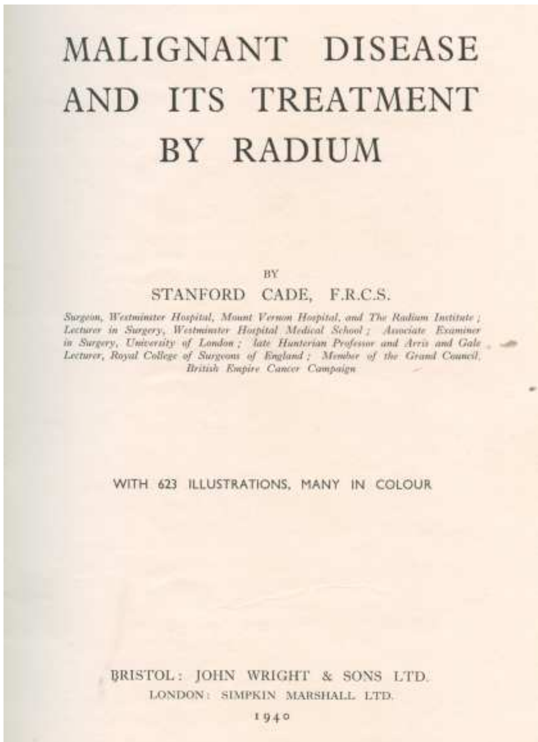
The Invisible Light

The Journal of the British Society for the History of Radiology



MALIGNANT DISEASE AND ITS TREATMENT BY RADIUM

BY

STANFORD CADE, F.R.C.S.

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WITH 623 ILLUSTRATIONS, MANY IN COLOUR

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Fig. 124.—X-ray epithelioma of thumb.

This is now the 56th issue of *The Invisible Light* which developed out of the newsletter of the Radiology and History Charitable Trust. This seems astonishing, and illustrates how much has been achieved over the years. There have been many fascinating articles, and this issue is no exception. I am pleased that we are able to print the winners of our John Clifton essay prize, and we have a particularly interesting one by Samuel Ward writing about Josef Rösch who was an early influential interventional radiologist.

Edwin Aird has written an interesting article on history of brachytherapy from the early years up to the present time. This paper is a mixture of history and personal experience. I am pleased that Edwin has discussed the work of Sir Stanford

Cade(1895-1973)[1] . Sir Stanford Cade, KBE, CB was a British surgeon, who was born on 22 March 1895in Daugavpils, Latvia, then part of the Russian Empire. Cade pioneered the combined use of surgery and radiotherapy in the treatment of cancer. Cade made massive contributions to British radiotherapy, and would be a worthy topic of a full biography.

I have Cade's two books. His *The Radium Treatment of Cancer* of 1929 (London: J&A Churchill) and signed by Cade, and his hugely influential *Malignant Disease and its Treatment by Radium* of 1940 (Bristol: John Wright & Sons) and signed (twice) by the late Frank Ellis. Both books are profusely illustrated. I never met Cade since I had only just started medical school when he died in 1973, however I met Frank Ellis on several occasions. Frank had a deep knowledge of the history of radiotherapy to which he had made no small contribution himself.

The illustration that I reproduce (fig. 124) is from *Malignant Disease and its Treatment by Radium* and shows a skin cancer that has developed from chronic radium dermatitis. Cade describes radium dermatitis in some detail. Radium dermatitis was an industrial disease and was granted legal composition in Great Britain under the Workmen's Compensation Ast surprisingly in 1924 which does seem rather late to me. I find radiation dermatitis interesting since many of the early radiation workers suffered from this condition. Alan Jennings [2] was an active member of our committee for many years. Alan worked with radon at the Middlesex Hospital, and I remember him allowing me to photograph his hands which has suffered from radium dermatitis. As a physicist Alan had been involved in producing radon needles.

In this *The Invisible Light* I have made brief reviews of an old book and several new books. I do get frustrated in finding new books. It is difficult to locate new books on radiology history, although the occasional search on Amazon is helpful. There is no real centre site for radiology history reviews, although the BSHR and *The Invisible Light* do what we can. If anyone comes across a new book and wants to submit a review then I would be delighted = or simply let me know about it. Also – if you have a favourite old book on the history of radiology then you might also like to send me a 'review', telling me/us what appeals to you and what we can learn from the book today. As an example, I came across a book by Émil H Grubbé on X-Ray treatment which I discuss below. A definitive history of radiotherapy and radiation oncology would be good.

Adrian Thomas
adrian.thomas@btinternet.com

[1] Plarr's Lives of the Fellows: Cade, Sir Stanford (1895 - 1973) https://livesonline.rcseng.ac.uk/client/en_GB/lives/search/detailnonmodal/ent:$002f$002fSD_ASSET$002f0$002fSD_ASSET:378216/one?qu=%22rcs%3A+E006033%22&rt=false%7C%7C%7CIDENTIFIER%7C%7C%7CResource+Identifier (accessed 24 April 2025)

[2] The Guardian: Alan Jennings. https://www.theguardian.com/science/2016/may/26/alan-jennings-obituary (accessed 24 April 2025).

An Old Book, X-Ray Treatment by Émil H Grubbé.

By Adrian Thomas

I love old books – and particularly old books in hard copy, and with stamps and signatures of past owners. It's a fancy of mine that when I find an old book with a signature of a previous owner to sign below in a similar style and with a similar pen. My book by Émil H Grubbé was signed, and was from the 'Library of Hugh Caumartin.' Using the Internet it was relatively straightforward to research Hugh Caumartin. [3] The Internet does take some of the fun out of finding things, however the ease in obtaining information more than compensates.

Hugh T. Caumartin was a Michigan radiologist, and he volunteered to serve with the People-to-People Health Foundation [4] (also were also the sponsors the hospital ship 'Hope'). This 'medical mercy mission' had been proposed by President Lyndon B Johnson in 1965. Caumartin had suffered leg injuries from machine-gun fire during the Second World War II and needed fitness clearance. Hugh T. Caumartin, United States Army, is reported to have been awarded the Silver Star under the below-listed General Orders for conspicuous gallantry and intrepidity in action against the enemy while serving with the 101st Airborne Division during World War II. [5] The Orthopaedist Hugh L. Sulfridge Jr. examined Caumartin and having pronounced him fit to go abroad, himself caught the volunteer spirit. Both doctors flew out to Vietnam in April 1966, Caumartin to read X rays and teach radiological techniques in Saigon, while Sulfridge went to the '70-year-old complex of decaying buildings' that made up the hospital at Can Tho, 80 miles southwest of the capital, in the Mekong Delta. It was fascinating to find these details resulting from research into the signature in my book.

And so, to the book itself. It's unusual for me to come across a book that I have not encountered before, and one such is *X-Ray Treatment* by Émil H Grubbé. [6] Émil Herman Grubbé (1875-1960) was a pioneer American radiologist and radiotherapist from Chicago. Émil Grubbé is the originator of the Memorial Award of the Chicago

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[3] Doctors: Volunteers for Viet Nam. TIME Magazine, MAY 20, 1966, 12:00 AM GMT-4. https://time.com/archive/6629421/doctors-volunteers-for-viet-nam/ (accessed 19 February 2025).

[4] The People-to-People Foundation (PPHF) is a non-profit organization that aspires to better the lives of people affected by marginalized people. PPHF is a health organization, working with a mission of transforming lives for improved health and well-being through locally driven solutions. https://pphfglobal.org

[5] Hugh T. Caumartin https://valor.militarytimes.com/recipient/recipient-79962/ (accessed 24 April 2025)

[6] Émil H Grubbé. *X-Ray Treatment* (1949) Saint Paul & Minneapolis: The Bruce Publishing Company.

Radiological Society which has published an interesting biography on their web-site. [7] The British radiologist Sebastian Gilbert Scott (1879-1941) [8] wrote about Grubbé: [9]

> At various periods after the discovery of X-rays, - in fact after even 10 years - there has been periodically considerable controversy as to who published the first radiograph in England, who was the first to reproduce a radiograph of this, that or the other part of the anatomy, who first used X-rays for treatment etc. I recently came across an article in an American journal, dated many years back, where a certain Mr. Grubbe sets forth his reasons and produces documental evidence in the form of old letters which had apparently been hidden away in boxes in an attic. The items in which he claims priority with no uncertain voice are rather interesting:
>
> 1. He was the first human being to develop X-ray dermatitis and incidentally lost a hand from this complaint.
> 2. He was the first person to apply X-rays to pathological lesions, but this was at the suggestion of a certain Dr. Spilman.
> 3. He was the first to use sheet lead as a protective against unwanted X-ray effects. This example is quoted just as a reminder of the period when the claims for priority in many futile directions were rampant.
> 4. Once the apparatus and X-ray tubes became more reliable and easier to manipulate, many hospitals began to use this new help in diagnosis.

Grubbé's book *X-Ray Treatment* is most interesting. It is a fascinating resource for the history of radiology and radiotherapy. There are many illustrations, and discussions on all aspects of the new discipline by a pioneer who was there. There are chapters on X-ray burns and X-ray therapy. Of particular value are his descriptions of his own radiation injuries. Finally, he discusses the future of radiotherapy. The book is of great value to all those interested in the history of radiotherapy, and unfortunately the numbers of books on the history of radiotherapy and oncology are limited. I admit to finding the history of radiotherapy confusing at times, and it's not obvious who did what when and who has priority.

The book seems to be rare and I cannot find another copy. However, I managed to locate and order his biography written by Paul Hodges *The Life and Times of Emil H. Grubbe* [10] and will leave a brief review and thoughts in the next *The Invisible Light*.

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[7] https://chicagoradiology.org/history/narratives/biography-of-emil-grubbe/ (accessed 19 February 2025)

[8] Sebastian Gilbert Scott qualified in medicine in 1904 and following his house appointments started X-ray and electro-therapeutic work at King's College Hospital. He was appointed as Radiologist to the London Hospital in 1909 and held the post until his resignation and appointment as Consulting Radiologist in 1930.

[9] Sebastian Gilbert Scott. *X-Rays and Reminiscences*. Unpublished manuscript, undated.

[10] Hodges, Paul C. *The Life and Times of Emil H. Grubbe.* (1964) Chicago, University of Chicago.

And as it turned out, *The Life and Times of Emil H. Grubbe* arrived quickly and is most interesting. Grubbe is presented as one of the most colourful 'medical men' in the Chicago area for more than forty years. Grubbe has stated that he made a fortune as a young man by refining platinum, he was witness to the Mont Pelée eruption, he synthesized diamonds in his basement, he invented the fluoroscope, and was the first to employ the X-ray to treat disease.

Hodges noted that only this last claim has been verified.

Grubbe became interested in X-rays, developing a severe radiodermatitis of his hand. A colleague suggested that the rays might damage diseased tissues as well as normal tissues, and Grubbe started treating diseases of the skin, including cancers. Hodges said that advancement of his own career took precedence over any research, and that Grubbe made no further significant contribution to the new science of radiology. Grubbe developed disfiguring radiation damage. In later years Grubbe 'became the darling of news reporters', and his flair for publicity made himself into a combination of martyr to the cause of scientific research, and unrecognized expert in clinical radiology.

So, Grubbe desired immortality and therefore wanted an official biography written after his death, hoping to give his many claims the apparent veracity of print. This task fell to Dr. Paul Hodges. Hodges came to the conclusion that the real Grubbe was more interesting than the legend that he wanted. Hodges saw that by the time that he was writing his biography, that the legend was so well established that it would not give way to the factual portrait that was being presented. The legend is what Grubbe wanted, however Hodges preferred the real and factual man: "I see him as a tough, shrewd, intelligent, relatively uneducated second-generation European, clawing his way up in the social and economic struggle that was being repeated thousands of times all about him in the Chicago of his youth; asking and giving no quarter, dreaming great dreams, turning some of them into hard fact and in others substituting for frustration the illusion of fact."

Here are some sections from Hodges' postscript. They make interesting reading:

- Over the ages there have been a few men and women so truly great that their reputations are immune to the bias or ineptitude of individual biographers. If one biography dwells with too much emphasis on the clay-like nature of their feet and another bestows halos or wings where none belong, little harm is done because still other biographies will follow and eventually from the whole, the truth will emerge. It is the solitary biography which is dangerous to reputations, and since the obscure unlike the great can expect at most a single biography they should, if they are wise, elect oblivion rather than risk the ministrations of a solitary and particularly an amateur biographer.
- Emil Grubbe certainly was obscure, and by my criteria he was unwise as well because he insisted that this biography be written.
- I have taken the job seriously and to the best of my ability have portrayed the man as he really was; one of us; one of the world's all too plentiful ordinary people; vain, boastful, incompletely truthful, and only moderately able. This is far from the image he built for himself, an image which an uncritical contemporary press handed back to him (frequently as a result of his own skilful prodding) rearranged, gilded, and sometimes garbled. In this image he was scientist, investigator, martyr; but actually he was none of these except as one uses "martyr" colloquially to mean a "great Or

constant sufferer, as from disease." He was not consciously a charlatan but, like some actors who have devoted a lifetime to dramatic roles, he carried posturing and phraseology from his own personal stage into everyday life. Even stellar billing in "The Grubbe Story" was not enough. He was, in addition, copywriter, press agent, and advertising manager.

- Eventually he convinced himself that the immortality he was seeking lay in enshrining his name among the medical great and, having reached that decision, he allowed nothing to stand in the way. Always a careful man with a dollar, he now became frankly miserly, hoarding income from practice and business ventures and spending as little as possible on himself. Friends were allowed and, in fact, encouraged to provide him gratis materials and services they could afford less well than he, governmental and other agencies were importuned to remit taxes and bestow pensions, and, when patients were unable to pay their bills in cash, he accepted other things of value.
- After some years of inquiry and consideration, he set up an arrangement under which the University of Chicago names part of its radiation therapy program for him and the Chicago Medical Society conducts a lectureship and grants a medal in his name.
- Shall we call him egomaniac? Shall we emphasize the accidental, non-scientific, ill-advised nature of his early use of X-rays for the treatment of disease? Shall we make much of the fact that in no true sense does modern radiation therapy stem from his pioneer I think there is no advantage in doing any of these things; in-stead, we should remember him for attributes which have become rare in modern society. Let us remember him rather for self-sufficiency, self-confidence, tenacity, and for a lust for life so great that it enabled him to contrive it not immortality at least long survival for the name of Emil H. Grubbe.

And so we have the story of a man who fell victim not so much to the research he claimed to promote as to his own vanity and to the charlatanism that mar much of the medicine that he practiced.

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Notices of New Books:

Dr. Oliver Skock.

Dr. Oliver Skock is described on Amazon as being a medical doctor, historian, author, and illustrator from the Netherlands. He studied medicine at the University of Groningen, and English Local History at the University of Oxford. He wrote a Doctoral Thesis (PhD) about the History of Radiology and was trained as a consultant radiologist at the University Hospitals of Antwerp and Groningen. He has worked as a medical doctor in hospitals in the Netherlands, Belgium, Switzerland, Saudi Arabia, Channel Islands, Ireland, as well as Manx, and is currently working across Great Britain. Oliver is the author of the *Doctor Skock's World of Medicine* series, and of several other books. I have been unable to find any information about Dr. Oliver Skock on the internet apart from what is on Amazon. If anyone has and information about him then please let me know.

