享用到輻射應用所帶來的好處。無論在發電、醫療、工業方面，輻射的應用都多不勝數。只要運用得宜，輻射也可以造福社會。

- 發電
- 醫學用途
- 工業及農業
- 消費品用途
- 考古用途

Applications in Medicine 醫學上的應用

Radiation plays a fundamental role in patient care. The three main areas are:

1) Diagnostic and Interventional Radiology

The use of X-rays for examining patients can be dated back to 1895. Since then, its application has been proven to be extremely important for pre-treatment diagnosis, disease monitoring and evaluation of treatment outcome. In 2010, 5 billion medical imaging studies were done worldwide.

The earliest and most common application of X-ray in medical imaging is plain radiography examinations. The development of X-ray technology has evolved into many sophisticated medical imaging modalities including computer tomography (CT scan), fluoroscopy, angiography and mammography.

In the past decade, the application of these imaging modalities has expanded tremendously. The development is fostered by technological advancements integrated into medical imaging, such as the reconstruction of 3-dimensional imaging, computer-based post-processing and superior engineering of equipment. Nowadays, it is possible to scan the heart of a patient and depict all its small coronary arteries with extremely high resolution by CT scan within the duration of a single heart beat.

Besides facilitating doctors in making diagnosis, radiology can also be employed in the treatment of many diseases. In interventional radiology, images obtained are utilized to precisely guide the doctor to the internal structures of a patient, so that minimally invasive procedures can be performed. The advantages of interventional radiology are that it produces relatively small open wounds and allows safe access to structures that are difficult to be reached.

2) Nuclear Medicine

In nuclear medicine, a radioisotope coupled with a pharmaceutical is administered to the patient by injection, ingestion or inhalation. The radioisotope will be taken up by specific internal organs. When the radioisotope decays, it will emit radiation which is partially absorbed by the patient. The attenuated emitted radiation will then be captured by special detector called gamma camera to produce images.

The most widely used diagnostic radioisotope is technetium-99m which has a half-life of six hours and releases gamma rays during radioactive decay. The half-life is long enough to allow diagnostic studies and not too long to produce prolonged risk to the patients and medical personnel.

3) Radiotherapy

This is the field of medicine in which ionizing radiation such as high energy X-ray beams, gamma rays, electrons and heavy particles are used to treat cancers and indicated benign diseases. Radiotherapy can be applied externally by focusing radiation beams to the diseased sites (External beam radiation therapy), internally by inserting radioactive applicators at the diseased sites (Brachytherapy) or systemically by injection/ingestion of radioactive substances (Radioisotope therapy). The choice of method depends on the location, extent and type of cancers. Rapid technological advancements have substantially enhanced the capability of focusing high radiation dose to cancer targets with increasing conformity and precision. Examples of current state-of-the-art techniques include intensity-modulated radiotherapy with image-guidance, stereotactic radiotherapy, tomotherapy, and proton therapy. All these advancements have led to significant improvement in cancer control with decreasing risk of damage to adjacent normal tissues.

輻射在病人護理方面扮演根本的角色，當中主要的三個領域為：

1) 診斷及介入放射學

X 射線應用於檢查病人可追溯到 1895 年。自此以後，它的應用已獲充分肯定，在治療前的診斷，疾病監察，療效的評估都極為重要。在 2010 年間，全球醫學照像已達五十億次。

X 射線醫學照像最初期以 X 線平片為主，及後 X 射線技術己發展成為更多複雜的醫學照像術，包括電腦斷層掃描（即 CT 掃描），X 光透視，血管造影和乳腺 X 線攝影。

在過去十年，這些照像形式及應用已大量普及。其發展有賴於先進的技術能融入醫學照像術，例如三維照像的重構圖像，電腦化後處理技術，及裝備上運用了卓越的工程學等等。現今已能把病人整個心臟掃描，顯現出細小的冠狀動脈，並用超高解像度電腦掃描顯示一次心跳的過程。

除了促進醫生作出診斷，也可以應用於多種疾病的治療。在介入放射學，其圖像能精確地引導醫生進入病人內部結構，使最低的侵入性程序能順利進行。介入放射學的優點為：它只產生細小的傷口，但又能安全地進入極難去到的地方。

2) 核子醫學

在核子醫學上，常為病人注射，攝入或吸入放射性同位素標記的藥劑。放射性同位素將由特定的內部器官吸收。放射性同位素衰變時，會發出輻射，有部分由病人吸收。衰減了的輻射會被特殊探測器（稱為伽瑪相機）捕獲從而產生圖像。

最廣泛使用於診斷的放射性同位素是鎝 -99m，半衰期為六小時，衰變過程會釋放 γ 射線（即伽瑪射線）。半衰期六小時可長到足夠完成診斷，但又不致對病人和醫務人員產生長期的風險。

3) 放射治療

它指在醫學領域中，使用高能量電離輻射，如 X 射線束，γ 射線，電子和重粒子等等，用於治療惡性和良性腫瘤疾病。

放射治療可從外面把聚焦集中的輻射束照射到病變位置(稱為外照射治療)，或向內插入放射性使用器於病變位置(稱為近距離放射治療)，或全身注射 / 攝入放射性物質(稱為放射性同位素治療)。選擇那一個方法取決於位置，範圍和癌症的類型。先進的技術日新月異，大大提高了集中高輻射劑量於癌症目標，改善了適形度和精確度。當前最先進的技術包括：調強放射治療與影像導航，立體定向放射治療，斷層放療和質子治療。

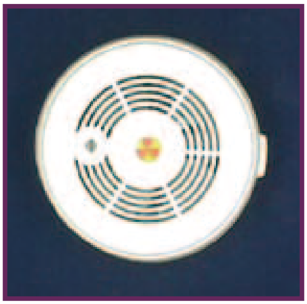
所有這些技術突破，帶來更有效的癌症控制，並減少損害鄰近的正常組織的風險。

CT Scanner
電腦斷層掃描

Applications in consumer products 消費品用途

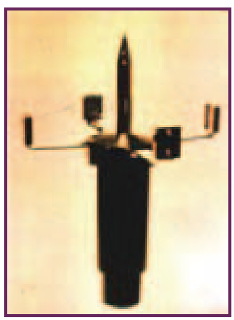
Radioactive materials are used in some consumer products. With suitable safety design and under appropriate use, their benefits significantly outweigh the associated radiation risks. These products include smoke detectors, luminous signs, radioactive lightning conductors, etc.

有些用品，如煙霧感應器、螢光指示牌和避雷針等都包含放射性物質。通過合適的設計和適當的使用，輻射的好處其實遠遠大於其所引起的危害。



Smoke detector
煙霧感應器

Luminous exit sign
(Source SRB Technologies)
螢光（出口）指示牌
（圖片來源：SRB Technologies）



Lightning conductor
(Source: Environmental Protection Department)
避雷針頭
（圖片來源：環境保護署）

Applications in consumer products 考古用途

Blue-and-white dish with grass and leaf design
草葉紋青花瓷碟

Hard pottery dou stem cup
硬陶豆

Thermoluminescence dating can determine the age of antiquities
(Source: Hong Kong Museum of History)
古物可以用熱釋光定年法判定年代
（圖片來源：香港歷史博物館）

4. How does ionizing radiation affect our body?
輻射如何對人體做成危害？

Radiation affects human body in highly complicated processes. Various degrees of biological effects, from damage to death of living tissues, involve a number of pathological changes in human cells.

Although radiation can cause damage to living tissues, human cells however can repair the damage through natural metabolic processes if the absorbed dose is not high. Recovery of cells depends on the degree of initial damage and may be different for different individuals.

Exposure to radiation can increase the risks of cancers to the exposed individuals and genetic defects to their offspring.

Radiation dose received by the general public in daily life are very low. Even for workers who are exposed to radiation in their work, the expected radiation induced mortality rate is small when compared with some common causes of death:

輻射對人體的作用是一個極其複雜的過程。人體從吸收輻射能量開始，到產生生物效應，乃至機體的損傷和死亡為止，涉及許多不同性質的變化。

雖然輻射可能對人體造成損傷，但如劑量不高，機體可以通過自身的代謝過程對受損傷的細胞或局部組織進行修復，這種修復作用程度的大小，既與原初損傷的程度有關，又可能因個體間的差異而有所不同。

接觸輻射會增加患癌和子女出現遺傳缺陷的機會。

一般人在日常生活中受到的輻照量極低，即使是工作時暴露於輻射中的工人，估計由輻射引致的死亡率仍較一些常見致命因素所引致的死亡率為低。

Average annual risk of death in Hong Kong from some common causes
香港一些常見致命因素的每年平均死亡率

Cause 致命因素	Annual risk of death 每年死亡率	
Smoking 10 cigarettes a day 每日吸煙 10 支	1 in	200
Malignant diseases 惡性腫瘤病	1 in	630
Occupational accidents 職業意外	1 in	55,000
Traffic accidents 交通意外	1 in	22,200
Radiation exposure in work for local workers (average 0.15 mSv/year) 本地工人工作時暴露於輻射中（平均每年 0.15 毫希沃特）	1 in	170,333

5. Legal controls
管制法規

The import, export, possession and use of radioactive substance and irradiating apparatus in Hong Kong is governed by the Radiation Ordinance (Cap 303), Laws of Hong Kong, which provides for the establishment of the Radiation Board.

A licence from the Board is required for any person to carry out any activity involving radioactive substance or irradiating apparatus. The Radiation Health Unit of the Department of Health serves as the licensing office of the Radiation Board. The unit also serves as Government's adviser on radiation health matters, provides occupational and environmental radiation monitoring services, and maintains the radiation metrology standards of Hong Kong.

在香港，放射性物質及輻照儀器的進口、出口、管有與使用受《輻射條例》(第303章)規管，條例並規定成立輻射管理局。

任何人如擬從事任何涉及放射性物質或輻照儀器的活動，必須向管理局申領牌照。衛生署放射衛生部負責為管理局處理發牌工作。此外，該部是政府的放射衛生事務顧問，並提供職業及環境輻射監測服務和維持本港的輻射計量標準。

Section II
第二章

Clinical Information on Radiation and Radiation Protection Symposium: From Evidence to Actions
輻射防護及輻射臨床知識講座：從實證到行動

17 June 2011 (Friday), 2:00pm – 5:40pm
二零一一年六月十七日（星期五）
下午二時正至五時四十分

Invited Speakers and Panel Members
專家講師及專題討論講師

Mr. Clement CHENG
鄭結文先生

Head of Radiation Health Unit,
Department of Health, Hong Kong Special Administrative Region

香港特別行政區衞生署放射衞生部主管高級物理學家

Prof. KHONG Pek Lan
孔碧蘭教授

Member of ICRP Committee 3 on Radiation Protection in Medicine

國際放射防護委員會會員

Dr. Lawrence LAU
劉樹榮醫生

Chairman, International Radiology Quality Network

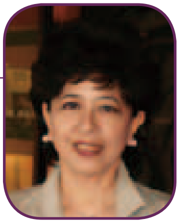
國際放射科質素學會主席

Dr. LAW Chun Key
羅振基醫生

President, Hong Kong College of Radiologists

香港放射科醫學院院長

Dr. Lilian LEONG
梁馮令儀醫生



Immediate Past President, Hong Kong College of Radiologists

香港放射科醫學院前院長

Ms. Joyce LEUNG
梁靄然女士

President, Hong Kong Association of Medical Physics

香港醫學物理學會會長

Dr. MA Tin Ging Hector
馬天競醫生

Council Member, Hong Kong College of Radiologists

香港放射科醫學院委員會會員

Dr. Madan REHANI

Radiation Safety Specialist, International Atomic Energy Agency & Secretary of ICRP Committee 3 on Radiation Protection in Medicine

