Reflections of a Septuagenarian – Radiology: Past, Present and Future

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Before I commence, I would like to thank the Singapore Radiological Society and the Chapter of Radiologists of the Academy of Medicine for inviting me to speak today on the occasion of the inauguration of the FY Khoo Lectureship. I was initially hesitant. Who would want to listen to a dinosaur of the profession even if it were to speak from a podium? But I was eventually persuaded that there is a special meaning in having the second-oldest living radiologist hold high the torch of honour for the oldest living radiologist, who had done so much for the profession. To my mind, it is a measure of full maturity for a profession to search its past and honour a hero, and I congratulate the Society and the Chapter of Radiologists for what they are doing today.

There is one apology I have to make – and that is that having been a diagnostic radiologist all my life, my remarks this afternoon are correspondingly oriented. My colleagues in Therapeutic Radiology and Nuclear Medicine will surely understand.

The inauguration of the Lectureship for a great radiologist who is also a great historian of Singapore Radiology appears to be an opportune moment to revisit briefly our origins.

The ultimate origin of radiology is encapsulated in this familiar picture (not included) showing the actual moment of the discovery of X-rays. Professor Wilhelm Roentgen saw a dim glow in some barium platinocyanide crystals on a table, and later in a screen of the same material, when his cathode ray tube was energised. At that time cathode ray experiments had been hot for a number of years, and phenomena similar to Roentgen's due to the effects of X-rays must have occurred, but their significance must have been missed. Not so with Roentgen. His keen powers of observation and deduction alerted him that the glow could not be explained except in terms of an unknown type of radiation, which he named "X-rays". And so was born the greatest single diagnostic and therapeutic tool Medicine has ever seen. For his discovery, Wilhelm Conrad Roentgen was awarded the first Nobel Prize for Physics in 1901.

Although an X-ray machine had actually been installed in Singapore as early as January 1898, just 2 years after Roentgen announced his discovery of X-rays, it was much later that clinical radiology proper began in this country.

The 1920s were a remarkable decade of landmarks for Singapore Medicine. Firstly, the Straits Medical School, which opened in 1905, was replaced by the King Edward VII College of Medicine at Sepoy Lines. Secondly, in 1926, a new General Hospital, costing $4½ million, was built in the same grounds as the College of Medicine. It was reputed to be the best hospital east of Gibraltar. It consisted of 2 main hospital blocks, which were re-named Bowyer and Norris Blocks after World War II, in memory of doctors who had died in that War. A small X-ray department was housed in a wing of Bowyer Block not far behind its well-known clock-tower. Bowyer Block was to remain unchanged in appearance for the next 55 years.

But for radiology, the event of the greatest significance was unquestionably the appointment of Singapore's first radiologist in 1925. He was no less a figure than the then Professor of Medicine, JS Webster. That appointment, to my mind, marked the true beginning of clinical radiology in Singapore. The fact that a Professor of Medicine actually switched over from medicine to radiology says a great deal about the impact radiology must have been making then. A picture is worth a thousand words – whether it was in Professor Webster's day or today. And clinicians of the 1920s must have loved the gorgeous X-ray pictures produced by the more powerful Coolidge tubes that the General Hospital bought from 1918 onward. Professor Webster retired in 1938. Over the 13 years he was Head of Radiology, annual X-ray examinations had grown more than 3½ times. This was the period of the Great Depression of the 1930s, triggered by the historic stock market crash of 1929. The serious downturn of the economy must have badly set back any plans Professor Webster might have had to develop the Department (Fig. 1).

In 1941 war broke out in the Pacific. When it ended in 1945, the world that emerged from it was very different in mood and temper to that before the war. Political activism

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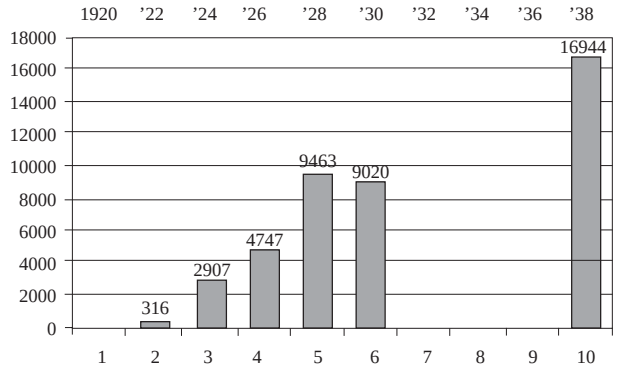

Fig. 1. Singapore General Hospital: Annual X-ray Examinations 1920-1938.

was rife in Singapore and led to the Peoples' Action Party coming into power in 1959.

