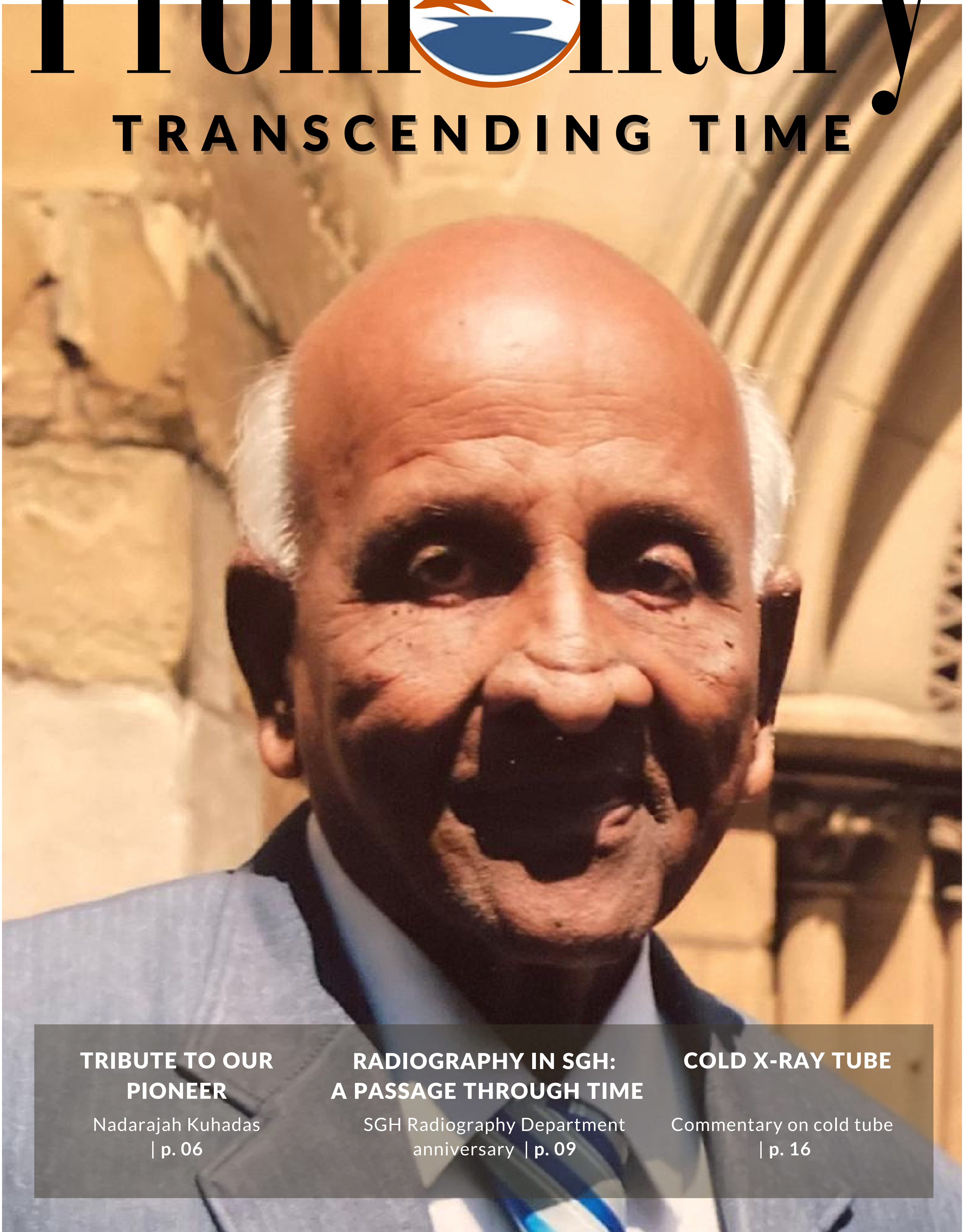
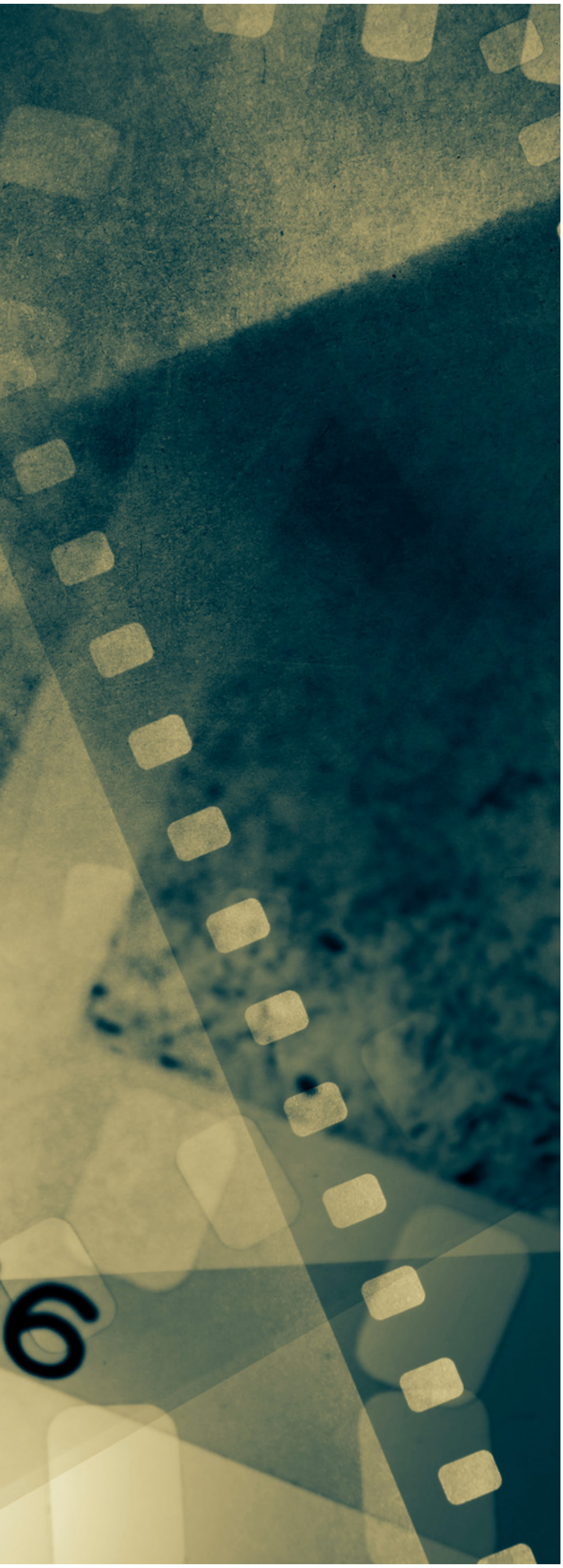
JULY 2021 ISSUE 2

SINGAPORE SOCIETY
OF RADIOGRAPHERS

Promontory

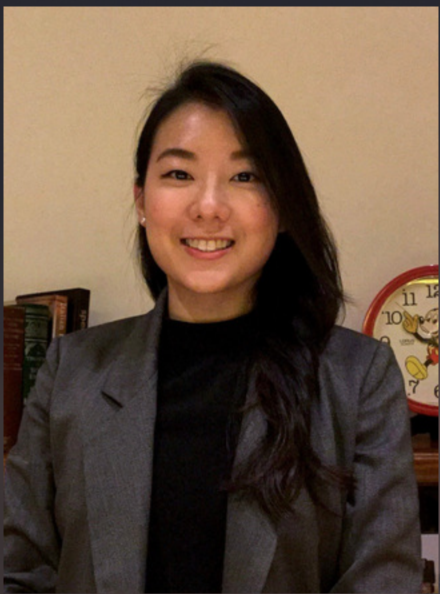
TRANSCENDING TIME





IN THIS ISSUE

President's Message



DENISE CHOONG

Our path to progress depends greatly on the lessons that we learnt from the past. Some have to be analysed quickly, while others are key messages distilled from years of experience.

