An outline of the history of radiotherapy at the Institute of Oncology in Ljubljana from its beginning till 1980s

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Background. *The article presents the milestone events in the history of radiotherapy at the Institute of Oncology since its establishment till 1980s. It reviews the facts deduced from various jubilee publications, seminar reports and staff interviews of the Institute of Oncology. The aim of the article is to present the chronological history of radiotherapy at the Institute of Oncology, and to supplement the fragmented and incomplete records written in the past.*
Conclusions. *Available records are occasionally discrepant, but the most significant events in the history of the Institute of Oncology and its Radiotherapy Ward can nevertheless be ascertained.*

Key words: radiotherapy - history - trends; medical oncology; Ljubljana

Introduction

The inception of the Institute of Oncology goes back to October 1917, when Dr Josip Cholewa (Figure 1), Chief Physician of the regional hospital in Brežice, used his modest resources to found an oncological laboratory. He successfully performed experiments in it, and published results in national and foreign scientific literature. Cholewa had studied medicine at the University of Krakow, and later specialized in surgery. While practising the latter, he became interested in oncology. His experimental inducement of cancer was based on the realization that cancer in humans did not differ significantly from cancer in other mammals.[1] He maintained contacts with prominent oncologists in the World, and attended many congresses abroad. In September 1921, he lectured on induced blastoma in a white mouse in Zagreb. His work aroused keen interest abroad. He was the initiator of the »*Yugoslav Committee for Cancer Abatement*«, and instrumental in the establishment of the *Institute for Research and Treatment of Neoplasms of Dravska banovina* (an administrative unit of the pre-war

Received 3 September 2003
Accepted 14 September 2003

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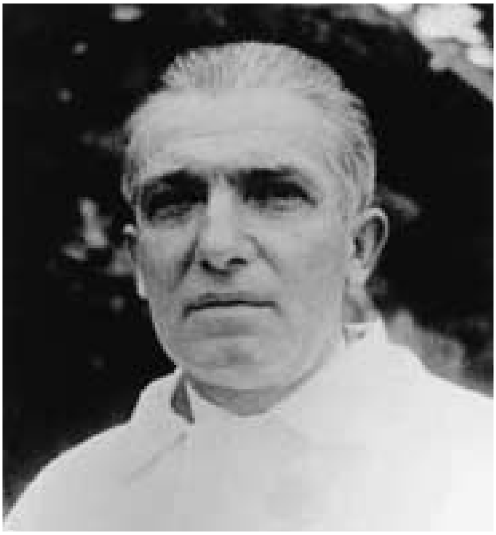

Figure 1. Dr. Josip Cholewa, who found an Oncological Laboratory and who was instrumental in the establishment of the *Institute for Research and Treatment of Neoplasms of Dravska banovina* (an administrative unit of the pre-war Yugoslavia, corresponding largely to the present-day Slovenia) in1937.

Yugoslavia, corresponding largely to the present-day Slovenia) in1937.[2]

Other people, besides Cholewa, must be given credit for the establishment of the Institute. One of them was Dr. Gerlovič, Principal of the State Hospital for Mental Disorders in Ljubljana, whose rich experience was always at the disposal of the Institute. Janko Dolžan, Senior Inspector of *Dravska banovina*, was a regular visitor to the Institute. Ever since the lecture of Professor Blumental in Ljubljana in 1935, the establishment of the Institute was strongly supported by Dr. Mayer, while Dr. Pogačnik, Head of the Department of Otology at the General Hospital in Ljubljana, supplied resources for radium treatment as early as 1928.

The Institute for Research and Treatment of Neoplasms (IRTN)

Prior to the establishment of the Institute for Research and Treatment of Neoplasms in *Dravska banovina* (IRTN), oncological patients had been treated in surgical, gynecological, otological, ophtalmological and other wards in hospitals throughout Slovenia, and the treatment consisted of surgical operations for the most part. Surgeons invested great efforts in saving operable patients, but their interest rapidly ebbed in case of recurring disease, metastases, or inoperable tumours. The new institute filled the void in the cancer treatment of the time.