It was during this period that Dr FY Khoo was made Head of Radiology at SGH. You have heard the citation on his many accomplishments as Head. To my mind, probably the most far-reaching was the establishment of the School of Radiography in 1963. By that single act of foresight not only was radiographer shortage eliminated as a bottleneck that could hold back the future development of radiology, but we ensured for ourselves the high standard of radiography so crucial to that development.

The School of Radiography started in a small building in the corner space between the X-ray and Surgical "B" wings. In 1965, the pioneer batch of diagnostic radiographers graduated – that was a proud milestone for the School! The course in Therapeutic Radiography did not commence until 1975. Finally in 1994, after 30 years as an internationally acknowledged first-rate training centre for radiography, the School closed its doors. Under new training trends, radiography training was given over to a tertiary institution, the Nanyang Polytechnic. By that time, the School had turned out a total of 310 Diagnostic and 48 Radiotherapy graduates.

Dr Khoo retired in 1967. In 1968, the Department was split in 2: a Department of Diagnostic Radiology headed by Dr KW Chow, and a Department of Therapeutic Radiology headed by Dr KB Chia (Table 1). The rapid growth of these 2 subspecialties made the division inevitable.

Table 1. Radiology Manpower and Workload in 1968

	Diagnostic	Therapeutic
Radiologists	7	3
Radiographers	26	6
Physicists		3
Total X-ray examinations	106,458	
Number of cancers treated		1500

Radiology was still a relatively small specialty at that time. Little did the 2 new heads realise that the fervour of nation-building, which had been gathering a head of steam, would turn the decade right in front of them into what I call the "Roaring Seventies" for Medicine.

The Roaring 70s

Expansion projects came piling one after another. They started with the Ministry of Health decision to step up the development of selected medical specialties. Among the first beneficiaries was the Department of Radiotherapy, which acquired a new home in the Institute of Medical Specialties. Tan Tock Seng Hospital (TTSH) was given a well-equipped Neuroradiology Section, and Singapore General Hospital (SGH) an upgrade of the Cardiovascular Laboratory.

In the second half of the decade, plans went into full swing to build 2 new major hospitals – an entirely new SGH and the National University Hospital (NUH). I had been interested in designs for radiology departments at that time, and this gave me the rare opportunity of incorporating some Swedish concepts into designing a 32-room department at SGH. For the department at NUH, flexibility for designing was constrained by the pre-set body framework approach favoured by the American architects. To have the opportunity to plan 2 radiology departments of such magnitude is the stuff dreams are made of, and I must say this has made my years in radiology exceptionally gratifying.

The 2 hospitals were completed by the early 1980s and formed the launching pads for a new era of immense growth of medical services in the country.

What is unique about Singapore Medicine is the extraordinary concentration of the entire range of medical specialties, including academic teaching and research, within such a small area. This promotes interaction among the specialties. The 1400-bed SGH is a case in point. Its grounds are studded with National Centres for various clinical specialties. The benefits of this sort of close interaction are not readily quantifiable, but must be substantial. It reminds one of the kind of unique synergistic environment that California's Silicon Valley provides for the computer industry and helps to turn it into the fabulously innovative capital of the computer world that it is.

Singapore Radiology flourished under these influences. The number of diagnostic radiologists multiplied 17 times since the days of Dr FY Khoo. With an annual recruitment of 10 to 12 trainees over the past few years, its future manpower outlook has never been healthier (Table 2).

The specialty's high professional standing may be inferred from the fact that the Royal College of Radiologists has elected to hold both parts of their Final Examinations in Singapore. Radiology in Singapore has reached full

Table 2. Number of Radiologists in Active Practice in 2003

	Institutional	Private	Total
Diagnostic	83	38	121
Therapeutic	15	3	18
Nuclear Medicine	6	1	7

maturity, with a standard the equal of the world's major medical centres.

As I look back over the years, the technological advances that have taken place have been mind-boggling. Just a couple of telling examples of the way the practice of radiology has changed serve to illustrate the point. When I first joined radiology, fluoroscopy required dark adaptation (images on the fluoroscopic screen were so dim). Very few in the audience here today have any experience of dark adaptation. It is irksome at best. It takes time to get the retina into condition to see in the dark. So you sit in the darkened fluoroscopic room with those huge wrap-around red goggles on, twiddling your thumbs. Once in a while a patient would suddenly ask, "Seen anything wrong, Doc?" And you had to tell him or her that you hadn't even started! That always left you feeling rather stupid! The only radiologist I knew that made good use of this waiting time was a spiritual-minded mentor of mine. Whenever she dark-adapted, she meditated!