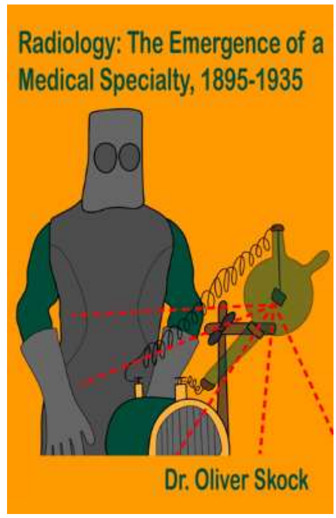
Radiology: The Emergence of a Medical Specialty, 1895-1935 Kindle Edition

by Dr. Oliver Skock (Author) Format: Kindle Edition

ASIN: B0DJ5HN8XQ

Publisher: Golden Tower Publishing (27 Sept. 2024)

The blurb tells us that the discovery of X-rays by Wilhelm Conrad Röntgen in 1895 sparked tremendous interest, and people worldwide, mainly physicists, teachers, pharmacists, electricians, photographers, and physicians, started using X-rays to take radiographs of human body parts, particularly the hands.

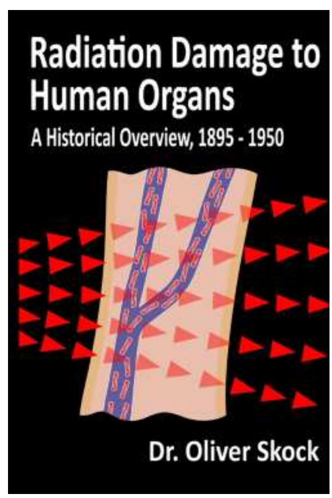


X-rays were also used for therapy. Initially, they were used to treat skin lesions, and over time, techniques were developed to treat more profound abnormalities. Radium was also utilized for these purposes from 1904 onwards.

This book explores the evolution of radiology as a recognized medical specialty. The author shows how the early radiologists who initially lacked sufficient radiology skills and examine how proper training in radiology was eventually established. There is also information on non-medical individuals who carried out radiological work, as well as the general and historical circumstances that influenced the development of the medical specialty of radiology. There are extensive footnotes and bibliography.

The books gives a good and relatively concise summary of the development of radiology. I found the large font size and very wide line spacings somewhat curious and made the book seem less serious than it actually is. The formatting of Dr. Skock's books is fine in the versions for the Kindle, and I would recommend purchasing the Kindle versions.

Radiation Damage to Human Organs. A Historical Overview, 1895-1950. Kindle Edition



by Dr. Oliver Skock (Author) Format: Kindle Edition

ASIN: B0CDCPGDBH

Publisher: Golden Tower Publishing (31 July 2023)

The blurb tells us that the initial enthusiasm in the early years of the medical application of X-rays and radium was soon tempered by reports indicating that there were serious risks involved in the medical use of the new radiation. The X-ray pioneers almost immediately were confronted with radiation damage to the human skin, whether they applied the X-rays for diagnostic or therapeutic reasons. The American medical student Émile

Grubbé (1875-1960), who had started experimenting with X-ray tubes immediately after hearing of Roentgen's discovery, had caused a severe roentgen dermatitis of his own hand as early as January 1896.

In the following years, numerous reports describing severe skin damage in patients following the use of x-rays or radium would spark worldwide research into the effects of radiation on the human body. From 1903 onwards, reports in the scientific literature emerged warning of radiation damage to the internal organs, but the genetic effects of radiation were not demonstrated until 1927.

In this book, a historical overview will be given of the identification of the harmful effects of X-rays and radium on the organs of the human body. At first, the identification of radiation damage to the skin will be discussed, followed by an overview of the research on damage to the individual internal human organs. Finally, the discovery of the stochastic genetic effects of radiation, and its consequences for medicine, are described.

Again, the Kindle version is recommended.

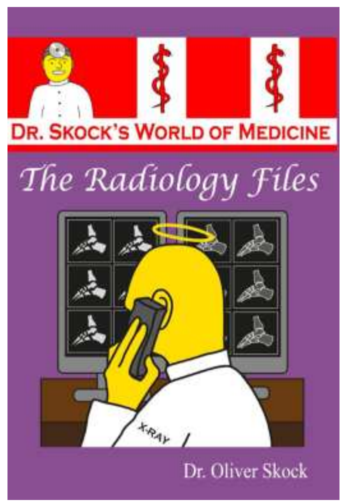
The Radiology Files (Dr. Skock's World of Medicine) Kindle Edition

by Dr. Oliver Skock (Author) Format: Kindle Edition

Part of: Dr. Skock's World of Medicine (10 books)

ASIN: B0CLL15RQ7

Publisher: Golden Tower Publishing (5 Nov. 2023)



In this book, an overview will be given of the origins of the medical specialties of Radiology, Radiotherapy, and Nuclear Medicine. You can find out why doctors have chosen for these specialities, and what their work entails.

There are descriptions of each of these three specialties, and every specialism is graced by mild banter and funny colourful illustrations.

In addition, the book presents several examples of Radiological Cross-Sectional Art.

Again, the Kindle version is recommended.

Medical Fine Art. A selection of Digital Works of Medical Fine Art: Art du Bain Kindle Edition

by Dr. Oliver Skock (Author) Format: Kindle Edition

ASIN: B0CBHWM9M6

Publisher: Golden Tower Publishing (8 July 2023)

Multiple digital medical art images and pictures are presented; shown are straightforward, colourful designs with subjects related to medicine. Several styles and categories are included: Classic Designs, Anatomical Art, and Medical Mondranism, the latter inspired by the works of Piet Mondrian (1872-1944), one of the pioneers of 20th century Abstract Art.

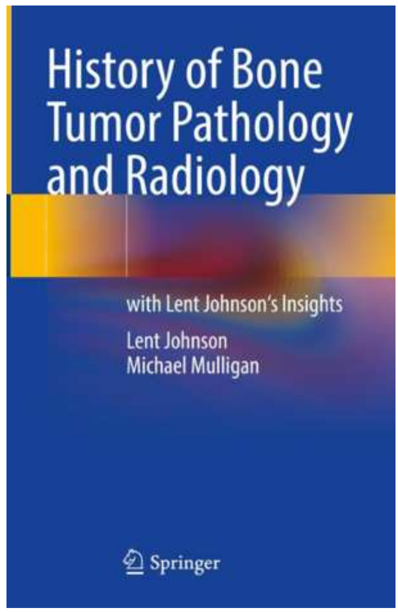
Again, the Kindle version is recommended.

History of Bone Tumor Pathology and Radiology: with Lent Johnson's Insights.

Hardcover – 4 Sept. 2024

by Lent Johnson (Author), Michael Mulligan (Author)

Publisher: Springer; 2024.



We are told that Lent Johnson was a member of the staff of the Armed Forces Institute of Pathology (AFIP) in Washington, DC from 1946. He served as the Chairman and Chief of Bone and Joint Pathology from 1946 to 1980. He remained an active member of the staff until his death in 1998. He was a founder member of the International Skeletal Society.

Michael Mulligan was a Professor of Radiology at the University of Maryland School of Medicine. He was a member of and remains a member of many medical societies including, the Society of Academic Bone Radiologists, the International Skeletal Society and the American Roentgen Ray Society.

This book builds on the work of Lent Johnson, who was a significant figure in the history of bone tumour pathology and bone tumour radiology in the United States of America. Johnson worked on this book following his career at the Armed Forces Institute of Pathology. Michael Mulligan worked with him there during his Army service as a Radiologist at the Walter Reed Army Medical Center. Johnson asked Mulligan to review his initial draft chapters, and following Johnson's death Mulligan was able to complete the book in tribute.

The book gives a good account of the early history of the development of the specialties of both bone pathology and skeletal radiology. There is an emphasis on the research and teaching programs established at the AFIP. There is additional information on subsequent developments of more recent times. The book is well worth reading, and I particularly liked the discussion of the work of Ernest Amory Codman (of triangle fame) on the classification of bone tumours and the development of the bone tumour registry.

The book is expensive with the hard copy costing £108.17 and the Kindle version only marginally cheaper at £103.71. This is a shame since the book is well worth reading, and the price will make it inaccessible to many.

Review of Pioneers in Radiology Worldwide at the time of Wilhelm Conrad Röntgen.

ISBN 978-2-916669-31-1

This publication is the collaboration between the International Society for the History of Radiology (ISHRAD) and the French Society of Radiology (SFR).

Reviewed by Elizabeth Beckmann.

This book provides a wonderful overview of the key pioneers and experimenters in the first 10 years after Röntgen's discovery of X-rays in 1895.

It provides a great opportunity to learn about Wilhelm Röntgen - the man behind the discovery of X-rays, and just how many people all around the world started working with X-rays very shortly after his discovery.

While there are some countries which have not been covered, this book has pulled together the key people in many of the areas around the world - Across Europe, North America, Latin America and the Caribbean, Asia and Oceania; from the early work by Frederick Clendinnen and William Hancock in Australia, Genzo Shimadzu in Japan, to people such as Ivan Puluj in Ukraine who had seen the effect of X-rays 10 years before Rontgen, but did not publish his findings until 6 weeks after Röntgen.

It made me appreciate just how far spread and fast people were experimenting. Within 6 months of Röntgen's discovery so many uses of X-rays in medicine had already been shown; from the first angiogram by Eduard Haschek in Vienna, the first military radiogram in Belgium, stereoscopic radiography by Elihu Thomson in the USA, Mackenzie Davidson in the UK taking radiographs of the skull and pelvis, Thomas Edison presenting on the fluoroscope, and Otto Walkhoff taking a dental X-ray.

The different approaches taken and how different cultures effected and encouraged progress in different countries is evident from the entries in this book.

It also highlights the diversity of people who became involved with X-rays in the early years from physicists, medical professionals, physicians, neurologists, academics, surgeons, scientists, botanists, photographers to many other professionals.

This book covers so much and it highlights the unique position which Röntgen's discovery of X-rays created - enabling 100s of people to start experimenting and using X-rays for themselves within just a few months of Röntgen's announcement. While reminding the reader how many of these early pioneers suffered from the effects of radiation due to their experimentation. I learnt about people I was unaware and it triggered me to look for more information on several of the people via the range of references and other sources included within the book. Whether you read through the book cover to cover, or dip into particular people or countries, this is a great reference book.

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The John Clifton essay prize 2024.

The John Clifton essay prize for 2024 had seven excellent submissions, and judging was difficult.

The first prize went to Kimberley Bradshaw for her excellent essay 'Albert Salomon: The Man Behind the Mammogram'. This essay was reproduced in issue 55 of *The Invisible Light*.

The runner up prize went to Samuel Ward for his essay 'The Making of an Early Interventional Radiologist', and this essay is reproduced below.

The Making of an Early Interventional Radiologist

By Samuel Ward
Foundation Year 2 Doctor
University of Leicester Hospitals Trust

Wilhelm Röntgen discovered X-rays in 1895 (Thomas, 2022, p. 154), and as I will describe, it did not take a long time for physicians to use this new form of investigation as a direct modality by which to treat disease. In other words, it was not a particularly long time after the birth of radiology that interventional radiology was born also. While mutterings around artificial intelligence and the long-term prospects of diagnostic radiology are ever-present, it is widely agreed that the future trajectory of interventional radiology is, quite simply, 'up'. With the present and future importance of interventional radiology in mind, in this piece I would like to review and reflect on the early life and formative moments in the career of one of the earlier and most influential interventional radiologists in history, Josef Rösch. I will draw in particular from his autobiography.

Rösch was born in 1925 in Pilsen, in western Czechoslovakia as the second of three children. His childhood and early twenties were spent there, and he would graduate from the medical school of Charles University in Pilsen in 1950 before beginning a winding journey through interventional radiology and angiography (Rösch, 2016, p. 3). Before we review Rösch's early career, it is worth getting a general flavour for some key, early moments in interventional radiology.

In 1907, British surgeon John Fawcett had a young man under his care with a pneumothorax (that is, roughly speaking, air between the outside of the lungs and the inside of the ribcage) which was not healing with non-invasive management. The patient was laid down, and with help from an intensifying screen, an X-ray was generated. The patient's lung was visibly compressed by the trapped air. Fawcett guided a trocar (a sharp, pointed instrument used to penetrate tissue), and placed a small tube in the space where the air was trapped. He then generated negative pressure through the tube, removing the air which was causing the compression. The patient's lung, on the intensifying screen, was seen to expand. After sealing the wound from the trocar, a radiograph confirmed the resolution of the pneumothorax. This was a significant moment in the treatment of pneumothoraces where, until that point, cannulation was more commonly reserved for tension pneumothoraces, where there is an immediate threat to a patient's life, and would not in any case have been performed in this novel, radiologically-enhanced way (Thomas, 2022, pp. 151 - 152).

In another notable moment in 1929, legendary German physician Werner Forssman performed the first known heart catheterisation. Using a urinary catheter, he catheterised the antecubital vein in the arm and, with the guidance of a fluoroscope (an X-ray machine allowing the visualisation of motion), directed the catheter to the heart's right atrium. I should probably mention, at this point, that the patient he chose to conduct this seminal procedure on was himself. Although this was not met with enthusiasm by his bosses (to be more precise, he was sacked), he was ultimately awarded the Nobel Prize in Physiology or Medicine in 1956 for his contributions to the development of the procedure, which is still used in modern medicine (with more safety measures, I emphasise) to assess heart function (Thomas and Banerjee, 2013, pp. 150 - 152).

Rösch.

For Josef Rösch, medicine was not a family affair; his parents owned and ran a plant nursery. Rösch nonetheless saw this as a contributor to his later success in work; he would work there, under the watch of his parents, in his early youth. This, he believed, gave him a healthy attitude to hard work. Further, his mother would instil in him the importance of working and living for the benefit of others, and not merely pursuing his own wants and interests. With discipline and persistence, she taught him, his future could be what he wanted it to be. She taught him the millennia-old 'Golden Rule' of ethics: Treat others as you would want to be treated (Cofnas, 2022). Rösch felt that these basic and fundamental principles equipped him for his later career, as well as for the tumultuous political and social environment in which he spent the earlier years of his life (Czechoslovakia was invaded by Germany in 1939, for example) (Rösch, 2016, p. 3).

Rösch would not have said in his medical school interview that he had 'always wanted to be a doctor'. He was something of an all-rounder at school, enjoying and excelling in sports, as well as the sciences and arts. Sports further evidenced to him the value and potential reward of focus and discipline. Athletics were Rösch's sport of choice, and it was in this domain that he had a peculiar nudge towards a career in medicine (Rösch, 2016, p. 3).

This nudge came when Rösch's track friend had had his forearm pierced by a javelin (one wonders quite how this happened; Rösch makes no effort to elaborate on the precise mechanism of this trauma. As Werner Forssman has already demonstrated to us, health and safety was of lesser concern and refinement in the earlier 20th century). Rösch delivered basic first aid, and took his friend to a doctor. The doctor was complimentary about Rösch's aid and Rösch took great satisfaction in this. Indeed, it inspired him to pursue medicine. His mother, the opinion of whom he undoubtedly would have valued, was approving (Rösch, 2016, pp. 3 - 4).

Given the background in which he grew up, Rösch was not able to progress through his formative years without outside interruption. In 1943, he was conscripted to Technische Nothilfe, that is, 'Technical Emergency Help'. Technische Nothilfe was part of the German military effort, and, at the time of Rösch's recruitment, existed to provide non-combative support to areas under the German Reich which had been struck by disaster. Rösch was placed in a Pilsen barracks, and would, where possible, work to restore areas struck by air raids - a frequent occurrence in Pilsen at that time. His time in Technische Nothilfe was short-lived, and he was discharged following a diphtheria infection, which secondarily caused him a brachial plexus neuritis, that is, inflammation in the nerves of his upper limb (Rösch, 2016, p. 4).