The IRTN was opened in the southeastern extension of the military hospital in Šempeter. On the ground floor, a boiler room and facilities for test animals were installed. Four patient rooms with 30 beds, an office, a library, the principal's office, a tea kitchenette, toilets, two bathrooms, a waiting room, an outpatient surgery, roentgen - and radiumtherapy facilities, and an operating theatre were provided on the first floor.[3]

The radiotherapy equipment of the IRTN consisted of three units.[4] The *Siemens Stabivolt* (Figure 2) was used for deep therapy, and its orthovoltage roentgen tube worked at 15 mA and 200kV. The tube was mounted on a special casing, which functioned as the shield against high voltage and secondary radiation. The tube was adjustable along all three axes, so that the rays could reach any part of the body. At the time, the *Stabilivolt* was a state-of-the-art radiotherapeutical de-

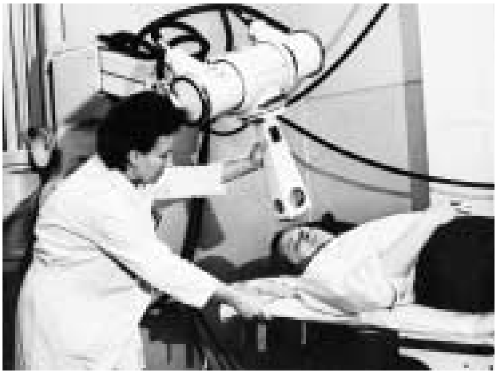

Figure 2. Stabilivolt, a 200 kV device for radiotherapy, made by Siemens.

vice. Its high quality enabled the Oncological Institute to use it until the year 1977, for no less than four decades.

The second unit of the radiotherapy equipment was a *Schafer-Witte*, used for contact intravaginal irradiation. It worked at the maximum voltage of 100 kV and with maximum amperage of 5 mA. A special x-ray tube irradiated neoplasms with straight beams or at an angle, so that cervical cancer could be treated without damaging healthy tissue.

The third device was a *Chaoul*, similar to the *Schafer-Witte* in construction, but working at a lower voltage of 60 kV and maximum amperage of 5 mA. The apparatus was used for contact irradiation of superficial neoplasms. The roentgen tube was cooled with water.

All three pieces of radiotherapy equipment had timers on their respective switch boards, which controlled the duration of irradiation. The control unit was separated from the devices with lead-coated partitions and lead-glass windows, shielding the staff from radiation. The dosimetry was performed with an electrostatic *Hammer dosimeter* with two ionization cells.

The southeastern extension of former military barracks in Šempeter, where the IRTN was set up, was short of room, but an operating theatre with adjoining scrubbing facilities was nevertheless installed. It was small, but fully equipped for major surgeries. The attic accommodated separate rooms for patients' wardrobe, sterilization, chemical, chemobiological and histopathological laboratories, pharmacy, filing cabinets and storage, three rooms for physicians, a room for orderlies, three rooms for nurses, a bathroom and toilets.

Although the IRTN was fully equipped for research and treatment of neoplasms, the shortage of room soon became an impediment, since, in addition to the Institute's own patients, outpatients were sent there for radiotherapy by other medical institutions. Meals were delivered from the nearby hospital for mental diseases, where the laundry was done as well.

The IRTN's resources depended largely on external sponsors. The purchase of 300 mg of radium, for example, was made possible by the *Savings Bank of Dravska banovina*. The material lasted for quite some time, since the *Schafer-Witte* and the *Chaoul* substantially relieved and partly replaced the radium-therapy.[3]

The Principal of the IRTN was Dr Cholewa, the Chief Physician was Dr Lev Šavnik, a gynecologist, who had previously been in charge of radiotherapy at the Roentgen Department of the State General Hospital in Ljubljana. The two of them were assisted by three younger physicians. The histopathological laboratory was lead by Professor Alija Košir, the roentgen equipment, radium and other physical appliances were taken care of by France Avčin, an electroengineer, the scientific chemical laboratory was lead by Professor Vladimir Premru.

From World War II to the Institute of Oncology

During the Italian occupation (1941-1943), the IRTN of *Dravska Banovina* was replaced, to a limited degree, by the *Institute for Neoplasms of the Ljubljana Province* (since *Dravska banovina* no longer existed). After the death of Dr Cholewa in 1943, the management was taken over by Professor Šavnik.

In August 1945, the Institute merged with the Roentgen Institute of the former General Hospital, and became the *Institute of Roentgenology and Radiology* of the newly established *University Hospitals* in Ljubljana.[5] It was headed by Dr. Josip Hebein. Already in April 1946, the two institutes were separated again, and the name of the former changed to *Institution of Oncology.*

In December 1948, the *Chair of Oncology and Radiotherapy* was opened and the same time the name *Institution of Oncology* changed to *Institute of Oncology.* The management of the Institute, which was still attached to the University Hospitals, was taken over by Professor Šavnik, who remained its principal until the year 1963.