The change I welcomed most had to do with an examination called pneumoencephalography (air encephalography) for the investigation of lesions in the central nervous system. Again, very few of you have seen how an air encephalogram is done. You first inject air into the lumbar spinal canal. The air has to be manipulated up into the cisterns and ventricles of the brain. You try to imagine how the air would float up the spinal canal into the base of the skull, and then turn, angle, press up or down, swing, or twist the head of the patient blindly to coax air into the cisterns or ventricles you want. It was a frustrating experience for the radiologist and a very distressful one for the patient, most of whom had bad headaches after it. The Mimer Unit we installed when the Neuroradiology Section was set up in TTSH brought a sea change to the procedure. Life became so much easier for everyone, though the patient still suffered from bad headaches. It was a massive unit that seemed an overkill for the job. Results were much better. Still, the procedure remained crude and diagnostically far from optimal.

But the advance that really formed the watershed between past and future ways of practising radiology, as you well know, was digital cross-sectional tomographic imaging (CT), pioneered by Hounsfield in the early 1970s. First CT, then magnetic resonance imaging (MRI), ushered in a great new era of radiology that is now in full bloom.

Contrast the exquisite anatomical detail of the common MRI brain scans today, done without manipulation or patient discomfort, with the pneumoencephalograms of yesteryear. The latest so-called "virtual" angiography by multi-slice multi-detector CT and MRI, for example, are simply out of this world. No arterial catheterisation needed! To someone like me, who had toiled hard at selective angiography, this is magic! And as for the fly-through views of virtual colonoscopy, that is nothing short of voodoo!

CTs have become the workhorse of radiology departments with demand coming from all quarters. MRIs are not far behind. Both continue to displace older examination techniques. You can see from the number of annual X-ray examinations in the SGH from 1998 to 2002 (Table 3), that CT, MRI and the "virtual" examinations now make up half of the Special Examinations done (Table 4). Just in the 5 years covered, fluoroscopic examinations plunged by more than 50%.

The total number of CT and MRI machines installed in the country reflects the trend.

Radiology has been riding on a tidal wave of technological advances, which looks to have quite a way more to go. It has taken radiology beyond the traditional use of ionising radiation, beyond morphological imaging into functional,

Table 3. SGH: Annual X-ray Examinations from 1998 to 2002

	1998	2000	2002
Plain films	240,418	261,761	251,950
Ultrasound	18,880	20,845	23,208
Mammography	5541	6117	7242
Urography	3681	3826	4172
BMC	1329	714	133
Fluoro/Non-fluoro	9799	6175	4495
CT	22,516	21,153	23,040
MRI	8385	10,169	11,020
VIR	2445	2797	3430
Total "Specials"	69,576	71,796	76,740

CT: computed tomography; MRI: magnetic resonance imaging; VIR: virtual imaging research

Table 4. Number of CT and MRI Units in Singapore in 2003

	CT	MRI
Public Hospitals	10	7
National Cancer Centre	1	1
National Neurological Institute	1	2
National University Hospital	2	2
Private Hospitals/Practices	7	8
Total	21	20

CT: computed tomography; MRI: magnetic resonance imaging

metabolic, molecular and genetic imaging, and even beyond its "diagnostic" role to include therapeutic interventional radiology. Names such as "diagnostic radiology" and "diagnostic imaging", long considered inappropriate, have become commonplace. The term "biomedical imaging" covers the ground better since it encompasses research and other non-diagnostic functions, but it does not cover interventional radiology. The question of an appropriate name is not merely a matter of semantics. A specialty needs to define its territory so that others may recognise and hopefully respect it. This is especially pertinent when turf wars loom.

Scintillating advances add glamour, but also bring with them a host of issues. They often upset existing patterns of practice. Virtual angiography and CT and MRI fluoroscopy, for example, seem set to change coronary and cardiac imaging, and render much of existing fluoroscopic equipment prematurely redundant. The potential impact of drug eluting stenting (DES) on coronary artery bypass grafting (CABG) is instructive. Readmission rates using bare-metal stents are currently about 20% per annum. They have been projected to decrease by 25% in the first year after DES, and by as much as 90% in Year 2 or 3. Something in the range of 10% of CABG could shift to DES every year. If we factor in the impact of a healthier lifestyle, healthier diet, the anticipated "explosion" in the use of statins, new technologies (cholesterol vaccines, angiogenesis-based treatments), advanced screening methods, and surgical techniques (off-pump CABG, ventricular assist devices, minimally invasive ablation and the like), then CABGs may fall below the minimum threshold volume required for accreditation, with major repercussions on hospital cardiac training programmes worldwide.

Turf Wars

Dislocation of existing practice patterns is a fertile source of so-called "turf wars". Unfortunately, radiology is intrinsically at a disadvantage in "turf wars" because it does not control a patient base. As Professor Wang Shih Chang pointed out in his chapter on "Future Trends in Diagnostic Radiology" in Dr Wilfred Peh's *Asian Textbook of Radiology*, the specialty has lost a number of such wars in the past. A solution is not easy. The most fundamental and obvious is to keep building on our strength, which traditionally lies in adding value to our services. To ensure this, the profession must maintain the highest level of competency at all times – to the point that it must be ready to lead as major imaging advances emerge. Earlier I referred to advances made by radiology beyond morphological imaging. At the cutting edge among them is "genetic imaging". It is gratifying to learn that radiologists are actively involved in the 250 or so known genetic trials in the US seeking to develop interventional systems for delivering genetic material to target tissues, ways to image genetic expression in vivo, and so on. This is as it should be.