Rösch's first hospital experience of medicine came at the end of the war in 1945, where Czechoslovakia was liberated from German rule. Its hospital system, as a result of the war, was deeply burdened. Rösch began work in a laboratory, processing urine and blood samples. He would later help the department of medicine's chair, Professor Karel Bobek, with X-ray studies in the same laboratory. Professor Bobek was another influence on Rösch, and oriented him to a career in research and innovation. His time in the laboratory was formative for him both professionally and personally, for it was here that he met his future wife, Bohunka (Rösch, 2016, pp. 7-8).

Towards the end of 1945, Rösch began to study medicine formally, and would continue his lab work alongside this. Professor Bobek continued to influence him, and arranged for him, following his graduation, to spend his first few months as a doctor covering a medical ward at the military hospital in Pilsen (doctors were required to offer 2 years of service to the military post-graduation). Rösch's vision for his career was to follow in professor Bobek's footsteps, that is, to be a physician with a heavy emphasis on the use of X-ray for examination (during this time, medical specialities were less numerous, and less clearly demarcated. These days, however, clinicians interpreting and acting on images without any specialist radiologist input is quite rare - I wonder if Professor Bobek might roll his eyes at this!) Rösch had taken a course in radiology in the latter part of his medical training under the chief of radiology, Frantisek Dulik, at Pilsen Military Hospital. Dr. Dulik appreciated Rösch's enthusiasm for radiology, and arranged a post at the radiology department in Central Military Hospital in Prague, where Dulik himself would end up in the role of chief of radiology (Rösch, 2016, pp. 7-9).

Rösch fully prioritised his work and education in radiology, leaving his wife and newborn daughter, Eva, with his parents in Pilsen. He worked at first with fluoroscopy, but soon moved into a broader diagnostic role. Although he had hoped for a brief stay in Prague, so that he might return to Pilsen as a well-formed physician, this was not possible, in the end, when the government extended obligatory medical service to five years for physicians due to a staffing shortage. Instead, Rösch moved his family to Prague, and settled in for further work. Around this time he had his son and last child, John (Rösch, 2016, p. 9).

With time in Prague, Rösch shifted to an entirely research-based role, with a special emphasis on angiography of abdominal organs. He was particularly influenced, during a course, by the work of Drs. Leo Steinhart and Vladimir Brzek, who were working on transparietal splenoportography for diagnosis of an enlarged spleen. This procedure involves a direct, through-the-skin ('percutaneous') puncture of the spleen with a contrast fluid to visualise it and its tributary blood vessels. With his colleague, Jiri Bret, Rösch imported this procedure to Prague, where he further refined it, using fluoroscopy to more precisely target the spleen ahead of the puncture. He would ultimately use it more broadly as a means of diagnosis of hepatopancreatobiliary disease. Indeed, his first academic paper was published in 1957 on 'The Improvement of Diagnosis of Epigastric Tumors by Splenoportography'. He would go on, a year later, to publish a book on splenoportography with Dr. Bret. In 1958, his specialism in the procedure was further recognised, when he was commissioned to make a film on splenoportography. He presented this at the International Congress of Radiology in Munich; his first opportunity to travel beyond Czechoslovakia (Rösch, 2016, pp. 11-13).

Rösch's research work, particularly in the radiology of abdominal organs, in Prague continued. He and his colleagues, at this point, had their own room for angiography. These were still formative years for interventional radiology, and they had little research to go on. Unsurprisingly, bespoke equipment was scarce. They would have to, for example, expose catheters to steam in order to reshape them to be properly-sized for whatever blood vessel was to be examined (Rösch, 2016, p. 13). Equipment in general was scarce, indeed, and at times they would have to re-use old catheters, soaking them overnight in a sterilising solution. I won't make any further comments about health and safety!

As he continued to hone his craft, Rösch's work became more sought out, and he would publish in journals in Europe and the USA, as well as present all over his own continent. In 1962, he was invited to write another book. This time, he was asked to write more broadly on the radiology of the spleen and pancreas. Rösch accepted in self-confessed naivety, not realising that it would take three years of research to put together the book. He further put together another teaching film based on this work, 'Roentgenology of the Pancreas', which, at the International Congress of Radiology in Rome, earned him the first place scientific prize. His work was recognised by the same university at which he studied, Charles University of Prague, where he was awarded a doctorate, and named a Docent (i.e. one rank below a professor) of Radiology (Rösch, 2016, pp. 13-14).

Rösch and Dotter.

Charles Dotter has been dubbed the father of interventional radiology. Following a Bachelor of Arts degree, he trained in medicine at Cornell in New York, and after a period of service with the US Marines, spent the vast majority of his career at the University of Oregon Medical School, where he would become a professor, and ultimately the chairman of radiology. A defining moment of his career, and interventional radiology in general, occurred in January of 1964. Alongside a trainee, Melvin Judkins, Dotter was able to percutaneously dilate an elderly woman's stenosed superficial femoral artery, and thereby restore circulation to the branches of the vessel beyond the narrowing. In other words, Dotter performed the first ever angioplasty on a patient. The angioplasty was a success, and the woman died of unrelated causes three years later. Until this point, vascular catheterisation had been for diagnostic purposes alone, and further, there was quite a gap between clinicians' ability to diagnose vascular disease and to effectively treat it (Payne, 2001).

Rösch and Dotter became pen pals (his words, I emphasise), after Dotter took an interest in Rösch's book on transparietal splenoportography. The two met in person in 1963, at a congress on angiography (one of the first of its kind) organised by The

Czechoslovak Radiologic Society. It took place at the Grand Hotel Pupp, a quite beautiful 17th century hotel in western Czechoslovakia. Dotter was offered a 30 minute slot in which to speak, but refused, saying that the duration didn't justify the significant travel required to get from the United States to Czechoslovakia. His point was taken, and he was given an hour to talk on 'Cardiac Catheterisation and Angiographic Techniques of the Future'. Rösch was enthralled, claiming it to be the most exciting talk he'd heard (this is a particularly striking claim, given that around 100 lectures on angiography took place during the congress. Rösch would not have been short of opportunities to be excited) (Rösch, 2016, pp. 17-18).

Dotter covered various current and potential aspects of cardiac angiography. There was a key moment in the talk which, to Rösch at least, was the founding moment of interventional radiology. Dotter described a technique for an angiographic catheter endarterectomy (a means of clearing plaque from the inside of an artery) technique, emphasising that this would constitute not just a means of diagnosis via radiology, but an actual contemporaneous treatment of the identified disease. Dotter received a standing ovation at the conclusion of the talk. The conference organisers, I suspect, would have felt that he had earned his additional 30 minutes! Only a few months after this event, Dotter would go on to perform this procedure, with the percutaneous dilation described above. It is Rösch's view that Dotter's talk, and this later procedure, changed the course of radiology, and medicine more broadly, for good (Rösch, 2016, p. 18).

Dotter would later visit Rösch in Prague. They sauntered around the city, Rösch showing the sights, and they of course visited his angiography suite in the hospital also. He proudly shared with Dotter his teaching films and interesting cases. It is clear, from the way he writes, that Rösch had a great fondness for Dotter, and perhaps saw him as something of, as it were, a radiological father figure. Dotter evidently shared a kind of fondness, as well as a respect for Rösch's work, and would go on to invite him to the US for a fellowship at Dotter's institution in Oregon (Rösch, 2016, p. 20).

After two years of snail-paced bureaucracy, Rösch was finally permitted to go to Oregon for his fellowship in 1967. At first it was just he and Eva, his daughter, but his wife and son would soon follow. During their first weekend, Rösch was able to witness, in some awe, Dotter performing his angiographic interventions on patients. He would then experience a different kind of awe, when Dotter took him and Eva for a drive in his Porsche. Dotter as a chauffeur was not, it turned out, particularly interested in delivering a comfortable ride (Rösch, 2016, p. 21).

Rösch's responsibilities were different in Dotter's department. He would teach and supervise the doctors in training on performing angiographic and catheterisation techniques. He would additionally assist in Dotter's research work. This work was chiefly performed on canines, and included reviewing the long-term viability of grafts, and how different types of contrast might affect the spleen. Rösch was also involved in making further movies (Dotter was familiar, as mentioned, with Rösch's filming experience), and organising Dotter's files on angioplasty in preparation for publication, with the hope that methodology would be more widely adopted (Rösch, 2016, pp. 21-22).

Rösch made two new movies under Dotter's watchful eye. Hypotonic Duodenography described a technique of the same name that allowed for visualisation of the duodenal anatomy without distortion from normal bowel peristalsis. Dotter inimitably narrated the movie, which included clips of waves (a nod to peristalsis) lapping on a beach; he wanted a more 'Hollywood' approach to teaching. The second film, Transluminal Angioplasty, was not without its quirks either. The film features Dotter and a patient of his on Oregon's tallest peak, Mount Hood (Bakken-French et. al, 2024), and the place where his ashes would eventually be spread. Another clip shows an aeroplane trip, featuring one of the film's creators as the pilot (Rösch, 2016, p. 23).

It wasn't all theatre, though, and Dotter described in Transluminal Angioplasty the benefits to transluminal angioplasty over surgery; particularly that it was less invasive. Vascular surgeons, Rösch recalls, were not fond of the idea. I suppose a turkey is unlikely to vote for Christmas. Indeed, Dotter's aspiration was initially in vain, and angioplasty was not more widely adopted. The procedure, for some time, was solely performed in Oregon. Eventually, though, Eberhardt Zeitler, a German physician, would take on the procedure also. The phenomenon, cutely known as 'Dottering', spread across Europe. Of note, the Europeans added their own flavour to the procedure, with the addition of a balloon catheterisation technique (Rösch, 2016, p. 22-23).

Rösch and Dotter continued to enjoy a friendship outside of work. They would hike and climb in Oregon together, Eva alongside them. They would venture to other nearby states, and would routinely drive to Colorado for a weekend exploring together. There they would camp, and ascend some of the various peaks of the Colorado mountains. Rösch recalls climbing 17 different summits with Dotter, who himself climbed, says Rösch, all 68 summits in the US. I wonder if either man were aware of what impressive prevention against cardiovascular disease this made (Rösch, 2016, p. 23-24).

It is evident from his reminiscences that Rösch fell in love with Oregon, and with frequent trips to other states, the US in general. He would often combine work with pleasure, and would lecture and travel simultaneously. Following a lecture at UCLA, the chairman of radiology, Bill Hanafee, offered a visiting professorship to Rösch, to begin when his fellowship with Dotter was complete. With loosening bureaucracy in Prague, Rösch was granted a lengthier stay in the US. After a year of fellowship and friendship with Dotter, Rösch felt an interventionist in his own right, and went to Los Angeles in 1968 to continue his adventures in the US and in radiology (Rösch, 2016, pp. 24-25).

UCLA and beyond.

Rösch's time in Los Angeles began on the coast, with a flat in Santa Monica. At this stage, all of his immediate family were with him, and Rösch and Bohunka wanted to give their children a holiday-like experience before they were to return to Prague for schooling (Rösch, 2016, p. 23). The climate changed, though, in Prague, and the 'Prague Spring' (a time of liberalisation for the country) ended (Williams, 1997). A return to Prague for any of the family was now a less favourable prospect. It was difficult for Rösch and family (both personally and logistically), but ultimately they decided to stay in the US permanently as a result of this change in the social landscape (Rösch, 2016, p. 23).

Rösch continued to prioritise and thrive at his work in UCLA, and this was potentiated by the up-to-date facilities and enthusiastic staff at the institution. True to his sense that he was able to stand on his own feet as a radiologist, alongside continuing to learn and research, he was able to significantly improve practice at UCLA. This was to the pleasure of the senior staff there, including the surgical chairman and surgical dean; no small feat. A key credibility-boosting moment for Rösch was his angiography of a young man with a GI bleed, through which he was able to demonstrate the location of the patient's bleeding point (Rösch, 2016, pp. 27-28).

It was at UCLA that Rösch had what is likely his most significant singular achievement in radiology, i.e. his founding of the transjugular intrahepatic portacaval shunt or 'TIPS' procedure. Whilst performing a diagnostic procedure to assess the biliary tree via the jugular vein in the neck, Rösch would occasionally accidently enter the portal veins within the liver. From this, he naturally considered the potential diagnostic value of deliberate venography of the portal circulation. Further, his mentor Dotter had once advised him to always consider how there might be interventional potential in an otherwise diagnostic procedure. Thus, the TIPS was conceived (Rösch, 2016, p. 28).

The goal of the TIPS procedure was to create a channel for blood flow between the inferior vena cava (accessed via percutaneous entry to the jugular vein), and the portal vein (accessed via gradual dilation of the tissue of the liver). If this was practicable, so the idea went, it would allow increased flow out of the portal vein, and thereby reduce the pressure in some of the branches of the portal vein (such as the umbilical and coronary veins) (Rösch, 2016, p. 28). This excess pressure, unmanaged, causes increased stress to blood vessel walls as well as disordered blood flow, both of which increase the possibility of potentially fatal bleeding in patients with portal hypertension (that is, high pressure in the portal venous system) (Burroughs, 1993.).

Of course, Rösch's initial attempts at honing this procedure began on animals. At first, he was able to keep a shunt patent for two weeks. The primary issue that so limited the lifespan of the shunt was the formation of a clot in the tubing, which would ultimately fully occlude the passage between the two veins. Further work went into experimenting with different parameters, but ultimately, says Rösch, the TIPS was not feasible with the technology that was available at the time. Any tubing that was large enough to remain patent could not at that time be inserted percutaneously. As time and technology advanced, though, multiple attempts were made to pick up and run with Rösch's TIPS concept. A key additional issue in performing a successful shunt was adequate dilation of the liver tissue. Attempts were made to freeze, or balloon-dilate, the liver in order to create space for the shunt, but long-term results were poor (Rösch, 2016, pp. 28-29).

A breakthrough came in the mid-1980s, over a decade after Rösch conceived of the TIPS. Expandable, metal stents were developed. This offered a solution to the issue that Rösch faced: tubing that was small enough for percutaneous insertion could yet be large enough to maintain the patency of the shunt following inflation. Julio Palmaz, an Argentinian physician working in the US, conducted a study on canines with this new shunt. At the end of the 48-week study, the shunts were still functional. On examination following autopsy, the shunts were found to have 'endothelised', which is to say they had gained a natural inner lining akin to the lining of an organic blood vessel. This study was a green light for the TIPS to be put into clinical practice (Rösch, 2016, p. 29). To this day, the TIPS procedure is a widely used procedure for managing portal hypertension complications (Vizzutti et al., 2020).

Rösch was to make a second major contribution to interventional radiology during his time at UCLA. He and a team of angiographers worked also on vasoconstrictive management of GI bleeding. Again, their research began on canines, where they noted that the infusion of vasoconstrictive (i.e. narrowing) drugs to an artery could visibly reduce its blood flow. Of course, if blood flow to a haemorrhaging vessel is reduced, so too will blood loss from it reduce. Rösch and his colleagues used this technique to manage gastrointestinal bleed in a group of patients, and sent their results to a gastroenterology journal. As appears to be a running theme in these earlier moments in interventional radiology, the editing physicians at the journal were not particularly impressed by the innovation. Nonetheless, Rösch continued to perform the technique, and with adoption from other colleagues, vasoconstriction by infusion became widely used (Rösch, 2016, pp. 30-32).

