Radiotherapy – Past and Present an Indian Update

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NCD – Role of Radiographer

- Non communicable disease- NCD
  - Chronic one
  - Non infectious
  - Not transmissible directly from one person to another
  - Leading cause of death and disability in world
  - Tend to be long duration
    - Combination of genetic, physiological, environmental and behavioural factors
  - Cardio Vascular Diseases, Cancers, Chronic Respiratory diseases and diabetes are some of Non Communicable disease

- Role of Radiographer in handling Non communicable disease
  - Communication
  - Comfort
  - care

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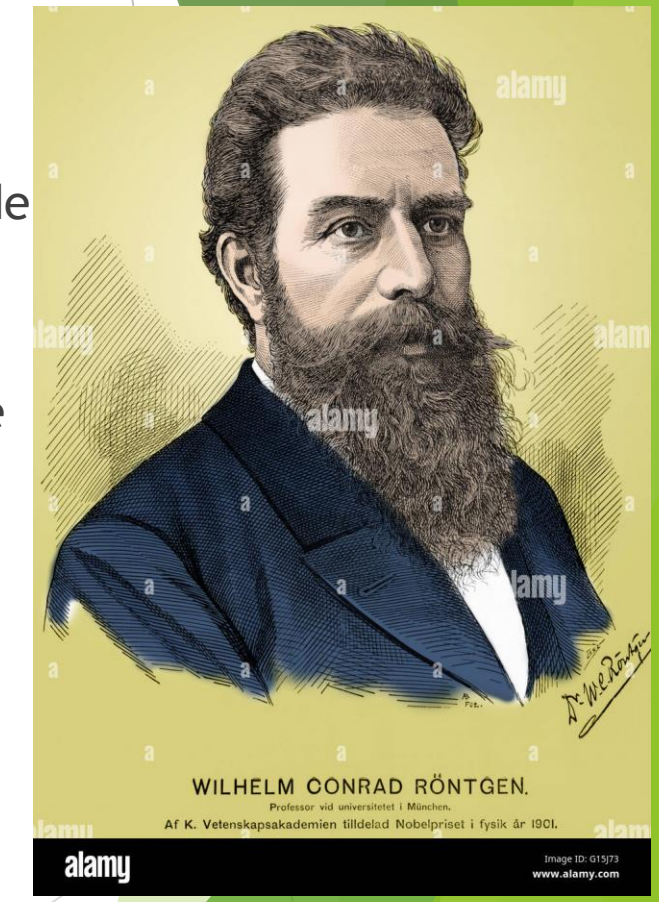
- Introduction
- Invention of X ray, Radium etc
- Radiotherapy development – international scenario
- Radiotherapy history and development – An Indian scenario
- Education opportunities and update

Radiotherapy - Basics

- Oncology
  - Study of tumours
- Radiation Oncology
  - Study and deals with generation, conservation and dissemination of knowledge , expertise in therapeutic application of ionizing radiation (x rays and other radioactive sources) to treat benign and malignant tumours
- What is Radiotherapy
  - Branch of Radiation Oncology, where x rays, Gamma ray emitters utilized to treat patients suffering from benign and malignant tumours and other malformations
  - Aim is to deliver precisely measured dose to target and minimize the radiation to adjacent OAR and other healthy tissue

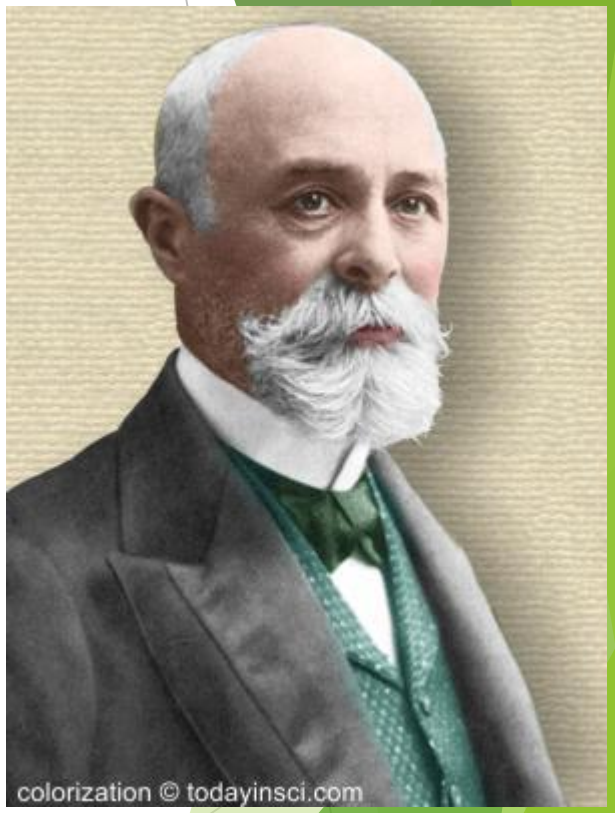
Development across globe
1895 - Roentgen