國際原子能機構放射安全專家及國際放射防護委員會秘書

Dr. WU Po Man
胡寶文博士

Committee Member, Hong Kong Association of Medical Physics

香港醫學物理學會會員

Scientific Programme
會議日程

Time 時間	Lecture Titles 演講題目	Speakers 專家講師/ Panel Members 專題討論講師
14:00-14:20	Local, national and global actions to improve quality care and radiation safety 通過地方，國家和全球行動來提高護理質量和輻射安全	Dr. Lawrence LAU 劉樹榮醫生
14:20-14:40	Adverse effects of radiological exposures from diagnostic imaging 醫學診斷成像輻射的不良效應	Prof. KHONG Pek Lan 孔碧蘭教授
14:40-15:00	Essential radiation protection: The role of and actions of referring physicians 輻射防護的要點：轉介醫生的角色和行動	Dr. Lawrence LAU 劉樹榮醫生
15:00-15:20	Radiation risks in X-ray imaging: Are we safer now than 50 years ago? X光成像的輻射風險：現在是否比五十年前更安全？	Dr. Madan REHANI
	Coffee Break 小休	
16:00-16:20	Radiation doses to the public arising from medical exposures in Hong Kong 香港醫療照射對公眾造成的輻射劑量	Mr. Clement CHENG 鄭結文先生
16:20-16:40	Time for change: Building a radiation exposure history for every patient 構建每位病人輻射照射量史，邁向時代新進展	Dr. Madan REHANI

Time 時間	Lecture Titles 演講題目	Speakers 專家講師/ Panel Members 專題討論講師
	FORUM : Clinical Information on Radiation and Radiation Protection (in Cantonese) **輻射防護及輻射臨床知識專家座談會**（以粵語演講）	
	Opening 講題簡介	Dr. Lilian LEONG 梁馮令儀醫生
	Radiation Protection in Medicine 醫療輻射防護	Ms. Joyce LEUNG 梁靄然女士
	Radiation Protection Infrastructure in Hong Knog 香港輻射防護基礎體系	Mr. Clement CHENG 鄭結文先生
16:40-17:40	Potential hazard in high-dose radiological examination 高輻射放射診斷的潛在風險	Dr. MA Tin Ging Hector 馬天競醫生
	Use of Ionizing Radiation in Cancer Treatment 電離輻射在癌症治療之應用	Dr. LAW Chun Key 羅振基醫生
	Essential Radiation Protection for Patients 輻射防護　病人需知	Dr. Lawrence LAU 劉樹榮醫生
	Panel Discussion 專題討論 Mr. Clement CHENG 鄭結文先生/Dr. Lawrence LAU 劉樹榮醫生/ Dr. LAW Chun Key 羅振基醫生/Dr. Lilian LEONG 梁馮令儀醫生/ Ms. Joyce LEUNG 梁靄然女士/Dr. MA Tin Ging Hector 馬天競醫生/ Dr. WU Po Man 胡寶文博士	

RP-1-01 **14:00-14:20** **N101**

Local, national and global actions to improve quality care and radiation safety

Dr. Lawrence Lau
Chairman
International Radiology Quality Network

In the last three decades, the use of radiation in medicine has greatly expanded. By using new techniques and technologies, the providers have improved radiation safety and the quality of care. Patients benefit from earlier diagnoses and less invasive treatments.

The stakeholders apply a range of actions to achieve better quality, radiation safety and more appropriate use of radiation in medicine. These actions will be discussed under a framework of measures and strategies applicable at local, national and global levels. The strategies include: conducting research, promoting awareness, providing education and training, strengthening infrastructure and implementing policies.

Stakeholders are informed and empowered by awareness campaigns and web-based informative resources from trustworthy sources. Examples are the Image Gently Campaign and the International Atomic Energy Agency Radiation Protection of Patients websites respectively. The International Radiation Protection Association is collaborating with others to promote a radiation protection culture in the workplace.

Examples of research actions include an assessment into the biological effects and risks of radiation and population exposure surveys. Research provides the evidence to control and communicate risks, inform decisions, implement preventative actions and strengthen policies.

Providing education and training at undergraduate and postgraduate levels is an effective means to promote appropriate use of radiation and radiation safety. Procedure justification, optimization of image quality and radiation protection and error reduction are useful topics.

Building capacity, ensuring competency, applying workplace improvement actions, participating in accreditation, collaborating in integrated initiatives, improving equipment design and providing sustainable funding are useful actions used to strengthen a system's infrastructure. Funding for system-based research into radiation safety in medicine is minuscule when compared to other enterprises with similar budgets.

Examples of radiation safety policies include the International Basic Safety Standards, International Action Plan for the Radiological Protection of Patients and International Action Plan on Occupational Radiation Protection. Some recent actions from regional and national regulatory authorities will be outlined.

Under a globalized environment, collaboration will provide strength and synergy, minimize duplication and spearhead these actions to improve patient care and radiation safety. Agencies, authorities, professional organizations and individual stakeholders play specific roles in the development and implementation of these actions. These actions will eventually affect the users of radiation in medicine in their daily work. Therefore, it is important to engage them, to ensure their input and the implementation of such actions.

RP-1-01	14:00-14:20	N101

通過地方，國家和全球行動來提高護理質素和輻射安全

劉樹榮醫生
國際放射科質素學會主席

在過去的三十年，在醫學上使用的輻射用途大大擴展。通過使用新的科技和技術，輻射安全和護理的質素亦相對提高。患者可受益於及早診斷與減低治療創傷，治癒的成功比率亦因此相對提高。

利益相關者可以使用一套綜合行動去改善在醫學上使用輻射線來檢驗與治療，提高質素，保障安全。這些行動，措施和策略於地方，國家和全球層面上都適用。這些策略包括：展開研究，提高意識，提供教育和培訓，加強基礎設施和執行政策。

經過宣傳運動和可靠互聯網資料，大眾會更了解輻射檢驗的利益，風險與保障。例子如溫和影像網站和國際原子能機構患者的輻射防護網站。再者，國際輻射保護協會與其他機構和團體合作，去提倡一個工作機構可有的輻射防護文化。

研究的例子包括：考證輻射線對生物的影響，效果和風險及公共輻射量調查。研究的結果會提供證據，引至加強措施與實施政策去預防輻射，控制風險和改善溝通。

為大學及畢業生提供輻射知識和培訓，是促進適當使用輻射和輻射安全的有效途徑。包括：選用適當檢驗，採用適量輻射及恰當圖像質素措施和減少錯誤。

加強系統的基礎設施的例子包括：增加醫療人力，確保放射科專家符合規定條例，應用改良放射設施行動，參與鑑定計劃，合作及參與綜合改善輻射保障計劃，改良儀器設計和提供可持續的經費方案。與其他相似的企業相比，輻射安全研究的經費可說是微不足道。

輻射安全政策的例子包括：國際基本輻射安全標準，為患者和職業醫務人員而設的國際放射防護行動計劃。在這個講座會上，會為大家介紹一些最近區域和國家監管當局採用的行動。

在一個全球化的環境下，合作將會增進協同作用，減少重複和帶導這些行動去改善病人護理和輻射安全。聯合國機構，監管當局，專業團體和個人利益相關者會執行其特別責任去發展和實行這些行動。這些行動最終會影響醫療與輻射工作者。因此，他們必須參與，以確保他們的投入和實行這些輻射安全措施。

RP-1-02 **14:20-14:40** **N101**

Adverse effects of radiological exposures from diagnostic imaging

Prof. Khong Pek Lan
Member of ICRP Committee 3 on Radiation Protection in Medicine

The use of radiation for medical diagnostic examinations contributes over 95% of man-made radiation exposure and is only exceeded by natural background as a source of exposure to the world's population (UNSCEAR 2008). For several developed countries, the increased use of high-dose X-ray technology, in particular computed tomography, has resulted for the first time in history, in a situation where the annual collective and per capita doses of ionizing radiation due to diagnostic radiology have exceeded those from the previously largest source (natural background radiation) (UNSCEAR 2008). UNSCEAR (2008) compared estimates of the 1991-96 and 1997-2007 periods and concluded that the worldwide collective effective dose for medical diagnostic procedures increased by 70 percent. It was also estimated that worldwide there were about 3.6 billion imaging studies per year (survey covering period of 1997-2007) using ionizing radiation compared to the previous report of 2.4 billion per year (survey covering period of 1991-1996) – an increase of approximately 50%.

The biological effects of radiation can be grouped into two types: deterministic effects (tissue reactions) and stochastic effects (cancer and heritable effects). Deterministic effects are effects that only result when many cells in an organ or tissue are killed, and will only be clinically observable if the radiation dose is above some threshold. Such effects can occur in the application of ionizing radiation in radiation therapy, and in interventional procedures, particularly when fluoroscopically guided interventional procedures are complex and require longer fluoroscopy times or acquisition of numerous images. Stochastic effects are due to radiation damage to the DNA that can transform cells that are still capable of reproduction. Despite the body's defenses, which are normally very effective, there is a small probability that this type of damage can lead to a malignant condition. If the initial damage is to the germ cells in the gonads, heritable effects may occur. These effects are called 'stochastic'. The probability of a stochastic effect attributable to radiation increases with dose and is probably proportional to dose at low doses. At higher doses and dose rates, the probability often increases with dose more markedly than simple proportion. Calculations performed on the assumption of a linear non-threshold model of radiation action estimate that the proportion of cancer deaths in a general population that could be attributed to exposure from radiological procedures may reach a level from a fraction of one to a few percent of that cancer mortality (NAS/NRC, 2006). In addition, the risk is non-uniformly distributed in a population. Some groups of patients are examined much more frequently due to their health status. Also, some groups show higher than average sensitivity for cancer induction (e.g. embryo/fetus, infants, young children, those with genetic susceptibility). All these circumstances indicate that proper justification of radiation use and optimisation of radiation protection in medicine are indispensable principles of radiological protection.

醫學診斷成像輻射的不良效應

孔碧蘭教授
國際放射防護委員會會員

來自醫學診斷成像的輻射佔人工輻射的比例超過 95%，且僅次於自然本底對全世界人口造成的輻射 (UNSCEAR 2008)。在某些發達國家中，由於高劑量 X 射線技術尤其是 CT 的廣泛應用，來自醫學診斷的人均年度累計劑量甚至首次超過了自然本底輻射 (UNSCEAR 2008)。UNSCEAR (2008) 比較了 1991-96 和 1997-2007 兩個時期的數據之後認為，來自於醫學診斷成像的輻射增加 70%。另據估計，1991-1996 之間平均每年有 24 億次醫學成像；而在 1997-2007 期間，全世界每年有 36 億次，而也就是增加了 50%。

輻射的生物學效應有兩種類型：決定性效應（組織反應）和隨機性效應（癌症和遺傳學效應）。決定性效應是指，如果輻射劑量高於某一閾值，組織或者器官中的大量細胞將會死亡，並且這種情況可在臨床觀察到。這種效應可能發生於放射治療時，或者介入放射過程中，尤其是當 X 射線透視引導的介入放射過程比較複雜而需要長時間的、大量的成像的時候。

隨機性效應的產生是由於 DNA 的輻射損傷導致仍可進行自我複製的細胞發生變異。儘管一般情況下身體的免疫功能依然有效，但這種損傷仍存在較小的可能性導致惡化。如果這些損傷是在性腺內的生殖細胞發生的，那麼可能會發生遺傳性效應。這些效應被稱為“隨機性效應”。輻射導致的隨機性效應的可能性隨著劑量而增加，且有可能在低輻射的情況下跟輻射量成正比。高劑量或者高劑量率的情況下，這種可能性會比普通正比例關係更大更顯著。基於輻射危害性線性無閾模型假設的計算顯示，來自醫學診斷的輻射造成的癌症致死數量，可能占所有癌症致死數量的一個到幾個百分點 (NAS/NRC, 2006)。

另外，這些風險在人群中並非平均分佈。某些病人可能由於健康狀況經常受到照射；另外，某些人群可能更容易因輻射而致癌（例如胚胎 / 胎兒，嬰兒，幼童等遺傳易感性人群）。所有這些情況表面，在醫學應用中，輻射應用的正當化，輻射防護的最優化是輻射防護必不可少的原則。

RP-1-03 **14:40-15:00** **N101**

Essential radiation protection: The role of and actions of referring physician

Dr. Lawrence Lau
Chairman
International Radiology Quality Network

Procedures employing radiation are increasingly used in medicine to accurately diagnose and non-invasively treat many conditions. However, some of these procedures are neither justified nor necessary. If radiation was inappropriately used, population exposure could become a public health concern.