At this stage, unsurprisingly, Rösch had become a known and respected figure in radiology. After his professorship at UCLA came to an end, he was offered a permanent position there, as well as at other US institutions. On the other hand, his old friend Charles Dotter wanted him to return to Oregon. UCLA promised him whatever he needed (I suspect his market value at this time meant it was more like he was interviewing them), and he accepted. Dotter would not give up so easily, though, and wrote a letter to Rösch urging his return to Oregon, appealing to a recent loss of faculty members, as well as a personal struggle with lymphoma. Dotter further emphasised their friendship, as well as the leg-up he had given Rösch in his career, and Rösch felt he could not refuse. So in 1970 it was to Oregon he returned, now as Professor of Radiology (Rösch, 2016, pp. 32-33).

Rösch and his family moved into a beautiful house on a large, idyllic plot in Portland, Oregon (at the time of writing his autobiography at 90 years old, Rösch still lived there). At that point in his life, things were no doubt rosy for Rösch. He was a respected and accomplished radiologist, and had returned to a part of the world of which he was so fond, and where he had built up a social network. Without wanting to stray too deep into the weeds of philosophy, I expect that most of us would agree that there is a peculiar tendency for God, the universe, chance, or whatever other force we may believe to be at work in our lives to humble us when we appear to have everything just where it ought to be. Certainly this was Rösch's experience when his life was thrown into chaos three years after moving to Portland. Following a beach trip with her friend, his daughter Eva was killed in a car accident (Rösch, 2016, p. 33). Anyone who has experienced a shock bereavement such as this will know how material wealth and worldly achievements do not offer much respite in the face of such a tragic and world-shattering event.

Rösch reflects that he, his wife, and his son did not deal with the passing of Eva in a healthy way. Naturally, one would hope a family would come together after a shocking loss such as this, but Rösch and his remaining family grew apart. Bohunka channelled her emotions into maintaining the garden, and John threw himself into his studies, later qualifying as a radiology technician. Rösch himself, unsurprisingly, looked to his work for a reprieve from the grief, doubling his publishing output. He also adopted Eva's dog, and they would run together. I imagine he found solace in this, given his fondness for track sports as a teen.

Rösch was eventually, in his words, 'reborn' with a re-prioritisation of his working life. He returned to scientific meetings which he previously abandoned as a distraction from work. He started lecturing again, rekindling his interest in teaching, and his career felt as if it were moving again (Rösch, 2016, p. 34). It would, of course, be beyond the scope of this piece to attempt to detail all of its highlights. As mentioned, my hope was to outline the formative moments in the early life and early career of this particularly successful interventional radiologist.

Concluding Remarks.

It will be a surprise to nobody that Rösch continued to create and innovate with his work in angiography and interventional radiology, and no doubt did much good, and helped many people, throughout this. He won droves of awards through the years, and would ultimately author and coauthor 494 articles, book chapters, and books (Rösch, 2016, p. 94). Of particular note, he was the founding Director of the Dotter Institute for Interventional Therapy as part of Oregon Health and Science University (OHSU), which was formed after the passing of Charles Dotter, for the sake of excellence in the advancement of interventional radiology. He would consider this his greatest lifetime achievement (Rösch, 2016, p. 97). Even after retiring from his clinical work, and his role as the director of the institute, Rösch remained as a director of research at the centre into his 70s. The institute continues to exist today, performing both clinical work and research (Ohsu.edu, 2024). A 'Josef Rösch Chair of Interventional Radiology Research' was ultimately formed at OHSU, to honour him (Legacy, 2016).

Rösch died at the age of 90, in the same year that his autobiography was published (Legacy, 2016). In his final words of the book, he notes that his mother would be proud of the rich life that he had lived (Rösch, 2016, p. 101). I expect she would particularly be pleased that he followed her advice to work for the good of others. Rösch was a motivated and focused individual, and it is apt, I think, to conclude with some quite pithy wisdom from him on what it may take to be excellent in one's field: 'If you want to learn a lot about the subject, write a peer review paper about it. If you want to learn almost everything, write a book' (Rösch, 2016, p. 35).

References.

Bakken-French, N., Boyer, S.J., Southworth, B.C., Thayne, M., Rood, D.H. and Carlson, A.E., 2024. Unprecedented 21st century glacier loss on Mt. Hood, Oregon, USA. The Cryosphere, 18(9), pp.4517-4530.

Burroughs, A.K., 1993. The natural history of varices. Journal of Hepatology, 17, pp. S10-S13.

Cofnas, N., 2022. The Golden Rule: A Naturalistic Perspective. Utilitas, 34(3), pp.262-274.

Ohsu.edu. (2024). Dotter Department of Interventional Radiology | OHSU. [online] Available at: https://www.ohsu.edu/dotter-interventional-institute [Accessed 23 Oct. 2024].

Legacy (2016). Josef Rösch Obituary (1925 - 2016) - Portland, OR - The Oregonian. [online] Legacy.com. Available at:

https://obits.oregonlive.com/us/obituaries/oregon/name/josef-Rösch-obituary?id=21418044 [Accessed 23 Oct. 2024].

Payne, M.M., 2001. Charles Theodore Dotter: the father of intervention. Texas Heart Institute Journal, 28(1), p.28.

Rösch, J., 2016. An Interventional Radiology Odyssey: The Story of My Life and Work. Springer.

Thomas, A., 2022. Invisible Light: The Remarkable Story of Radiology. CRC Press.

Thomas, A.M. and Banerjee, A.K., 2013. The history of radiology. OUP Oxford.

Williams, K., 1997. The Prague Spring and its aftermath: Czechoslovak politics, 1968-1970. Cambridge University Press.

Vizzutti, F., Schepis, F., Arena, U., Fanelli, F., Gitto, S., Aspite, S., Turco, L., Dragoni, G., Laffi, G. and Marra, F., 2020. Transjugular intrahepatic portosystemic shunt (TIPS): current indications and strategies to improve the outcomes. Internal and emergency medicine, 15, pp.37-48.

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A History of Brachytherapy from the early years to the present day (125 years).

By Edwin Aird.

Introduction.

This article will describe the beginnings of brachytherapy in 1900s, through its rationalisation in the 1930s (particularly at the Christie Hospital in Manchester), onto the use of man-made radionuclides, remote afterloading, and computer planning to the end of the century; (including a short account of developments to the present day-125years). I have included (as an Addendum) my own direct experience as part of my experiences as a medical physicist from 1967 (50 + years).

Brachytherapy (from Greek "close to") distinguishes this subject from external beam radiotherapy, which developed over the same period from treatments with low energy x-rays (which were not very penetrating) to very high energy x-rays 10-20MV. The development of IMRT and VMAT, together with 3D treatment planning has had a profound effect on the general level of brachytherapy that could be usefully used for cancer treatment (see conclusion: GEC-ESTRO survey of 26 countries).

The main centres where brachytherapy developed were France; UK; Sweden and USA. I will concentrate on France and the UK, with some mention of the other two centres (Radiumhemmet in Sweden and Memorial Hospital in New York).

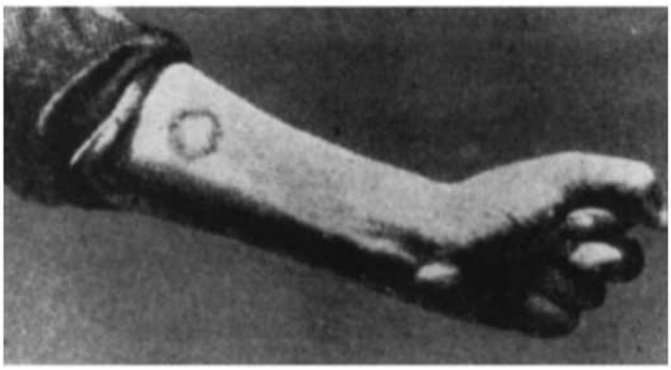
Early History

It is interesting to note that Alexander Graham Bell suggested the use of the term "Curietherapy" before the term Brachytherapy (see Pasteau below) was first used in medicine.

(Bell had stated: "there is no reason why a tiny fragment of radium sealed up in a fine glass tube should not be inserted into the very heart of the cancer").

Pierre Curie had demonstrated that radium on his skin produced caustic damage.

The deterministic effects of radiation



Pierre Curie: Courtesy Museum Marii Sklodowskief Curie , Warsaw
(following Friedrich Geisel)

He interpreted this as the possibility for producing damage in tumours. Indeed, many early attempts using radium to cure skin problems resulted in severe erythema, and worse; since the therapists hadn't yet realised the need to screen out the beta rays which gave high doses of radiation to the skin. Indeed, much of the early uses of radium were empirical until some level of quantification was developed (see Cade and then Paterson/Parker below).

By 1900s it was widely accepted that exposure to radium radiation had unique biological properties. Wickham (L F Wickham (1861-1913), known as "The father of radium therapy") recognised that, and stated that when reporting results there was a need to specify radium quantity and irradiation time. So, Milligram-Hours (mgh used in this text) became a routine "dose" describer; but it wasn't until *Manchester Dosimetry* (see below) was developed that the Roentgen was used.

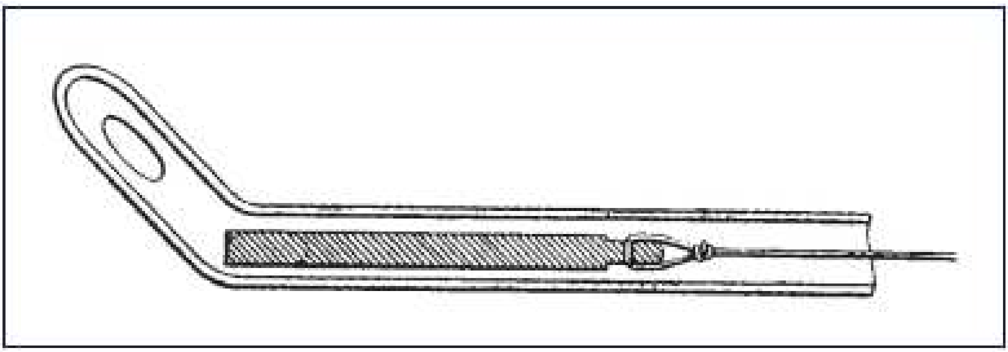
France

In 1906 Danne, Dominici, Degrais and Wickham established the first "Radium Biological Laboratory" in Paris. [Note: L-F Wickham and P-M Degrais (both radiation martyrs) co-authored the first textbook exclusively on radium therapy: "*Radiumtherapy*" by Louis Wickham and Paul Degrais London: Cassell, 1910.]

Also, in 1909 the French doctors Desnos and Minet used radium encased in silver to treat prostatic hypertrophy and prostate, bladder, and rectal cancers. These were inserted using a trocar (Dominici used goose quills!)

For the prostate Minet developed a technique to enter through the urethra with a "probe" containing a cylinder of 10-20 mg radium for 20-120 min. And Ocatave Pasteau and Paul-Marie Degrais in 1909 used a silver capsule containing 10-50mg radium at tip of a17 French catheter (diagram) into the urinary catheter: 5 fractions 2-3 hours over 2 weeks, followed by an annual maintenance dose.

Pasteau and Degrais' radium-bearing urethral catheter.



The catheter was slowly advanced until urine began to drip out. At this point it was slowly withdrawn until the dripping stopped, and the radium was in the prostate.

Radium Plaques/Applicators.

The earliest applicators were crude devices: a small rubber bag or small celluloid or aluminium cases containing radium salt. Metal sheets on which radium salt was glued with various (typically disc shaped and sometimes curved), with areas 1-10cm and activity a few mg. to 10s of mg. These "applicators" would be held in place by the patient's hand.

By 1908 Wickham had 17 applicators at his disposal and made more than 8000 applications; mostly for non-malignant skin diseases (for which x-rays were already used).

1905 For intracavitary treatments sphere or tubes were coated with radium.

Wickham treated cervical cancer with his uterine applicator; but permanent cure was not usual. It was only when a better understanding between surgeons and radiologists together with radium intracavitary combined with the use of external beam that cure became a reality. (See Charles Regaud comment below).

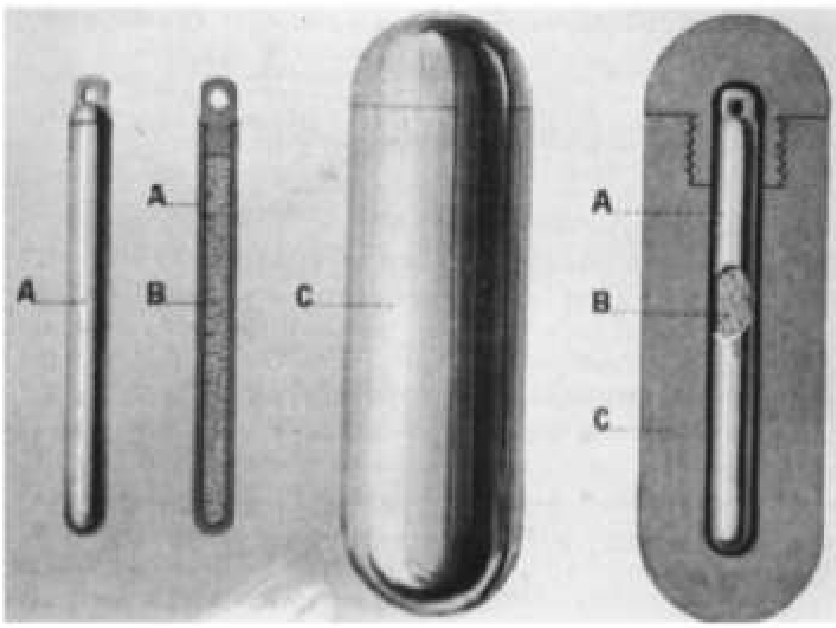
However, it was Danlos (assistant to Pierre Curie) predicted "a great future for radium in dermatology."

Radium Tubes (with heavy filtration to remove beta rays).

It was in Paris that H Dominici (with Danne) designed radium tubes, using gold or silver that would absorb all the alphas and betas

The Dominici tubes (see diagram). [later tubes used in the UK the heavy filtration was provided by 0.5mm platinum].

0.5-1 mm gold or silver (UK 0.5mm platinum)



More Paris experiences.

Radium needles were of platinum with a wall of 0.5 mm thickness (1.6 mm overall diameter), containing 1 mg of radium per cm of length (Fig. 1) and tubes were also of platinum of 1 mm thickness (3 mm overall diameter), containing 10 mg of radium. These were used by the medical team at the Curie Foundation, with Antoine Lacassagne in charge of the radiophysics and radiobiologic quality control. Regaud, on the basis of his experimental data advocated low dose rate irradiation with a protraction of 8 to 15 days. He stated: “L’ailongement du temps d’application, saris accroissement de la dose est donc une condition qui favorise beaucoup l’efficacite de l’irradiation. Il parait meme plus important d’augmenter la duree que d’augmenter la dose.…….” (“The prolongation of the treatment duration without increasing the total dose improves markedly the efficacy of the irradiation. It even seems more important to lengthen the duration than to increase the dose....”). *(See also his visit to UK 1929 below).*

The first evaluation of treatments appeared in 1913, confirming the importance of keeping to strict procedures when using radium. During the same year the Curie Foundation added skin surface radium moulds made with the “Colombia paste,” a mixture of wax and wood sawdust that had been developed by a Colombian co-worker, Esguerra-Gomez, and which enabled the external irradiation of large or superficial tumours at greater depth. (see Cade: in London below).

At the 1913 International Congress of Medicine in London, Pasteau and Degrais presented their results which had the effect of increasing interest in the use of brachytherapy worldwide.

New York (A brief look at Brachytherapy in the USA in the early days.).

Hugh Hampton Young was at that 1913 conference in London. On his return to USA, he purchased 100mg radium (the price of 1g was $100,000) to treat bladder and prostate cancers.

He acquired 102 mg of radium and developed his own system of delivering treatment through the rectum, urethra, and bladder, as well as by applying external radium plaques.

