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Opinion

Celebrating 50 years of the first human CT scan: The untold South African connection

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INTRODUCTION

October 1, 2021, marked the 50th anniversary of the very first computed tomography (CT) scan of a patient. The scan was performed at Atkinson Morley's Hospital in Wimbledon, London, revealing for the very first time a direct live image of the human brain. The unfortunate patient, a 41-year-old woman, harbored a brain tumor which the scan, although grainy, clearly and unequivocally revealed.(1) (Fig. 1) This image has come to capture imagination in much the same way as that of Mrs. Röntgen's hand in 1895.

Unlike the controversy surrounding the invention of the MRI,(2) Godfrey Hounsfield is the indisputable inventor of the clinical CT scan. Nevertheless, two South Africans who both completed their undergraduate degrees in South Africa, made seminal and original contributions toward the foundational theory and clinical development of the CT scan.

This South African contribution is today, 50 years on, rarely acknowledged, let alone celebrated, by even South Africans themselves: in a widely circulated South African online article commemorating the 50th anniversary of the CT scan, no mention was made of the South African connection.(3)

This brief vignette aims to tell the story of the CT scan and the South Africans central to its development, which came to completely revolutionise the practice of neurology and neurosurgery and, shortly thereafter, of medicine itself.

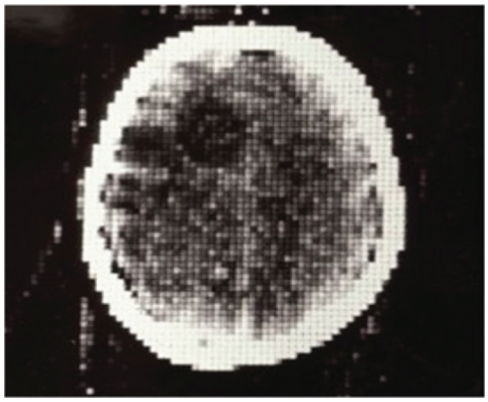

Fig 1: The First Clinical Scan

THE CT SCAN OF THE BRAIN

Prior to the invention of the CT scan only indirect images of the contents of the intracranial cavity could be produced through pneumo-encephalography and cerebral angiography, both prohibitively invasive tests. Pneumo-encephalography had been the only method of visualisation of the intracranial cavities by outlining ventricular and cisternal spaces since the first description of the technique by Dandy in 1919.(4) This technique could indirectly suggest the presence of large parenchymal lesions by showing changes in the outline of the ventricles. Pneumo-encephalography was associated with a wide range of sometimes disabling side effects, thought to be brought about by transient brain displacement.(5)

Cerebral angiography was first described and performed by Moniz in Lisbon in 1927 and came to be seen as major advancement over pneumo-encephalography.(6) The presence of non-vascular intracranial lesions could be inferred if such lesions altered or displaced the normal appearance of the cerebral vasculature. As a method of intracranial imaging, cerebral angiography was indirect, invasive, labour intensive and associated with potentially devasting and fatal side effects such as stroke. Its considerable advantages over pneumo-encephalography notwithstanding, the fear of the complications of angiography was so pervasive that psychosurgery was for a time more readily accepted and practiced throughout the world.(6) Illustrating this fear, Moniz won a Nobel Prize for his work (since abandoned) in psychosurgery, rather than cerebral angiography.

Into this realm of indirect and invasive neuro-imaging stepped Godfrey (later Sir) Hounsfield, an English electrical engineer who conceived of the idea of producing an image of the contents (however irregular) of a container by dividing the container into multiple 'slices' and taking X-rays of each 'slice' from multiple different angles. Thereafter, a computer would analyse the various absorption co-efficients and produce an image of each 'slice', using a pre-determined mathematical algorithm. The cranial cavity

can similarly be divided into slices; slices were taken only in the axial plane in the first iterations of the CT scan. Each slice is then sequentially imaged by an x-ray beam rotating through 360 degrees. Hounsfield developed the CT scan based on this idea while working for Electrical and Musical Industries (EMI), well known for producing the music of the most famous music band of the time, The Beatles. It is believed, arguably, that EMI was only able to fund the considerable amount required for the development of the CT scan from the valuable musical success of the Beatles. So central was EMI, that CT scans were initially referred to as EMI scans.(7)

Practically, there are no contra-indications to the use of the CT scan.

From angiography to molecular imaging the current and future applications for the CT scan paradigm appear boundless. *Physics today* in celebrating 50 years of the CT scan, very aptly described it as 'a stethoscope on steroids.(8)

JAMES AMBROSE

James Abraham Edward Ambrose was born in Pretoria in 1923 and saw service in the second world war as a fighter pilot flying Sptifires from 1941 to 1945. Following demobilization, he returned to Cape Town and received his degree in Medicine from the University of Cape Town in 1952. He moved to England and became a consultant neuro-radiologist at Atkinson Morley's Hospital in 1962.

Ambrose was already a much respected and insightful neuro-radiologist when Hounsfield, at the behest of the Department of Health, sought him out in 1969. Hounsfield had by then already been unceremoniously rebuked, among others, by a neuro-radiologist at the National Hospital for Neurology and Neurosurgery, London. Unlike his colleague, Ambrose immediately foresaw the potential of the new device described to him and was central to its final development over the next 2 years culminating in the first clinical scan of 1971. Ambrose's initial description of physiological and pathological tissue densities has undergone **no** revision since his first description. He was also the first to suggest that the CT appearance of, particularly pathological, tissue could be enhanced by the administration of compounds which contained atoms of high atomic number.(9)

In November 1972 the new CT scanner along with its clinical results was displayed to a crowd of 2 000 doctors in Chicago, earning Ambrose a standing ovation. Nevertheless, Ambrose today is rarely remembered for his contributions to the development and immediate and universal acceptance of the CT scan. Many of his contemporaries believe that Ambrose was never appropriately recognised for this contribution despite his receipt of various honorary fellowships and memberships.(10) For all Hounsfield's technical ingenuity, his greatest stroke of fortune in developing the CT scan may have been meeting James Ambrose.