In this issue of Promontory, we pay tribute to one of Singapore's radiography greats, Mr NK Das, who left us in March 2020 just as the COVID pandemic hit our shores. He was a courageous leader and a dedicated professional. His daughter shares with us fond memories of how her father inspired others, and her as well, with his contributions and achievements in the local radiography scene.

Along with this memoir, we follow the evolution of the Radiography Department at Singapore General Hospital (SGH), taking us on a journey of how the imaging department advanced and expanded to cope with the ever-changing healthcare challenges in Singapore to become the institution that it is today. Congratulations to the Radiography Department on their 1st anniversary.

As we celebrate our past, we work on our present to create a brighter future. The SSR Student Chapter has been very busy working on growing their team through a specially tailored student ambassador induction and leadership program, developing their language skills to improve their patient's experiences and connecting the current students with newly graduated radiographers through the Fireside chat initiative to share experiences and foster opportunities for bonding between professionals and students. This undoubtedly paves the way for stronger connections between students and the profession.

We also explore some of the future possibilities in medical imaging, with an opinion piece by a radiation physicist. He shares how the industry has resurrected and refined the old concept of cold cathode x-ray production to develop a new x-ray system that promises more precise and efficient production of x-rays.

I hope that you enjoy this reflective issue of the SSR Promontory.

Happy reading!

NEWLY APPOINTED HONORARY TREASURER

PASSING THE TORCH

On 27th March 2021, SSR held our 63rd Annual General Meeting (AGM) in conjunction with our 4th Annual Scientific Meeting. During the AGM, Jasmine Lee was appointed the new Honorary Treasurer.

Muhammad Zulhilmi
Outgoing Honarary Treasurer

Back in 2018, I was approached to take on the role of Honorary Treasurer by then- SSR President Chong Chun Meng. I was still green to the inner workings of the society, having only served in the EXCO for a year. I had expressed my concerns in shouldering the colossal task of managing Society's assets. Chun Meng was supportive and believed that I was the right fit for the role. He was certain my administrative skills were sufficient, and the rest will naturally fall into place. The year 2018 was also a milestone in the Society's chapter as we celebrated our Diamond Jubilee. I was lucky to have past Honorary Treasurers to mentor on budgeting the event. I learnt the value of striking a balance between spending too extravagantly and being too prudent. I was fortunate to work with the EXCO who were equally committed and supported the budgeting decision.

The same budgeting principle has guided me to keep our accounts healthy. I am happy that after 3 years, the Society is in a better financial position, and hope that this will aid in the preparation of bigger events like SEARC and ISRRT's World Congress. Being Honorary Treasurer allowed me to appreciate the business aspect of the industry. From inter-institutional collaborations to cost estimation, I gained a heightened awareness of the symbiotic relationship that hospitals, businesses, and SSR form, and how this plays a part in advancing the profession.

I would like to thank the 60th, 61st, and 62nd Executive Committee for having faith in my ability to exercise my duty and responsibility as the Honorary Treasurer. I would also like to thank the auditors for keeping a sharp eye and for their valuable feedback. Last but not least, I would like to thank the members of the Society for your patience as we improved and optimised the workflow for payment of events and memberships.

As I pass the baton to my successor, Jasmine Lee, I wish for continued support to her as the Honorary Treasurer in the 63rd Executive Committee.

Jasmine Lee
Incoming Honarary Treasurer

The first time when I came across SSR was when I volunteered for an event during my student days back in 2008. Since then, I have been keeping track of the events held by SSR and participated if I could. In 2015, I decided to join the SSR Executive committee (EXCO) as the Publicity chairperson. I was new to the EXCO and had many things to learn. In 2016, I took a 2-year break to concentrate on my studies. When I returned to the EXCO as the Professional Matters Chairperson, I was very impressed by the progress the Society had made.

In my years as an EXCO member, I met many passionate individuals who sacrificed their time for the Society. We had organized many major international events as a team. For example, AACRT in 2015 and Diamond Jubilee in 2018, where Singapore's President graced the event. I hope that we will continue to receive the support of the radiographers and radiation therapists, when we organise upcoming bigger events like South East Asian radiographer's conference (SEARC), Asia Radiotherapy Symposium (ART), and International Society of Radiographers and Radiologic Technologists (ISRRT) World Congress.

With the support of the SSR EXCO team, I will be taking on the role of the Honorary Treasurer on top of my current role as professional matters chairperson. It will be challenging to continue the good work of my predecessors who have done an excellent job of keeping the accounts in order and ensuring our coffers are healthy. I am confident that with the support of the EXCO and my colleagues, the same standards can be maintained.

I also want to take this opportunity to thank Zulhilmi for his commitment to the SSR EXCO as the Honorary Treasurer, I wish him well in his future endeavours.

TRIBUTE TO OUR PIONEER

NADARAJAH KUHADAS

Article and photos by his beloved daughter
Vijayalakshimi Mahesan

Early life and education

Born on a rubber plantation in Pajam Estate in Malaya, Seremban, he was the second of three children and was orphaned at an early age. He grew up with his eldest brother, late Dato Mr Nadarajah Kularajah and was brought up by their uncle in Mantin, Negri Sembilan. He had his primary education at the Kings George V School in Seremban. At 16, he moved to Singapore with his brother and studied at the Victoria School. After the completion of his School Certificate, he returned to Malaya with his brother in December 1941. The Japanese War broke out in February 1942. At that time, he obtained a place to study Medicine at a Japanese Medical College in Malacca between 1943 and 1945. As the Japanese occupation ended in 1945, the college ceased to function before he completed his training. He returned to Singapore in 1946 to be trained as a hospital assistant and in 1951, he became a state registered nurse.

Remembrance

Another day has come again,

As time moves surely on—

But nothing now seems quite the same, to know that he is gone.

The days the weeks and months ahead

Will never be the same—

Because a treasure beyond words

Can never be replaced

The loss cannot be measured now

The void cannot be filled—

And although someday the grief may fade,

His mark will live on still.

For even with my heavy heart,

I know that I've been blessed

To have been one whose life he touched,

with warmth so infinite

To support Singapore's development to be an independent nation by establishing our own pool of healthcare professionals, the Radiology Department at SGH started to recruit trained medical professionals for radiography. My father commenced two years of training there in 1952.

Due to the reliance on foreign expatriates providing radiography service in Singapore, a Colombo Plan Scholarship was offered to Singaporeans by Commonwealth countries in the agreement in July 1955 for any medical professional to train for radiography. Three people were awarded this Scholarship that year, the late Mr. CF Reincastle and late Mr. K Vaithilingam, the third person was Mr. N K Das, my father. My father studied Radiography at Bromley Hospital, Kent in the UK from October 1956 and graduating with a Diploma from the School of Radiography in October 1958.

Mobile X-ray van

Mr NK Das standing in front of TB Control Unit at 144 Moulmein Road

Working at Tuberclosis Control Unit

Upon his return, he requested a transfer to Tan Tock Seng Hospital (TTSH) from Singapore General Hospital(SGH). From there he was deployed to run the new mobile service as well as a new X-ray department from the TBCU at 144 Moulmein Road. TBCU was managed by TTSH for tuberculosis patients and coordinated all aspects of tuberculosis control.

At the end of the Second World War, the incidence of tuberculosis was on the rise and became a serious public health challenge in Singapore. The State had to implement a series of environmental, medical, and housing reforms. As part of the anti-tuberculosis campaign, mass radiography was introduced in Singapore with mobile chest radiograph screening.

After the official opening of the TB unit, staff was rotated daily and driven by two Land Rovers each day. One had a heavy-powered generator the other carried the x-ray tube. When the power supplied was not sufficient by the generators, a transformer was used. Sustaining adequate power was a challenge. However, they managed to perform between 200-300 patients on one trip.

Initially, there was 45 healthcare personnel involved in the delivery of the anti-tuberculosis program but fear of contracting the disease was understandably high. With no proper protective equipment, some personnel backed out. Eventually, there were only seven radiographers to help run this department for the whole of Singapore.