The radium department was established at Memorial Hospital in New York in 1915 with Henry H Janeway as the surgeon. Around this time Benjamin Barringer started using radium tubes to treat bladder and prostate cancers. He inserted the sources directly into the prostate (other surgeons had placed the sources via the urethra or rectum.) He left the sources in-situ for 6 hours in each of the prostate lobes; then waited 2-3 months to allow recovery.

William Duane (who had worked with the Curies) built a radium emanation plant at Memorial Hospital. Radium produces radon gas, which is highly radioactive, with a half-life of 2.8 days. The gas was trapped in glass tubes (with silver filters for beta absorption) containing either 1-4mCi in small tubes or 100-400mCi in large tubes. He used these to treat various conditions.

Several other surgeons used various techniques for treating prostate cancer with radium and radon throughout the years 1915-1922.

Surgeons at Memorial Hospital made use of the short half-life of radon to preform permanent implants with “seeds” of radon. (later “Gold Grains” and Iodine 125 seeds took the place of radon seed for permanent implants in various parts of the body; particularly in prostate with I-125 seeds, see below).

UK 1920s-1930s.

The BIR Silvanus Thompson (Memorial) Lecture: "A new weapon and a powerful one has been placed in the hands of the medical profession, though how effective it maybe it is impossible, as yet, to say. Nor is it yet established whether patients with malignant disease should be treated with radium alone, or with radium combined with surgery or X rays. It is probable that a judicious use of all three methods may be required; but in any case, clinicians must be familiar with them all."

But see also a warning: Lee (Viscount Lee of Fareham): Silvanus Thompson Lecture 1932 (BJR 1933;6: 7): ".... must restrict the use of radium to experts who are fully qualified. ....in the hands of the inexperienced the use of radium in any form is dangerous....... may lead to the gross destruction of tissues ...extreme ulceration...and even death".

[See also: Jesse Aronowitz paper: "Lost radium files: Misadventures in the absence of training, regulations, accountability" (in USA) ...including reference to a paper: "Finding radium inside a pig "Sci Mech 1936 ;13:49]

The National Radium Trust and Commission UK was formed following a speech by Mr Churchill in the House of Commons on April 16th, 1929, the Sub-committee included: Lord Rayleigh (as chair; Sir Sydney Chapman and Sir Ernest Rutherford....and Sidney Russ as a members of the Commission). They were given the main aim to elevate the UK to the standard of The Foundation Curie (Claude Regaud and others) and that of the Radiohemmet (Gösta Forssell and others). It was not until 19 years later that the status of radium therapy in UK equalled the best in the world (particularly for training of doctors).

These institutions were formed on 25th July 1929 and lasted until the creation of the NHS in 1948. The purchase of radium was part public, as national thanksgiving for King's recovery from illness, and an equal part government (both contributing £125,000 at that time). The Commission then loaned the radium to hospitals for 2% rent per year. (List of first hospitals: England: Birmingham, Bristol, Leeds, Liverpool, Manchester, Newcastle, Sheffield; Scotland: Aberdeen, Dundee, Edinburgh, Glasgow; Wales: Cardiff.

London designated separately to include the National Postgraduate School of Radiotherapy: Radium Institute (1g radium from Radon) and Mount Vernon Hospital (3g radium).

A major contribution to clinical brachytherapy in the UK 1920s.

Sir Stanford Cade (22 March 1895 -19 Sept 1973) was a British surgeon; his contribution to our understanding of the use of radium for cancer treatment was extensive, and best seen in his textbook on the subject (see below).

Following his emergency evacuation to England he passed his first medical examination (which he was allowed to take in French), and joined Kings College in London before winning a scholarship to Westminster Hospital Medical School. He became a British Subject, changing his name from Kadinsky to Cade.

As a consultant surgeon he became interested in cancer treatment, particularly with radium.

Following visits to the Radium Institute in Paris, where he was influenced by Claudius Regaud, who had developed his own techniques in all modalities: interstitial; intracavitary, and mould/plaque treatments. Cade wrote these up in a textbook: "The Radium Treatment of Cancer" (Churchill 1929), by which time the Roentgen was well established, along with the concept of mg.hours as a quantity of "dose", for radium treatments. He admits that the biology at this time is not well researched/documented: ("The effects of irradiation on tissues is at present imperfectly understood").

[Claude Regaud gave a review of 30 years of radium treatments at a lecture in London ("Progress and limitation in the curative treatment of malignant neoplasms by radium" BJR 1929; 2: 461); in which he implies that the treatment of gynae cancers is the sole triumph for *intracavitary* radium.(He had already suggested to Marie Curie that some form of fractionation should be used with radium treatment)...."instead of destroying en masse....all living cells, it aims at utilising the difference of radiosensitivities of cells ..., It works when neoplastic cells must be more radiosensitive than normal cells which it is essential to preserve". We need to "acknowledge the narrowness of margin between radio-sensitivities of normal and neoplastic tissues". These were a truly fundamental findings which had been researched and analysed since Regaud's statement extensively! (Jack Fowler, Douglas Lee, Harold Gray, Rod Whithers and others built on his work)]

Cade categorises the effects of radiation on the skin from his own experiences:

Erythema

Following irradiation (he doesn't attempt to quantify doses levels...but we now know these[11] in units of the Gy: see NCI below); after 3-4 days the skin is red, and irritated (he states: "this is used as a basis for dosage by many radiologists. But isn't sufficient dose to produce cure of tumours").

Peeling Dose

Beyond the stage of erythema, the skin blisters and is darker (deep red or purple). By the 10th day blisters from and the superficial layers of the skin peel off by 15th day leaving a "moist, smooth, pinkish grey surface covered in fibrin". [Regaud called this "acute selective radio-dermatitis"].

If no further radiation given the skin heals rapidly in 2-4 weeks.

[NCI now categorises skin effects, linked to dose received:

2-5Gy[1] Transient erythema develops as a prompt effect, and epilation may be present/. All effects are expected to heal in long-term (>40 weeks.)

At 5-10Gy transient erythema appears as a prompt effect within 2-8 weeks.; with the possibility of dry desquamation; which is expected to recover within 2-8 weeks. In the long term, dermal atrophy and /or induration are expected. Radiation induced telangiectasia and skin weakness are also probable (These are grades 1 and 2 on NCI scale.)

The most severe skin reactions (Grade 3 and 4) may appear for doses exceeding 15Gy: transient erythema as a prompt effect in less than 2 weeks. At very high doses it is possible that oedema and acute ulceration appear in the same time frame. Early effects include: moist desquamation. In the mid-term (6-52 weeks) dermal atrophy may occur (grade 4). Ulceration due to failure of moist desquamation healing may appear. Dermal necrosis may require surgery.

Very long term...induction of basal cell carcinoma]

Cade describes the many uses of radium at Westminster giving specific examples.

[11] For simplicity I have assumed: 1R=1rad=1cGy throughout this paper

Summary of Cade's some of treatment methods

Cade Examples [including a few similar examples from Manchester Radium Tables 1934 to show some similarity in prescription...mgh only for Cade examples and converted into dose in R from Manchester tables]

Intra-cavitary: Oral, rectal, vaginal.

Cade quote: "The radium is introduced through the natural opening and maintained in position by means of holders which vary in construction accorded to the anatomical site".

It is particularly useful to consider Cade's treatment of the cervix ......so that this can be compared to Paterson/Parker (Manchester).

- 4 tubes (5 or 10mg) were placed in the cervical canal for 4-6days (giving a total dose of 5000mgh)

Cade also developed a "needling" technique (see figure) with 10-15 needles (total of 35mg) giving 6000mgh. (Compared with a typical "dose" recommended by Manchester (1934) of 7000mgh)

"Needling" for Cancer of the Cervix treated by per vaginal method
(Dr Cade notes: "care must be taken not to perforate the bladder or rectum")

Bladder.

Cade followed Barringer's techniques (1928) where the bladder is opened by the suprapubic method ("needs enough light" ....in theatre).

10-12 small (0.5-0.6mg) needles were used over 10 days, giving a dose of 2500mgh.

Anal cancers

in female patients were treated transvaginally.

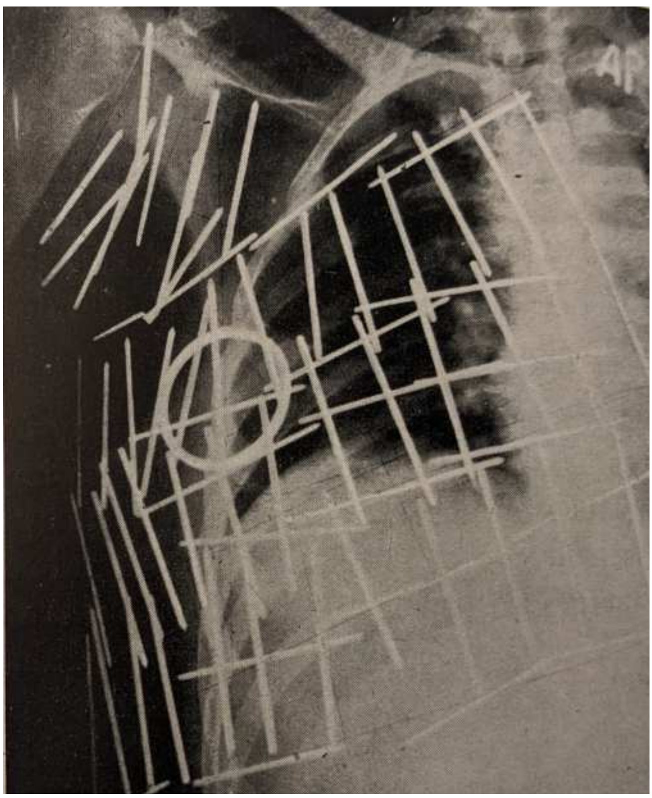
1^{st} stage: giving 3500mgh over 5 days.

2^{nd} stage: using plaques of Columbia paste to gain 15mm stand-off covering the sacrum and perineum; and 2 other plaques for right and left inguinal regions

Interstitial Tongue implants

Squamous Cell cancers treated with 12 x 0.5mg and 3 x1mg needles for 7 days giving dose of 1500 mgh.

[A similar Manchester implant (4x5 cm^2) (for 6500R/7days) requires 2391mgh.]



Breast Implants.

(Radiograph from Cade's book)

Using complex techniques for inoperable cancers (over an extensive array of areas ... see also Geoffrey Keynes surgical assistant at St Bart's Hospital under George Gask in 1932).

Typically, 40-50 needles (75-100mg) to a dose of 16,000-21,000mg.h.

Radon

Cade also used radon seeds: these are made of capillary glass filled with radon and then encased in gold torpedo-shaped platinum cases (to absorb the alpha and beta rays), (see P Gosse Lancet Aug 18th, 1928; 323). The seeds were placed using an "introducer" (a trocar).

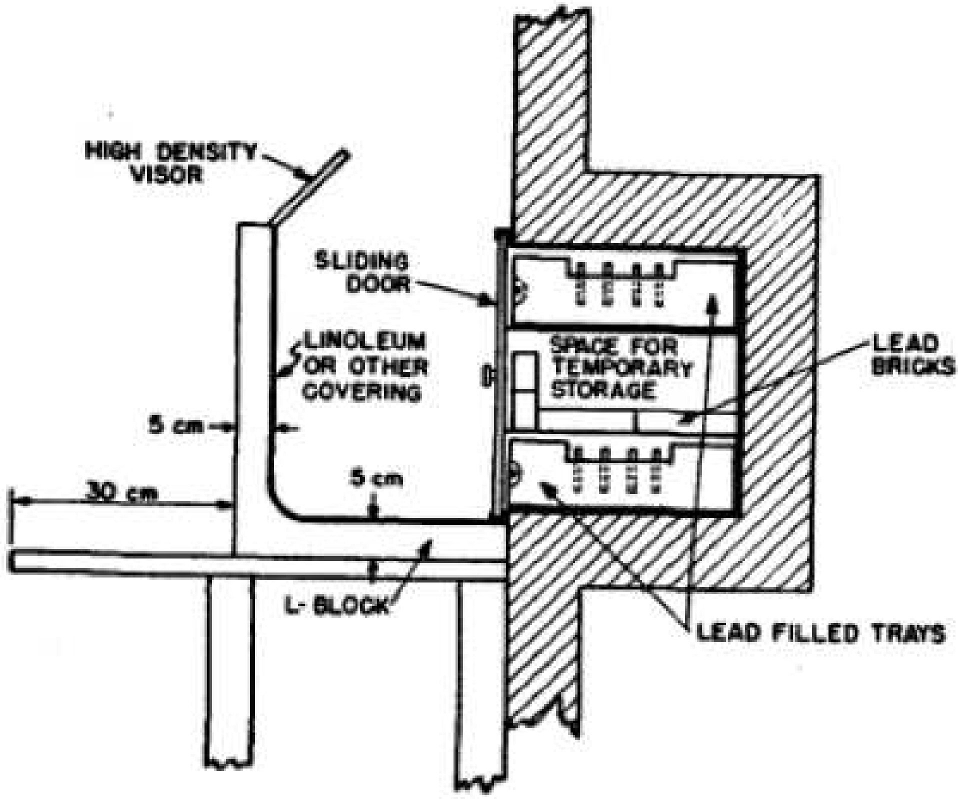
These were permanent implants (see similar implants in below: "the development to using I-125 seeds for prostate implants 1970s")

Cade concludes (in his book) that *"the effect of irradiation on tissues is at present imperfectly understood"*.

Cade also had serious ideas concerning protection in his radium department:

> "It certainly pays every radium department to be lavish in the provision of suitable lead protection devices at every point in the hospital at which radium is likely to be kept or used" (See also "protection section" below").
> e.g.: 4-inch think lead storage box in main radium lab.; benches to contain 2-inch lead.

Photo of Two types of lead bench at NPL.



Cross-section of bench and temporary radium storage safe

Dosimetry 1930s-1940s.

Various methods for calculating implant and radium plaque doses were developed in USA (Quimby) and France (Pierquin); but it was earlier that in Manchester, that Paterson and Parker (and others) developed their work over several years (1934-1940s). These were considered the most accurate thorough and comprehensive systems (covering: interstitial; plaques and intracavitary calculations).

Ralston Paterson became Director of the Holt Radium Institute in 1914 (together with the purchase of 200mg radium); he then integrated this institute with the Christie Hospital. He visited Stockholm to learn from Elis Berven and James Heyman (of "Heyman Capsule" fame for treatment of carcinoma of the cervix) in Stockholm; and in Paris: Octave Monod (surface mould); Juliette Baud (implants); Claude Regaud (intracavitary) (these being the 3 main "applications" for radium treatments).

He recognised the need for physics to understand radium (the mathematics of dose distributions particularly), and appointed Herbert Parker as a research physicist (he later insisted on giving Parker an equal rank to the doctors).

Paterson and Parker and others published several papers on use of radium sources for all these modalities (the distribution and the amount of radium to be used depending on area, or volume to be treated). These were combined to form: "Radium Dosage; The Manchester System (1934)". These tables recommended *the arrangements of radium* as well as the amounts in milligram hours (mgh); which could then be used to determine total treatment times.

French Dosimetry.

Bernard Pierquin was one of the first therapists to use man-made radionuclides. In 1956 he used short gold wires inserted into afterloading guides. The he started to use Ir-198 with its higher specific activity, using wire rather than stranded seeds. He performed 3000 implants over 10 years). In: neck, skin, breast, penis, prostate, gynae (see Ann Radiol 1966;9:757). The wires were not necessarily straight, so a new dosimetry system was developed specifically for these implants (see references below).