Medical students and practitioners are not well informed on the effects, risks, safety and appropriate use of radiation in medicine. The strengthening of undergraduate and postgraduate education will improve awareness and knowledge, and minimize inappropriate use.

The essentials of radiation protection for the referring physicians include a discussion of: the effects (why); the aims, principles and roles (what); the steps along the patient journey (when); and the responsibilities and actions (how). The aims are to provide patient-centered care, to promote informed decision-making and to apply radiation protection measures. The radiation protection principles are: procedure justification, optimization of image quality and radiation protection, and error reduction. The roles and responsibilities for the referring physicians in radiation protection will be discussed. Appropriate actions should be applied along the patient journey: before, during and after the procedure, towards good medical practice.

Evidence-based referral guidelines, relative radiation level tables and informative web-based resources are supporting tools for the referring physicians when selecting a procedure. Referring physician must provide relevant information and assist the service provider to optimize protection by using the most suitable protocol. Legible and unambiguous referral notes will minimize misunderstanding, prevent error and avoid the undertaking of an incorrect procedure.

In essence, a '4-A' approach is suggested: to be <u>aware</u> of the effects and roles, to <u>aim</u> towards patient-centered care, to <u>assume</u> and share responsibilities, and to <u>apply</u> practical actions. These efforts will improve patient care, radiation safety, radiation protection and more appropriate use of radiation procedures in medicine. In practice, this simply means selecting the right procedure (justification), using the right dose (optimization) and reducing errors, which is appropriate for the local setting.

RP-1-03	14:40-15:00	N101

輻射防護的要點：轉介醫生的角色和行動

劉樹榮醫生
國際放射科質素學會主席

輻射在醫學上的應用日益增多，它能準確地診斷病症，同時在很多情況下進行無創治療。但是，其中的一些程序可能是既不當做亦不需做。如果不恰當地使用輻射，人口輻射量可構成一個公共健康問題。

醫科學生和醫生並非都知道放射醫學所帶來的生物效應，風險，安全性和正當的使用。加強大學及畢業生教育將提高對輻射保護的意識和知識，並盡量減少不適當使用。

輻射防護的要點對轉介醫生而言，其討論應包括：影響（為什麼），目標，原則和角色（什麼），病人所經歷的過程的步驟（何時），以及責任和行動（如何）。宗旨是提供以病人為中心的護理，以促進知情決策和應用輻射防護措施。輻射防護原則是：程序的正當化，優化圖像質量和輻射防護，和減少錯誤。轉介醫生的角色和職責在輻射防護將被討論。應採取適當的行動配合病人的治療過程：包括程序之前，期間和之後，邁向良好的醫療實踐。

以證據為基礎的轉介指引，相對輻射水平表和信息網絡為基礎資源都是醫生在選擇過程中有用的工具。轉介醫生必須提供有關資料，並協助放射學專家，以優化輻射防護，通過使用最合適的檢驗程序 (Protocol)。清晰，明確轉介摘記 (referral notes) 將會減少誤會，防止錯誤和避免因不正確的程序所作出的承擔。

從本質上講，"4 - A" 的做法建議如下：(1) 對輻射影響和角色需有意識 (Awareness)，(2) 實現以病人為本的護理為目標 (Aim)，(3) 承擔 (Assume) 和分擔責任，(4) 應用 (Apply) 實際行動。

以上的努力將會改善病人護理，輻射安全，輻射防護和更恰當地使用在醫學中的輻射程序。在實踐上，這是指選擇正確的程序（Justification 選用適當檢驗），使用恰當的輻射劑量（Optimization 即優化），減少錯誤，以適應當地環境。

RP-1-04 15:00-15:20 N101

Radiation risks in X-ray imaging: Are we safer now than 50 years ago?

Dr. Madan Rehani
Radiation Safety Specialist, International Atomic Energy Agency &
Secretary of ICRP Committee 3 on Radiation Protection in Medicine

Radiation induced cataract among staff in interventional radiology and cardiology, skin injuries to patients undergoing interventional procedures and recently computed tomography (CT) are the new findings not witnessed several decades ago. Patients undergoing more than 10 CT scans in few years and in some cases few tens with resultant radiation dose of few hundred mSv is of recent origin. Children undergoing high dose procedures such as CT and interventional procedures are at higher risk of cancer in their life time.

Half a century ago, radiography was the main technique in radiology departments with small component of fluoroscopy. Even though radiography still may account for nearly 90% of all radiological examinations in most radiology departments, it has become fairly safe for patients and staff with improvements in technology. Patient doses have decreased by more than 10 times as compared to a century ago and facility design makes radiography rooms fairly safe for staff who, while following norms, can perform over a hundred radiographic examinations a day and still get less than 1 mSv per year against dose limit of 20 mSv per year. The extensive use of fluoroscopy and associated image sequences, while having immense clinical benefits, has posed new risks not encountered fifty years ago. While for most patients the benefits outweigh the risks, even though much higher as compared to several decades ago but still much smaller than the risk in surgery which the patient would have to undergo if interventional procedure is not performed. Typically one patient out of 10,000 undergoing interventional procedure is estimated to have risk of skin injury. For staff the risk of cataract although merits attention, but it can be minimized with the use of protection devices and tools to a level at which the staff can perform many interventional procedures every day without suffering radiation effect. With more and more newer interventional procedures being added every year, the risks to patient and staff are going to increase requiring attention in coming years. CT has attracted lot of attention in recent years earlier because of carcinogenic risks associated with multiple CT scans but lately the tissue reactions (skin injuries).

We face newer challenges in radiation protection where radiation risks to patients require continuous vigil and actions. There are issues of staff protection too that cannot be ignored. While over 90% of patients and staff are safer than 50 years ago, smaller percentage is at significant risks which are new and challenging.

RP-1-04 15:00-15:20 N101

X 光成像的輻射風險：現在是否比五十年前更安全？

Dr. Madan Rehani
國際原子能機構放射安全專家及國際放射防護委員會秘書

放射工作人員因介入放射學，心臟 X 射線診斷可引致白內障；病人因進行介入手術及近年電腦斷層掃描導致的皮膚損傷，是最近新發現的個案，也是過去數十年前不曾見到的。若病人在數年內接受過超過十次電腦斷層掃描，及在某些情況下接受超過數十次電腦斷層掃描，總劑量可達數百毫希；正是發病的原因。所以兒童接受高劑量的 X 射線檢查，例如電腦斷層掃描和介入診斷檢查，在兒童往後一生中都存在着較高的致癌機會。

半世紀前，在放射科中以 X 光照相術為主；X 光透視檢查只佔一小部分。儘管在大多數部門 X 光照相術仍可能佔近 90% 的放射影像學檢查時，它已成為相當安全的技術。病人劑量比一個世紀前減少了 10 倍以上，防護設施的設計，使在 X 光室工作的人員可安全地工作，如遵循正常程序，一天可以進行多於過百次 X 光檢查，仍然可以做到少於每年 1 毫希劑量，比每年劑量限值為每年 20 毫希為低。

X 光透視及其相關的圖像序列受到廣泛使用，固然帶來極大的臨床效益。但是引起新的風險 也是幾十年前沒見過的。雖然大多數病人的得益大於風險，儘管輻射照射量比數十年前大很多，仍比手術風險低得多；若不做介入診斷，病人只能選擇手術。通常一個病人接受了介入診斷估計有 1/10,000 機會皮膚損傷的風險。對於員工值得關注的白內障的風險，通過使用防護裝置和工具可得到一定保護程度，使員工進行介入診斷時避免產生不良的輻射效應。

但隨著每年越來越多新的介入診斷，在未來幾年內，病人和員工都需對增加的風險密切留意。近年來電腦斷層掃描（CT）亦受到廣泛關注，一方面因接受多次電腦斷層掃描相關的致癌風險，另一方面是最近經常談論的組織反應（皮膚因輻射而受傷）。

我們已面臨輻射防護新挑戰：病人的輻射風險需要持續的監察和相應的行動。員工的防護問題亦不能忽視。當九成的員工和病人比五十年前更安全時，尚有少部分人的輻射風險明顯偏高，它們既是新生事物亦頗具挑戰性。

RP-2-01 **16:00-16:20** **N101**

Radiation doses to the public arising from medical exposures in Hong Kong

Mr. Clement Cheng
Head of Radiation Health Unit
Department of Health, Hong Kong Special Administrative Region

It has been relatively well established that human exposure to ionizing radiation at doses exceeding about 1 sievert may result in harmful effects to health. There is also an increased risk of the exposed individual of developing cancer in later years of life. However the risks of cancer induction associated with doses below about 200 millisievert are less obvious because of the large underlying incidence of cancer caused by other factors. At low doses, radiological protection standards assume that any dose of radiation, no matter how small, involves a possible risk to human health.

However, ionizing radiations may be used to help in the diagnosis and treatment of diseases. The use will need to be properly justified by clinical judgments of the attending doctors, so that more good than harm will be done to the exposed patient. Furthermore, radiation doses to patients will need to be kept to as low as reasonably achievable. This can be achieved by, amongst the various means, proper training of health care professionals, proper choice of equipment and proper equipment settings.

According to the United Nations Scientific Committee on the Effects of Atomic Radiation Report to the General Assembly (2008), medical radiation exposure is the single largest artificial source of exposure to human and the second largest source of exposure after exposure to the naturally occurring radioactive gas radon. Both the annual frequency of medical radiological examination and the annual per caput radiation dose have increased significantly over the past two decades.

A study on the radiation doses to the public arising from medical uses of ionizing radiation in Hong Kong was conducted in 2003-2004. Effective doses to patients who received various types of medical diagnostic radiological procedures were determined and the prescribed doses to target volumes of patients who were given radiotherapy treatments were collected. The annual collective dose and per caput effective dose were estimated to be 4 880 man sievert and 0.71 millisievert respectively. The annual per caput effective dose from diagnostic medical procedures in Hong Kong was comparable to those of the healthcare level I countries/areas, such as Australia, Canada, France, Sweden and United States.

RP-2-01 **16:00-16:20** **N101**

香港醫療照射對公眾造成的輻射劑量

鄭結文先生
香港衛生署放射衛生部主管高級物理學家

人體接受超過約 1000 毫希的電離輻射量時，健康將會出現較明顯的傷害，晚年患上癌症的風險也會因而增加。然而當劑量低於約 200 毫希時，輻射致癌的風險則不太明顯，因為其他種種致癌因素已經構成巨大的癌症發病基數。現行輻射防護理論假設任何不管多麼小的輻射劑量，都可能對人體健康構成風險。

不過，電離輻射可用於診斷和治療疾病。為了保障病人福祉，用於病人身上的醫療照射必須由主診醫生基於適當的臨床判斷，肯定該照射對病人的利益將會大於傷害的情況下才應施行。而且即使有關醫療照射已確定屬於恰當，執行照射時仍需留意確保病人的輻射劑量達到合理可行的最低水平。要實現這目標，必須有受過適當培訓的醫護人員，適當的醫療照射設備和在執行時為放射儀器作適當的設定。

根據「聯合國原子輻射效應科學委員會」2008 年向聯合國大會提交的報告，醫療照射是人類受照的最大人工輻射來源，也是繼天然放射性氡氣之後的第二大輻射照射來源。在過去二十年間，無論每年的醫學造影檢查頻率以至每年的人均輻射劑量都有顯著的增長。

衛生署在 2003-2004 年間就電離輻射在香港公共醫療用途產生的輻射劑量進行研究，收集了病人從各類醫學放射診斷程序和放射治療的有效劑量的數據。集體劑量和人均有效劑量估計分別為每年 4 880 人 - 希和 0.71 毫希。結果顯示香港人每年從醫學診斷程序接受的人均有效輻射劑量，與屬於一級醫療保健水平的國家和地區，如澳洲、加拿大，法國，瑞典和美國看齊。

RP-2-02 **16:20-16:40** **N101**

Time for change: Building a radiation exposure history for every patient

Dr. Madan Rehani
Radiation Safety Specialist, International Atomic Energy Agency &
Secretary of ICRP Committee 3 on Radiation Protection in Medicine

It is now a fact that some individual patients are receiving radiation doses in excess of 100 mSv from repeated diagnostic CT examinations. It is also a fact that hair loss and erythema have been reported in the last 3 years in patients undergoing CT scans.

