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Albert Salomon: The Man Behind the Mammogram.

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‘I bet this was invented by a man!’- Introduction.

In the United Kingdom, one woman is diagnosed with breast cancer every 10 minutes and one1 in 7 women will be diagnosed with breast cancer in their lifetime (Breast Cancer Now, 2024). Men are also affected, albeit rarely. On average, approximately 400 men are diagnosed with breast cancer in the United Kingdom every year, compared with around 55,000 women (Breast Cancer Now, 2024).

Historically, breast cancer diagnoses had been made entirely through clinical evaluation (Nicosia *et al*, 2023). Today, mammography is the gold standard modality for imaging breast tissue due to its ability to detect fine pathologies using a low radiation dose (Hogg *et al,* 2015). It is, consequently, the most frequently used diagnostic test in the world (Nicosia *et al*, 2023). In the year 2022-2023, in England alone, 2.18 million women over the age of 45 received a mammogram, as part of the National Health Service Breast Screening Programme (henceforth NHSBSP; NHS England, 2024). A detection-rate of 8.7 cases per 1000 women screened in the NHSBSP (NHS England, 2024) underscores just how vital mammography has become in the detection of asymptomatic breast cancer. For symptomatic men and women, meanwhile, mammography is also a vital element of the one-stop clinic. NICE (2016) states that for patients presenting with symptoms of breast cancer, a triple assessment should be performed. This consists of a clinical assessment, mammography and/or ultrasound imaging, and a biopsy. Although many challenges are faced by the modality, and the practitioners involved in modern mammography, it continues to prove its worth in the clinical setting.

Despite its proven facility, women have been widely reported to exclaim “I bet this was invented by a man!” whilst undergoing a mammogram examination. In this regard, they would be absolutely correct. Albert Salomon (1883–1976) was one of the earliest pioneers of this intricate radiographic technique, which has since become such an integral element of breast cancer diagnosis, treatment and aftercare.

Early Life and Education.

There is very little literature around Albert Salomon’s early life. We do know that he was born in the municipality of Röbel, Mecklenburg, on the 26th of January 1883, that his mother died in childbirth, and he was raised by his father and various other relatives. At the time of Albert’s birth, Germany was in a period of great political and economic change. The German Empire was in its infancy, having only formed in 1871, following three successful wars led by Prussia (Ureña Valerio, 2019). Liberal reform resulted in independence for Germany, along with their own banking system, coinage, legal system and administration. As a result, Germany saw a massive increase in its economy, and by 1914 it was considered an industrial giant (Geary and Berentsen, 2024).
Albert came from a working-class background. He was successful at school and began studying medicine at the University of Berlin in 1900. Fischer-Defoy (2024) remarked that Albert graduated with the grade ‘very good’ before eventually receiving his licence to practice medicine. His early

career was spent working as a Junior Doctor at Friedrichshain and Pankow Hospitals in Berlin, as well as the Jewish Hospital in Breslau. In 1909, he began working at the University Hospital in Berlin under the renowned surgeon, Dr August Bier (1861-1949). It would be this post that would set Albert off on the path to becoming a pioneer.

Early Experimentation.

Dr August Bier was a pioneer of medicine in his own right. He experimented with cocainisation of the spinal cord and is credited as being the first surgeon to complete a spinal anaesthetic (Johnson and Cadogan, 2022). It will have no doubt been an honour for Albert to have Dr Bier as his mentor, given his involvement with pioneering medical techniques. Even to this day, Dr Bier's many accolades are celebrated, including his invention of the steel helmet in World War I (Jackson, 2024).

Under Dr Bier's mentorship, Albert found an interest in breast cancer and how imaging could be used to benefit diagnosis, although there is limited literature available regarding this. Dr Bier clearly had an experimental approach to learning, and it may be fair to suggest this influenced Albert to conduct his own experiments. As remarked by Thomas (2022) Roentgen's discovery of x-rays in 1895 was phenomenal, and medicine was never the same again afterwards, as practitioners strived to discover how x-rays could enhance the diagnosis and treatment of patients.

The first mammogram was not performed on a patient, but on specimens obtained through mastectomies. Albert x-rayed over 3000 specimens, documenting his findings in his paper 'Contributions to the Pathology in Clinical Medicine of Breast Cancer' (Nicosia *et al*, 2023), which was published in the German journal *Archives of Clinical Surgery* (Thomas and Banerjee, 2013). Albert's work with the breast specimens allowed him to distinguish how different types of breast cancer present on x-ray, leading him to conclude that different types of breast cancer behave differently (Knipe, 2024). He also correlated the microscopic, gross and radiographic anatomy of the breast (Bassett and Gold, 1988).