He had visited Henschke in New York in 1960 (Heschke played a crucial role in the renaissance of brachytherapy in USA. At the faculty of Ohio State University with the surgical oncologist Arthur James (and Nuclear medicine expert William Myers), they replaced radium with thin nylon tubing containing 3mm sections of Co-60 wire. The end of the tube was heated to form a point that could be treaded into a needle.

Henschke (1960s) developed his own gynae applicator used in afterloading techniques."

In the 1970s the "Paris" system of dosimetry was developed for use with Ir-192 wires, particularly to be able to deal with curved surfaces (e.g. breast implant). Tubes were implanted in theatre; Ir-192 wire cut to the appropriate lengths and then inserted into the tubes (using long forceps).

References to French Dosimetry: Chassagne D, Raynol M, Pierquin B. "Technic of endocurietherapy by Ir-192 with plastic tubes in breast tumours" (in French). J Radiol Electrol Med Nucl 1963 ;44: 269. Also: (Pierquin and A Dutreix BJR 1967; 40:184 and in UK: Paine CH Clinical Radiology 1972; 23:263

Brachytherapy (1930s-): Intracavitary Brachytherapy, particularly for gynae cancer treatment.

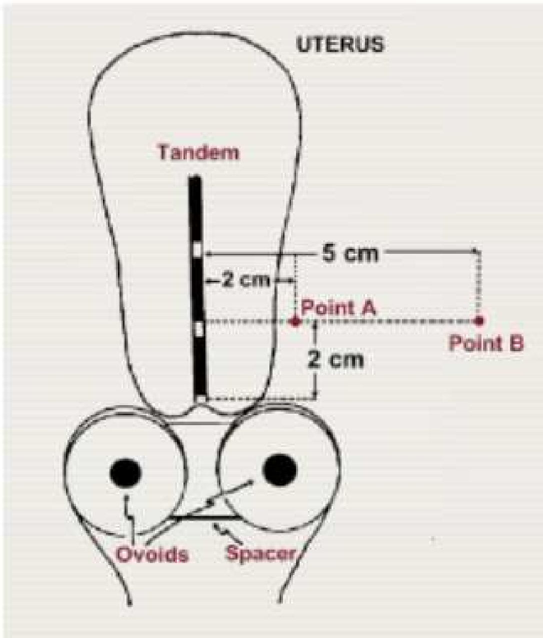
Manchester Gynae Brachytherapy.

The Manchester "Ovoids" and "uterine" tubes are a classic starting point for studying the various methods for treating cervical cancers.

The applicators used in the vagina were essentially a modification of the corks used in the Paris technique (and in Stockholm). Made of hard rubber and approximately ellipsoids of revolution they were given the name "ovoids". They were used in pairs and locked into position by a spacer or a washer; with sizes 2.0, 2.5 or 3.0 cm in diameter.

Intrauterine tubes of the thinnest rubber were used. Depending on the length required the uterine tube could be 2 or 3 radium tubes long (or in special cases just 1 tube was used. Typical radium loadings: Long: 15-10-10mg; medium: 15-10mg; with 2

20mg ovoids. These loadings would give about 56-58R per hour at point A (see diagram.)

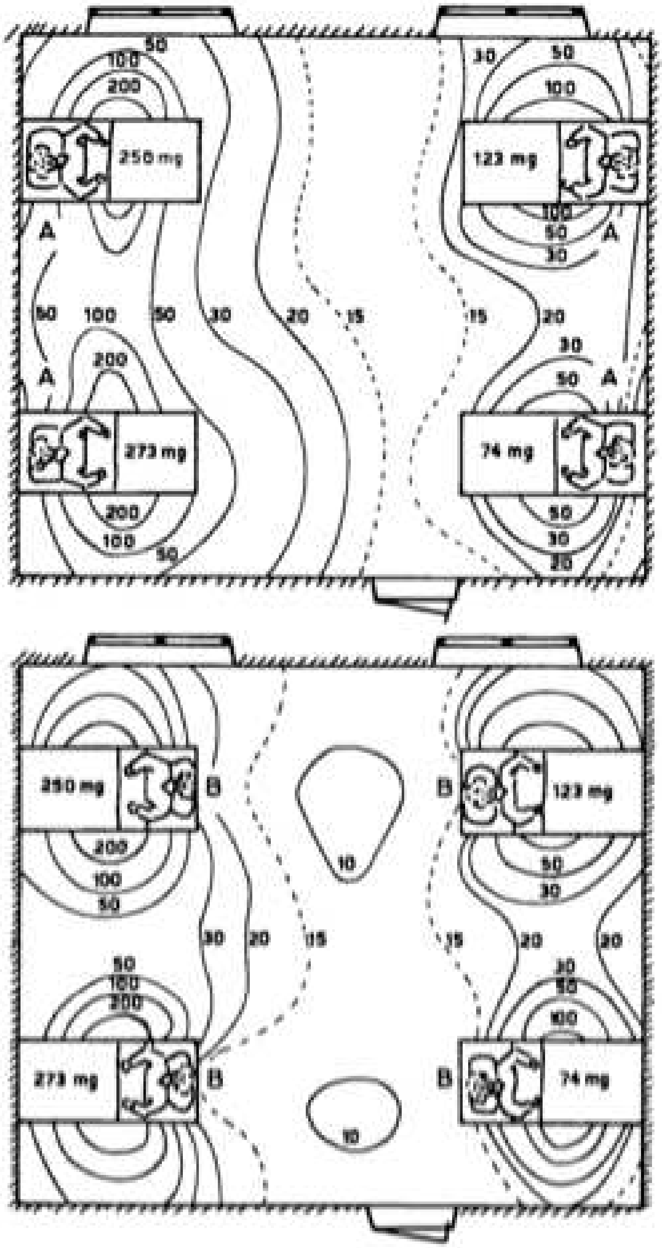


A Classical Manchester Radium Intrauterine Implant with Vaginal Ovoids

Radiation Protection for Gynae Patients

The manipulation of sources within theatre and on nursing procedures on the wards meant that the doses to staff could be quite high, depending on how many patients treated at the same time. [Appendage: A delightful article by Rune Walstam (Acta Radiol 1953) in the RadiumHemmut where patients were treated with up to 350mg for 7-35hours ...was able to half the staff doses by turning the beds to face the walls (see figure below)]

A PROTECTION ARRANGEMENT FOR INTRACAVITARY RADIUM IN WARD PATIENTS



A 4 -Bedded ward showing the radium dose rates in mR/h.

Bottom figure after turning the patients through 180deg (The figures over the beds are mg radium content in each patient).

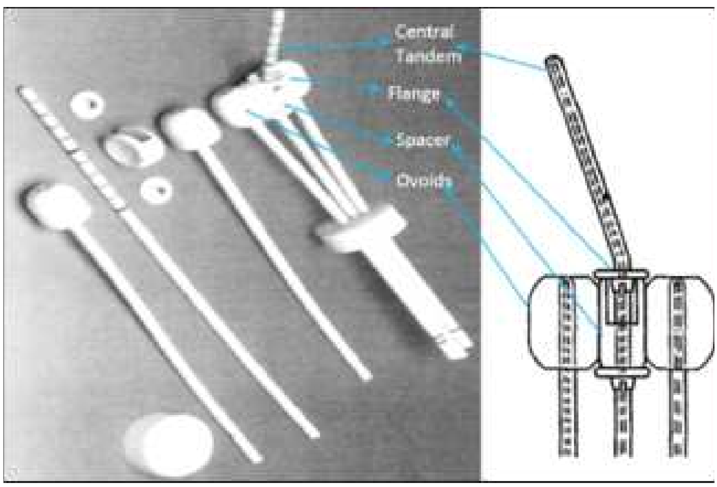
These concerns, together with the possible benefits of superior implant and insertions led to the development of afterloading systems using the newly developed various isotopes: Cs-137; Ir-192.

Cobalt 60 was also used around this time, particularly in the newly developed Cathetron. *This is discussed in a separate section below since this equipment stands alone at that time (1960s).*

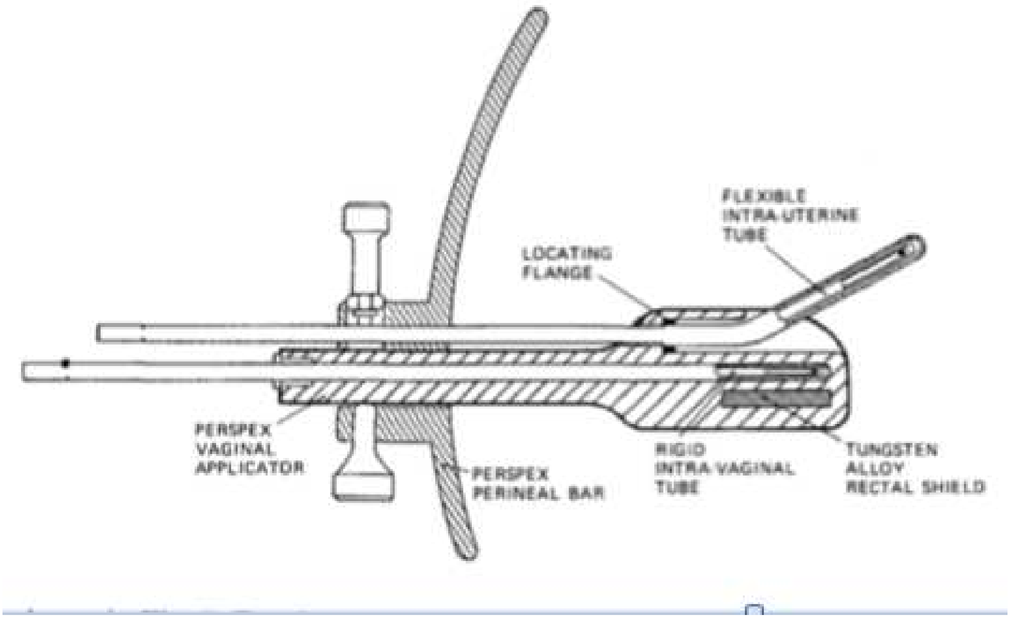
Use of Caesium for Gynaecological Treatments

Following the removal of radium from medical use (1976), the main replacement radioactive source was Caesium 137 (with a half-life of 30 years…so there was a need to adjust the calculation times every 6 months by 1%). Needles were used in similar ways to radium for interstitial implants and plaques. But gynae applicators were developed in various centres for afterloading (which reduced doses to theatre staff).

Manual Afterloading



Amersham applicator(left) and showing bead positions on right (for Selectron remote afterloading, see below)



The Newcastle small Perspex gynae applicator with intrauterine and vaginal tubes.
(EM Dean et al BJR 1988;61:1053)
(Note rectal shield to reduce the rectal dose)

Protection on the ward when using caesium manual after loading

Although theatre doses were eliminated with these afterloaded caesium applicators, the nurses on the wards still received some radiation dose during nursing operations with the patients. Mobile lead shields were developed that reduced these personal doses to staff.

[In Newcastle in 1967 no such shields were used for Radium, but (much lighter for caesium radiation, with a lower photon energy) lead shields were used when gynae treatments were given with Cs-137 (using the Newcastle applicator). Also at Mount Vernon in 1988 (before the use of remote afterloading) lead shields were used successfully for manual afterloading caesium using Amersham applicators.]

A bed shield used when inserting or removing caesium sources on the ward
(TJ Bateman et al BJR 1983;56:401)

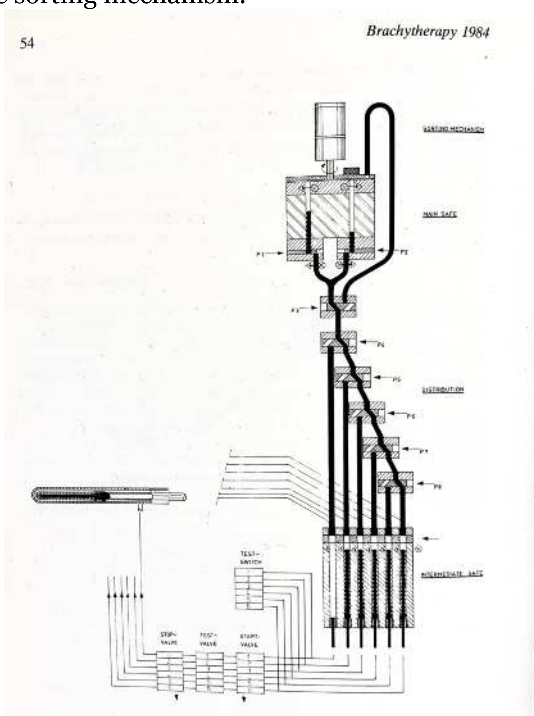
Remote afterloading systems.

Most radiotherapy centres moved towards the use of remote afterloading systems in the 1970s-1980s. The next sections will deal with this standard practice.

LDR Afterloading System. (LDR <=2Gy/h) LDR using Cs-137 pellets.

The Selectron.

One of the first remote afterloading systems using caesium sources was developed in 1977 by Eric van't Hooft (Nucletron Trading BV, Leersum, Netherlands, together with medical institutions in Holland). The main aim was to reduce radiation exposure to staff and improve dose distributions within the patient. The first machines used Cs pellets (2,5mm diameter :10-40mCi/pellet), kept in the main safe and 6 delivery tubes connected to the sorting mechanism.

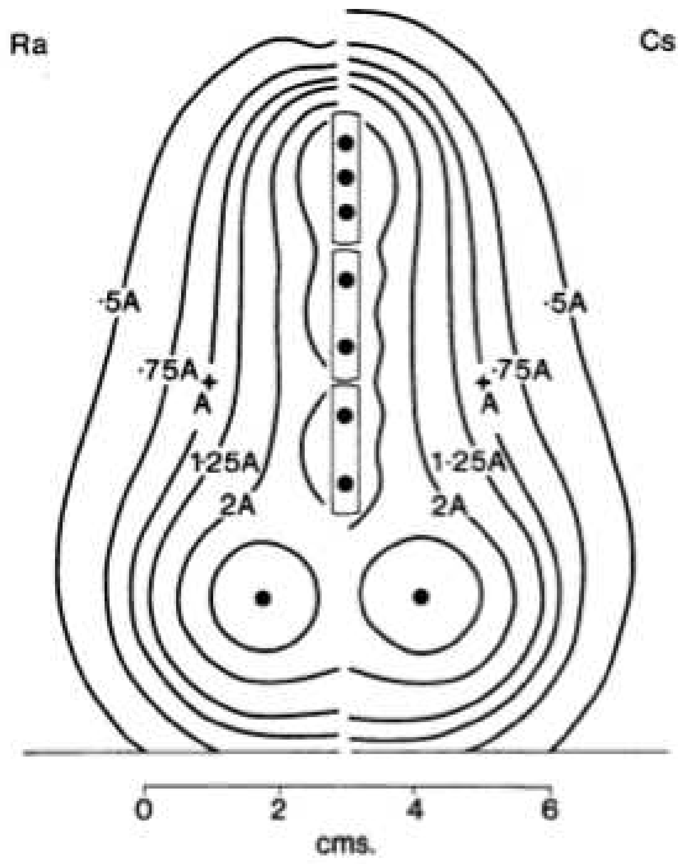


The Selectron showing the main safe and 6 delivery tubes.
Eric van't Hooft Brachytherapy 1984 Proceedings of the 3rd International SELECTRON Users Meeting 1984 (ed RF Mould)
Up to 48 sources could be selected with inactive spacers to be delivered to appropriate applicators.

The Selectron LDR systems were used in Newcastle with the Newcastle gynaecological applicator.