The concept of "radiation passport" or something similar has been around for over a decade but the current impetus is based on a) realization of increased radiation doses to individual patient in diagnostic and interventional procedures and b) possibility of electronic means to achieve tracking of procedures.

In the past, many countries laid emphasis on the establishment and use of diagnostic reference levels (DRLs) that have contributed immensely to the optimization process. DRLs cannot help handling the problem of multiple and unjustified exposures which in some situations account for as much as 50% of all examinations. The approaches utilized have been awareness and use of appropriateness criteria developed by professional societies. Obviously, the current situation with high unjustified examinations indicates that this alone is insufficient. A compelling answer is to track lifetime radiation exposure (radiation history) of patients. The IAEA had launched a project called Smart Card/ SmartRadTrack few years ago.

Technology is advancing at a fast pace and some countries have recently reached the stage of tracking radiation exposure of patients instantaneously when the procedure is conducted in several dozen hospitals in the country connected by picture achieving and communication system (PACS), and through slightly increased effort where conducted in another part of the country from where data can be transferred through PACS. A large number of countries have this possibility restricted only to individual hospitals. Some countries are advancing to a nationwide system. The image data transfer standards now involve radiation exposure indices with which major vendors are now complying. It is envisaged that existing bottlenecks will be taken care of in the coming years. While sub-national systems are a reality, and national systems a possibility achievable within a few years, the international systems are something that require political agenda. The call for action role that the IAEA is playing, besides being initiator and facilitator, is visionary towards achieving radiation protection of the patients in future through radiation exposure history for every patient.

RP-2-02	16:20-16:40	N101

構建每位病人輻射照射量史，邁向時代新進展

Dr. Madan Rehani

國際原子能機構放射安全專家及國際放射防護委員會秘書

有個別病人因為接受重複的電腦斷層掃描檢查診斷而所受到的輻射劑量超過 100 mSv. 現在已成為事實。另一個事實是，在過去 3 年有報告顯示病人因進行電腦斷層掃描檢查而導致脫髮和紅斑。

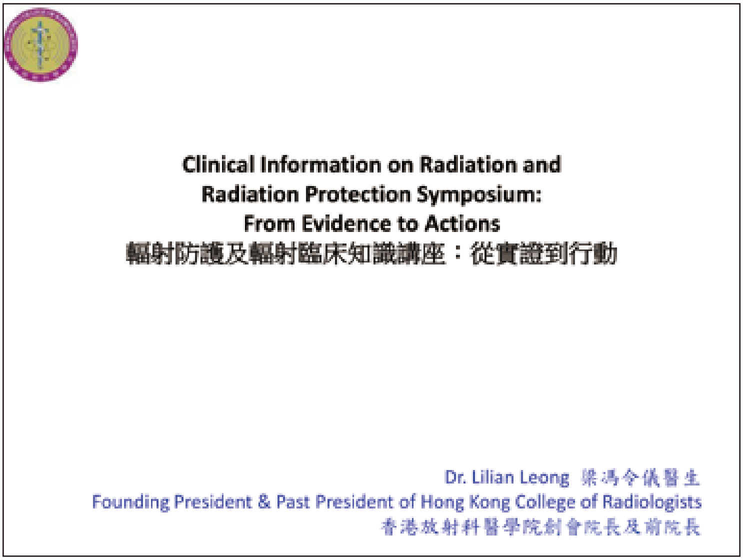
“ 輻射護照 ”或類似概念已經存在了十多年，但目前的推動力是基於 a）認識到個別病人因診斷和介入程序而增加輻射劑量和 b）用電子方法來實現跟踪程序的可能性。

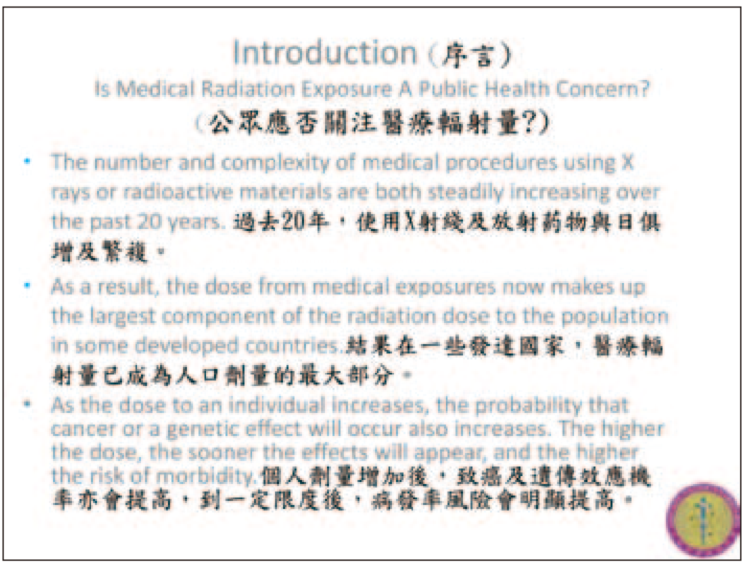
在過去，許多國家制定側重於建立和使用“ 診斷參考水平 ”（DRLs），在劑量優化進程方面作出極大的貢獻。“ 診斷參考水平 ”不能幫助處理不應做的輻射診斷檢查和重複輻射診斷的問題，這些問題有些情況下已超過所有檢查的 50%。DRLs 曾被專業協會使用和發展出一套“ 恰當性準則 ”。顯然，目前的形勢表明已有太多不應做輻射診斷檢查，單靠 DRLs 是不足夠的。一個令人信服的解決方案是跟踪病人一生中所接受的輻射量（輻射記錄）。國際原子能機構在幾年前發起了一個項目叫做智能卡 / 智能輻射量追踪 (SmartRadTrack)。

技術正在高速前進，一些國家最近已能做到一個階段，在該國數十間醫院利用連接到一起的圖片和通信系統（PACS），立即跟踪病人曾受輻射的照射量。並通過進一步的努力，透過圖片和通信系統（PACS）可以傳輸數據到位於國家另外的一端。通過 PACS 系統，這種可能性在大部分國家應用只限於個別醫院。有些國家正在邁向一個全國性的系統。目前各大廠商已能包括輻射照射指數，並符合圖像數據傳輸標準。在未來幾年可期望現有的瓶頸將獲得疏導。雖然如今“ 次國家級規模 ”是一個現實，在幾年內有可能實現邁向“ 國家級規模 ”。 但“ 國際級規模 ”則需要政治議程。國際原子能機構正在擔當行動者的角色，除了是發起者和推動者外，更極力爭取將來通過“ 輻射量史 ”為每一位病人實現更佳輻射防護為目標。

Presentations of Forum
專家座談會內容

Opening 講題簡介 Dr. Lilian LEONG 梁馮令儀醫生





輻射保障原則

- 適當輻射線檢驗應用於
  - 指導病人護理;
  - 提升民眾健康; 及
  - 在錯過可以治療的疾病相比之下，輻射線檢驗的風險較低
- 鞏固輻射保障的三項措施
  - 選擇適當及合理的檢驗, 益處應比壞處多;
  - 優化輻射保障措施及圖像質量技術, 原則上應用最低及有效的輻射量; 及
  - 盡量減少人為錯誤

Principles of Radiation Protection

- Radiation procedure is used if
  - It will guide patient management;
  - It will improve population health; &
  - Risk of procedure less than risk of missing a treatable disease
- 3 protection measures
  - Procedure justification, i.e. benefit more than harm;
  - Optimization of radiation protection & image quality, i.e. apply As Low As Reasonably Achievable (ALARA) Principle; &
  - Error prevention

Introduction（序言）

Is Medical Radiation Exposure A Public Health Concern?

(公眾應否關注醫療輻射量?)

- In this public lecture, the concern of medical radiation exposure and potential hazard will be discussed by different prestigious speakers.

為了推廣普及輻射知識，關注醫療輻射量帶來的潛在危害，特此舉辦公開講座，為大家請來幾位專家，歡迎….


1st speaker（第一位講者）
Ms. Joyce Leung（梁靄然女士）
President, Hong Kong Association of Medical Physics
香港醫學物理學會會長
Title (講題):
Radiation Protection in Medicine
醫療輻射防護


2th speaker（第二位講者）
Mr. Clement Cheng（鄭結文先生）
Head of Radiation Health Unit, Department of Heath
Hong Kong Special Administrative Region
香港特別行政區衛生署放射衛生部
主管高級物理學家
Title (講題):
Radiation Protection Infrastructure in Hong Kong
香港輻射防護基礎體系

3rd speaker (第三位講者)

- Dr. Ma Tin Ging, Hector (馬天競醫生)

  Council Member, Hong Kong College of Radiologists

  香港放射科醫學院委員會會員

Title (講題):

- Potential hazard in high-dose radiological examination

  高輻射放射診斷的潛在風險

4nd speaker (第四位講者)

- Dr. Law Chun Key (羅振基醫生)

  President of Hong Kong College of Radiologists

  香港放射科醫學院院長

Title (講題):

- Use of ionization radiation for cancer treatment

  電離輻射在癌症治療之應用

5th speaker（第五位講者）

- Dr. Lawrence LAU (劉樹榮醫生)
  Chairman, International Radiology Quality Network
  國際放射科質素學會主席

Title (講題):

- Essential Radiation Protection for Patients
  輻射防護 病人需知

Acknowledgement

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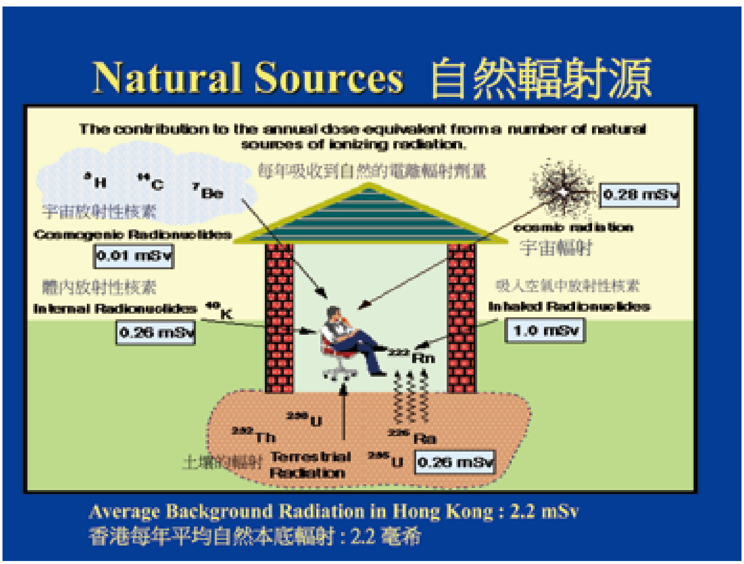
Radiation Protection in Medicine
醫療輻射防護
Public 公眾
Patients 病人
Staffs 職員
Ms Joyce Leung
Hong Kong Association of
Medical Physics
梁靄然
香港醫學物理學會會長