Through the x-rays of the samples, Albert not only distinguished between cancerous and non-cancerous breast tissue, but his early observations led to the discovery that microscopic calcifications can be significant in breast cancer presentation. In modern day mammography, breast calcification presentation is a significant marker used in both breast screening and in symptomatic diagnosis (Elfeky, 2023). He also demonstrated how breast cancer can spread through lymph nodes. This proved a significant finding for the future development of breast imaging. In his paper, Albert concluded that "Roentgen photographs of excised breast specimens give a demonstrable overview of the form and spread of cancerous tumours" (Salomon, 1913).

These early findings enabled Albert to develop new methods of breast cancer analysis, and further evaluate how treatment could be tailored to an individual patient (Fischer-Defoy, 2024). This work created the foundation on which mammography would later be developed and contributed to the progression of breast cancer treatment. However, the outbreak of war saw such medical developments halted, and no further literature was published regarding the use of mammography until 1927 (Knipe, 2024).

World War I, Married Life and Personal Tragedy.

World War I broke out on the 28th of July 1914 and would prove to be one of the deadliest conflicts in World history. Although the war resulted in major advancements in medicine (Holder, 2004), it would also be uncontroversial to argue that doctors faced many setbacks in the development of their profession, and this is true of Albert Salomon. Whilst stationed abroad during the war, Albert met Franziska Grunwald, a military nursing sister. They married in 1916, and their daughter Charlotte

was born a year later.

For the remainder of the war, Albert worked as a senior military physician for the German Army and spent time stationed at a military hospital in Tucquegnieux, France. When hostilities finally ended, Albert returned to Berlin and qualified as a professor in 1921 (Fischer-Defoy, 2024). He continued to work under August Bier, as Associate Professor at the Berlin Charité University Hospital, combining his love of medicine with teaching, and inspiring the next generation of doctors.

In 1926, tragedy struck when Albert's wife Franziska committed suicide. She had suffered with chronic depression, but Felstiner (2009) suggests her depression was worsened by Albert's distant nature as he overworked to succeed in medicine. Her death not only left Albert a widower, but a single father, with an 8-year-old daughter to single-handedly care for. The unexpected loss shook Albert, and he kept busy by further throwing himself into his work and research. He was promoted into the role of Extraordinary Professor of Surgery in 1927 (Fischer-Defoy, 2024).

The Nazi Rise to Power in Germany.

In 1930, Albert remarried internationally renowned singer Paula Lindberg. Paula was Jewish, and Albert made the decision to convert both himself and his daughter Charlotte to the Jewish faith. Albert's family life was settled once more, but it was not long before further hardship and tragedy ensued.

In 1933, the Nazi Party came into power in Germany. This political change brought with it changes for the Jewish community. Felstiner (2009) reflects that as a result Albert lost his post as Extraordinary Professor of Surgery, and his wife's singing career ground to a halt. Albert's daughter Charlotte was forced to leave school, and began putting all her efforts into her love of art. She would eventually become a famous artist, whose work is still admired to this day. In truth, most of the literature written about Albert's life exists only because of Charlotte's continued legacy in the world of art. Despite being committed to his Jewish faith, Albert managed to retain his licence to practice medicine and worked as the Head of the Surgical Department at the Jewish Hospital in Berlin. Fischer-Defoy (2024) reports that his licence was not revoked purely on the basis that Albert was a World War I veteran, who had served Germany in the war. Albert was, however, only permitted to treat Jewish patients, and was no longer authorised to teach.

On the night of the 9th of November 1938, savage antisemitic attacks against the Jewish communities across Germany took place. This event is also known as the 'November Pogrom' or 'Kristallnacht' meaning 'crystal night' or 'the night of broken glass'. On this night, the Nazi Party ordered the police to arrest some 30,000 Jewish men (Ross, 2019), one of whom was Albert Salomon (Felstiner, 2009). Those who were arrested were processed and sent to concentration camps. Following his arrest on the 10th of November 1938, Albert was sent to Sachsenhausen Camp in Oranienburg, Germany. The camp had been established in 1936 and was just 22 miles north of Berlin. During his time as a prisoner, he was starved, tortured, and forced into intense labour alongside his fellow inmates. Bentley (2017) reflects that just four months after being imprisoned, Albert lost half of his entire body weight and was completely emaciated. It is speculated that Paula, who was well connected via her career as a celebrated singer, managed to have forged documents drawn up to have Albert released. Although it is known that Albert did escape the camp, there is no evidence to suggest who had helped Paula with the documentation.

