

Contents

1	Introduction	1
1.1	A Brief History of Radiotherapy and Types of Radiation	1
1.2	Cancer: Statistical Considerations	2
1.3	Conventional Radiotherapy	7
1.4	Status of Protontherapy	9
1.5	Status of Carbon-Ion Therapy	15
1.6	Hadron Therapy Timeline	17
1.6.1	Timeline Key Event (in Detail)	21
	References	24
2	Equipment and Techniques	25
2.1	The Big Bang, Hadrons, and the Evolution of Energy	25
2.1.1	The Big Bang	25
2.1.2	Hadrons	26
2.1.3	Evolution of Energy	27
2.2	The Cyclotron, Ernest Orlando Lawrence, and Equations	29
2.2.1	Motion of Particles: Equations	30
2.2.2	Calculating the Frequency of the Cyclotron	31
2.3	The Proton Synchrotron, E.M. McMillan and V. Veskler	32
2.4	Hybrid Systems: C400 from IBA and New Synchrotron from Brookhaven National Laboratory	36
2.4.1	Summary	39
2.5	Gantry Specifications: Compact Gantry	40
2.6	Obtaining Particles (Protons, Neutrons) and Heavy Ions for Hadron Therapy	42
2.6.1	How Are Protons Obtained?	43
2.6.2	How Are Neutrons Obtained?	43
2.6.3	How Are Heavy Ions Obtained?	44

2.7	Other Techniques in Development: Cyclinac, Laser, Dielectric Wall Accelerator	44
2.7.1	Cyclinac	44
2.7.2	Use of Lasers in Hadron Therapy	45
2.7.3	How Are Protons Accelerated with a Laser?	46
2.8	Phantoms	50
2.8.1	Microdosimetry Measurements	52
2.9	Fluka: A Simulation Code	53
	References	55
3	Physical and Biological Rationale for Using Ions in Therapy	57
3.1	Biophysical Properties.	57
3.1.1	Stopping Power and Linear Energy Transfer	57
3.1.2	Radiation Dose	60
3.2	Biological Properties.	62
3.2.1	Relative Biological Effectiveness	62
3.2.2	Oxygen Enhancement Ratio	66
	References	68
4	Modelling Heavy Ion Radiation Effects	69
4.1	Biophysical Models	69
4.2	The Alpha/Beta Ratio	72
4.3	Local Effect Model.	74
	References	76
5	Clinical Experiences with Carbon Ion Therapy	77
5.1	Carbon Ion Therapy Facilities	77
5.2	What Are the Characteristics of Carbon Ions?	78
5.2.1	Physical Aspects	78
5.2.2	Radiobiological Aspects	78
5.3	How Is Treatment Planned?.	79
5.4	Carbon Ion Exploration in Future Clinical Trials	80
5.5	Clinical Results	82
5.6	Clinical Advantages of Carbon Ions	82
5.6.1	Improved Therapeutic Gain.	82
5.6.2	Hypofractionated Radiotherapy (Without Enhancing Toxicity)	83
5.6.3	Potential Suppression of Metastases	83
5.7	The Risk of Secondary Malignancies	83
5.8	Clinical Trials at HIT	85

5.9 Consolidated, Prospective, and Exceptional Indications
Using Carbon Ion Therapy 86

5.9.1 Consolidated Indications 86

5.9.2 Prospective Indications 89

5.9.3 Exceptional Indications 91

5.10 New Cancers Where Charged Particles May Potentially
Lead to a Breakthrough. 91

5.11 Protontherapy Versus Carbon Ion Therapy: Advantages,
Disadvantages, and Similarities 92

5.12 What Do We Need? 96

References 98

Appendix 101

Index 107

Protontherapy Versus Carbon Ion Therapy
Advantages, Disadvantages and Similarities

Nunes, M.d.

2015, XX, 110 p. 71 illus., 16 illus. in color., Hardcover

ISBN: 978-3-319-18982-6