During the first few years after the war, radiotherapy was the fastest developing activity, propelled by the newly acquired equipment. Until 1949, radiotherapy was performed by only one radiologist, who was in charge of x-ray diagnostics as well. The shortage of manpower made it necessary to engage physicians who were trained as radiotherapists on the job. After the year 1949, the Institute started to educate radiotherapists systematically. In 1955, two physicians (Dr. Danica Žitnik and Dr. Majda Mačkovšek-Peršič) successfully passed the specialist exam in radiotherapy. This achievement was

Figure 3. Stabilipan, a 300 kV device for radiotherapy, suitable for superficial irradiation, and allowing 3 to 5 combinations of voltage, made by Siemens.

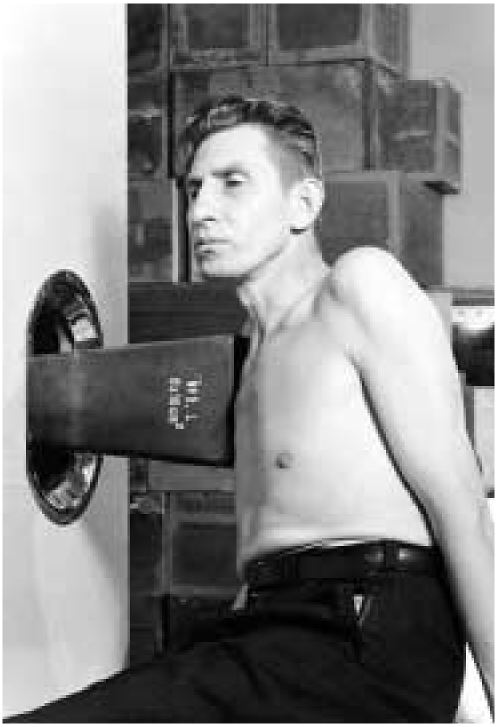

Figure 4. Betatron, the 31 MeV circular accelerator, enabling supervoltage radiotherapy.

the beginning of radiotherapy as an independent branch of medicine in Slovenia. By the year 1963 six other physicians had passed the same exam.[4]

At that time, radiotherapy was the most important therapeutic activity at the Institute. The equipment was relatively modest in the beginning, but it improved considerably over the first few years. In addition to the Stabilivolt and two other out-dated roentgen devices, the Institute acquired, in 1952, a *Siemens Stabilipan* (300 kV), suitable for superficial irradiation, and allowing 3 to 5 combinations of voltage (Figure 3). It was used primarily in the treatment of superficial and semi-deep seated tumours. The focus of source-skin distance and the size of the field were regulated by a special accessory unit, an *applicator*, which reduced the scattering of rays and adjusted the field of irradiation. In those years, the Institute received 600 mg of radium from the

United Nations Relief and Rehabilitation Agency (UNRRA).

In 1955, the irradiation of patients with a *31 MeV Betatron* (Figure 4) started, which was another milestone event. The Betatron was the first circular accelerator and, due to its high energy potential, the first device enabling supervoltage radiotherapy. It was bought by the Institute of Physics *Jožef Stefan*, and also installed there. It was used both for research and for treatment. Unfortunately, patients had to be transported all the way through the city, which made the therapy even more complicated. During the irradiation, patients were placed on an adapted operating table. The position of the patient had to be adjusted to the horizontal emanation of beams - patients with lung cancer were treated in sitting position.

In 1958, the idea of complete autonomy of the Institute was reborn. The aspirations resulted in the Institute of Oncology becoming and independent institution on August 1, 1961, exactly after 23 years of its existence.

The development of radiotherapy at the Institute of Oncology from 1961 till 1980

The period between 1961 and 1970 was marked by the efforts to build new facilities and acquire larger premises, as well as to expand the research activity. The Institute obtained some new radiotherapy equipment, but the shortage of room hindered its efficiency. Towards the end of the 1960s, the blueprints of a new building for teleradiotherapy were designed. By the year 1968, the bulk of resources necessary for the construction of the new Institute of Oncology had been accumulated in the *fund for the construction of the new Institute of Oncology* (set up in 1965). The building was to be erected on the right side of the Ljubljanica river. The facilities for the teleradiotherapy were the first to be built, but the plans fell through because of the construction of the new University Clinical Centre.