Natural Sources 自然輻射源
The contribution to the annual dose equivalent from a number of natural sources of ionizing radiation.
每年吸收到自然的電離輻射劑量
宇宙放射性核素
Cosmogenic Radionuclides
0.01 mSv
0.28 mSv
cosmic radiation
宇宙輻射
體內放射性核素
Internal Radionuclides
0.26 mSv
吸入空氣中放射性核素
Inhaled Radionuclides
1.0 mSv
Rn
Th
Ra
土壤的輻射
Terrestrial Radiation
0.26 mSv
Average Background Radiation in Hong Kong : 2.2 mSv
香港每年平均自然本底輻射 : 2.2 毫希


Natural & Man-made sources
美國天然和人工制造輻射平均分佈
人體內
太空
土壤
氡和釷
電腦斷層掃描
工業
核子醫學
From NCRP Report No. 160, "Ionizing Radiation Exposure of the Population of the United States" (2009)


Application in Medicine 在醫療上的應用
放射學 (Radiology)
X光照相術 (Radiography)
X光透視檢查 (Fluoroscopy)
電腦斷層掃描 (Computed Tomography)
介入放射 (Interventional Radiology)
HKAMP


Application in Medicine 在醫療上的應用
核子醫學 (Nuclear Medicine)
同位素掃描 (Radionuclide Imaging)
正電子電腦斷層掃描機 (PET/CT)
HKAMP


Application in Medicine 在醫療上的應用
放射治療 (Radiotherapy)
外束放射治療 (External Beam Radiotherapy)
短距離/ 近接治療 (Brachytherapy)
非密封放射物質治療 (Unsealed Source Therapy)
HKAMP

Procedure 程序	Effective Dose 有效劑量	Increase Risk of Cancer 增加癌症的風險	Equivalent Period of Natural Background相當於吸收相同自然本底輻射所需之時間
No Dose 沒有輻射劑量 MRI磁共振 Ultrasound超聲波掃描	Not applicable 不適用	Not known 不詳	Not equivalent 不能比較
Low Dose低劑量 Chest X-ray胸部透視 Extremities手足四肢	<0.1	One in a Million 百萬分之一	Few days 幾天
Intermediate Dose中度劑量 IVP靜脈注射腎盂攝影 Lumbar Spine腰椎 Abdomen腹部 CT head & neck 頭頸部CT	1-5	1 in 10,000 萬分之一	Few months to a few years 數月至數年
High Doses高劑量 Chest or Abdomen CT胸部或腹部CT Nuclear Cardiogram核子醫學心動圖 Cardiac Angiogram心臟血管造影 Barium enema鋇劑灌腸攝影	5 - 20	1 in 2,000 二千分之一	Few years to several years 數年至幾十年
Natural background 自然本底輻射 (Source: IAEA)	2.4	1 in 5000 五千分之一	–

Radiation Dose (輻射劑量)

- This is the amount of X ray or gamma radiation received by a patient during an examination or treatment procedure in unit of Sievert (Sv).
  病人接受X射線或伽瑪輻射檢查或療程吸收的輻射量，單位為「希」，簡寫作Sv。

- In diagnostic procedures the dose is small in millisieverts (mSv). 一般診斷檢查的劑量都很小，常用單位為「毫希」，簡寫作mSv。

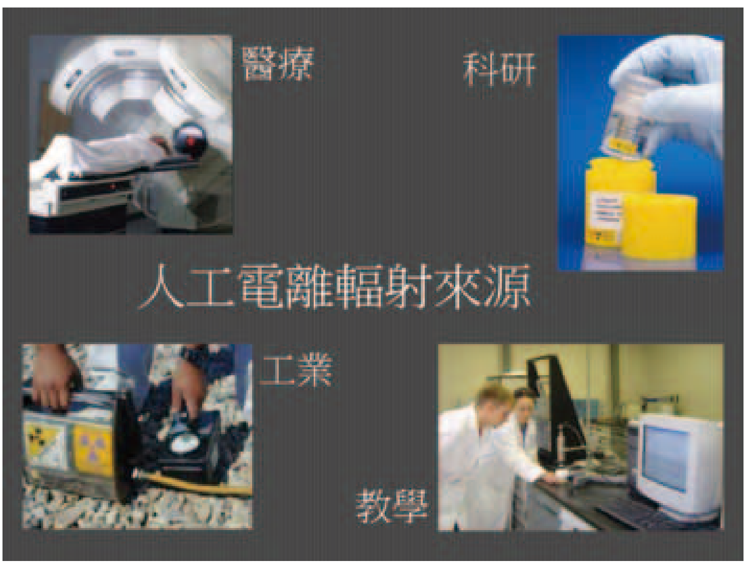
1 Sv (希)=1,000 mSv (毫希)


Principle of Radiation Protection
輻射防護原則
Justification (正當化)
No practice should be adopted unless its introduction produces a positive net benefit. (除非使用輻射能產生正面淨益處，否則不應使用)
Optimization (優化)
All exposures shall be kept As Low As Reasonably Achievable, economic and social factors being taken into account. (所有照射量必須保持可合理做到的儘可能低劑量水平,經濟及社會因素都應考慮在內)
Dose Limitation (劑量限額)
Dose limit NOT applicable to medical exposure (劑量限額不適用於醫療照射量)
資料來源 ICRP 60 (1990)國際輻射防護委員會第60号報告書


Medical Exposure (醫療照射量)
Necessary (是否需要做？)
Appropriate (是否恰當？)
Net benefit outweighs the risk of harm
(淨益處是否超越危害風險？)
Optimization & Dose ALARA
(是否已優化劑量？即符合 "可合理做到的儘可能低劑量水平的原則"？)
Recent films/images readily available to avoid unnecessary repeats
(找到最近的膠片或影像, 避免重複照射)
Comparison with Diagnostic Reference Level (DRL)
(比較 "診斷參考水平")

香港輻射防護基礎體系
Radiation Protection Infrastructure in Hong Kong

Mr. Clement CHENG 鄭結文先生




保障從業員和場外公眾的安全和利益


International Labour Organization
"Promoting decent work for all"
World Health Organization
規管基礎
IAEA
ICRP
INTERNATIONAL COMMISSION ON
RADIOLOGICAL PROTECTION


基本原則
• 由始至終管理 (cradle to grave)
• 風險相稱 (risk based)
• 國際協調 (international harmonization)
• 任何應用實踐必須正當 (justification)
• 防護必須最優化 (optimization)
• 從業員和公眾劑量限制 (dose limitation)


輻射條例（第303章）
– 輻射（管制放射性物質）規例
– 輻射（管制輻照儀器）規例


規管範圍
進口
運輸
放射性廢物管理
使用

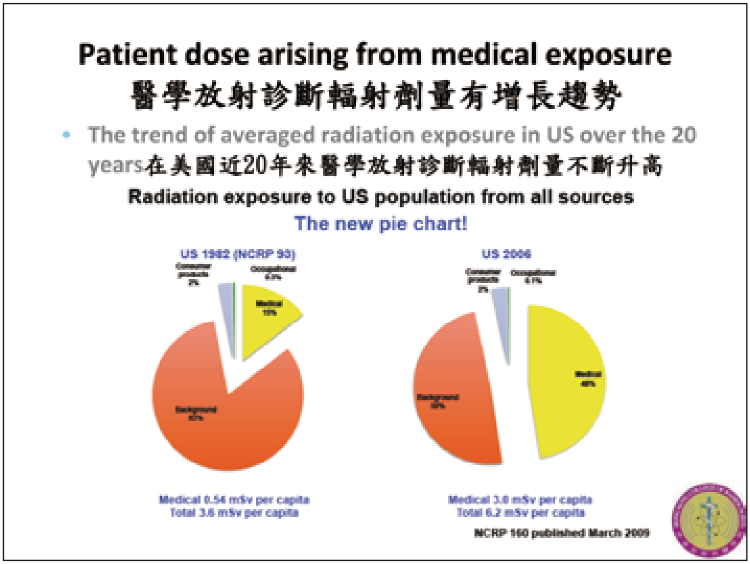

安全規格
安全工作場所與
安全操作
場所與環境
監測
個人輻射監測
與體檢
儀器
校準與
人員培訓

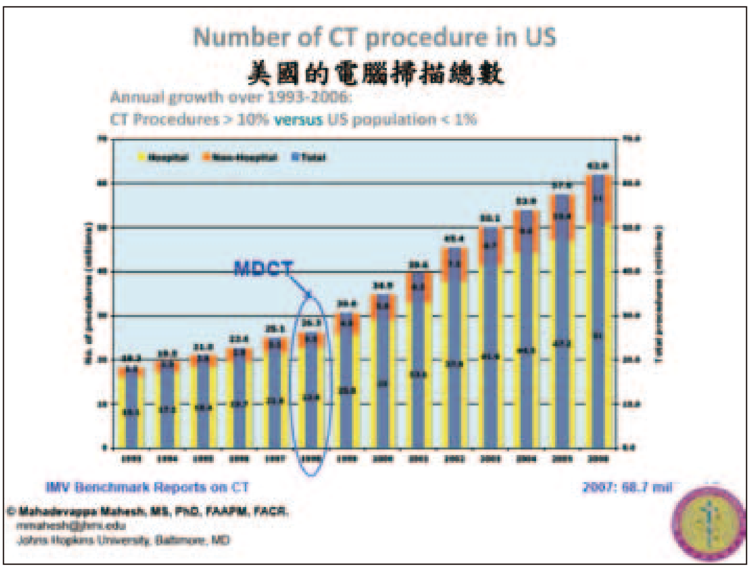

廢物處置
歷史廢物
低放射性廢物標準容器
低放射性廢物貯存庫
Department of Health, HKSAR


更多資料
http://www.info.gov.hk/dh-rhu
Department of Health, HKSAR


Hong Kong College of Radiologists
Clinical Information on Radiation and Radiation
Protection Symposium: From Evidence to Actions
輻射防護及輻射臨床知識講座：從實證到行動
Potential hazard in high-dose radiological examination (高輻射放射診斷的潛在風險)
Dr Hector T G Ma
馬天競醫生
香港放射科醫學院委員會會員


Topics
醫學放射診斷所帶來的輻射劑量 (Patient dose arising from medical exposure)
近年醫學放射診斷輻射劑量增長趨勢及潛在危害(例如：CT-灌注造影 (CT perfusion)介入放射診斷可能引起皮膚輻射損傷Radiation skin injury等) → population dose 人口劑量↑
高劑量放射診斷使個人累積劑量不斷升高已引起關注 (Cumulative dose of high dose examination) → Patient dose ↑
病人輻射劑量應參照"診斷參考水平"並需優化 (Diagnostic Reference Level of diagnostic dose)


Patient dose arising from medical exposure
醫學放射診斷輻射劑量有增長趨勢
The trend of averaged radiation exposure in US over the 20 years在美國近20年來醫學放射診斷輻射劑量不斷升高
Radiation exposure to US population from all sources
The new pie chart!
US 1982 (NCRP 93)
US 2006
Medical 0.54 mSv per capita
Total 3.6 mSv per capita
Medical 3.0 mSv per capita
Total 6.2 mSv per capita
NCRP 160 published March 2009


Number of CT procedure in US
美國的電腦掃描總數
Annual growth over 1993-2006:
CT Procedures > 10% versus US population < 1%
MDCT
IMV Benchmark Reports on CT
© Mahadevappa Mahesh, MS, PhD, FAAPM, FACR.
mmahesh@jhmi.edu
Johns Hopkins University, Baltimore, MD

Potential hazard of increasing medical exposure to patients
不斷升高的診斷輻射劑量潛在危害

The radiation risks increased with the increasing trend of more radiological examination (愈多輻射診斷，劑量及輻射潛在風險就愈高。)

Examples of some high exposures procedures高劑量放射診斷例子:

- Myocardial Perfusion CT Scan (心肌灌注CT掃描)
- Brain Perfusion CT Scan (腦 CT灌注掃描)
- Risks from repeated examination (重複檢查的輻射風險)

The Risks include 風險包括

- Skin Burns 皮膚灼傷
- Cancer Risk 癌症風險

Optimization of protection for medical exposures (病人輻射劑量需優化)

- The doses from medical exposures should be the **minimum** necessary to achieve the required diagnostic objective or the minimum to the normal tissue for the required therapeutic objective (醫療劑量應愈低愈好，但又要達到診斷的目標，並減少正常組織的輻射損傷)
- Choice of imaging modalities is important (選擇什麼方法極為重要)
- Fast advance in equipment technology would significantly reduce radiation dose (先進的醫療設施已大大減低了病人輻射量)

How to optimize the medical exposures?
如何優化醫療照射量?