- Discovery of X-Rays by Wilhelm Roentgen in 1895, while studying the cathode rays.
- Observed another type of radiation produced and detected outside the tube
- These rays could penetrate opaque substance, producing fluorescence, damage photographic plates
- Coined as X-Rays
- Awarded First Noble prize in Physics in 1901



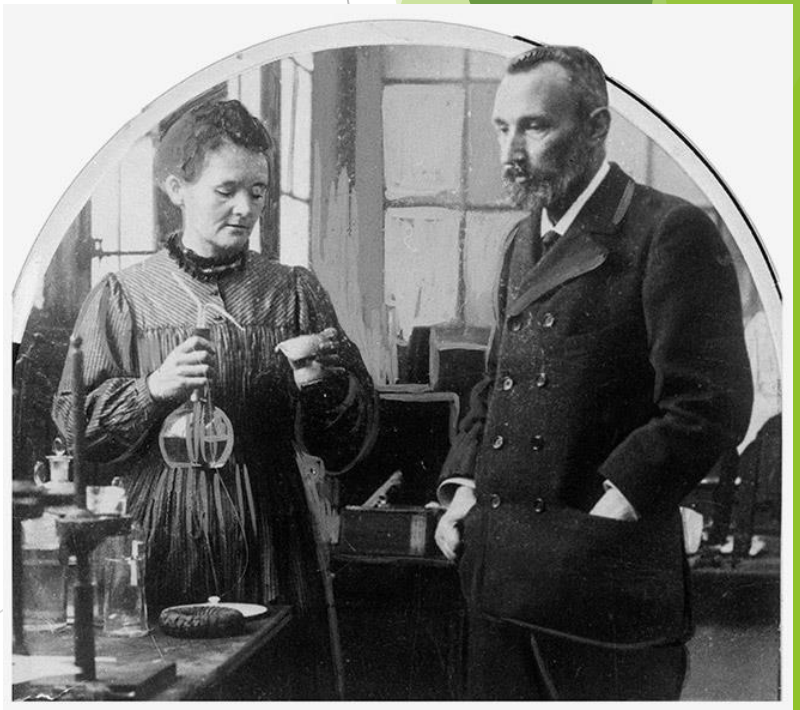
Development across globe
1896 - Henri Becqueral

- Discovery of spontaneous Radioactivity
- Thought of phosphorescent material like Uranium salts might emit penetrating radiation when subject to bright light
- May 1896, announced penetrating radiation from Uranium comes out without any need of excitation by external sources



Development across globe
1898 – Marie Curie, Pierre Curie

- Student of Becquerel
- Found that the Amount of Radiation intensity is directly proportional to the amount of Uranium in a substance
- Isolated Polonium (after home town POLAND) and Radium in 1898
- Received Noble prize in Physics shared with Becquerel in 1903



1920 – 1930
Claude Regaud

- High dose delivery in short period – Initial day practice
- Claude advocates differential effect of x rays on cancer and normal tissue.
  - Healing process very much better when skin cancer treated over a period instead of a day
- Fractionation principle is the most commonly used process now a days
- Henry Coutard, an French Radiation oncologist used this fractionation in widely to different variety of tumours, successfully utilized in advanced laryngeal cancer in 1934. PIONEER of Fractional dose

1951 - 2010

- October 27, 1951 – world 1st cancer treatment with cobalt 60 radiation
  - 43 year patient with cervical cancer treated
- 1956- Medical Linear Accelerator developed by Dr Henry Kaplan and Physicist Edward Ginzton at Standord University, San Francisco
  - Capable of producing high energy, deep penetration, without excessive damage to skin and other normal tissues
  - 2 year child, Gordon Isaacs with Retinoblastoma received treatment using Linac
    - Disease free for more than 40 years with good vision
- 1990 – Introduction of 3D conformal therapy
  - CT images used for getting patients 3 dimensional information for planning
- IMRT- advanced form of 3D conformal therapy
  - Using sophisticated soft ware and hardware
- IGRT – Image guided Radiotherapy
  - Modern linacs with Imaging facility _ OBI

Teletherapy - KV Era

- Development of Radiotherapy facilities and procedures, mostly followed the western pattern.
- Mostly 60 kV – 100 kV units available for treatment, including the Radium institutes
- In the early 1950's ortho voltage 200 – 400 kV range deep X-ray units available for treatment in India.
- Draw backs- Quality and Depth dose were very poor

Megavoltage – Time line

- To Overcome the drawbacks like depth dose and quality issues of orthovoltage units