"My father shared that in the 50s, people view the tuberculosis outbreak as a bad omen. People used to avoid you as if you had SARS".

Vijayalakshimi Mahesan recounting her dad's experience fronting TB.

Life after retirement

My father retired when he was 55 years old but was re-employed and worked till he was 80 years old. He enjoyed his working life and loved his profession. He had some lovely consultants and colleagues who supported him throughout his profession.

After retiring, despite being over 80 years in age, he was fortunate to retain good health. He went on to travel the world both with his wife and, as he grew older, his children and grandchildren. He was always focused on the grandchildren and was very attached to each and every one. He stressed the importance of education and was very proud of his grandchildren as they qualified as lawyers and doctors. In truth, his dream was always to be a doctor and although it never materialised, he was thrilled to see his grandchildren achieve this dream. Despite a career in radiography not being his original plan, my father loved being a radiographer. It allowed him to be a pioneer in Singapore. It was his passion that spurred me to join the profession.

Sadly, he died last year from diabetic ulcer. He spent a long time in hospital during this last illness and I cannot thank enough the team of doctors, nurses, and health care professionals in TTSH who took very good care of him. Due to the pandemic, the funeral was limited to just 15 people. I am sure that there are many people who would have liked to bid him farewell.

His devoted wife Ratnam Ratnam regrettably developed severe dementia in her last two years but was looked after at home. She passed away a month after him. I followed the footsteps of my father and qualified in Singapore School of Radiography in 1975 under Principal Mr. Lee Wai Sum back then. I worked in SGH till 1982 After marriage, I migrated to UK and continued my profession. This biography is just a small insight into Mr N K Das life. I was privileged to know him and am honoured to call him my father.

I would like to end this with his personal motto:

"No matter how prejudiced and how wronged, one should not give up easily. There are many times in our lives when we get misunderstood and discouraged with no way out but it's important you do not accept defeat but persevere through it all." - NK Das

Proud Grandparents attending their granddaughter's Medical Graduation in the United Kingdom

Professional Achievements

1958: Founding member of Association of Singapore Radiographers (ASR)
1959-1960: General Secretary of the Medical services Union
1961-1962: Second President of the Association of Singapore Radiographers (ASR)
1967: Assisted to set up the World TB conference
1970: Assisted the Ministry of Health (MOH) to set up the Central Manpower Base to recruit radiographers
1971: Awarded a Fellowship for Anti TB X-ray Survey. He went to Bangalore India to the National Institute for TB from September 1971 to December 1971
1973: Appointed Senior Radiographer of the TB control unit.
1979-1980: Appointed Chief Radiographer of TTSH, KKMH, TPH and Sembawang.
1979-1980: Secretary of the Organising Committee of the 3rd ISRRT conference held in Singapore for the 1st time
1981: Represented Singapore in Korean conference in Seoul

Radiography in SGH: A passage through time

Contributed by radiographers from Singapore General Hospital Radiography Department in celebration of their 1st Year Anniversary

Figure 1: The Administration Bowyer Block of General Hospital which first opened in 1926 where the clock tower section still stands within the compounds of Singapore General Hospital. Photo credit: Singapore General Hospital

Introduction

Singapore started the use of X-rays in 1898, within a span of 3 years after Wilhelm C. Roentgen's discovery. Singapore General Hospital (SGH) (Figure 1) has a rich history. The first X-ray unit was installed in May 1913. Since then, medical imaging was an indispensable part of nearly every healthcare team in aiding both patients' diagnosis and treatment. The training and education of radiographers were reshaped in response to the need for specialisation and advancement in medical imaging technology. Amidst this challenging period complicated by an unprecedented pandemic, the year 2021 brings important milestones for SGH. As SGH celebrates 200 years of caring for the nation, medical imaging professionals from SGH are rejoicing the 1st Anniversary of the Radiography Department (RD) formation. We highlight the key events from our radiography first humble beginnings, the achievements, and how we can embrace the future through medical imaging.

Figure 2: Mr W J Ashworth (2nd from left) with the pioneer radiographers
Photo credit: Mr Ng Hon Wing

The School of Radiography

The conception of the School of Radiography began in the mid-1950s, where the need emanated for the training of radiographers. Dr F Y Khoo, Dr M S Ackers, a Consultant in Hospital Administration and Planning, and Mr CF Reincastle, Superintendent Radiographer, submitted the proposal to the Ministry of Health (MOH). In 1959, Mr W J Ashworth (Figure 2), an official from the Society of Radiographers, United Kingdom (UK), provided advice to MOH, and the school was built on the recommendations, at the location between the Radiology Department SGH and Surgical Unit B in 1963.

In 1963, the school commenced with the first batch of 9 students, with the first tutors Mr D R E Emborg, and Mr CF Reincastle, who was also the Principal. Dr Khoo was the director of the school. Mr K Vaithilingam, Mr Lee Wai Sum (Figure 3), and Mr Martin Chew returned from their tutorship training in UK and groomed the first batch of students. Mr Vathilingam became the Principal of the school from the period of 1968 to 1973 and continued as a tutor. Mr Lee Wai Sum assumed the Principal role thereafter. In 1992, the Singapore government decided to move the Diagnostic Radiography course to Nanyang Polytechnic (NYP). After a 26-year journey, the final cohort of NYP Diagnostic Radiography students graduated in March 2018. In line with the evolution in training and professional development plans, a new radiography degree course is currently being offered at the Singapore Institute of Technology since 2016- marking a new chapter in Singapore's radiography education.

The Present

The healthcare profession had to make reforms in a healthcare system that is increasingly complex, specialised and technologically sophisticated. Patient-centred care became the core mission. This came against the backdrop of numerous challenges confronting the healthcare sector. In addition, patients are now better informed and likely to take a more active role in their health, increasing their expectations of healthcare services delivery. It is undeniable that understanding patient expectations of healthcare is central to improving patient satisfaction and delivering patient-centred care. Therefore, it is crucial for the medical imaging profession to embrace the emergence of these new trends.

In principle, early detection of diseases would lead to improved patient outcomes. As general radiography is often the primary imaging technique of choice, much emphasis has been placed on improving general radiographic services provided. Technological advances have brought about the transition from film-screen radiography (Figure 4) (Figure 5) to the current use of computed radiography (CR) and digital radiography (DR). These modern radiographic techniques allow faster image acquisition and produce higher quality images. In addition, the introduction of mobile X-ray units added much impetus in enabling bedside imaging of critically ill patients in the intensive care units. The advancement of DR over CR in allowing greater flexibility and efficiency, increasing the throughput for image acquisition (Seibert, 2009). The ability for viewing acquisition instantly is a key factor for faster turnaround time compared to CR, essentially contributing to faster patient management.

Figure 3: Mr Ng Hon Wing (left) and Mr Lee Wai Sum (right) celebrating Christmas in December 1961 within Singapore General Hospital
Photo credit: Mr Ng Hon Wing

Figure 4: (a) Mr Ng Hon Wing positioning a paediatric patient for a Chest X-ray in the late 1960s in Singapore General Hospital (SGH) (b) X-ray units in the early days where SGH installed their first X-ray apparatus in May 1913.
Photo credit: Mr Ng Hon Wing and SGH Museum

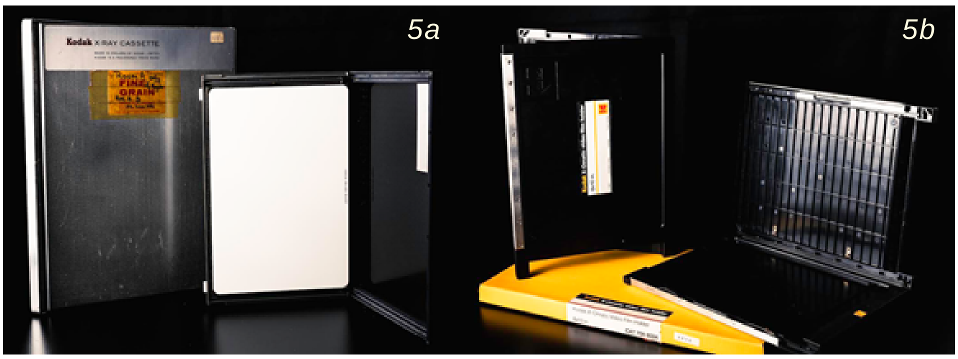


Figure 5: (a) Kodak film-screen X-ray Cassette with intensifying fluorescent phosphor screens where medical x-ray films taken had to be processed in a dark room. (b) Curved film-screen X-ray Cassettes were used for closed contact x-rays like mandible, or inter-condylar views of the flexed knee.
Photo credit: SGH Museum