- Use of Diagnostic Reference Levels (DRLs)

  "Diagnostic reference levels" means dose levels in medical radio- diagnostic practices or, in the case of radio-pharmaceuticals, levels of activity, for typical examinations for groups of standard-sized patients or standard phantoms for broadly defined types of equipment

  These levels are expected not to be exceeded for standard procedures when good and normal practice regarding diagnostic and technical performance is applied (診斷參考水平：輻射量可參照世界上一般放射診斷病人的輻射量作為參考)

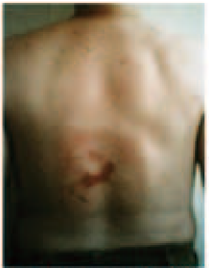
Trend of Medical Exposures
醫療照射量的趨勢

- The most important contribution to this increase is the 1.46 mSv from CT scanning alone (人口輻射劑量主要來自CT)

- The nuclear medicine (including PET) contribution is up from 0.14 mSv to 0.77mSv. This evidently must be due to significant changes in medical radiological practice in the US tied to the increase in the availability of CT and PET imaging facilities (核子醫學的輻射量亦有顯著增加，其原因是電腦斷層及正電子掃描照射設備日益普及)

Over-exposure injury
輻射過量引致的損傷

- Skin injury
- Hair loss



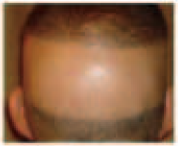
Condition of patient's back 6 to 8 weeks following multiple coronary angiography and angioplasty procedures
(Source: FDA)

Appearance of skin injury approximately 18 to 21 months following procedures, evidencing tissue necrosis
(Source: FDA)

Over-exposure injury
輻射過量引致的損傷

- Skin injury
- Hair loss

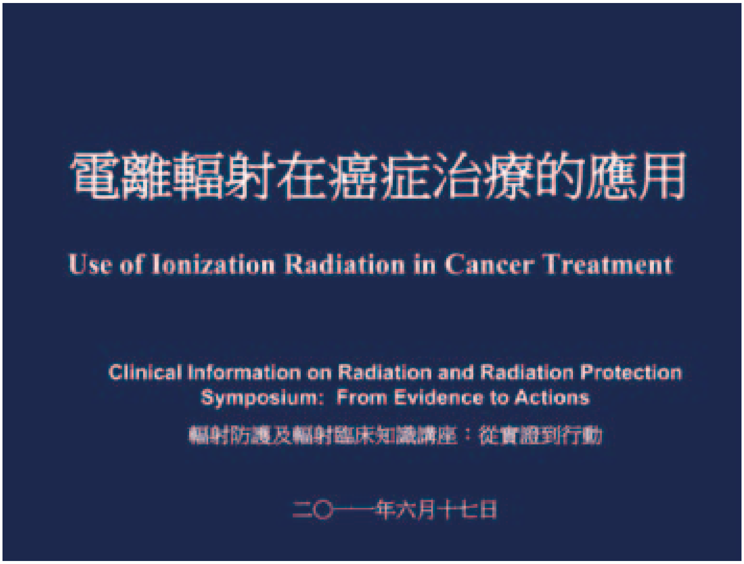
Deterministic Effects - Rare but possible in CT

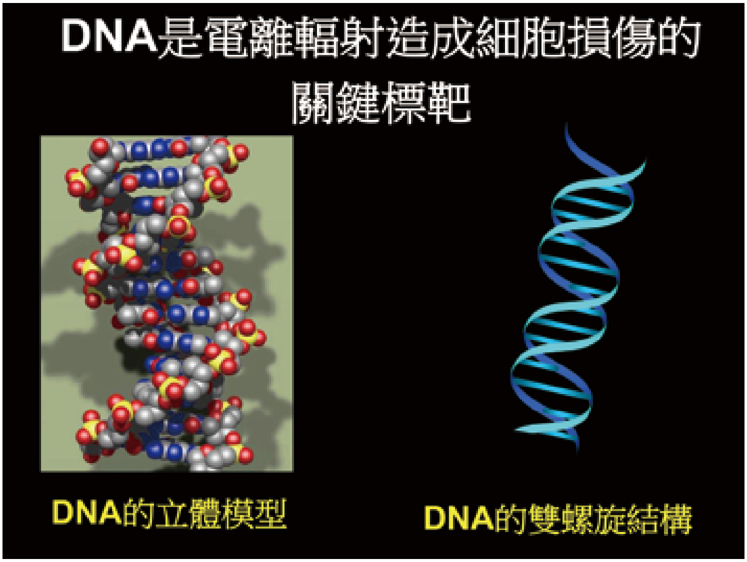


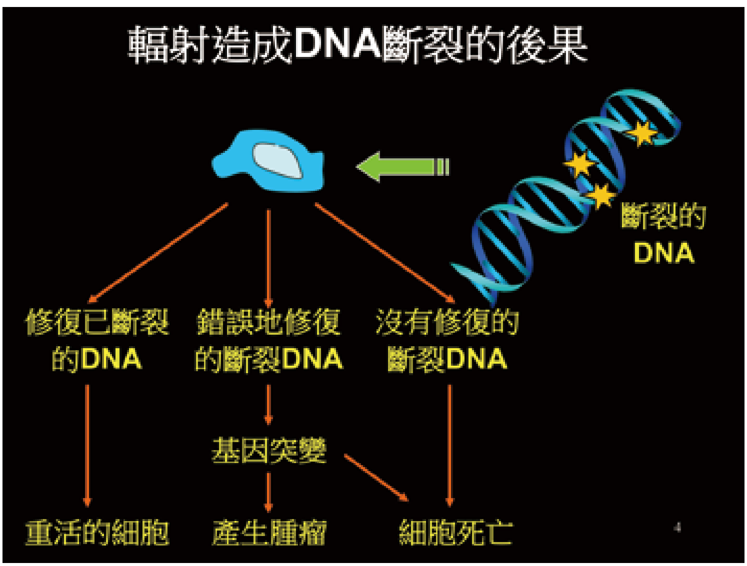
Incident of CT Brain Perfusion in USA
(不恰當的CT灌注造影可導致頭髮脫落)
(Source: IAEA)

電離輻射在癌症治療之應用
Use of Ionizing Radiation in Cancer Treatment

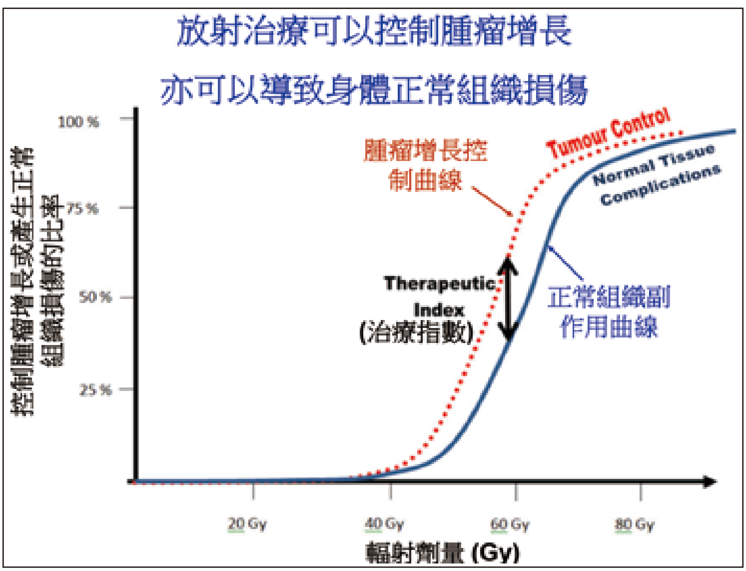
Dr. LAW Chun Key 羅振基醫生

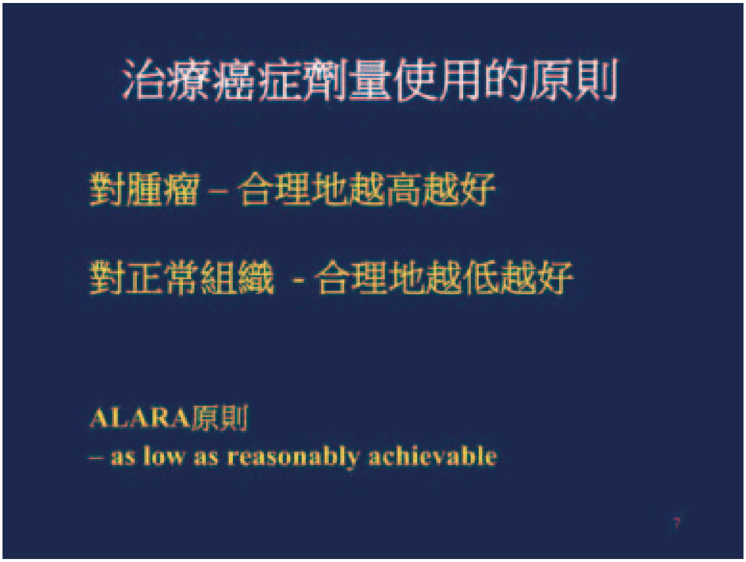


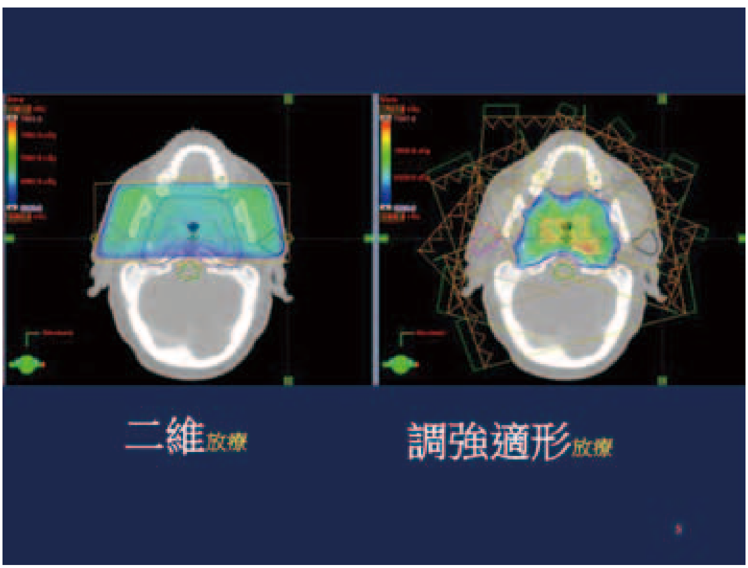

DNA是電離輻射造成細胞損傷的
關鍵標靶
DNA的立體模型
DNA的雙螺旋結構


輻射造成DNA斷裂的後果
斷裂的
DNA
修復已斷裂
的DNA
錯誤地修復
的斷裂DNA
沒有修復的
斷裂DNA
基因突變
重活的細胞
產生腫瘤
細胞死亡

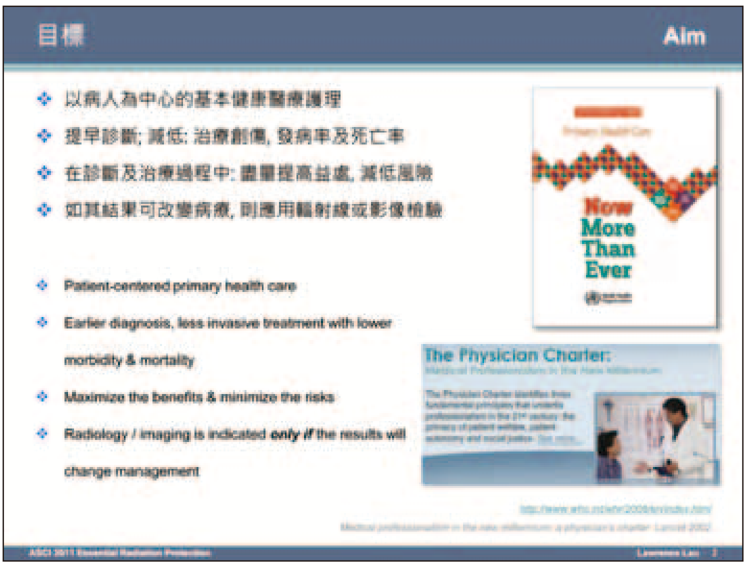

輻射劑量的單位
輻射防護
~ 10 -3 Sv (希沃特)
或 mSv (毫希沃特)
放射治療
~ 10 1 Gy (戈瑞)
相差10,000倍 !!
1 Gy = 1 Sv (光子輻射)


