

3rd Edition

Radiation Oncology

A Question-Based Review

Boris Hristov

Steven H. Lin

John P. Christodouleas



Wolters Kluwer

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Third edition
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Preface

It is with great excitement that we introduce the third edition of *Radiation Oncology: A Question-Based Review*. As a result of many favorable responses to the first two editions, we have again updated this text to ensure that it continues to provide both trainees and practicing radiation oncologists with the most current and salient information in our field. This edition has been thoroughly reviewed and updated to include the latest AJCC 8th edition staging, seminal new studies, and practice-changing trials published since the last edition, and a new primer section/chapter on immunotherapies.

In spite of these changes and additions, the book's core format and objectives have essentially remained the same, namely to provide medical students, residents, and radiation oncologists with a succinct briefing on the clinical management of all the major cancer types and conditions that are currently treated with radiation. An enduring goal of this edition is to serve as a user-friendly means for self-assessment and, with this objective in mind, we continue to include popular mnemonics and tie in useful facts from other relevant disciplines such as radiology, anatomy, and medical oncology. The most challenging goal of this edition was to keep the overall length of the book similar to that of past editions by deleting older and less relevant data when incorporating newer studies and techniques. By tasking experienced section editors specializing in particular areas of radiation oncology (e.g., pediatrics, breast, GI, etc.) and by empowering them to distill each chapter to its most salient points and evidence-based principles, we strongly feel that we have met this goal.

We hope that our third edition of *Radiation Oncology: A Question-Based Review* continues to serve as a proven high-yield study-aid and that it grants both students and practitioners alike a somewhat firmer footing in the ever-shifting and evolving field of radiation oncology.

The Editors

Abbreviation Key

<i>Abbrev</i>	<i>Full Spell-Out</i>
2D	two-dimensional
3D	three-dimensional
3D-CRT	three-dimensional conformal radiation therapy
5-FU	5-fluorouracil
ABMT	autologous bone marrow transplant
abnl	abnormal
APBI	accelerated partial breast irradiation
ACTH	adrenocorticotrophic hormone
ADH	antidiuretic hormone
adj	adjuvant
Adr	Adriamycin
AFP	alpha-fetoprotein
AI	aromatase inhibitor
AIDS	acquired immune deficiency syndrome
AJCC	American Joint Committee on Cancer
aka	also known as
alk phos	alkaline phosphatase
Alt	alternated with

am	morning (ante meridian)
ANC	absolute neutrophil count (lab)
ant	anterior
anterolat	anterolateral
AP	anterior–posterior
APC	adenomatous polyposis coli (gene mutation)
appx	approximately
APR	abdominoperineal resection
ARUBA	A Randomized Trial of Unruptured Brain Arteriovenous Malformations
ASCO	American Society of Clinical Oncology
ASCUS	atypical squamous cells of unknown significance
ASTRO	American Society for Therapeutic Radiation and Oncology
AUC	area under the curve
avg	average
BAT	B-mode acquisition and targeting
b/c	because
b/t	between
BCT	breast conserving treatment
BED	biologically equivalent dose
BED	biologically effective dose
bFFP	biochemical freedom from progression
β-HCG	beta-human chorionic gonadotropin

bid	twice daily
bilat	bilateral
BM	bone marrow
BMI	body mass index
BMP	basic metabolic panel
BMT	bone marrow transplant
BTSG	Brain Tumor Study Group
BWS	Beckwith–Wiedemann Syndrome
Bx	biopsy/biopsies
C	cervical (spine level)
c/w	compared with
CA19-9	cancer antigen 19-9
CA125	cancer antigen 125
CALGB	Cancer and Leukemia Group B
C/A/P	chest/abdomen/pelvis
CBC	complete blood count (lab)
CBCT	cone beam computed tomography
CCCG	Colorectal Cancer Collaborative Group
cCR	clinical complete response
CD	cone-down
CD4	cluster of differentiation 4 (for immune cells)
CEA	carcinoembryonic antigen

CESS	Cooperative Ewing Sarcoma Study
CHART	Continuous Hyperfractionated Accelerated Radiotherapy Trial
chemo	chemotherapy
CHF	congestive heart failure
CIN	cervical intraepithelial neoplasia
CIS	carcinoma in situ
cm	centimeter/centimeters
CMP	complete metabolic panel (lab)
c-myc	(gene)
cN0	clinically node-negative
CN	cranial nerve
CNS	central nervous system
Co-60	cobalt-60
COG	Children's Oncology Group
COPD	chronic obstructive pulmonary disease
contralat	contralateral
CPT	common procedural terminology
Cr	creatinine
CR	complete response
CRT	chemoradiation
CSF	cerebrospinal fluid
CSI	craniospinal irradiation