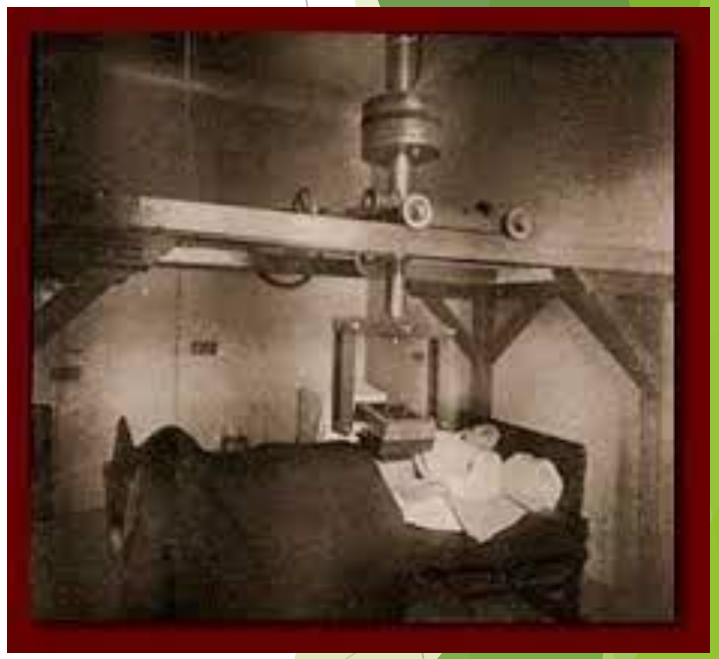
- In 1951 designed by Harold Johns, made by Atomic energy of Canada, commercial model of co 60 teletherapy starts functioning from 8th Nov 1951

Radiotherapy in India

- January 25, 1910 –
  - Countess of Minto opened the First Radiotherapy Department
  - @ Calcutta Medical College Hospital
  - Deep x rays and Radium used for treatment
  - Use of radium date not known, but established reports
    - 1920 Deep xrays utilized in cancer treatment
    - 1926, Radium usage in Brachytherapy

Radium Institutes

- 1930 Radium in Bulk arrived at Ranchi- transported to Patna – clinical use
- Over the years 20 Grams of radium – powder form
  - Hundreds of thin platinum-iridium tubes and needles



- Early 1940, four - Radium institutes established
  - Radium Institute @ Patna
  - Radium Institute @ Agra
  - Barnard Institute of Radiology in Madras (Chennai)
  - Medical College of Lahore (at present in Pakistan)

- 1941- First Radon Plant at Tata Memorial Hospital
  - By Ramaiah Naidu- Associate of Madame Curie

- 1956 the first co 60 based unit, Eldarado A commissioned at Chennai cancer institute
- 1958- Theratron junior – first isotope teletherapy unit installed at Tata Memorial hospital, Mumbai
- 1965 Either co60 or Caesium based 19 units in functioning in India
- JANUS- (named – Roman Mythological God)- Two headed cobalt unit at TMH
  - Installed at adjacent rooms- source movement from head to another head

- 66 RT depts. With Megavoltage units in 52 towns
- Tamil Nadu, Kerala and UP, Delhi regions had 26 RT centres with 38 equipments by 1970
- 1962, cancer institute in Chennai developed first Tele cesium unit in collaboration with Atomic Energy establishment, Trombay

Fig. 1. Pneumatic 5-gm. Unit and Storage Safe, connected by flexible metal pipe.

Growing numbers

- By 1975 the number of installation IN India fastly grown to 49
- 1978- around 57 Telegamma units on operational
  - 10 ceasium based units
  - 34 co based units
    - 17 Eldorado
    - 17- dual headed vertical beam units (Janus) manufactured in india
    - Rotation therapy units starts functioning

Linac Era

- 1976- First LA Clinac-4 with 80 cm SAD - installed at Cancer Institute Chennai
- 1978- The only Betatron in India – Christian Medical College, Vellore
  - High energy Particle Accelerator
- March 1990- Indigenously developed LA-Jeewan Jyoti
  - Installed at Post Graduate Institute of Medical education and Research (PGIMER), Chandigarh
- 1994- Cone based Stereotactic procedure started @ Apollo Cancer Hospitals, Chennai
  - LA modification by attaching cone based system –