放射治療可以控制腫瘤增長
亦可以導致身體正常組織損傷
控制腫瘤增長或產生正常組織損傷的比率
100 %
75 %
50 %
25 %
腫瘤增長控制曲線
Tumour Control
Normal Tissue Complications
Therapeutic Index
(治療指數)
正常組織副作用曲線
20 Gy
40 Gy
60 Gy
80 Gy
輻射劑量 (Gy)


治療癌症劑量使用的原則
對腫瘤 – 合理地越高越好
對正常組織 - 合理地越低越好
ALARA原則
– as low as reasonably achievable


二維放療
調強適形放療

輻射防護　病人需知　Essential Radiation Protection for Patients　　Dr. Lawrence LAU 劉樹榮醫生



輻射防護原則 Principles of Radiation Protection

- 輻射線檢驗應用於
  - 引導病人護理;
  - 提升公眾健康; 及
  - 其風險低於錯過可治疾病之風險
- 輻射防護的三項措施
  - 適當檢驗, 即是益處比壞處多;
  - 適量輻射及恰當影像質素佳化措施: 使用偏低而有效的輻射量為原則; 及
  - 防止人為錯誤

- Radiation procedure is used if
  - It will guide patient management;
  - It will improve population health; &
  - Risk of procedure is less than risk of missing a treatable disease
- 3 protection measures
  - Procedure justification, i.e. benefit > harm;
  - Optimization of radiation protection & image quality, i.e. by applying As Low As Reasonably Achievable (ALARA) Principle; &
  - Error prevention

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醫生及放射學專家的責任 Roles for Doctors & Radiologists

- 病人利益為首
- 提供檢驗資料以助決擇
- 採用有效輻射防護措施
- 如其結果可改變病療, 則該使用檢驗
- 適當選用超聲波或磁共振檢驗 (無輻射副作用), 尤其是用於兒科診斷上
- 避免對孕婦使用輻射線檢驗
- 恰當技術
- 實行質素保證措施

- Support the primacy of patients, i.e. your interest comes first
- Facilitate informed decision
- Use radiation protection measures
- Refer procedures only if the results will change management
- Choose ultrasound or MRI (i.e. procedures without irradiation) when appropriate, especially in children
- Avoid radiation procedures in pregnancy
- Optimize technique
- Apply quality assurance measures

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相對輻射額　Relative Radiation Level (RRL)[1]

相對輻射額 RRL	成人有效劑量 Adult effective Dose (mSv)	例子	Examples
0	0	超聲波, 磁共振檢驗	Ultrasound, MRI
☢	< 0.1	X光照肺, X光照四肢	X-ray chest, limbs
☢☢	0.1-1	X光照盆骨, X光乳房檢查	X-ray pelvis, mammography
☢☢☢	1-10	核子骨骼掃描, 胸部或腹部電腦斷層掃描	NM bone scan, body CT scan
☢☢☢☢	10-30	多區域電腦斷層掃描, 全身正電子發射斷層掃描	Multi-region CT scan, whole body PET

- 盡可能選用超聲波或磁共振檢驗(無輻射副作用), 尤其是用於兒科診斷上
- Use ultrasound or MRI when appropriate, especially in children

政府機關的責任　Roles for Authorities

- 改善方便優質與安全的輻射線服務
- 提倡以病人為中心及綜合醫療護理
- 確保放射科專家及設施符合規定條例
- 提倡, 維持及固定一個安全的醫療結構及文化
- 鼓勵採用符合經濟效益的輻射線檢驗
- 建立一個可持續的健康醫療系統

- Improve access to quality & safe facilities
- Advocate patient-centered & integrated care
- Ensure provider competency by regulation
- Promote, maintain & regulate a safe health care framework & culture
- Encourage cost-effective use of radiation procedures
- Aspire to a sustainable health care system


病人的責任
Roles for Patients
提供正確病歷及過往檢驗資料
幫助醫生避免
重複檢驗;
過早或太頻密的跟進檢驗; 及
無需及無實效的保健輻射線檢查
如可能已懷孕, 請通知醫生
由醫生及放射學專家選擇適當檢驗
如結果有助於病療, 應同意接受檢驗
跟進檢驗時, 要攜帶過往記錄作參考
Give an accurate history, including past imaging procedures
Help your doctor to avoid
Duplication;
Inappropriate follow-up interval, i.e. too early or too often; &
Unnecessary wellness screening, especially those without proven benefit
Tell your doctor if you could be pregnant
Leave procedure choice to your doctor & radiology specialist
Consent to a procedure if the result will change management
Bring previous imaging records for follow up
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Lawrence Lau


可靠資料
Useful Resources
溫和影像網站1
明智影像網站2
放射學內部網站3
病人輻射防護網站4
放射學知識網站5
放射學安全資源網站6
仿真放射學部門網站7
Image Gently1
Image Wisely2
InsideRadiology3
Radiation Protection of Patients4
RadiologyInfo5
Radiology Safety Resources6
Virtual Departments7
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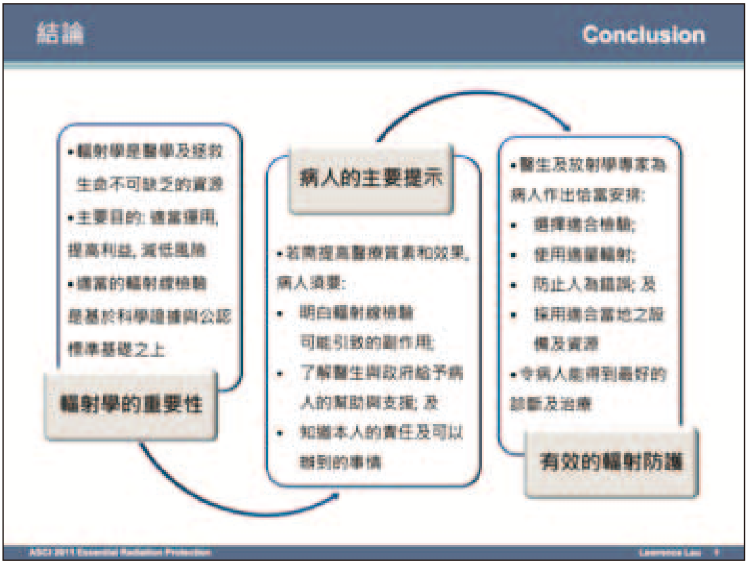

結論
Conclusion
•輻射學是醫學及拯救生命不可缺乏的資源
•主要目的: 適當運用, 提高利益, 減低風險
•適當的輻射線檢驗是基於科學證據與公認標準基礎之上
輻射學的重要性
病人的主要提示
•若需提高醫療質素和效果, 病人須要:
• 明白輻射線檢驗可能引致的副作用;
• 了解醫生與政府給予病人的幫助與支援; 及
• 知道本人的責任及可以辦到的事情
•醫生及放射學專家為病人作出恰當安排:
• 選擇適合檢驗;
• 使用適量輻射;
• 防止人為錯誤; 及
• 採用適合當地之設備及資源
•令病人能得到最好的診斷及治療
有效的輻射防護

ASCI
ASCI 2011 HONG KONG
5th Congress of Asian Society of Cardiovascular Imaging
17-19 June 2011
www.asci2011.org
輻射防護講座
Radiation Protection Symposium
輻射防護 病人需知
Essential Radiation Protection for Patients
謝謝你的關注
Thank you for your attention
INTERNATIONAL
QUALITY NETWORK
Collaboration is Strength

Section III
第三章

Glossary & Tables
詞彙及圖表索引

Typical Doses from Diagnostic Radiology Exams

Doses Received Undergoing an Entire Procedure

Complete Exams	Effective Dose (mSv)
Intravenous Pyelogram (kidneys, 6 films)	2.5
Barium swallow (24 images, 106 sec fluoroscopy)	1.5
Barium meal (11 images, 121 sec fluoroscopy)	3.0
Barium follow-up (4 images, 78 sec fluoroscopy)	3.0
Barium enema (10 images, 137 sec fluoroscopy)	7.0
CT head	2.0
CT chest	8.0
CT abdomen	10
CT pelvis	10
CT (head and chest)	11
PTCA (heart study)	7.5-57
Coronary angiogram	4.6-15.8
Mammogram	0.13
Lumbar spine series	1.8
Thoracic spine series	1.4
Cervical spine series	0.27

Plain Film X-Rays

Single Radiographs	Effective Dose (mSv)
Skull (PA or AP)	0.03
Skull (lateral)	0.01
Chest (PA)	0.02
Chest (lateral)	0.04
Chest (PA and lateral)	0.06
Thoracic spine (AP)	0.4
Thoracic spine (lateral)	0.3
Lumbar spine (AP)	0.7
Lumbar spine (lateral)	0.3
Abdomen (AP)	0.7
Abdomen	0.53
Pelvis (AP)	0.7
Pelvis or hips	0.83
Bitewing dental film	0.004
Limbs and joints	0.06

ICRP – Diagnostic Reference Levels

- Diagnostic Reference Level (DRL) is used in medical imaging to indicate whether, the patient dose or administered activity (amount of radioactive material) from a specified procedure is unusually high or low for that procedure
- DRL are considered as a useful tool to help optimize Interventional Radiology

Use of Diagnostic Reference Levels (DRLs)

Medical Imaging Task	(General, U.S.) CRCPD 1988	(General, U.K.) IPSM 1992	(BSS) IAEA 1996	(General) EC 1990, 1996a, 1999a	(General, U.S.) AAPM 1999	(General) NRPB 1999
Dental Panoramic						65
Dental (periapical)			7			[DWP in mGy mm]
AP Dental	[ESAK in mGy]		5		[ESAK in mGy]	
Dental Cephalometric	0,3				0,25	
Dental intraoral (bitewing) (ex: 70 kVp and E speed)	function or kVp & speed 2.1 to 3.1 (range)				2.3 (70 kVp, E) 3.5 (70 kVp, D)	mandibular molar 4, **1.8** [PED, mGy]
PA or AP Skull		5	5	5		5, **1.5**
LAT Skull	1.3, 0.6	3	3	3		3, **1**
AP Cervical Spine	1.2, 0.8				1,25	
PA Chest	0.1, 0.04 no grid 0.2, 0.1 grid	0,3	0,4	0,3	0,25	0,3
LAT Chest		1,5	1,5	1,5		1,5
AP Thoracic Spine			7			
LAT Thoracic Spine			20			
AP Full Spine	2.3, 1.3					
AP Abdomen	4.3, 2.6	10	10		4,5	10, **6**
AP or PA Lumbar Spine	3.9, 3.1	10	10	10	5	10, **5**
LAT Lumbar Spine	(two film speeds: 200, then 400)	30	30	30		30, **12**
LAT Lumbar Spine (umbo-sacral joint)		40	40	40		40, **24**
AP Pelvis		10	10	10		10, **4**
AP Hip Joint			10			[reference dose, then **achievable dose**]
AP Urinary Tract (plain film or before contrast)				10		
AP Urinary Tract (after contrast)				10		