From the simple forms of still radiographic images in the past, today's form of medical imaging has more dynamic roles. The advancement of technology has led to specialised imaging and revolutionised patient care. The ability to reduce the turnaround time effectively improves the quality of patient care and minimise the resources needed. Currently, radiographers performing Ultrasound (US) play an important role in reducing turnaround time by performing the US independently. In the past, SGH started with a small group of radiographers managing one US room where all examinations were checked by radiologists (Figure 6). US service was extended to SGH inpatient in 1995, and the modality has since expanded to 38 US radiographers today, handling a total of 17 rooms with the extension of service to SGH Urology Centre Extracorporeal Shock Wave Lithotripsy and SingHealth polyclinics. US radiographers in SGH have extended their roles further to reduce patient turnaround time by drafting preliminary reports via Picture Archiving and Communication System reporting.

Figure 6: The first Ultrasound Unit in Singapore General Hospital
Photo credit: Ms Koh Bee Hua

Technological progression has paved the way for new US applications which provide supplementary diagnostic information from previous applications, facilitating early patient management. SGH recently initiated a new US service named "Ultrasound Elastography Liver" which gives a quantitative value of the degree of liver fibrosis (Figure 7). Provision of this new service allows prompt clinical management for patients with underlying liver cirrhosis disease and monitoring of disease progression. Such technological progression is also evident in other imaging modalities like Computed Tomography (CT) (Figure 8). SGH's present-day inpatient and outpatient CT scanners are now equipped with the latest Dual-Energy capability.

SGH is the first hospital in Singapore to fully integrate the use of dual-energy capability into routine scanning. The image acquisition with spectral energy separation, utilizes both low and high polychromatic X-ray beams which allows superior lesion detection and characterisation (Grajo et al 2016). Special CT scan protocols (including MAKO robotic arthroplasty and Image Guided Sinus Surgery protocols) are now carried out to aid surgery in SGH for better precision and effectiveness of treatment. In addition, these protocols would reduce radiation exposure and examination time while producing high diagnostic quality images for patients.

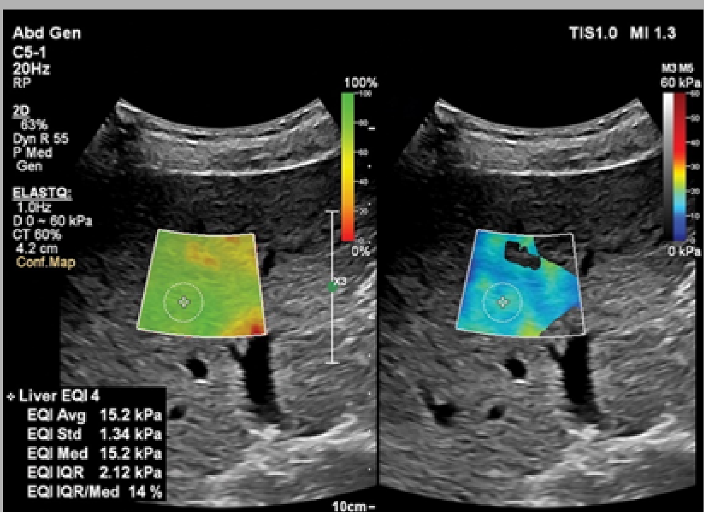


Figure 7: Ultrasound Shear wave Elastography technology imaging used for assessing degree of liver fibrosis
Photo credit: Barr, R.G., Wilson, S.R., Rubens, D., Garcia-Tsao, G., Ferraioli, G., 2020. Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement. Radiology 296, 263–274.. doi:10.1148/radiol.2020192437

Figure 8: The first Computed Tomography Unit in Singapore General Hospital
Photo credit: Ms Aw Lian Ping

As we strive to achieve lower radiation doses without compromising image quality, today's modern mammography equipment is fitted with these enhanced capabilities. Currently, the mean glandular dose per view averaged 2.37mGy for screen-film mammography and 1.8mGy for Full Field Digital Mammography. This is 22% lower for digital than screen-film mammography (Hendrick et.al). Patients undergoing a mammogram were known to be subjected to discomfort and pain during the examination. SGH has adopted new approaches to improve the patient's experience in breast imaging while maintaining the high accuracy of mammogram results. An example of this is the Curved Compression Paddle. It is designed to be used in mammograms to provide patient comfort without compromising image quality, exam time and radiation dose, compared to the standard flat paddle (Figure 9).

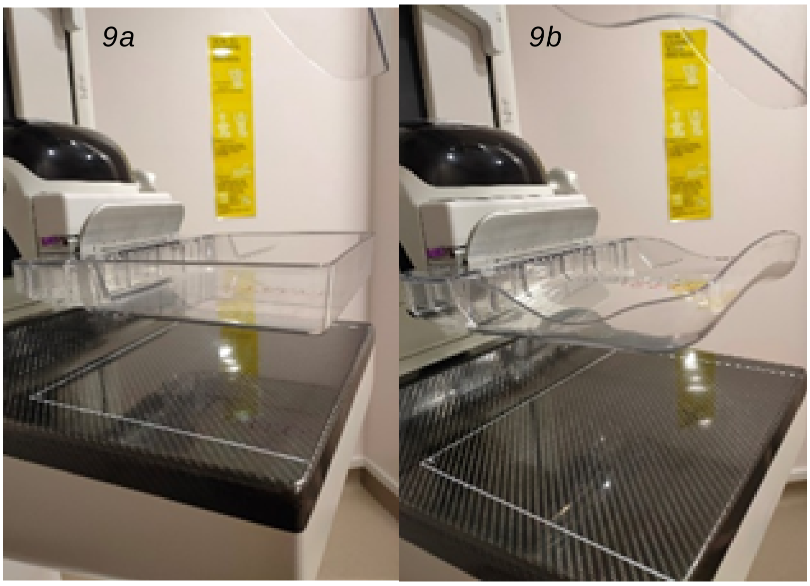


Figure 9: Mammography compression paddles used during examinations (a) Standard compression paddle (b) Curve compression paddle
Photo credit: Department of Diagnostic Radiology, Singapore General Hospital

Latest developments in breast imaging such as Tomosynthesis and Contrast Enhanced Spectral Mammography have also contributed to the early detection of breast diseases with increased sensitivity and specificity. Enhanced imaging technology aided in early detection, progress in protocols and advanced applications. With the advent of Magnetic Resonance Imaging (MRI), new useful applications have been constantly introduced. Current MRI technology has provided quieter and faster scans compared to the old "jack-hammer" noise. Latest hardware and software development also allows for studies to be completed in half the time. Coupled with advanced motion correction software features, better diagnostic quality images are produced with increased signal to noise ratio and reduced motion artefacts (Weiss, 2018).

Figure 10: Intraoperative Magnetic Resonance Imaging (iMRI) suite enabling MRI real-time images to be taken during surgery, particularly neurosurgery.
Photo credit: Department of Diagnostic Radiology, Singapore General Hospital

Radiographers in MRI have been working actively with radiologists and MR physicists to provide specialised services using these advanced applications. The services pioneered by SGH include Vessel Wall Imaging for Moya-Moya disease, 3D Inversion Recovery for Meniere's disease and Simultaneous Multi-slice Susceptibility Weighted Imaging and Quantitative Susceptibility Mapping for Parkinson's disease. MRI radiographers would also have to aid neurosurgeons in surgical planning and navigation to ensure treatment success. An intraoperative MRI (iMRI) suite was commissioned in 2008 and remains the first and only iMRI in the region (Figure 10). Intra-operative evaluation to confirm complete resection of brain tumours is a key outcome to prevent a recurrence. During the surgery, diffusion tensor images (DTI) and 3D images are integrated with neuro-navigation software to improve spatial orientation. Surgeons are also able to use the DTI images for mapping and to test the cognitive functions of the patient during awake craniotomy.