James Ambrose died in Scotland in 2006 at the age of 82.

ALLAN MACLEOD CORMACK

The worlds first heart transplant was performed at UCT's Groote Schuur Hospital on the 3rd of December 1967. It has been argued that an even more significant scientific breakthrough was achieved at the same university 10 years earlier, as on the 5th of September 1957, Allan MacLeod Cormack with the assistance of UCT staff conducted an experiment which together with a second experiment performed six years later led to two seminal papers, published in the Journal of Applied Physics in 1963 and 1964.(11,12) The apparatus used to perform these experiments (Fig. 2) can arguably be considered to be the first 'CT' scanners ever built except that the calculations performed in these instances were done on a desktop calculator rather than a computer.(13)

Cormack was a nuclear physicist and UCT physics lecturer working 1,5 days a week in the department of Radiology at Groote Schuur Hospital attending to the use of radioisotopes in 1957. He realised that the isodose charts used to deliver radiotherapy, treated the human body as though it was homogenous in density when this was very evidently not the case. Cormack recognised that the ability to determine the different radiation attenuation (absorption) co-efficients of the various tissues would result not only in better radiation treatments but could also be used diagnostically. He concluded that the solution to this problem would be mathematical in nature. His papers of 1963 and 1964 thus provided a theoretical basis for the development of the CT scan and his experiments, albeit rudimentary, in hindsight confirmed its practical feasibility. For reasons that will forever remain speculative, Cormack's work drew little to no attention. One reason was possibly the limited ability of computers of the time to perform the complex calculations required for image reconstruction.

Allan MacLeod Cormack was born in Johannesburg on the 23rd of February 1924 and received bachelors (BSc) and masters (MSc) degrees in physics from UCT in 1944 and 1945 respectively. He worked for a time in the famed Cavendish Laboratory in Cambridge under Otto Frisch

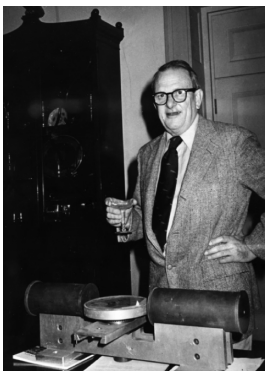

Fig 2: Cormack and his rudimentary 1963 CT scan device, consisting of cylindrical collimators containing the source, Co^{60} gamma rays, and the detector (courtesy American Institute of Physics)

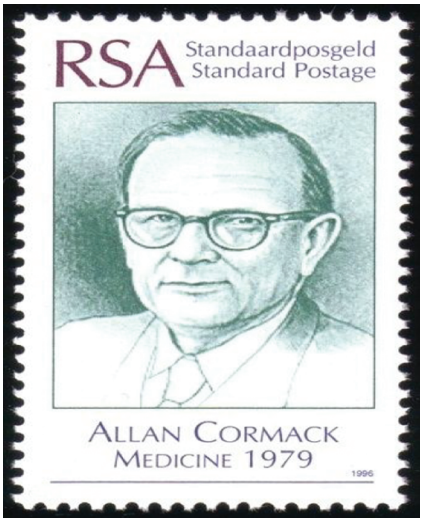

Fig 3: A South African issued stamp of Cormack (1996)

but chose not to complete his PhD. He returned to Cape Town in 1950, eventually moving permanently to the United States in 1957 with his American born wife. In the USA, he spent his entire career at Tufts University holding the position of chairman of the physics department from 1968 to 1976. Cormack died in the USA in 1998. He remained a citizen of South Africa, despite acquiring American citizenship later in life.

Hounsfield was unaware of Cormack's work while developing the CT scan, nevertheless Cormack, unlike Ambrose, received wide acclaim for his work. He shared, equally with Hounsfield, the 1979 Nobel Prize in medicine and physiology. The irony of two non-physician, non-biological scientists winning the ultimate prize in medicine was not lost on Cormack. He famously remarked while delivering the Nobel banquet speech '…it is not much of an exaggeration to say that what Hounsfield and I know about medicine or biology could be written on a small prescription form!'(14)

Cormack was posthumously awarded the national medal of science by the USA in 1990. He was honoured by the first democratically elected South African government in 1996, when a series of stamps (Fig. 3) was issued by the Post Office, commemorating South Africa's Nobel Prize winners. The order of Mapungubwe (Gold) was posthumously awarded to Cormack in December 2002. He was a humble and unassuming man who sought neither fame nor fortune, having never patented any of his work.

CONCLUSION

In a recent poll, invited readers of the Journal of Neurology, Neurosurgery and Psychiatry voted brain imaging (CT and MRI) as the most transformative development over the last 100 years.(15) The South African contribution toward the development of the CT scan should take its rightful place among other more recognized achievements in and out of the medical sphere and should not be allowed to be forgotten. South Africa and South Africans must be filled with a sense of pride that two of the three most pivotal people involved in the development of the CT scan were born, nurtured, and educated to a high level on these shores.

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