    BRW frame

    GTC- SRT process

Dedicated X-Knife system – 600SR

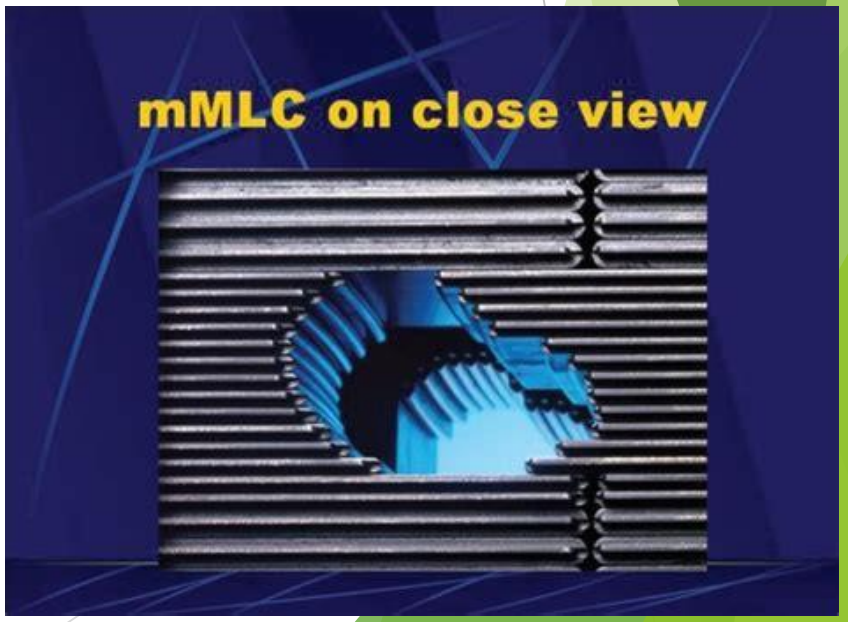
- 1996

- 600 SR unit by Varian @ Indraprastha Apollo Hospitals, New Delhi
- South Asia's First Dedicated Radiosurgery System
  - Cone based
  - Circular field opening,0.25 cm upto 4 cm with 0.25 increment cone size
  - BRW – for SRS
  - GTC – SRT
  - Sophisticated alternative treatment for AVM-

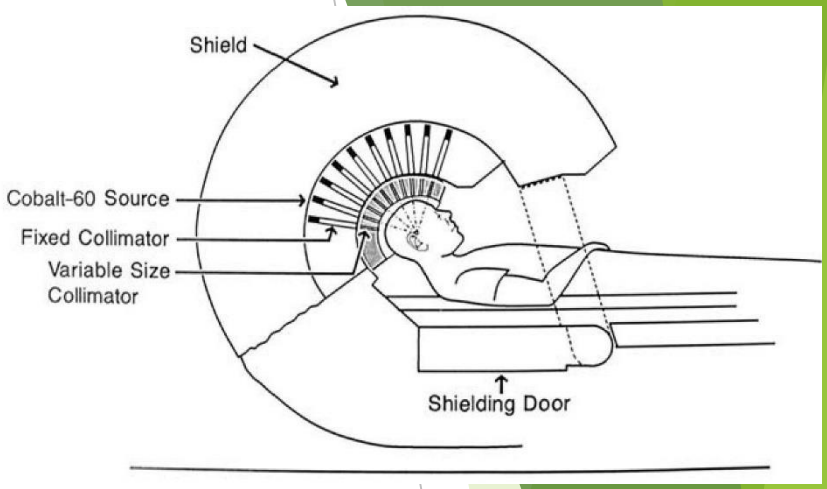
Micro MLC based xknife

- Pit falls of cone based X-knife system
  - Circular
  - More isocentres
  - Complex dose distribution and software system
- Field size limitation up to maximum 4 CM

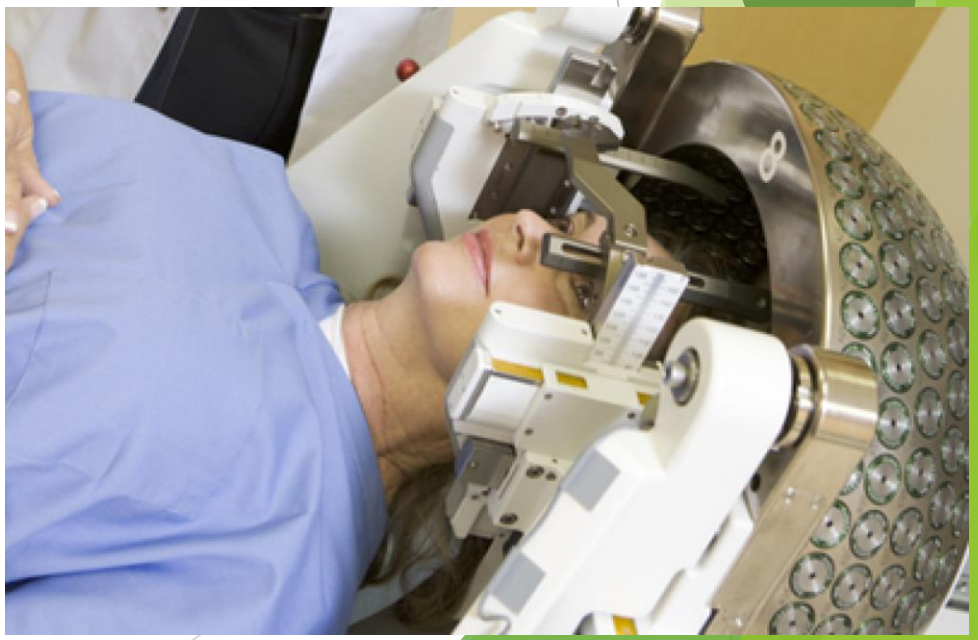
- M3- mMLC system
  - Micro MLC system
  - Attachment as secondary collimator in existing LA
  - PTV volume more than 4 CM also can be treated
  - Head and Neck regions can be covered



Gamma Knife



- Introduction of Gamma Knife system in India
- Ist installation @ P D Hinduja Hospital, Mumbai in 1996, and At AIIMS, N delhi
- Few Gamma Knife system existing in India
- 201 cobalt sources
- Multiple helmet's different field apertures



Cyberknife

- Robotic controlled
- Mini compact 6mV linear accelerator
- 360 degree movements and rotation
- Circular collimation and IRIS collimation
- SRS, SRT, SBRT and Gating