Intra-operative CT (iCT) suite in SGH has also been made available for its many applications to aid in neurosurgical procedures for example localisation of bleeds, tumour or hydrocephalus surgery and for surgical approach planning.

Fusion imaging technology takes advantage of various imaging techniques. It combines the use of contrast-enhanced CT, MRI or Positron Emission Tomography (PET)/CT with real-time US images to allow detection and documentation of lesions, via an electromagnetic field transmitter with a US transducer-mounted sensor (Kim et al, 2015). This is valuable in providing a real-time guide of ablation for inconspicuous lesions ensuring treatment success while minimising risks and harm for patients during interventional radiology ablation procedures.

With the acquisition of the combined hybrid Angio-CT system and robotic angiographic C-arm units in 2008 and 2009 respectively, the interventional radiologist is now able to perform more precise and complex procedures to save the life and limb of patients, something unheard of a mere 20 years ago. In fact, the acquisition of the hybrid Angio-CT system actually placed the department in the spotlight as we were the first hospital in South-East Asia, outside of Japan, to purchase such a unit. For the next few years, the SGH radiology department even became a show site for users interested in purchasing this specialized imaging system for their healthcare centres. In addition, this new form of combined medical imaging enabled our interventional radiographers in SGH to develop specific intra-arterial CT protocols to optimize imaging of body lesions vascular supply undergoing interventional treatment procedures.

Nuclear medicine and Molecular Imaging (NMMI) is another field in medical imaging that works closely with interventional radiology to enable a more effective treatment plan for patients. SGH Department of NMMI (DNMMI) was one of the pioneers in introducing Peptide Receptor Radionuclide Therapy and Prostate-Specific Membrane Antigen Radioligand Therapy in Southeast Asia, initially attracting up to 40 referrals annually from neighbouring countries, as well as China and Taiwan. In 2003, with the first Cyclotron and first PET/CT scanner installed in Singapore, PET/CT imaging was now possible. The PET/CT scans, which is one of the main imaging techniques for the investigation of cancer, has been shown to be cost-effective to reduce additional diagnostics for patients. This invariably would allow better clinical management while facilitating individualised treatment for patients (Reinert et al, 2020). In addition, DNMMI collaborates with many departments in research especially with Endocrinology, National Cancer Centre Singapore & Singhealth Experimental Medicine Centre (SEMC). MicroPET and NanoSPECT scanners, located in SEMC have been operating since 2008. While these are very small FOV scanners utilised for small animal research, such nuclear imaging technology opens a new avenue for improving the efficiency of the drug development process (Jang, 2013).

Future direction

The rapid advent of digitization and improvements in miniaturization with advancing medical research will lead to an upward trajectory for Artificial intelligence (AI) in medical imaging expansion. Future technological advancements may include more superior field strengths in MRI, even photon-counting technology and grafting-based phase-contrast and dark-field CT. Artefacts will be minimised with metal streaking reduction in CT images, to deep-learning for enhanced tissue characterisation and automated abnormality detection in scans. Mammography can benefit from high quality, low-dose diagnostic images to be obtained without the involvement of breast compression during the acquisition.

Many years from now, AI will be contributing significantly to the improvement of diagnostic accuracy in medical imaging with reduced inter-observer differences. Especially in the US, Computer-Aided Detection of elusive tumours will be able to improve and expedite patient management. AI can also aid in the screening of diseases and prognosticating them in advance, using prediction models, to allow early intervention. Patients can benefit from faster turn-around of diagnostic test results, and early intervention to reduce disease outcomes.

In addition, imaging equipment of the future would likely be more portable. Bedside imaging could be more routine with Singapore's greying population. Mobile CT and MRI scanners will be able to allow timely completion of urgent scans. With more mobile and lightweight MRI systems, weight-bearing MRI scans such as those for musculoskeletal disorders of the knees and feet might even be possible. Similarly, mobile CT scan machines will be much more compact with significantly higher spatial resolution. Importantly, radiation doses would be significantly lower for safer use at the bedside. Portable low-dose mammograms and DR can be easily brought to the homes to facilitate screening and urgent diagnosis. This service will benefit the general public especially those who have mobility issues.
Although technology for remote scanning is still at its infancy stages, there is vast opportunity for such an approach to be applied widely in medical imaging in the distant future. This can be implemented in outpatient settings, polyclinics, or even critical care units in the future, to meet demands for increasing medical imaging. Patients in the future could assume the required positions for medical imaging independently. Anatomy detection and planning can be done by the scanner automatically, reducing the time required to complete imaging examinations significantly.

Technological advancement could also encourage the embracement of robotics in medical imaging. Remote US scanning using a robotic arm will minimise contact between healthcare providers and the patients therefore reducing the risk of cross-contamination. The deployment of robotics has great potential in preserving the sustainability of our healthcare system and promoting continuation of business in a pandemic.

Medical imaging professionals in the future will be embracing formalised advanced practice roles. There may be opportunities for role expansion for radiographers such as consultant radiographers who perform specialised clinical work for example biopsies and excisions. In tandem with the role expansion, the patients will be able to experience a holistic one-stop diagnosis service which can reduce their waiting time and improve their outcome. Radiologists can shift their time and efforts to other domains like medical imaging treatments for patients, and work hand-in-hand with advanced imaging practitioners improving quality of patient-centred care.

Conclusion

Since the first introduction of X-rays in Singapore, medical imaging has progressed from purely diagnostic purposes to medical screening, and even combined with treatment planning. Medical imaging professionals are playing an important role in delivering value to patients through appropriate care and the efficient use of state-of-the-art technology. Indeed, the field of medical imaging in Singapore has a rich history going back nearly 123 years. Today, we stand on the verge of a paradigm change, where the rise of AI in clinical medicine will ultimately refine health care. Medical imaging can be the forefront of prognostication of diseases in the future. Given the acceleration in technological trajectory, the future of our profession is bright and promising.

Acknowledgements

We thank Ms Koh Bee Hua, Mr Martin Chew Boon Keng, Mr Ng Hon Wing and Mr Lee Wai Sum for their expert advice and encouragement throughout this write-up.

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COMMENTARY

COLD X-RAY TUBE

The 'new' kid on the block.

Historical origins of hot and cold tube

X-ray machines have come a long way since Roentgen took his “Hand mit Ringen” radiograph in 1895; modern x-ray systems in our hospital radiology departments bear almost no resemblance to the x-ray machines of the early twentieth century. You could use several pairs of adjectives to describe these differences: old versus new; bulky versus compact; safe versus hazardous; primitive versus modern. Interestingly, even hot versus cold.

“Hot” and “cold” does not refer to the use of heat and ice in the x-ray system. Rather, it is a reference to the method of electron production in the x-ray tube. Back in the day, Roentgen’s x-ray tube (invented by the physicist William Crookes) used an electric field to liberate electrons from a metal source. This is known as field emission. Modern x-ray tubes, on the other hand, heat a tungsten filament (introduced by William Coolidge in 1913) to boil off electrons in a process called thermionic emission (Figure 1). Hot and cold simply mean whether the heating is required to generate the electrons [1].