Figure 5. Gamatron, supervoltage device with sealed radioactive source for deep irradiation, the source of Co60 with activity of 111 TBq (3000 Ci), made by Siemens.

The first supervoltage device with sealed radioactive source used at the Institute of Oncology (in 1962) *was a Siemens Gamatron* (Figure 5), a *Co60* unit, with the initial activity of 111 TBq (3000 Ci). The activity of the cobalt source (Co60) was 111 TBq, and its head made of wolfram, which shielded the environment from radiation, weighed more than half a ton. It was used for deep irradiation, and soon nick-named *the Cobalt Bomb*. In addition, two roentgen diagnostic devices were bought. They were used for tracing the localizations of irradiated fields and the position of brachytherapeutic sources of radium, as well as for diagnostic purposes.[5]

Figure 6. The lead wire for tracing the body contour, in which the position of the tumour and of other organs were marked while devising the irradiation plan,

Figure 7. Needle contour device with radially arranged metal needles for tracing the body contour.

The body contour, in which the position of the tumour and of other organs was marked while devising the irradiation plan, was traced with the help of a lead wire (Figure 6). It was wrapped around the patient, then carefully removed and copied to tracing paper. The method was very imprecise, since distortions of the wire were inevitable during its removal from the patient.

In the middle of the 1960s the body contours were traced with a special *needle contour device (NCD)*, with radially arranged metal needles (Figure 7). The tips of the needles were pressed against the patient's body, and then the dots were copied to the tracing paper and connected into a line.

In the beginning, the protection of healthy tissue around the irradiated area consisted of standardized lead blocks of different shapes (Figure 8), attached to an acrylic plate (or inserted between two such plates). This method is still applied with sealed sources of radiation (cobalt), but for linear accelerators it was replaced by customized shields in the 1990s. The only exception in the use of standardized shields was the treatment of patients with Hodgkin's disease. Custom shields were made for them at an early date. Depending on the shape of the part of the body that needed shielding, holes were cut out of a Styrofoam board with a hot wire, filled with protective lead pellets, and sealed with paraffin.

Figure 8. The standardized lead blocks of different shapes for protection the healthy tissue around the irradiated area.

Figure 9. A special cardboard profile, which allowed the resumption of the patient's position during the planning and during the irradiation process.

It is crucial that the position of the patient remains the same throughout the therapy, especially when the patient's head and neck with many sensitive organs are within the irradiation field. It is the only way to make irradiation effective, and the protection reliable.

In the beginning, patients with tumours in the head and neck were secured in their position with the help of a special cardboard profile (Figure 9), which allowed the resumption of the position during the planning and during the irradiation process. The profile was taken with the help of a special device made of metal needles. Once the position of the patient was secure, the metal needles were arranged along the patient's profile and fixed. The contour was copied to the cardboard and the profile was cut out of it.

Figure 10. *Theratron 80*, the supervoltage device with sealed radioactive source for deep irradiation, the source of Co60 with activity of 222 TBq (6000 Ci), made in Canada.

In 1969, another sealed source apparatus (Co60) joined the slightly out-dated and overloaded *Siemens Gamatron*. It was a *Theratron* 80, 222 TBq (6000 Ci), made in Canada (Figure 10). It was provisionally set up in the adapted former garage near the isotopic laboratory. Its specialty was the so-called »beam stopper«, which intercepted the exiting radiation, so that the room needed considerably less shielding than in the case of devices with no such accessory.

Still, it was yet another proof of how the shortage of space impeded the development of radiotherapy.

Towards the end of the 1960's, body contour tracing was performed with a pantograph (Figure 11), a mechanical device which traced the contours of the body on paper while a radiographer moved its antenna along the surface of the patient's body. Several types of pantographs were used, from mechanically very simple ones, to complex and precise devices. A pantograph is still part of the standard equipment of the Teleradiotherapy Department. Being a mechanical instrument, it can hardly ever fail. It serves as a back-up device to more modern and complex appliances (such as CTs or lasers).