  - Limitation
    - Small collimation
    - Long treatment time

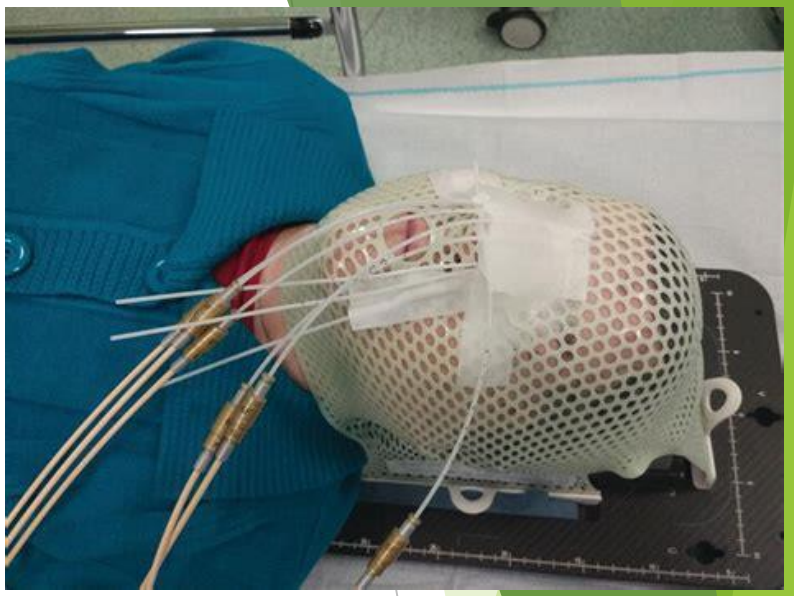
South Asia's FIRST PROTON SET UP

- Particle Accelerator
- South Asia and Middle east 1st Proton Therapy
- Apollo Proton cancer centre, - Chennai
- Inauguration January 25, 2019

- 16th country in the world to offer Proton therapy to millions of people across globe

- JCI accredited hospital.

Brachytherapy



- Starts from 1920
- Contact Therapy
- Radium-226, Cesium-137, cobalt-60, Radioactive sources used in the form Needle, Pellets and wires
  - After 6 decades Iridium sources call back from use by BARC
- By 1990 Manual after-loading, LDR, MDR, HDR
  - Intraluminal, intra cavitary, surface mould and interstitial
- In HDR iridium-192 wires were used
- Remote after loading techniques were also introduced

- IAEA directory of 2012 mentioned India included along with the poorest sub Saharan African countries with less than one RT equipment per million people
- Globally india has the largest people living below the world bank poverty line
- As on 2019
  - India has 545 Teletherapy equipments
    - 180 tele cobalt, 365 medical LA
  - 22 advanced therapy machines
    - 7 cyberknife
    - 7 gamma knife
    - 8 Tomotherapy and
    - 2 intra operative machines
  - Remote afterloading brachy – 250
  - One particle accelerator - Proton

Particle accelerator

- Particle Therapy Cooperative group estimates (PTCOG)
  - 57 proton Accelerators across world
    - 19 in USA
    - 12 in Japan
    - 6 in Germany
    - 37 more in pipe line till 2022
    - 2 more upcoming proton centre in India
    - One at TMH, Mumbai
    - One at National cancer Institute Delhi

Regional Cancer centre

- Under National cancer control program during 75-76, several Regional Cancer Centres established
  - Each RCC will look after
    - Manage cancer patients within the defined region
    - Develop education
    - Training and research
    - Provide palliative care
  - 27 RCC identified
  - 40 units added every year
  - 15 units decommissioned

Education

- India Needs well structured Teaching program
  - Common academic syllabus for’
    - Radiation Oncology
    - Medical Physcis
    - Radiotherapy Technology programs

Radiation Oncology Program

- First Medical degree in Radiation Oncology
- Initially Radiologists handle the cancer treatment speciality
  - With addition of CT, MRI, and other sophisticated equipment, work load increases to Radiologist, hence speciality Radiotherapy / Radiation oncology initiated
    - Post Graduate Institute of Medical education and Research (PGIMER) chandigarh
    - First RT resident graduated in 1972
    - Later the momentum unites the Radiation Oncologists practising to start AROI
    - 59 college offers MD radiation Oncology
    - 2000 + radiation oncologists practising with post MD