To help further to abort or temper potential blatant "turf wars", we need to foster a climate of goodwill and a habit of teamwork among specialties that encourage the open discussion of areas of conflict as and when they emerge, and before they become insurmountable.

Unfortunately, to achieve professional competency of the "highest level" that I spoke about requires subspecialisation. And the exacting demands of many subspecialties lead to a tendency for more and more subspecialisations to become "exclusive" and alienated from the rest of the main specialty. This opens the profession to fragmentation. Here is another key issue that needs to be kept under constant review as well as timely and prudent handling by our professional bodies.

"Screening" Examinations

A controversial issue facing diagnostic radiology, and arising from the recent advances in fast CT/MRI scanning and "virtual" imaging, is that of self-referred screening examinations – whole body scanning, colorectal screening, lung screening, and so on. In the USA, public surveys found unexpectedly strong support for such screening, despite knowing that it may not be helpful, and may even be harmful (because of what has been labelled as "incidentalomas", "medical cascade syndrome" and the like). It seems likely that the movement to offer screening examinations will accelerate, especially in the USA, where the Food and Drug Administration regulates and licences equipment, but tends to be lax regarding its clinical use. Before the profession finds itself swamped, it would be wise for our professional bodies to have the implications sorted out well ahead, so as to be in a position to issue guidelines, educational material, warnings, and so on, any time they are called for.

Clarification of the legal issues involved is especially important. If patients are self-referred, radiologists may find themselves legally the temporary primary physician of the "patient". They will then remain so until such time as the patient is taken over by another physician. Meanwhile, the responsibility for dealing with results (including "incidentalomas" of no immediate clinical importance), explaining them to or advising patients, will fall on the radiologist. The legal implications will be influenced by case law, which has not as yet been sufficiently built up. How the Mayo Clinic handles this issue is noteworthy. The Clinic does screening, but its system calls for a house physician to "accept" the self-referred as his or her patient before screening actually proceeds.

Computer-assisted Diagnosis

With computer power growing by leaps and bounds and neural intelligence unrelentingly improving, computer-assisted diagnosis, or CAD, is set to feature more and more in screening and other diagnostic software programmes. The manner and extent its development affects the profession is one more area that needs vigilant scrutiny – if we are not to find ourselves suddenly and unpleasantly surprised by runaway developments.

Ionising Radiation

Consider the age-old question of the long-term health effects of ionising radiation. CT has shown unexpected resilience in the face of the impressive technical performance of MRI. CT was expected to lose popularity because of its reliance on ionising radiation, but it did not. However, radiation exposure is always a potential medicolegal problem that may appear years down the line. The profession cannot afford to be complacent about this issue. We need the help of our professional bodies to keep watch and stay on top of this still-sensitive, core issue.

The Digital Future

One bright spot just ahead is the so-called "digital future". There is no question that "digital future" is well on its way. Technology can now completely integrate the different digital systems of hospitals used in administration, archiving and imaging. Many hospitals in Singapore are already committed. Cost and technical problems of integration (mainly the compatibility of the different existing systems) are major deterrents that will eventually be overcome. The efficiency and benefits of such a completely digitised paper-less and film-less system should be phenomenal. Just imagine every radiologist having instant access to all clinical data, including all previous radiological investigations, and all kinds of reference resources right at the fingertips! "The digital future" has enormous possibilities. Teleradiology alone is likely to influence tremendously the education and training of radiologists and, on a personal level, the very way they work and live. Patients' expectations in terms of service will be radically expanded. It is truly a "Wonderworld" kind of future to look forward to. And to think that just a little farther down the road is the dawn of nanotechnology. What that could bring defies imagination!

Concluding remarks

I have tried to convey something of the immense sense of awe I feel when I scan the half a century from when Dr Khoo took me into Radiology, through the time both of us were taken out of it, and up to the present. I have also expressed genuine concerns over some troubling old issues, as well as some newer ones that loom ahead.

It seems to me that the professional bodies – the Singapore Radiological Society and the Chapter of Radiologists of the Academy of Medicine – have a greater responsibility than ever to act as the watchdogs of professional interests, as well as provisioners for think tanks. Also, perhaps more than at any other time, there is urgency to act proactively to counter divisive forces and promote unifying ones within the profession.

Technologically for Radiology, a great and exhilarating future lies ahead. I wish all of you an equally great and exhilarating future in all the other aspects of your professional life.

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