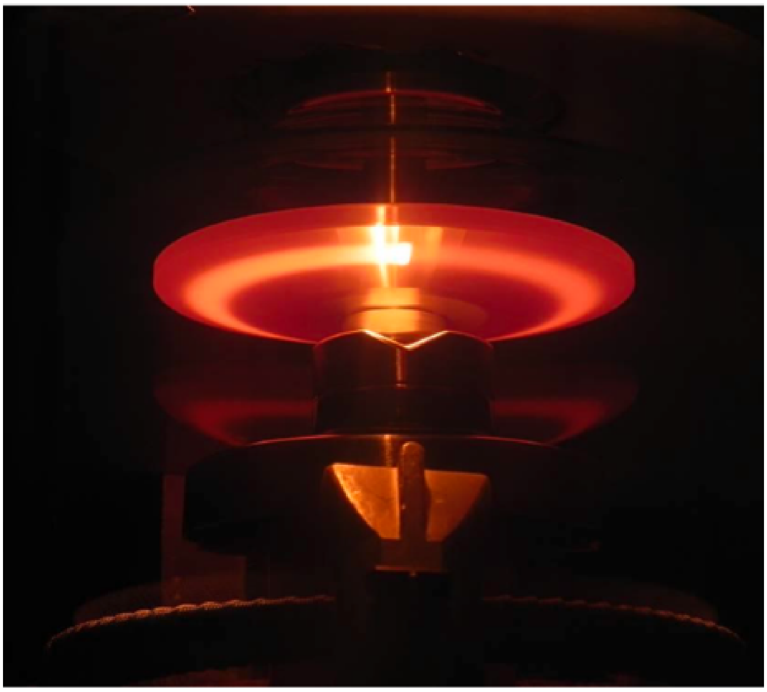
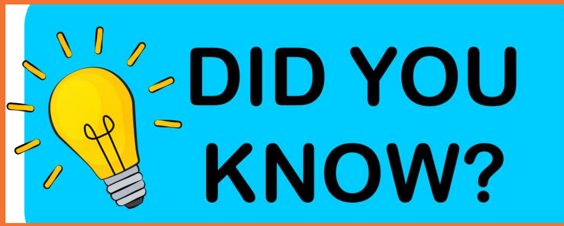


Figure 1: Thermal radiation of a rotating anode from a hot tube [2].



The two Williams were not related. In 1901, a major improvement in radiation safety was to enclose x-ray tubes in a shielded lead box before energising. This recommendation was made by William H. Rollins (no relation to Crookes nor Coolidge), who found that pregnant guinea pigs would die when continuously exposed to ionising radiation but showed no visible signs of radiation burns.

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In the early days of x-ray imaging at the turn of the 20th century, cold tubes were far from ideal. One big problem radiographers faced was that the tube mAs could not be independently controlled. This was due to the inability to regulate the amount of electrons flowing to the anode, so the exposure factors were coupled together where the output mAs increased with the desired kV. To make matters worse, as the x-ray tube was used, more and more gas would be absorbed into the glass walls and this resulted in an ever increasing minimum kV! [2] In essence, cold tubes gave very little control over the exposure factors, so radiographers were unable to consistently take good quality radiographs while keeping radiation doses to the patient at acceptable levels.

Hot tube

Hot tubes, although having undergone around a hundred years of technological and engineering development, still have an inherent set of problems that are yet to be solved. Thermionic emission produces a lot of waste heat and x-ray production is extremely energy inefficient: both the filament and anode have operating temperatures of approximately 2000 degrees Celsius and only 1% of electrons reaching the anode is converted into x-rays with the other 99% becoming unwanted heat energy.

The cooling mechanisms and the oil reservoir required for efficient heat dissipation, as well as the heavy metal compounds required to withstand the searing operating temperatures, make the tubes heavy, bulky, and costly. Also, as the filament is unable to instantaneously adjust to the required temperature, hot tubes take a relatively long time to respond to changes in exposure parameters. Radiographers are all too familiar with seeing non-periodic motion artifacts [3], such as breathing and cardiac movement, unexpectedly showing up which will typically result in a reject/repeat scan.

Cold tube

Interestingly, there has been a resurgence in cold tube development and technology over the past few decades. Instead of using a gas as the electron source (like in Roentgen's tube), the modern approach involves an electric current bring used to manipulate very small electron emitters which will produce a "cloud" of electrons (this would allow independent selection of kV and mAs) [4]. Then, like in hot tubes, the electrons would be accelerated to the anode to generate x-rays (Figure 2).

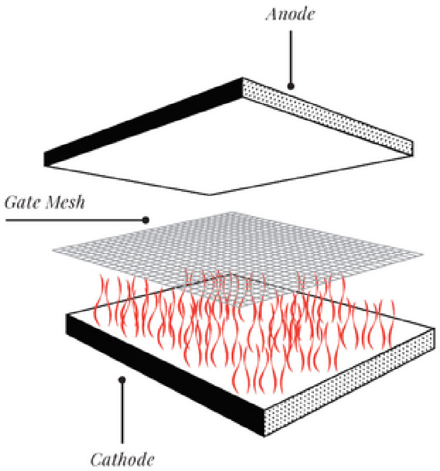

Figure 2: CNT tube basic design [1].

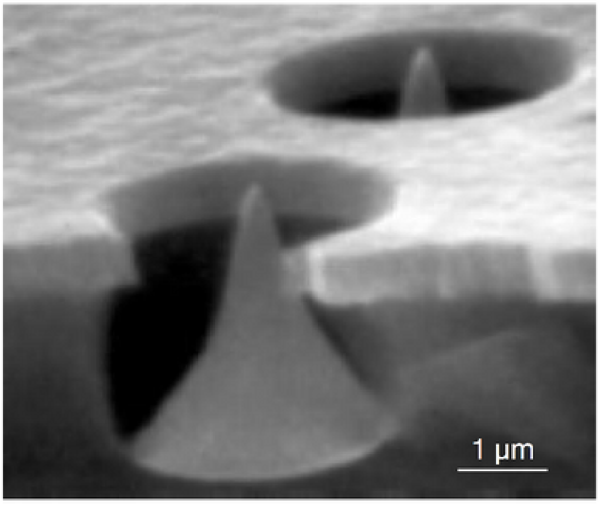

Figure 3: Spindt cathode [3].

Researchers have identified two promising structures that could serve as the electron source for a cold tube: Spindt cathodes and carbon nanotubes (CNTs) [5]. Spindt cathodes consist of cones of micrometre-sized molybdenum cones embedded in a housing structure (Figure 3), while CNTs are fields of sharp-tipped hollow tubules that are "grown" and then separately "pasted" onto a silicon chip [6] (Figure 4).

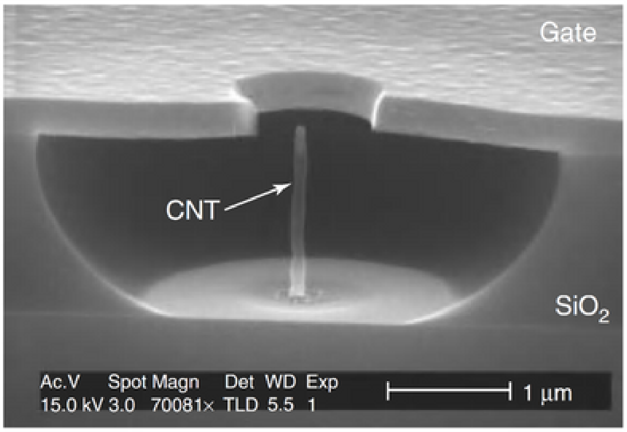

Figure 4: CNT cathode [3].

Both, however, have their drawbacks. Spindt cathodes are notoriously unreliable at high operational currents as random arcing causes the emitter tips to "explode" and erode. CNT output gradually degrades as the "adhesive" weaken over time, causing the CNTs to spread out nonuniformly leading to randomly overheating and failure [1]. Technological breakthroughs are required to make cold tubes reliable and long-lasting while sustaining high mAs output [3,5], just like their hot tube counterparts.