Medical Physics program

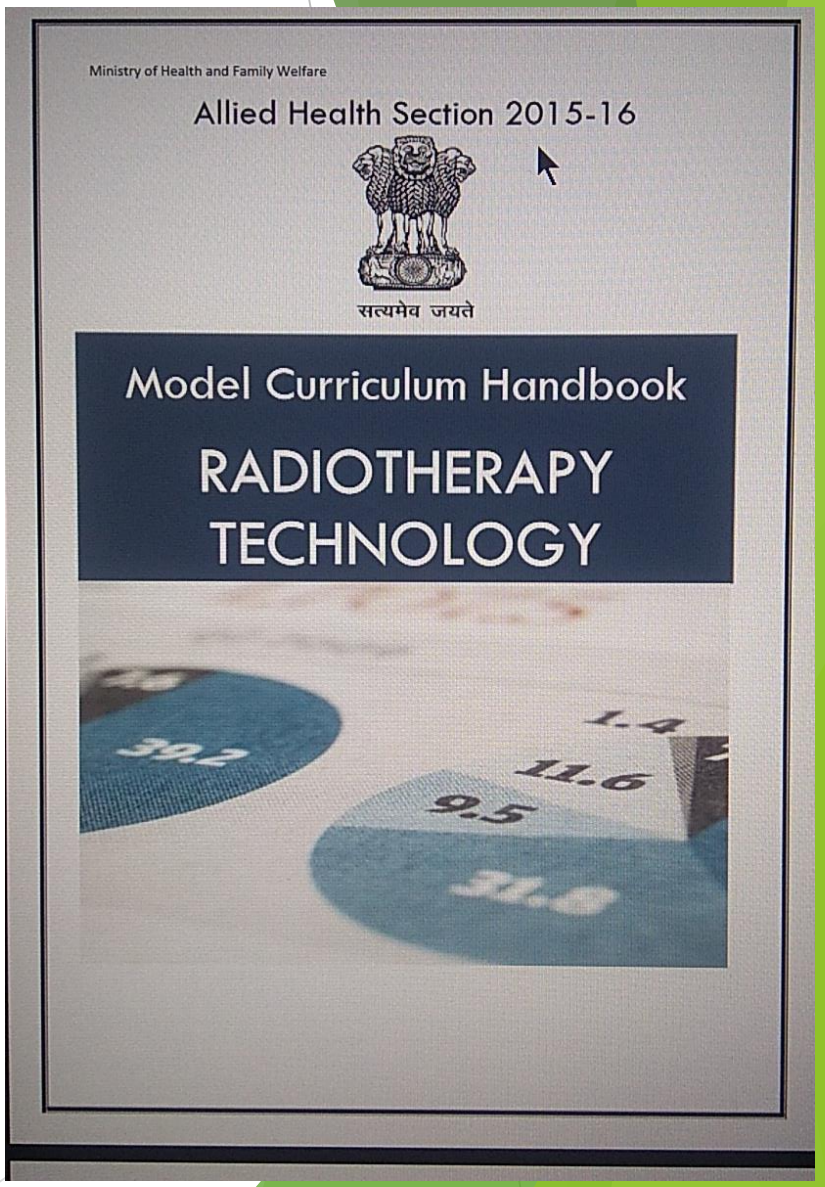
- 1st Teaching program for medical physics started during 1962
  - University of Bombay at Bhabha Atomic Research Centre Mumbai
  - Anna University Chennai started Post Graduate course in 1981
  - 17 courses producing 170 training Medical Physicist every year
    - 1150 Medical Physicists
    - 600 Radiation Safety Officers _ RSO

Medical Radiation Therapy Technologist

- Initially Nursing staff assist the Medical Radiologist
  - Few decades later Trained staff independently handle the equipment
  - Combined radiography course offer 2 year Diploma training
  - 1966 official Courses to train Radiographers in Radiotherapy specialisation
    - 1975 onwards Tutor Diploma courses offered to train the Teaching Technology to Radiographers
    - 1985- Bachelors degree in Radiotherapy Technology
    - 1990 - Master degree in Medical Radiotherapy Technology
    - Now around 60 Radiotherapy courses recognised by AERB.
    - Around 2500 certified Radiation Therapy Technologists practicing in India