(They were installed during my time at Newcastle, see addendum)

These machines were used on the ward. The control unit would be outside the room, but the source safe and sorting system inside the room. Some patient found this disturbing, particularly since the treatments would last overnight. The dose rates used in the Selectron were higher than the Manchester radium, so treatment times were reduced by 10-20% to allow for the enhanced biological effects. Treatment times were typically 24 hours (compared with 3-3.5 days with radium). For continuity of biological effects treatments were planned to produce the same dose distribution that had been used with Manchester Gynae Radium (see diagram below)



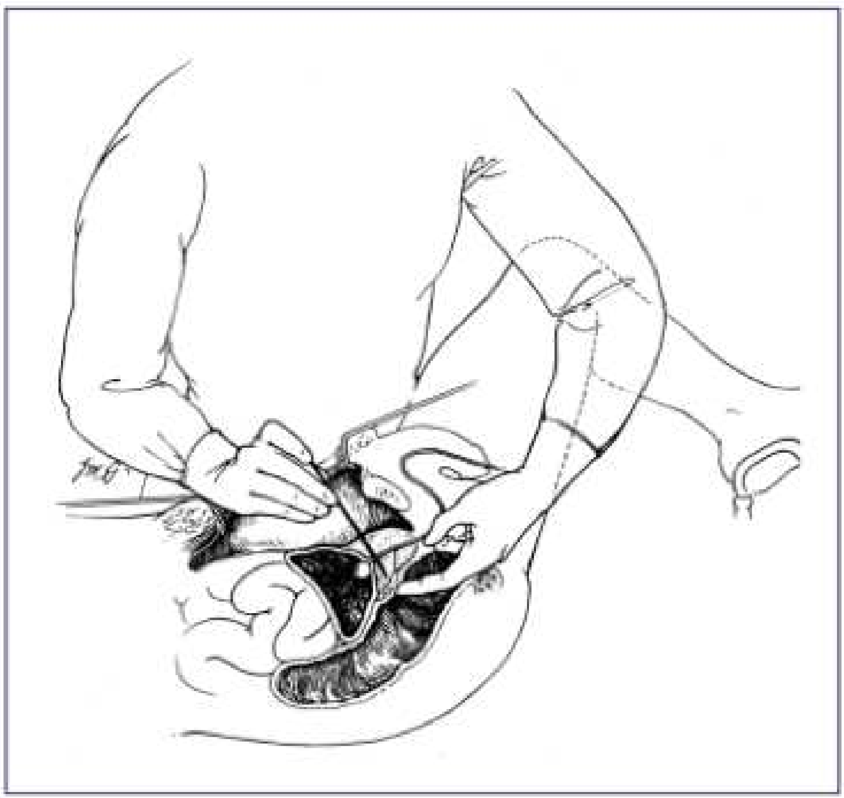
A Comparison of relative isodose distributions from radium tubes and corresponding caesium pellet loading pattern, for the reference geometry. The positions of the active pellets are shown, the intervening spaces being taken up by inactive pellets.

JM Wilkinson et al. BJR 1983;56:409

New Brachytherapy Systems for Prostate

1. Permanent Seed Implants.

The history of interstitial brachytherapy of the prostate began in 1917 when Barringer inserted radium needles (retropubic implantation) into the prostate guided by the finger into the rectum (see diagram below).



Retropubic implantation of needles toward a finger in the rectum.

(WF Whitmore et al MSK J Urol 1972;108:918-20)

Then, trans-perineal interstitial permanent prostate brachytherapy was first proposed by HH Holm and colleagues (see Semin Surg Oncol 1997;13(6): 431)

The basis for ultrasound (US)-guided seed implantation was established in the late 1960s by Kratochwil's description of the first puncture transducer for one-dimensional US-guidance.

1980s: the use of Iodine-125 (as "monotherapy" for early/intermediate stage prostate cancer).

The standard procedure consists of using a transrectal ultrasound probe to first define the prostate contours in 1–5 mm-thick transaxial images for dosimetric planning and then, some weeks later, delivering radioactive seeds (sources 0.8 mm in diameter × 4.5–5 mm in length) into the prostate gland. In both steps, the patient is placed in the lithotomy position. Needles containing the seeds are inserted through the perineum and into the prostate under the guidance of the transrectal ultrasound probe. The needles are prepared for the procedure in one of three ways: manual loading on site, purchased pre-loaded needles, and seed loading devices. Some customisation of the quality control guidelines presented here may be necessary to accommodate the particular method of needle loading in use.

Over the years, other approaches have been introduced such as intra-operative pre-planning and interactive planning. In such cases, treatment planning and seeds loading in needles take place during the operative procedure.

Radiograph of typical I-125 seed implant
(KKN Charyulu IJROBP; 6:1261)

At least 2 types of seed were developed:

I-125 (Half-life 59.4 days) and Pd 103 (Half-life 17.0days. They had similar energies: I-125 27-36keV; Pd 103 20.23keV

The radioisotopes deposited their energy over their lifetime; but theoretically only a little longer than their half-life, after which they could be considered in-active as far as radiation to family or general public. The guidance given to patients leaving hospital: "Avoid prolonged exposure with children and pregnant women; may have intercourse after weeks, but wear a condom"; (potential loss of seed)

The procedure (in brief).

The required team in the operating theatre consisted of: Urologist, oncologist, anesthetist, physicist and nursing staff.

The patients would be placed in the standard dorsal lithotomy position. Prior to treatment planning ultrasound scans would have been taken transrectally. A guide was then stitched to the anal area containing the holes through which the needles could be guided under US (together with 2 stabilizing needles to keep the prostate in position during seed loading). The seeds are dropped into place in the prostate.

Final images are taken to confirm seed positions which are verified by the physicist.

From early experience the typical dose planned for I-125 is 145Gy to 90% of prostate and 115Gy for Pd103 (there is little evidence to demonstrate a preference today).

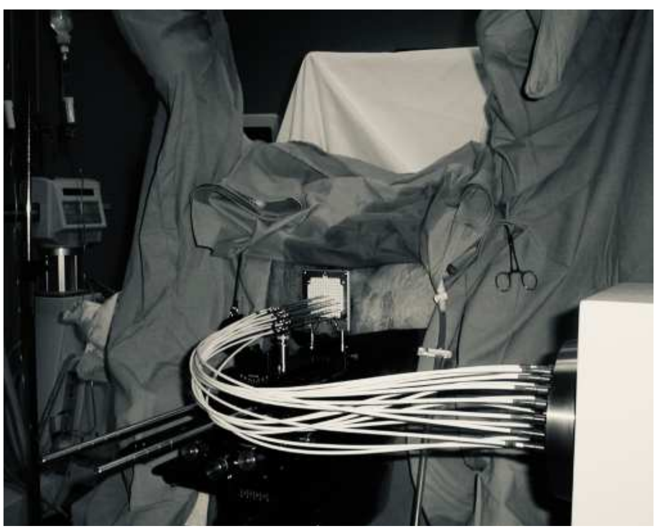
But it was "remote afterloading" that removed the exposure to all staff groups.

The first: Cs-137 Watstam in Radiumhemmet (Sweden) (PMB 1962; 7:225. The French Curietron (CGR ref58 J Urol 1986; 135(3):510); German Buchler (GmbH); The Dutch Selectron LDR Cs-137 (Nucletron Eng, BV, Netherlands …Eric van't Hooft 1979)

Move towards remote afterloading.

By the 1980s TRUS (Trans-Rectal Ultra-Sound) –guided remote afterloading systems were developed to deliver a high radiation dose to the prostate while limiting exposure to the surrounding tissues.

This method was used in: Sweden, USA, UK, Germany and Japan. In USA a trial of HDR monotherapy was conducted (1999-2000) published 2001. Patients with low-intermediate risk cancer were treated with 38Gy in 4 fractions: twice a day over 2 days. None of the patients developed severe acute effects.



The HDR Gammamed

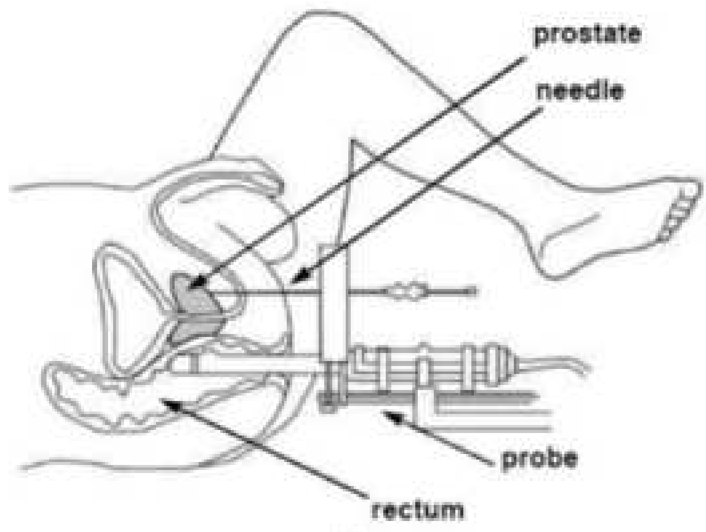
This uses only one high activity source (10Ci Ir-192 0.6mm diam; 0.5mm length) on the end of a stainless-steel cable 1300mm long. This source can move at 60cm/s and place the source accurately within "needle/tubes" to $^{+}_{-}$1mm. Within the machine there are 24 channels; 60 dwells within each channel to be planned; steps of 5mm typically (but can be 1-10mm).

Protection: The room must be well protected: 4cm lead or 35cm concrete, with a maze or heavy door.

The source requires changing every 3-4 months (Half-life Ir-192 is 74days)

The Gammamed HDR, with 12 tubes connected to the trans-perineal located needles

Pedro Prada 2013 in "Advances in Prostate Cancer" (Ed: Gerhard Hamilton)



Needle insertion is carried out via trans-perineal implantation under ultrasound guidance *Arrangement of US probe and needle through template for prostate HDR. (A Challapalli et al BJR 2012;85:S18-S27)*

Methods (HDR Prostate).

Once treatment planning is complete, the interstitial needles are connected to a remote afterloader that will deliver the radiation dose through each needle via a ^{192}Ir source. The source is driven sequentially along the implant needles (typically 8-12 needles) at specific positions determined during planning. Typical dose rate: 12Gy/h.

Depending on prostate size, dose prescribed, activity of the source, treatment delivery is usually completed in 15-25 minutes. The implant may then be removed from the patient if the treatment given is the final prescribed fraction or secured for delivery of subsequent treatment fractions.

As monotherapy: GEC-ESTRO recommendation: 34Gy in 4 fractions or 26Gy in two fractions (single fraction has been attempted but not now used).

As a boost (following External Beam typically 36-54Gy in 1.8-2Gy fractions):12-30Gy in 1- 4 fractions.
The interfraction treatment interval should generally exceed a minimum of 6 hours.

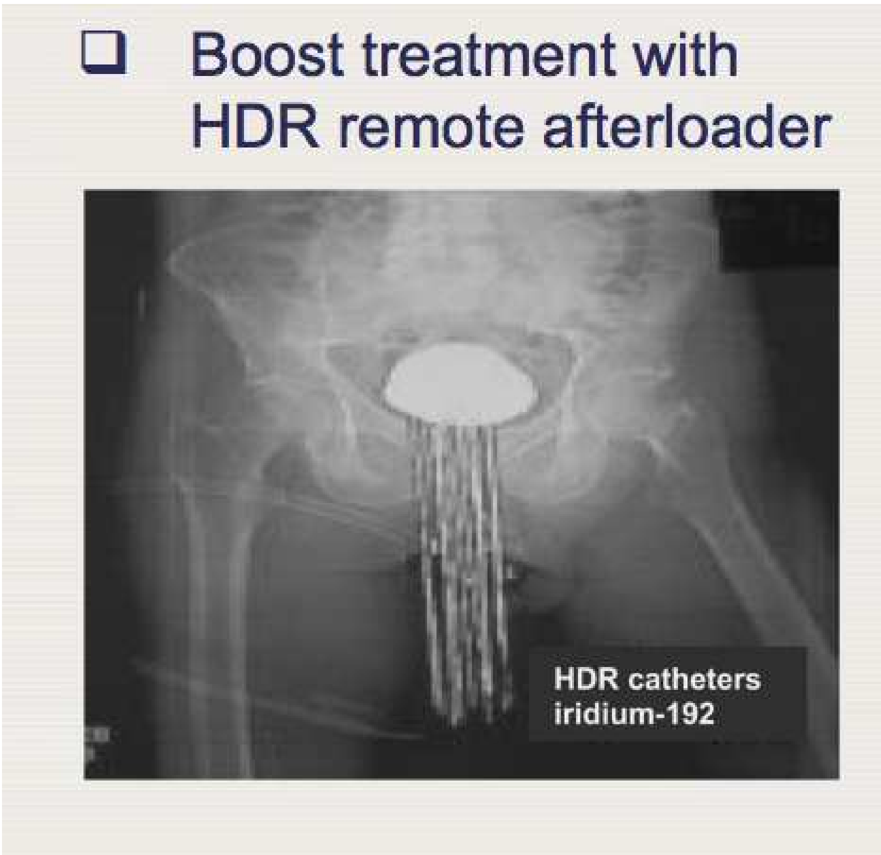


Figure showing cross-section view of needles into the prostate and ultrasound probe in rectum.
(And radiograph below).

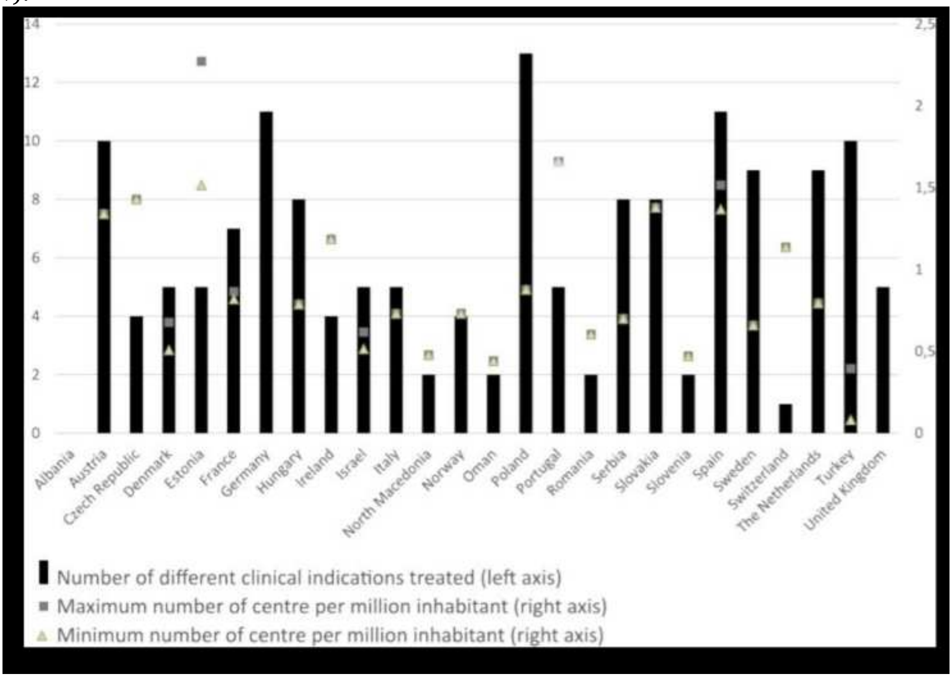
Present Status of Brachytherapy.

The advent of very accurate external beam radiotherapy has resulted in a fall off of the use of brachytherapy except for gynae and prostate cancers.

The most recent development: Electronic brachytherapy using very small x-ray tubes operating at typically 50kV are used to treat various cancers including breast. (D Eaton

"Electronic brachytherapy—current status and future directions" BJR 2015;88(1049):20150002).