Fearing for their lives, the Salomon family realised they would need to leave Germany whilst they were still able to do so. Albert sent Charlotte to live with her maternal grandparents in the South of France, and he and Paula left for Amsterdam on the 15th of March 1939. Fischer-Defoy

(2024) states that immediately after evading arrest, Albert and Paula's property and possessions were seized by the authorities.

Life in Amsterdam During World War II.

Upon arrival in Amsterdam, Albert learned that his German medical qualifications were not recognised. Determined to continue the work and research to which he was completely dedicated, Albert decided to study Dutch, and eventually enrolled to study Medicine once more (Fischer-Defoy, 2024). While Albert and Paula remained safe in Amsterdam, the same could not be said for Albert's daughter Charlotte. Tragedy had struck the family once more in 1940, as Charlotte's maternal Grandmother committed suicide. Following this tragic event, Charlotte's Grandfather admitted to Charlotte that her mother and aunt had both committed suicide also. Bentley (2017) reflects that, upon this sad discovery, Charlotte wrote to her father expressing her anger at him for keeping such secrets. The ghosts of the family's past will no doubt have widened the distance between father and daughter. It was at this time that Charlotte painted some of her most famous artwork.

In May 1943, Albert and Paula were arrested and deported to Westerbork Transit Camp. Westerbork was designed as a holding point for Jews arrested in the Netherlands, before they were processed and sent to death camps elsewhere (Etheredge, 2024). Fischer-Defoy (2024) reflects that during their time in the camp, both Albert and Paula worked as auxiliary helpers within the barracks of the camp. It was their working roles within the camp that secured them their eventual freedom. In November 1943 whilst pretending to collect medical equipment from Amsterdam, the pair escaped. For the remainder of the war, Albert and Paula remained in hiding in Southern Holland.

When the war eventually ended, and it was safe to return to Amsterdam, Albert learned that his daughter Charlotte had suffered the most tragic fate years earlier. Throughout the summer of 1940, Charlotte and her grandfather had been imprisoned in Gurs, a concentration camp in The Pyrenees. They were both eventually released, given Charlotte's Grandfather's infirmity, and were able to return home to Villefranche-sur-Mer in the South of France. However, upon their return, Charlotte is thought to have suffered a nervous breakdown and she moved out of her grandfather's home. Much of Charlotte's later life is debated in literature. Bentley (2017) suggests that Charlotte had suffered many years of abuse at the hands of her grandfather and may have even been responsible for his death in 1942, although it is hard to know what is factual and what is speculation. Just months after her grandfather's death in 1943, Charlotte who was now aged 26 and married, was arrested again. She was five months pregnant at the time and deported to Auschwitz concentration camp in Poland. She was killed within an hour of arriving at the camp, a fate that met the majority of pregnant Jewish women taken to Auschwitz. Albert had hoped to relocate to the United States of America and be reunited with Charlotte after the war, and so this latest tragedy in Albert's life was a heavy blow.

The End of World War II and Return to Amsterdam.

In 1946, Albert received his licence to practice medicine in the Netherlands. In 1947, Albert and Paula travelled to the South of France where they were presented with all of Charlotte's artwork. Mackenzie-Smith (2018) writes that before her arrest, Charlotte had entrusted her life's work to her friend Georges Moridis, telling him "Keep these safe, they are my whole life." The art of Charlotte Salomon is to this day celebrated, and widely viewed as a collection of pieces that portray her tragic life story. Albert ultimately donated Charlotte's artwork to the Jewish Historical Museum in

Amsterdam, where to this day it is subject to exhibition.

In the following years, both Albert and his wife Paula decided they could never face returning to Germany and assumed Dutch nationality, with Albert continuing to privately practice medicine. Albert passed away on the 7th of May 1976, and is buried in the Liberal Jewish Community cemetery in Hoofddorp, near Amsterdam. In 2000, a commemorative stone was placed at his grave in honour of his daughter Charlotte, and in 2011, a plaque in his honour was placed at the house in Robel where he was born. Albert's wife Paula outlived him by 24 years, passing away at the age of 102 in 2000. In 2012, memorial plaques for both Paula and Charlotte were placed at the site where the family once lived in Berlin.

Lasting Legacy and Modern-Day Mammography.

Although Albert Salomon's contribution to the world of breast cancer diagnosis and treatment was halted prematurely, his early findings paved the way for future generations of surgeons, clinicians and radiologists alike to further develop his ideas.