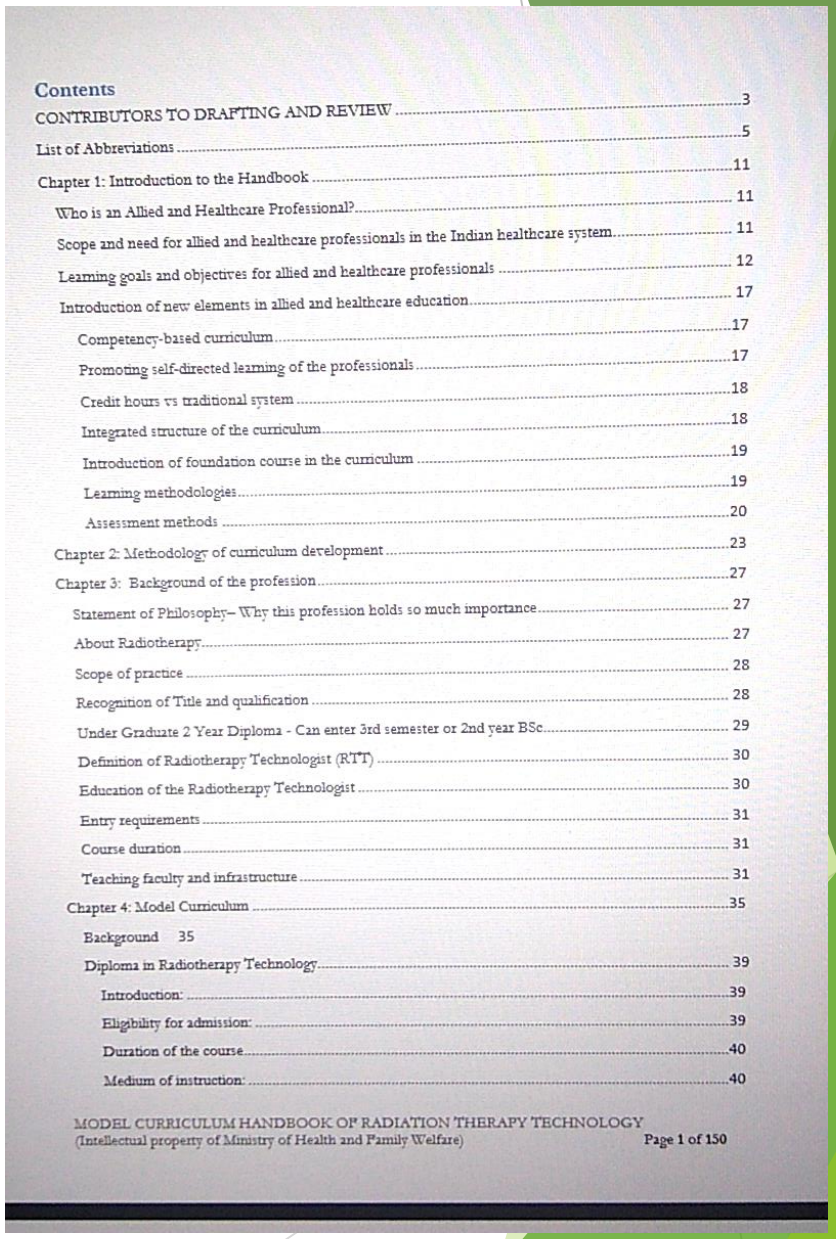
Model Course Curriculum

- Task Force to standardize the curiculam of professional courses
- By Ministry and Health and Family Welfare, Government of India
- 2015-16 –
  - 11 member team comprising
  - Radiation Oncologists
  - Medical Physicists
  - Radiotherapy Technologists
  - Representative from AERB



Model course Curriculum

- Need for Uniformity in syllabus
- Basic education requirements, Standardization
- Instructions, subjects, Time Periods
- Role of RTT in different levels
- implementation



Contents

Tele Gamma, Tele Cobalt

- Cesium Treatment Units
- Radio active Cobalt treatment units
  - Vertical operation equipments
  - Gantry Partial angulated units
  - 360 Gantry Movement units
  - Equipment with Beam stopper and its limitations
  - MLC attachment

Particle accelerators

- Betatron – First Particle Accelerator –
  - Christian Medical College, Vellore, Tamil Nadu
- Proton – South Asia 1st Proton Centre
  - Apollo Proton Cancer Centre, Chennai Tamil Nadu
  - National Cancer Institute Delhi and TMH Mumbai will soon get their equipments

Dual head Unit

- Janus Dual Head Tele therapy equipment
  - Named after Roman mythological God
  - To handle more work load, increased number of patients treatment, cost saving
  - Around 19 such unit installed in various centres – now out dated
  - Single source, Dual Head, source move from one head to another

Linacs in India

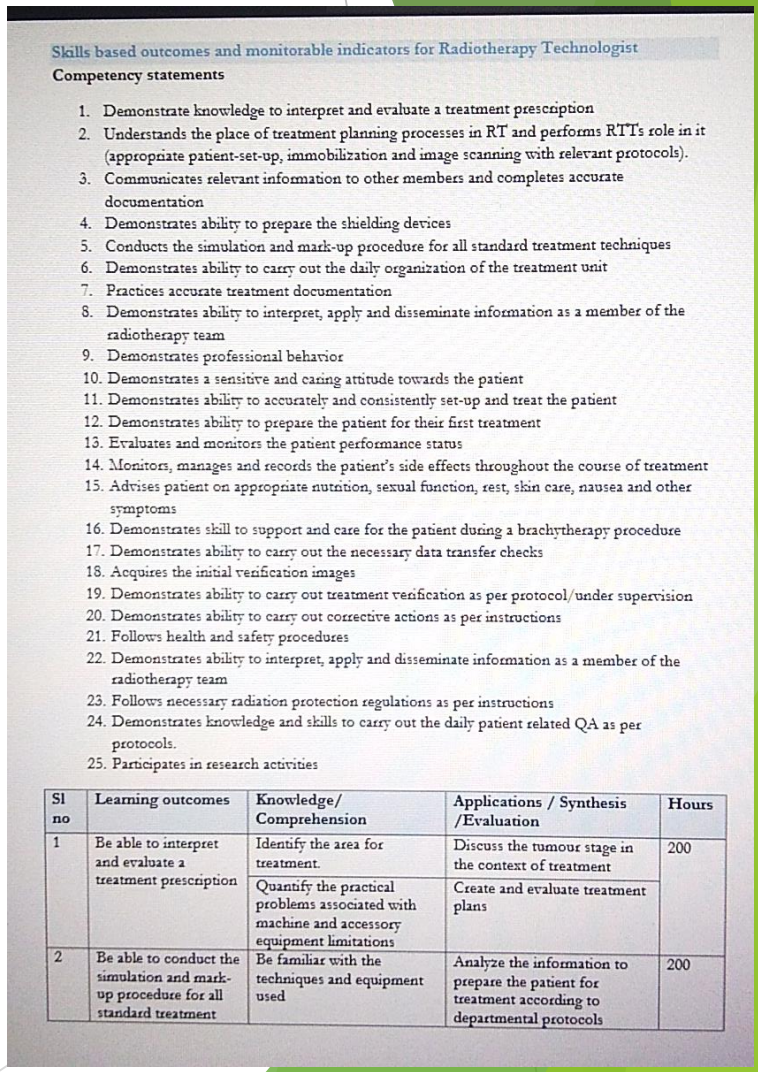
- Mostly Linear Accelerators replaced the Tele Gamma Units
- Simple indigenous linas, with EPID
- Linear accelerators with MLC , Micro MLC, HD MLC
- OBI-
- Tracking facility
- High end Linear accelerators capable of IGRT, SBRT, SRS
- Gamma Knife , Cyber Knife systems
- Particle Accelerator Proton