GEC ESTRO have performed an extensive survey of 26 countries (2 outside Europe) to assess the rates at which different sites were treated with brachytherapy (see figure below).



In the UK the number of brachytherapy treatment sites has reduced to 4; other countries even lower.

The special case of HDR Brachytherapy equipment: The Cathetron (1960s-1980s).

This was an idea developed in 1960s well before any development of the modern HDR brachytherapy equipment. (See CAF Joslin: Cardiff; (BJR 1972; 45: 257-270) Charing Cross Hospital (BJR 1967; 40: 895).

Cathetron Description.

Source pencils: containing stainless steel source capsule encasing cylinders of Cobalt 60. For classical Manchester ovoids activities were 2.1-2.7 Curies; Uterine tubes: 3.0-5.4 Curies

Dosage: see W E Liversage (BJR 1967; 40:887-894), using Manchester design:

Cathetron: 1000rads in 5-6 min (4 fractions of 1000 rads to point A was used; with the additional External Beam dose of 2400rads. *See table below*)

TABLE I

DOSES RECEIVED AT THE VARIOUS POINTS WITHIN THE PELVIS FROM EACH TREATMENT MODALITY

Pelvic dosimetry for carcinoma cervix			
Treatment modality	Point A dose	Point B dose	Rectal dose
Cathetron (4 fractions) External telecobalt 60 (12 fractions)	(4 × 1000) = 4,000 rads (12 × 200) = 2,400 rads	(4 × 275) = 1,100 rads (12 × 275) = 3,300 rads	(4 × 600) = 2,400 rads (12 × 166) = 2,000 rads
Total dose	6,400 rads	4,400 rads	4,400 rads

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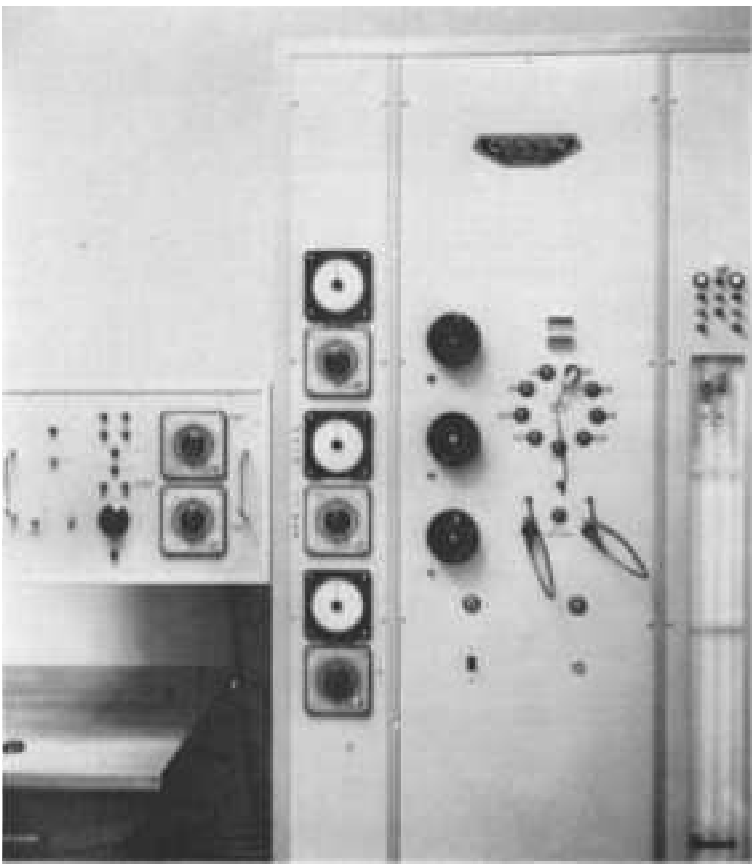
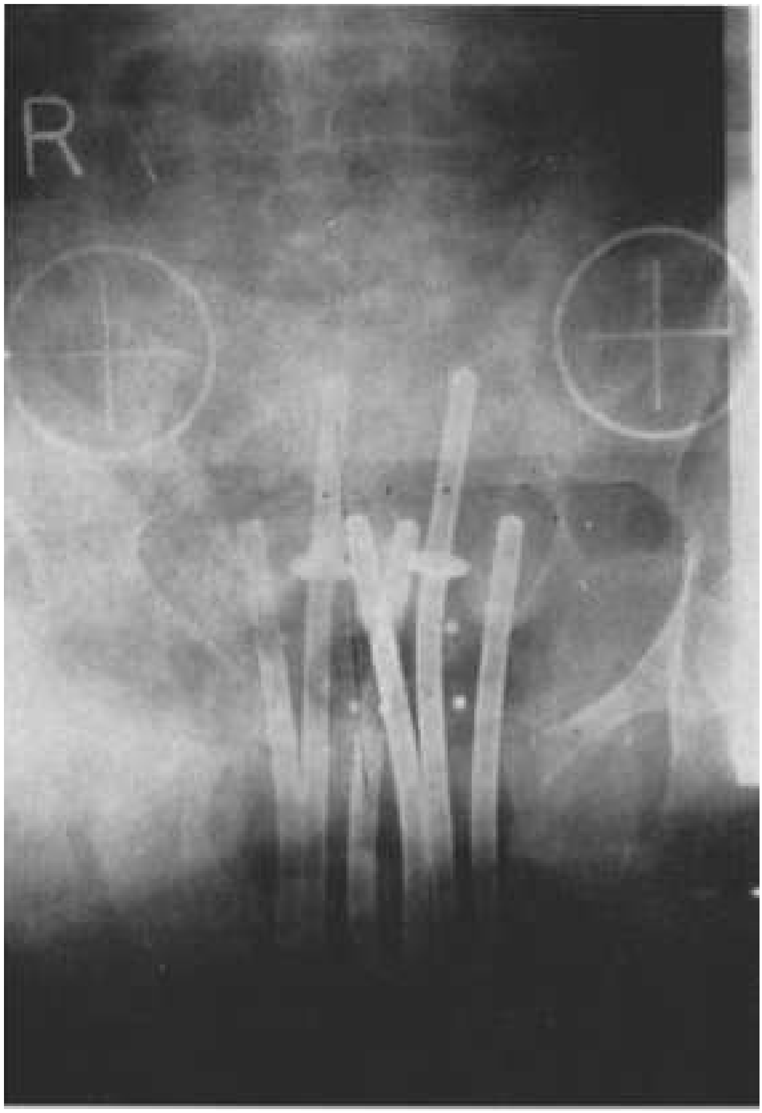


Cathetron Control Panel
D O'Connell et al. BJR 1967;40:882

Ingeniously a "monitoring source pencil" was used with a cobalt 60 source 1/1000 of the activity treatment sources, to measure rectal dose before treatment.



Shift radiographs are used to determine the Cathetron source positions.
(CAF Joslin et al. BJR 1972;45:257)

[As an aside (as an addendum to Skin Effects) Joslin used the Cathetron to treat skin cancers with moulds:

Case 1: 20-year-old female with a neurofibrosarcoma on chest wall (a recurrence after external beam) given 450 rad /6 fractions: skin effects; dusky erythema followed by dry desquamation; then after 4 weeks healed with pigmentation.

Case 2: 56 male fibrosarcoma on abdominal wall. 550Gy in 8 fractions over 14days.Impact on Skin: a patchy erythematous reaction at 1 week; leading to dry desquamation and healing in 4 weeks.]

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High dose-rate treatment moulds by afterloading techniques

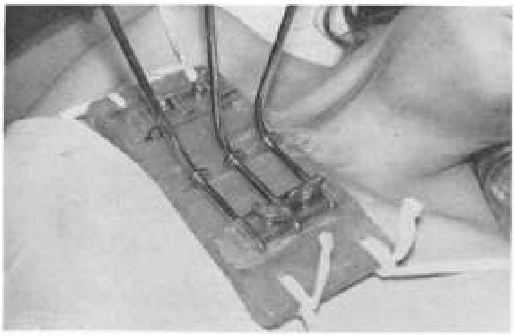

FIG. 1.

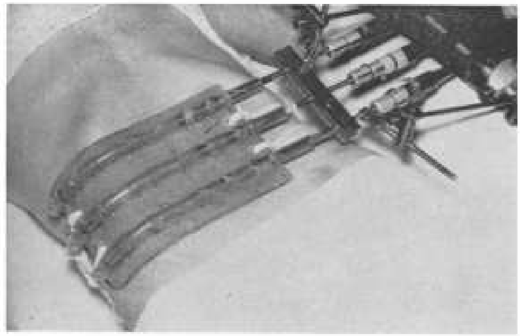

FIG. 2.

FIG. 1. Treatment set-up illustrating high-dose-rate therapy to a flat surface.
FIG. 2. Treatment set-up illustrating high dose-rate therapy to curved face.

Protection issues
(In particular the advantages of remote afterloading)

Kaye (BJR 1935; 8:6) had discussed 'The Tolerance Dose' to help build a system of protection. This was defined by way of "the erythema dose as a commonly accepted index of biological damage; and so 'The Tolerance Dose' as 1/100 of the erythema dose in 3 working days"; which then translates into 0.2R in a normal working day.

Then several articles (P Howes and S R Osborn BMJ 1962; 2:448) and F Ellis ("Reduction of radiation hazards in the use of radium and similar sources" BJR 1959; 34:408) deal nicely with this issue (Ellis includes details of advice re: bed making (fitted sheets), feeding etc. intended to reduce doses). He analysed the doses received by nurses on ward in which there were 430 radium and "isotope" cases: 6 staff received 1.5-3.5 R and 8 staff 1-1.5 R. per year.

At that time (1950-1970) the only document available was "The Code of Practice" which suggested a maximum permissible does for workers of 5R per year. (and 1R over 13 weeks; at that time: ICRP 15rem per year (0.3 rem /week)).

The protection issues [12] [See particularly: Ralston Paterson "Effects of radiation on Workers" BJR 1943; 16(181); 3-5].

During the early years of the use of radium little attention was given to radiation protection, although Marie Curie was aware of the possible dangers. Throughout that lengthy period of radium use: 1910-1976, there was an awareness, and indeed governed by laws in that later period (1952....); but still inevitable exposure to personnel:

[12] Throughout this paper: 1R=1rem=1cGy=1rad

preparation (although most of this behind lead screens); exposure in theatre performing the operations; exposure on the wards when caring for the patient.

Ralston Paterson outlines the protection "rules" for his own department in Manchester. (Christie and Holt Radium and Manchester Hospital).

[Recommends that "when planning a new department, the plans should be submitted to NPL for comments".

He followed the British X-ray and Radiation Protection Committee guidance from their 6th revised report Feb 1943.]

Paterson states: The first question which we have to ask ourselves is: what risks of permanent damage are run by workers in radium and X ray, whether in the commercial or medical fields. It should be stated from the outset quite bluntly that continued over-exposure can result in serious damage to health, or in death. Deleterious effects may be caused comparatively early in a career of over-exposure. At that stage they are easily recovered from if matters be attended to. Or they may represent the late results of long continued exposure; at this stage they are usually fatal. I would like to deal with the late results first. They are three in number:

First: the development of warty growths on the hands and fingers of workers receiving local exposure. These later become epithelioma.

Second: anæmia of a lethal type, resulting from general exposure to γ rays, or from ingestion of radium.

Third: the development of tumours in the body itself, *i.e.,* bones and lungs, consequent on ingestion or aspiration of radioactive substances."

Checks on Staff Health

1. Finger inspection (especially for those staff involved with "radon Pumping:" and radium threading)
   Effects included: reddened and glazed appearance of fingertips; cracking and "rag-nails" (which were still reversible. But heading towards the possibility of hyperkeratotic lesions leading to squamous cell cancer).
2. Monthly blood counts: white cell total; 3 monthly for red cell count.
3. Monitoring of body dose using dental film (which became common practice in NHS UK until TLD systems were developed (1980s).

Paterson also insisted on the best, with details of record keeping, radium movement etc.

(probable weekly inventory checks)

There were lost radium issues, development of later rules, and legal requirements.

Addendum: My experiences in aspects of brachytherapy as a medical physicist: 1967-2021.

I started work at Newcastle General Hospital in 1967 (Prof. Frank Farmer in charge of the Regional Medical Physics Department). The Radiotherapy Department had the full range of radiotherapy equipment: SXT, DXT (see my article in Invisible Light) and several Linear Accelerators. The Brachytherapy Department at that time included: radium store and work bench run by technicians.

I worked in all aspects of radiotherapy including brachytherapy, where I was involved with helping to plan treatments and then calculating the treatment times from radiographs and the implants/insertions in theatre. I would then take my results to sister on the ward to check removal times on the 24-hour clock. (Typically, 6-7 days for implants and 3-4 days for gynae insertions.

During my time at Newcastle (up until 1985) the radium needles were replaced with caesium needles; and the gynae radium (Manchester system) was replaced with a locally designed Newcastle Perspex applicator (see this paper).

I moved to Barts' in 1985 as Head of Radiotherapy Physics and part of my work in brachytherapy included the design of an I-125 applicator for eye melanoma (Mr J L Hungerford St Bartholomew's and Moorfields Eye Hospitals) as well as supervision of the caesium gynae treatments.

At Mount Vernon Hospital (from 1988) caesium was used at that time for implants and gynae treatments with the Amersham applicator. The first afterloading equipment to be installed was the Selectron; then the Gammamed. As well as my involvement with the commissioning of these I designed the improvements needed in radiation protection.

My final work with brachytherapy was assisting with the QA of absolute dosimetry for the INTERLACE Phase III clinical trial (Gynae HDR Brachytherapy). I took part in many of the visits by the QA group to 47 UK centres (PMB 2017; 62: 8832-8849).

General References.

G Kemikler "History of Brachytherapy" Turkish J Oncol. 2019; 34(Suppl): 1-10

Jess N Aronowitz "A Century of Brachytherapy (From the Prostate's Perspective)"; *with 192 references.* [13]

[13] **Editorial Note**: This is: *Brachytherapy, 2nd Edition (Applications and Techniques)* Edited by: Devlin, Phillip M., Cormack, Robert A., Holloway, Caroline L., Stewart, Alexandra J. The *Chapter 1: A Century of Brachytherapy (From the Prostate's Perspective)* is fascinating and well worth reading. I may be downloaded at https://connect.springerpub.com/content/book/978-1-6170-5261-3/chapter/ch01

M S Schaulin et al. "Tracing the Evolution of Prostate Brachytherapy in the 20th C" Oncology 2024; 102: 283-290

Jesse N Aronowitz "Afterloading: the Technique that Rescued Brachytherapy. IJROBP 2015; 92(3): 479-487

C S Melhus et al. "Learning form the past: a century of accuracy, aspiration and aspersions in brachytherapy" Review Article. BJR 2022; 95: 20220500

R Mould "A Century of X-rays and Radium" 1993 Taylor and Francis

R Mould "Priority for radium therapy of benign conditions and Cancer" Curr Oncol 2007;14(3): 118-122

N G Zaorsky et al. "Evolution of brachytherapy for prostate cancer" Nat Rev Urol. 2017; 14(7): 415-439

"Radium Dosage: The Manchester System (second edition). Ed WJ Meredith (Compiled from articles by R Paterson; HM parker; FW Spiers; MC Tod; SK Stephenson; WJ Meredith) E & S Livingstone Ltd Edinburgh and London 1967

A Henry et al; "GEC-ESTRO ACROP prostate brachytherapy guidelines "Radiotherapy & Oncology 2022; 167:244-251

RCR "Radiotherapy dose fractionation Fourth Edition" 2024

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