In spite of the fact that everything pointed to the Oncological Institute moving to a new location towards the end of the 1960s, the early 1970s clearly revealed that other projects had priority. The *Act on the Construction of the University Clinical Centre* (passed by the Assembly of the SR Slovenia in May 1981) stipulated the construction of the TRT on the left bank of the Ljubljanica river, on the premises of the old auxiliary units of the Clinical Centre. The postponement was a huge blow to the Oncological Institute, curtailing its spatial perspectives. To compensate for that, the Oncological Institute was given the old building of the Internal Clinic, which was renovated with the funds for the construction of the new Oncological Institute - the renovation cost 500 million dinars.[3]

Figure 11. A pantograph, a mechanical device, which traced the contours of the body on paper while a radiographer moved its antenna along the surface of the patient's body.

Figure 12. The simulator *Ximatron*, used for the preparation and planning of radiotherapy, made by *TEM* in United Kingdom.

The Teleradiotherapy Department moved to the renovated building of the Internal Clinic, which became the new building C of the Oncological Institute. All existing equipment was transported there, except the *Gamatron*, which went out of use. Two new roentgen devices were bought. The first one was the simulator *Ximatron TEM* (Figure 12), used for the preparation and planning of radiotherapy. The apparatus simulated the conditions on irradiation devices, determined the irradiation field in the patient, and tested the shielding. One of the major advantages of simulators is that the irradiation field is immediately visible on the screen. Since the table with the patient is movable as well, any aberration can be immediately detected and rectified, without the time-consuming radiography. This must be done only at the end, for verification, possible fabrication of shields, and records.

Figure 13. *Transversal Tomograph*, which enables the contactless tracing of body contour.

Figure 14. The *fixation mask*, which secures the patient's position during the treatment.

The second new device was a Japanese *Toshiba Transversal Tomograph* (Figure 13).

It changed completely the treatment planning and the body contour tracing procedure. It made it possible to locate the precise site of the tumour in relation to all internal organs in the vicinity, which was of crucial importance for the treatment planning. The body contour tracing became contactless, the wrapping of the patient with a wire, or pressing metal needles against the patient's body became superfluous.

In the middle of the 1970s *fixation masks* replaced cardboard profiles in securing the patient's position during the treatment (Figure 14). The procedure was long, uncomfortable and difficult for the patient. The masks were made in a special workshop, and their fabrication took one whole day.

Figure 15. The cornerstone for the new teleradiotherapy building was laid.

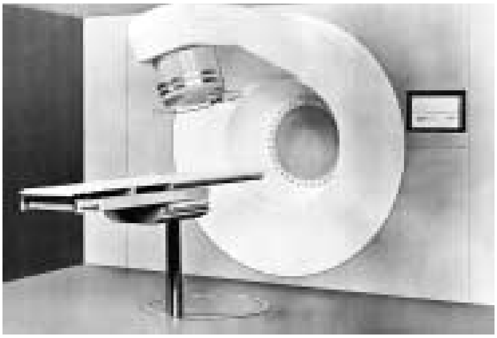

Figure 16. *The linear accelerator* SL75/20, a supervoltage radiotherapy device made by *Phillips*. It was used until the year 2000.

After the disappointment in 1971, the struggle to overcome the shortage of space continued. The staff of the Institute of Oncology became more optimistic on November 1974, when the cornerstone for the new teleradiotherapy building was laid (Figure 15). The construction took three years, and the Teleradiotherapy Department moved to new premises in 1977.

Figure 17. A sealed source radiation (Co60) device made by *Phillips*. It is still being used.

Figure 18. The Phillips simulator, which went out of use in 1999.

All the existing equipment, except the Gamatron, were moved to the new building. Two new supervoltage radiotherapy devices were installed there as well - a new *Phillips linear accelerator SL75/20* (Figure 16), which was used until the year 2000, and a sealed source radiation (Co60) apparatus of the same producer, which is still being used (Figure 17),. In addition to the *Ximatron* simulator, a new Phillips simulator was installed (Figure 18), which went out of use in 1999.

The Teleradiotherapy Department of the Institute of Oncology is still confined to the same premises, although it has outgrown them already. The number of patients has greatly increased since the 1980s, and so has the staff. The purchase of new equipment promotes the efficiency of the Institute, but the finalization of the new Institute of Oncology will have to be next step. Although the teleradiotherapy will remain in the same building, some additional room will be provided in the new building, reducing the shortage of space, especially in view of the imminent purchase of three new linear accelerators.

Acknowledgement

We thank all the staff of the Institute of Oncology for the help rendered in the collection of historical data. A special thank-you goes to Boris Sekereš.

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