Radiographs [values are ESD in mGy, except as noted for CRCPD, AAPM and NRPB]
[NOTE: CRCPD entries were converted from ESE In mR (x 0.00876) to ESAK in mGy]

(Source: ICRP, 2001)

Acknowledgement
鳴謝

The Organisers gratefully acknowledge the following companies / organizations (in alphabetical order) for their support and contributions :
我們衷心向以下贊助機構（依英文字母次序排）致謝：

CHINDEX Hong Kong Ltd.
美中互利香港有限公司

GE Healthcare
通用電氣（中國）醫療集團

Philips Electronics Hong Kong Ltd. - Healthcare
飛利浦電子香港有限公司 － 醫療保健業務部

Siemens Ltd.
西門子有限公司

Toshiba Medical Systems Corporation
東芝醫療系統

Varian Medical Systems Pacific, Inc.
瓦里安醫療系統有限公司

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對以下各機構提供的寶貴資料及支持，我們謹此致謝。

Department of Health	衞生署
Food and Drug Administration (FDA)	美國食品及藥物管理局
Hong Kong Observatory	香港天文台
International Atomic Energy Agency (IAEA)	（聯合國）國際原子能機構
International Commission on Radiological Protection (ICRP)	國際放射防護委員會
National Cancer Institute	美國國家癌病學院
National Council on Radiation Protection and Measurements (NCRP)	美國國家輻射防護與測量委員會

The Leader in Organ-Specific

Molecular Imaging

CHINDEX

Some parents wonder about radiation coming from their child after a radiotracer is given. In most cases, this amount is small. It is usually less than 2% of the radiation we get each year from nature. This amount of radiation can be similar to the radiation you get flying from Boston to Los Angeles. In most cases, the parent can stay with their child during the test.

(The Alliance for Radiation Safety in Pediatric Imaging)


BETTER HEALTH FOR MORE PEOPLE.
Low-dose three-dimensional CT scans.
Electronic medical records.
A 2½-pound EKG for rural areas.
Portable ultrasound machines.
Technology that reduces infant and mother mortality.
$3 billion invested in healthcare innovation.
Better health for more people.
We call it healthymagination.
We're just getting started.
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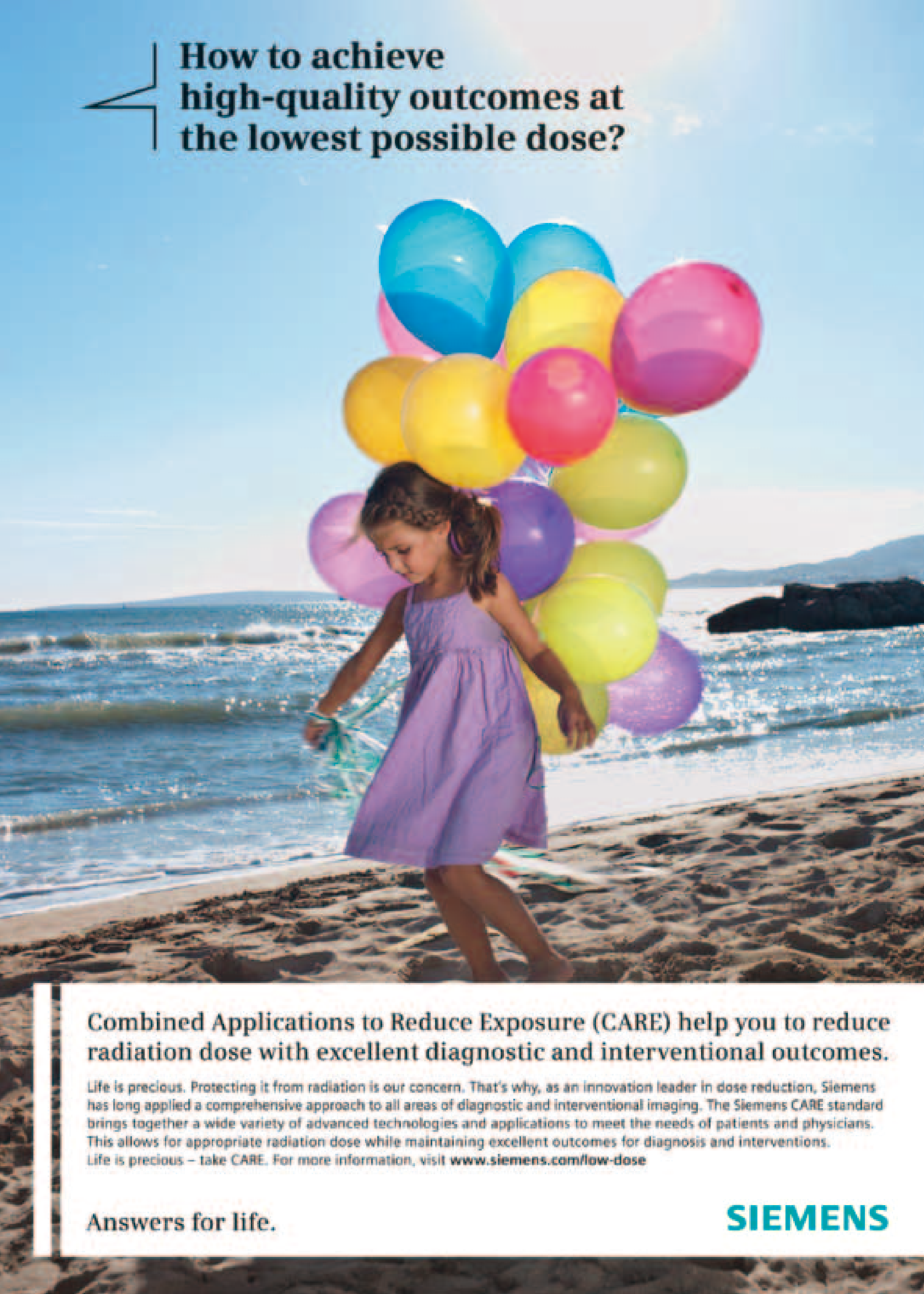
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English-Chinese Periodic Table of Elements 英漢元素周期表

alkalai metals	alkaline earths	lanthanide	actinide	transition metals
other metals	semi-metals	non-metals	halogens	noble gases

atomic num 元素
symbol
element name
atomic weight

Solid　Liquid　Gas　Synthetic

1 氫 **H** hydrogen 1.008																	2 氦 **He** helium 4.003
3 鋰 **Li** lithium 6.941	4 鈹 **Be** beryllium 9.012											5 硼 **B** boron 10.811	6 碳 **C** carbon 12.011	7 氮 **N** nitrogen 14.007	8 氧 **O** oxygen 16.000	9 氟 **F** fluorine 19.000	10 氖 **Ne** neon 20.180
11 鈉 **Na** sodium 22.990	12 鎂 **Mg** magnesium 24.305											13 鋁 **Al** aluminum 26.982	14 矽 **Si** silicon 28.086	15 磷 **P** phosphorus 30.974	16 硫 **S** sulfur 32.065	17 氯 **Cl** chlorine 35.453	18 氬 **Ar** argon 39.948
19 鉀 **K** potassium 39.098	20 鈣 **Ca** calcium 40.078	21 鈧 **Sc** scandium 44.956	22 鈦 **Ti** titanium 47.867	23 釩 **V** vanadium 50.942	24 鉻 **Cr** chromium 51.996	25 錳 **Mn** manganese 54.938	26 鐵 **Fe** iron 55.845	27 鈷 **Co** cobalt 58.933	28 鎳 **Ni** nickel 58.693	29 銅 **Cu** copper 63.546	30 鋅 **Zn** zinc 65.38	31 鎵 **Ga** gallium 69.723	32 鍺 **Ge** germanium 72.63	33 砷 **As** arsenic 74.922	34 硒 **Se** selenium 78.96	35 溴 **Br** bromine 79.904	36 氪 **Kr** krypton 83.80
37 銣 **Rb** rubidium 85.468	38 鍶 **Sr** strontium 87.62	39 釔 **Y** yttrium 88.906	40 鋯 **Zr** zirconium 91.24	41 鈮 **Nb** niobium 92.906	42 鉬 **Mo** molybdenum 95.96	43 鎝 **Tc** technetium [98]	44 釕 **Ru** ruthenium 101.07	45 銠 **Rh** rhodium 102.91	46 鈀 **Pd** palladium 106.42	47 銀 **Ag** silver 107.87	48 鎘 **Cd** cadmium 112.41	49 銦 **In** indium 114.82	50 錫 **Sn** tin 118.71	51 銻 **Sb** antimony 121.76	52 碲 **Te** tellurium 127.60	53 碘 **I** iodine 126.90	54 氙 **Xe** xenon 131.29
55 銫 **Cs** caesium 132.91	56 鋇 **Ba** barium 137.33		72 鉿 **Hf** hafnium 178.49	73 鉭 **Ta** tantalum 180.95	74 鎢 **W** tungsten 183.84	75 錸 **Re** rhenium 186.21	76 鋨 **Os** osmium 190.23	77 銥 **Ir** iridium 192.22	78 鉑 **Pt** platinum 195.08	79 金 **Au** gold 196.97	80 汞 **Hg** mercury 200.59	81 鉈 **Tl** thallium 204.38	82 鉛 **Pb** lead 207.2	83 鉍 **Bi** bismuth 208.98	84 釙 **Po** polonium [209]	85 砈 **At** astatine [210]	86 氡 **Rn** radon [222]
87 鈁 **Fr** francium [223]	88 鐳 **Ra** radium [226]		104 鑪 **Rf** rutherfordium [261]	105 𨧀 **Db** dubnium [268]	106 𨭎 **Sg** seaborgium [271]	107 𨨏 **Bh** bohrium [272]	108 𨭆 **Hs** hassium [270]	109 䥑 **Mt** meitnerium [276]	110 鐽 **Ds** darmstadtium [281]	111 錀 **Rg** roentgenium [280]	112 鎶 **Cn** copernicium [285]	113 **Uut** ununtrium [284]	114 **Uuq** ununquadium [289]	115 **Uup** ununpentium [288]	116 **Uuh** ununhexium [293]	117 **Uus** ununseptium [294]	118 **Uuo** ununoctium [294]

57-71 **lanthanides** 鑭系元素	57 鑭 **La** lanthanum 138.91	58 鈰 **Ce** cerium 140.12	59 鐠 **Pr** praseodymium 140.91	60 釹 **Nd** neodymium 144.24	61 鉕 **Pm** promethium [145]	62 釤 **Sm** samarium 150.36	63 銪 **Eu** europium 151.96	64 釓 **Gd** gadolinium 157.25	65 鋱 **Tb** terbium 158.93	66 鏑 **Dy** dysprosium 162.50	67 鈥 **Ho** holmium 164.93	68 鉺 **Er** erbium 167.26	69 銩 **Tm** thulium 168.93	70 鐿 **Yb** ytterbium 173.04	71 鎦 **Lu** lutetium 174.97
89-103 **actinides** 錒系元素	89 錒 **Ac** actinium [227]	90 釷 **Th** thorium 232.04	91 鏷 **Pa** protactinium 231.04	92 鈾 **U** uranium 238.03	93 錼 **Np** neptunium [237]	94 鈽 **Pu** plutonium [244]	95 鋂 **Am** americium [243]	96 鋦 **Cm** curium [247]	97 鉳 **Bk** berkelium [247]	98 鉲 **Cf** californium [251]	99 鑀 **Es** einsteinium [252]	100 鐨 **Fm** fermium [257]	101 鍆 **Md** mendelevium [258]	102 鍩 **No** nobelium [259]	103 鐒 **Lr** lawrencium [262]