Unlike conventional x-ray systems, the cold tube equivalent would consist of stationary arrays of cold tube-anode pairs which use electronic lensing to direct electrons from the electron field onto the anodes to cover the required field-of-view – no tube movement would be involved [3]. Also, because electron flow is controlled via electronic circuits, imaging time would be extremely fast on the order of microseconds [1]. Effective focal spot sizes of 100µm (compared to approximately 600µm in general x-ray and 300µm in mammography) have been achieved, which greatly improves spatial resolution due to the reduction in geometric unsharpness [3]. Not surprisingly, cold tube systems are being touted as being potentially smaller, cheaper, more compact, and require less overall mechanical complexity than their existing counterparts [1]. In theory, they can be deployed more flexibly and conveniently to remote clinics and sites.

Current developments

At the moment, clinical research is ongoing to evaluate the feasibility, benefits, and stability of cold tube systems. A group at Siemens Medical designed and simulated a cold tube-based digital tomosynthesis treatment planning system in radiation therapy [7]. The University of North Carolina has researched the clinical use of XinRay Systems cold tubes in stationary chest tomosynthesis to improve the detection sensitivity of small lung nodules at lower radiation doses [9]. Nitrosi et al investigated and found that both hot and cold tubes yielded almost identical responses in the digital detector of a Carestream DRX system [12]. This novel x-ray technology is close to being commercialised. A new entry into the imaging systems market, Israeli start-up NanoX Imaging, has recently debuted their Nanox.ARC x-ray scanner at RSNA2020 [13].

Figure 5: A representative slice from the reconstructed image stack obtained by stationary digital chest tomosynthesis, demonstrating the conspicuity of thoracic anatomy [6].

Figure 6: Images shown from left to right are axial, coronal, and sagittal tomographic slices from mouse cardiac micro-CT with respiratory and cardiac gating (free breathing) [8].

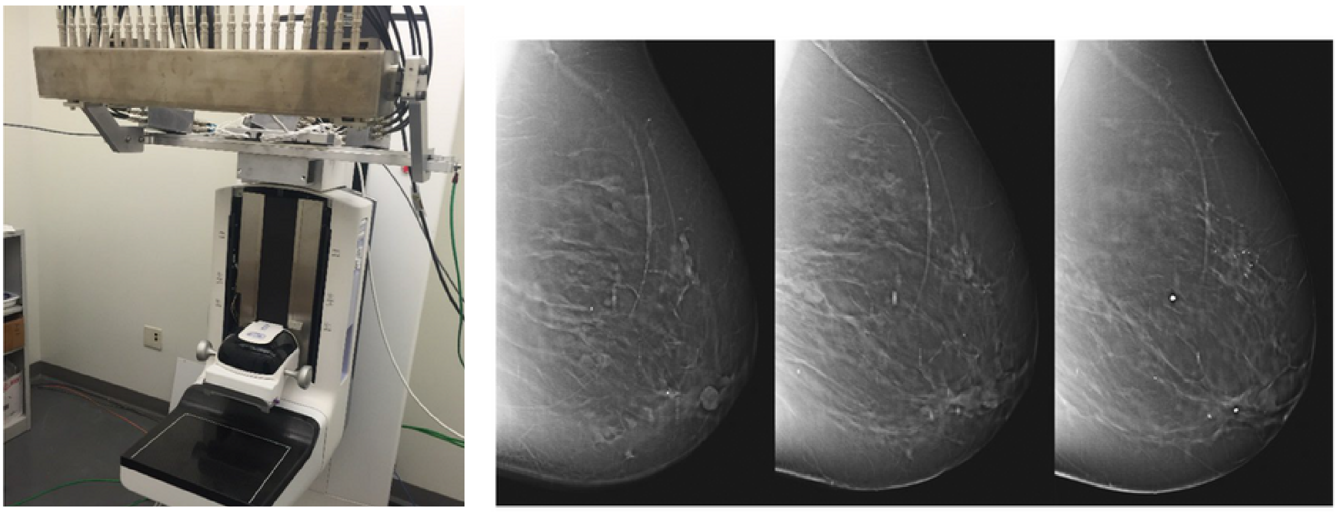

Figure 7: **Left**: 2nd generation stationary digital breast tomosynthesis (s-DBT) system with integrated CNT based distributed source array. The system comprises of 21 x-ray focal spots which can be electronically controlled instantaneously [11]. **Right**: Sample mediolateral-oblique views obtained by stationary digital breast tomosynthesis. These slices are a part of the reconstructed image stack generated from 15 X-ray projections. The reader scrolls through the slices to visualize the three-dimensional anatomy and pathology [6].

Can cold tube systems be adopted?

Cold tube x-ray systems seem to be the "next-big-thing" in medical imaging. Although the possible benefits of having a cheaper-better-faster system appear tantalising, we should bear in mind that the clinical use of technological breakthroughs is usually gated by their high initial costs. It is uncertain if cold tubes are set for mainstream adoption or will be limited only to niche applications. For now, several questions remain to be answered. Will there be any significant or appreciable differences in the quality of images acquired on either technology? Can cold tubes reliably sustain the same level of performance as hot tubes? And what are the lifetime system costs involved in the long-term clinic use of cold tubes? A wait-and-see approach seems to be appropriate for now.

The recent advancements in cold tube technology have brought many of us on the edge of our seats; finally, a much-anticipated innovation since the shift from film to digital radiography! The next logical step now would then be to carry out clinical trials in both diagnostic imaging and radiation therapy to demonstrate that cold tubes can possibly bring about a greater quality of care. As the maturation of technology will bring about more certainty of its associated benefits, let us then keep an open mind (and one eye on the future) if the chance presents itself to use such innovation for the betterment of our patients.

Disclaimer

The author has no affiliation with any of the aforementioned manufacturers and products. All opinions expressed belong solely to the author and do not represent the opinions of any entity.

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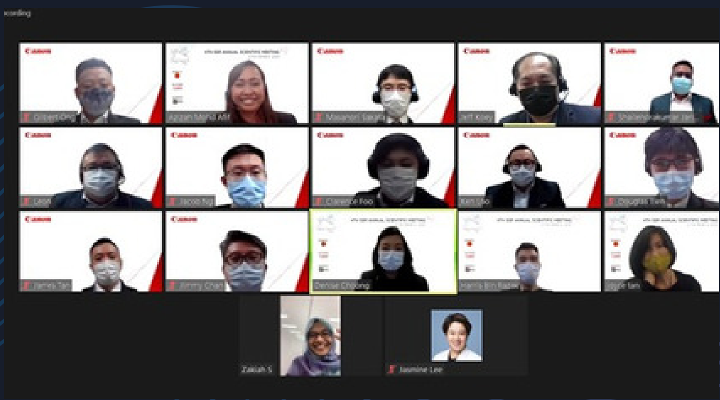
4TH SSR ANNUAL SCIENTIFIC MEETING

The society hosted our 4th Annual Scientific Meeting (ASM) as a virtual event on 27th March 2021. The theme of the ASM, 'The New Era of Professional Practice', reflects our professional commitment to develop and bring our professional practice to a higher level. The virtual event was live-streamed due to the restrictions on physical gathering. Nevertheless, it drew a considerable audience of 226 attendees. The one-day webinar consisted of professional practice topics in the respective fields of Diagnostic Radiography and Radiation Therapy.

Exco team on site at SIT



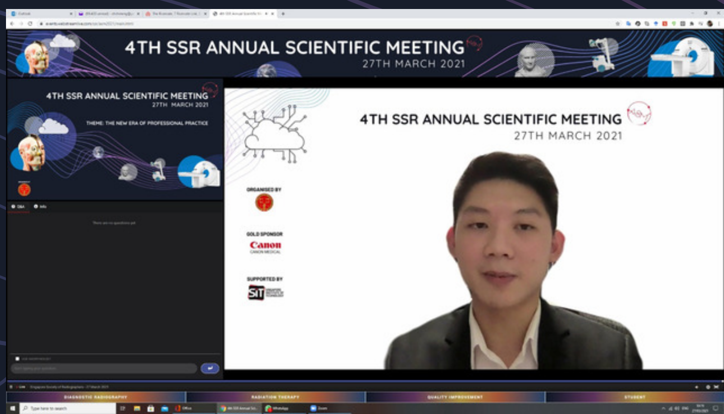
Canon webinar

ASM 2021 had a presenter from Canon, Dr Ravi, who presented "Effect & Clinical of canon AI on resolution recovery and advanced image processing.". Our plenary speakers, Prof Jenny Sim, Dr Poh Pei Ghim and Dr Tony Wong presented extensively on professional identity and AI. We were honoured to have Mr Gabriel Leong lead the keynote session with his presentation: "New era- Evolving role of radiographers".