Faculty development

- Specific role defined in faculty program
  - Medical Radiation Oncologists
  - Medical Physicists
  - Tutor Technologists
  - Lecturer
  - Associate professor

Technologists Development program

- Certificate of Radiological Associate
- Diploma in Radiography -1960
- Diploma in Radiotherapy -1968
- P G diploma in Radiotherapy -1976
- Bachelors in Radiotherapy -1980
- Masters in Radiotherapy - 1990
- Ph D- 2015



Skills based outcomes and monitorable indicators for Radiotherapy Technologist

Competency statements

1. Demonstrate knowledge to interpret and evaluate a treatment prescription
2. Understands the place of treatment planning processes in RT and performs RTTs role in it (appropriate patient-set-up, immobilization and image scanning with relevant protocols).
3. Communicates relevant information to other members and completes accurate documentation
4. Demonstrates ability to prepare the shielding devices
5. Conducts the simulation and mark-up procedure for all standard treatment techniques
6. Demonstrates ability to carry out the daily organization of the treatment unit
7. Practices accurate treatment documentation
8. Demonstrates ability to interpret, apply and disseminate information as a member of the radiotherapy team
9. Demonstrates professional behavior
10. Demonstrates a sensitive and caring attitude towards the patient
11. Demonstrates ability to accurately and consistently set-up and treat the patient
12. Demonstrates ability to prepare the patient for their first treatment
13. Evaluates and monitors the patient performance status
14. Monitors, manages and records the patient's side effects throughout the course of treatment
15. Advises patient on appropriate nutrition, sexual function, rest, skin care, nausea and other symptoms
16. Demonstrates skill to support and care for the patient during a brachytherapy procedure
17. Demonstrates ability to carry out the necessary data transfer checks
18. Acquires the initial verification images
19. Demonstrates ability to carry out treatment verification as per protocol/under supervision
20. Demonstrates ability to carry out corrective actions as per instructions
21. Follows health and safety procedures
22. Demonstrates ability to interpret, apply and disseminate information as a member of the radiotherapy team
23. Follows necessary radiation protection regulations as per instructions
24. Demonstrates knowledge and skills to carry out the daily patient related QA as per protocols.
25. Participates in research activities

Sl no	Learning outcomes	Knowledge/ Comprehension	Applications / Synthesis /Evaluation	Hours
1	Be able to interpret and evaluate a treatment prescription	Identify the area for treatment.	Discuss the tumour stage in the context of treatment	200
		Quantify the practical problems associated with machine and accessory equipment limitations	Create and evaluate treatment plans	
2	Be able to conduct the simulation and mark-up procedure for all standard treatment	Be familiar with the techniques and equipment used	Analyze the information to prepare the patient for treatment according to departmental protocols	200

Curriculum- career path way

- Defined career path established in Model Course Curriculum
  - Entry level criteria
  - Job description
  - Competency levels
  - Department management
  - Administrative level

Current scenario

- Radiation Oncology Department managed by
  - Mostly by Radiation Oncologists
  - Few leading centers managed by Medical Radiation Physicists
  - Technical part, Job description, allocation of duty, day to day activities managed by RTT
  - Quality Assurance by Medical Physicists
  - Limited faculty development programs
  - Few PhD scholars in Radiotherapy as limited seats for Masters and Research activities

Professional Organizations

- AROI – Association of Radiation Oncologists of India
- AMPI- Association of Medical Physicists of India
- ISRT- Indian Society of Radiographers and Technologists
- ARTTI- Association of Radiotherapy Technologists of India
- Actively participate in Government initiatives, task groups etc
  - Associate with International Professional groups
    - ESTRO, IAEA, AAPM, ISRRT, Astro etc

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-Mary Kay Ash
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