As noted above, Mammography is a vital tool in the diagnosis and treatment of breast cancer and has today been developed far beyond the early work of Albert Salomon. In the years following this groundbreaking work, further research was published by surgeon Otto Kleinschmidt in 1927. The first mammogram on a patient was performed in the United States of America by radiologist Warren Stafford in 1930 (Nicosia *et al,* 2023). We know that during the time of these advancements, Albert Salomon was experiencing great tragedy, stress and unrest in his life and his research was somewhat interrupted. Without the tragic personal circumstances with which he was faced, as well as the political unrest and horrific events caused by World War II, perhaps Albert Salomon would have been free to further his work and build on the success of his early research.

In the 1950s mammography was developed further by radiologist Raul Leborgne, who further determined the benign and malignant patterns of microcalcifications, as well as experimenting with breast compression to improve image quality and reduce radiation dose (Nicosia *et al, 2*023). Collins (2015) reflects that the first dedicated mammography unit was introduced in 1965. By the 1970s, mammography was recognised as a useful screening tool for breast cancer. In 2000, the U.S FDA approved the first digital mammography unit, resulting in high quality, low dose breast imaging.

Although the mammogram examination itself remains highly unpopular, its use has contributed to the many advancements that have been made in prognosis and care of patients diagnosed with breast cancer.

In the United Kingdom today, the role of the mammographer is a protected title, reserved for radiographers who have undertaken further postgraduate training. The introduction of the role has contributed to the widening scope of practice for diagnostic radiographers. Thanks to the developments within mammography, mammographers can easily enhance their scope of practice and undertake training to become advanced practitioners. Advanced practitioners may specialise in film reading, breast ultrasound, or stereotactic breast intervention. Mammographers can progress to a consultant breast radiographer role with experience. In the Society of Radiographers 2022-2023 workforce survey, 52.8% of consultant radiographers were working within the breast field (SoR, 2023), highlighting the opportunities for progression with the specialism.

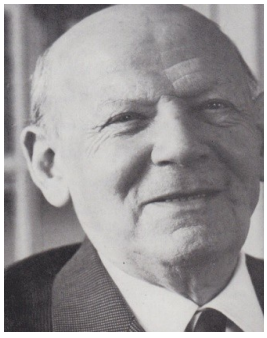
Despite the opportunities mammography can lead to, there is currently a workforce shortage in the field, with approximately 12% of posts currently vacant (National Breast Imaging Academy, 2023). As a result, roles such as the assistant practitioner, and more recently, the mammography associate have been introduced to strengthen the workforce in the United Kingdom and improve the

breast services offered within the National Health Service.

None of these advancements would have been possible without the early research of Albert Salomon, who overcame many personal tragedies, prejudices and adversities to continue his dedication to his work.

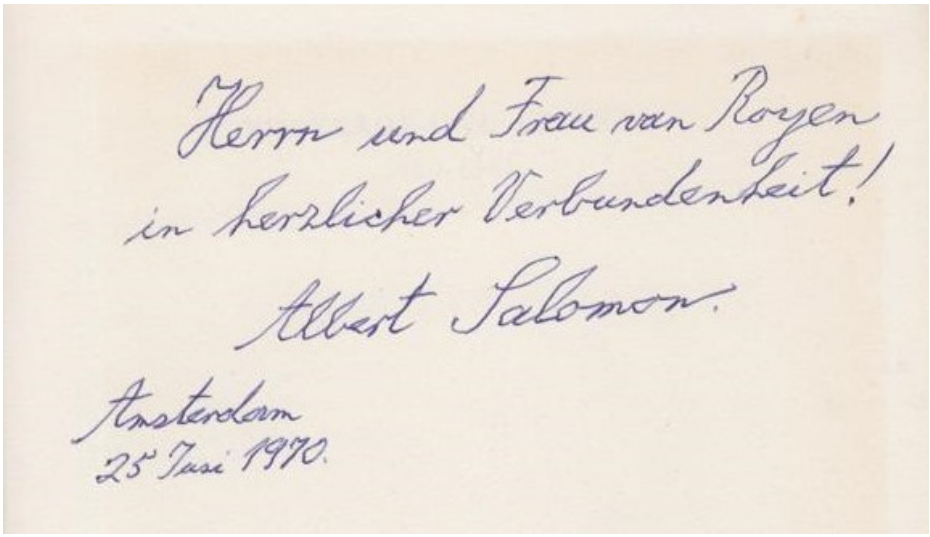
Images.

Dr Albert Salomon, pictured with his daughter Charlotte.
Case courtesy of Garth Kruger, Radiopaedia.org, rID: 30351



Dr Albert Salomon.
(Case courtesy of Garth Kruger, Radiopaedia.org, rID: 30351)

A letter written by Dr Albert Salomon, depicting his signature.
(Case courtesy of Garth Kruger, Radiopaedia.org, rID: 30351)



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