ASM 2021 is different than any of our webinar events. Traditionally, the ASM is held as an in-person event. Our last ASM was conducted in Senkang General Hospital in 2019 and we had to postpone the ASM planned for 2020 due to the pandemic.

We were fortunate to have an additional year to organise ASM. This gave the organising committee to review the logistics, finances, programme as we calibrate to the new normal of event management. We thank our speakers for being on board. We also had a troop of dedicated student volunteers who helped in the student track as well as administratively.

For those who have attended the ASM, you are entitled to the video on demand (VOD) to wath the session again at your leisure. Snippets of ASM 2021 is also available in the members section of the SSR portal for members. Enjoy!



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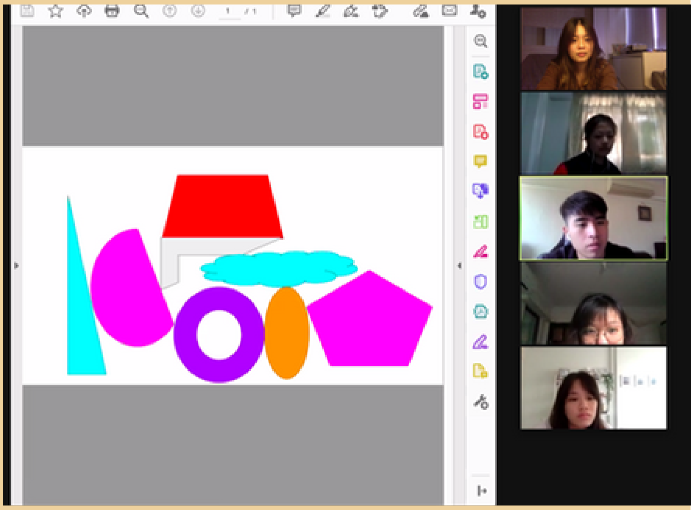
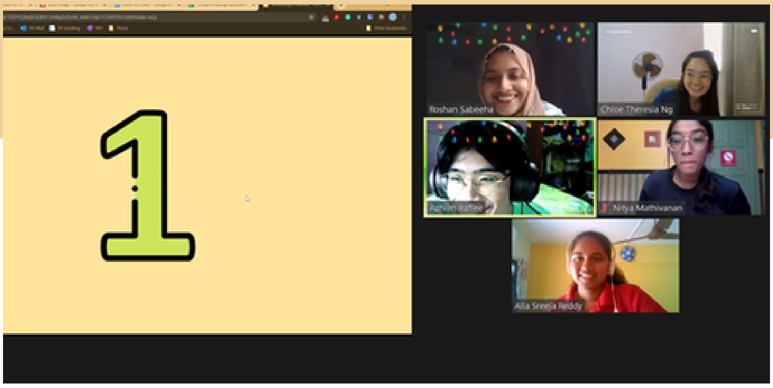
SSR Student Chapter (SSRSC)

Student ambassador: Induction & Leadership Program

The student ambassador programme was specially curated to offer unique leadership opportunities to selected student members who were keen on developing their leadership potential. Throughout their one year term, student ambassadors attended training programmes and shadowed the executive committee in planning events.



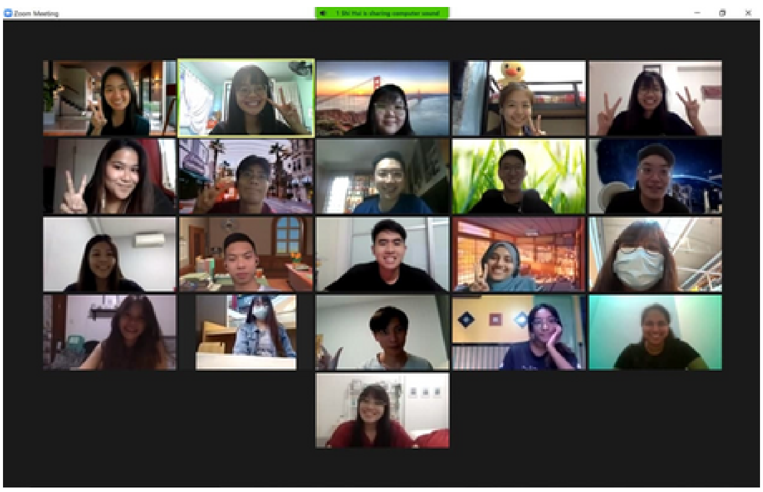
Full concentration from one of the groups playing "Tuckman's Battle" which gave a unique interpretation of teamwork in leadership.



All smiles from one of the groups playing "Screaming in Silence" which focuses on the value of empathetic listening.

The first induction programme was held on the 28th of December. Student ambassadors and SSRSC exco came together for a fun time of bonding and games through Zoom. Given the COVID-19 pandemic, interactive digital games were utilised to initiate our student ambassadors into the team.

On the 15th and 16th of January, student ambassadors also attended the inaugural leadership programme held jointly on Discord and Zoom. The purpose of the programme was to develop both their hard and soft skills whilst also promoting team bonding. A virtual amazing race was conducted to imbue the soft skills of effective communication, conflict management, empathetic listening, and leadership through a series of challenges and team games. The student ambassadors were then split into 4 committees and mentored by their respective exco in planning and executing events for the rest of the student members.



Student ambassadors and Exco group photo taking after the induction programme

Fireside chat

Group photo of speakers and participants of the first fireside chat.

The fireside chats were designed to provide student members and working professionals with light-hearted and informal sharing sessions. The goal of the fireside chats is to facilitate sharing of first-hand experiences from professionals and for student members to ask questions that only working professionals can answer. Currently, the first session of the fireside chat has been concluded. Our speaker, Eileen Leong, was a pioneer graduate of SIT's Diagnostic Radiography degree program. The session allowed for Eileen to share her experience transitioning from a student to a working professional.

Language classes

The student chapter started basic language classes to help boost the communication skills of our student members by teaching them basic words and phrases that are commonly used during our clinical placements. Currently, we have plans to teach four basic languages, mandarin, Bahasa Malayu, Bahasa Indonesia, and Tamil. Student ambassadors proficient in various languages are currently working together to translate a standardised set of words and phrases that are commonly used in our clinical placements. Classes would be held over zoom and will be made available for all student members of SSR.

Singapore society of radiographers

Now You're Talking

SHARING FOR MEMBERS BY MEMBERS

Share your latest research or topics of interests to the radiography community

TOPICS FOR SHARING

Research
Case studies
Current topics in radiography and radiation therapy
Clinician/Student experience
Clinician/Student Academic projects

An Initiative by Singapore Society of Radiographers and Singapore Society of Radiographers Student Chapter

'Now You're Talking' is a grassroot initiative, created in the spirit of SSR's mission to promote the pursuit or practice of radiography, education, training, and research in the technical aspects of radiation medicine and protection. This is a program that allows members to give a talk or presentation on latest research or topics of interest to the radiography community.

'Now You're Talking' aims to encourage knowledge sharing among members by:

Bringing thought leaders and subject matter experts together to share their insights

Fostering a culture of sharing among members

Connecting members from diverse cultures

Optimisation of digital chest radiography using scatter correction software with added filtration

'Now You're Talking' provides a platform for like-minded individuals to share and discuss freely on current topics of interest. It is great to be able to engaged the members within the SSR community through my short sharing.

- Tan Chieh Wei

Knowing right from left at first sight:
Physical versus digital markers and the effect of visual stimulus on right-left discrimination

'Now You're Talking' is a great way to promote sharing and learning among the members of the SSR community. I am glad to be a part of it by sharing my thesis research.

- Heena Ramesh Vasnani

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