CSM	cancer-specific mortality
CSS	cause-specific survival
CT	computed tomography
cT	clinical T-stage
CTV	clinical target volume
CW	chest wall
Cx	cervical (spine level)
CXR	chest x-ray
D/C	discontinue/discontinued
D&C	dilation and curettage
DCC	deleted in colorectal cancer (gene)
DDx	differential diagnosis
DFS	disease-free survival
DI	diabetes insipidus
DLBCL	diffuse large-B cell lymphoma
DLCO	lung diffusion capacity testing
DM	distant metastasis
DMFS	distant metastasis-free survival
DOI	depth of invasion
DRE	digital rectal examination
DSS	disease-specific survival
d/t	due to

DVH	dose volume histogram
DVT	deep venous thrombosis
Dx	diagnosis/diagnoses
Dz	disease/diseases
EB	external beam
EBRT	external beam radiation therapy
EBUS	endobronchial ultrasound
EBV	Epstein–Barr virus
ECE	extracapsular extension
ECOG	Eastern Cooperative Oncology Group
EFRT	extended field radiotherapy
EFS	event-free survival
e.g.	for example
EGFR	epidermal growth factor receptor
EM	electron microscopy
ENE	extranodal extension
ENI	elective nodal irradiation
EORTC	European Organisation for Research and Treatment of Cancer
Epo	erythropoietin
ER	estrogen receptor
ERCP	endoscopic retrograde cholangiopancreatography
ESR	erythrocyte sedimentation rate (lab)

et al.	and others
EUA	exam under anesthesia
EUS	endoscopic ultrasound
EWS	Ewing sarcoma
exam	examination
f/b	followed by
f/u	follow up
FAP	familial adenomatous polyposis
FDA	Food and Drug Administration
FDG	fluorine-18 2-fluoro-2-deoxy-D-glucose
FEV	forced expiratory volume
FFS	failure-free survival
FFTF	freedom from treatment failure
FIGO	International Federation of Gynecology and Obstetrics
FH	favorable histology
FHIT	fragile histidine triad
FISH	fluorescence in situ hybridization
FKHR	forkhead (drosophila) homolog 1 (rhabdomyosarcoma) (gene)
FLAIR	fluid attenuation inversion recovery
F:M	female to male ratio
FN rate	false-negative rate
FNA	fine needle aspiration

FOLFOX	5-FU/leucovorin/oxaliplatin
FPR	false-positive rate
FSH	follicle-stimulating hormone
FSR	fractionated stereotactic radiotherapy
fx	fraction/fractions
GBM	glioblastoma multiforme
GERD	gastroesophageal reflux disease
GH	growth hormone
GI	gastrointestinal
GK	gamma knife
GN-CSF	granulocyte-macrophage colony-stimulating factor
GnRH	gonadotropin-releasing hormone
GS	gleason score
GTR	gross total resection
GTV	gross target volume
GU	genitourinary
Gy	gray
gyn	gynecologic
H&N	head and neck
H&P	history and physical
HA	headache
HAART	highly active antiretroviral therapy

HCG	human chorionic gonadotropin (lab test)
HDC+SCT	high-dose chemotherapy with stem cell transplant
HDR	high dose rate
HER2	avian erythroblastic leukemia viral oncogene homolog 2/human epidermal growth factor receptor 2
Hgb	hemoglobin
HGG	high-grade glioma
HGSIL	high-grad squamous intraepithelial lesion
HIV	human immunodeficiency virus
HNPCC	hereditary nonpolyposis colon cancer
HPV	human papilloma virus
hr/hrs	hour/hours
HR	hazard ratio
HRT	hormone replacement therapy
HSV	herpes simplex virus
HTN	hypertension
HVA	homovanillic acid
Hx	history/histories
Hyperfx	hyperfractionation
IBCSG	International Breast Cancer Study Group
IC	internal carotid
ICP	intracranial pressure
IDL	isodose line

i.e.	that is
IELCAP	International Early Lung Cancer Action Project
IFN	interferon
IgA	immunoglobulin A
IGF	insulin-like growth factor
IgG	immunoglobulin G
IGRT	image-guided radiation therapy
<i>IJROBP</i>	<i>International Journal of Radiation Oncology, Biology, and Physics</i>
IM	internal mammary
IMA	inferior mesenteric artery
IMRT	intensity-modulated radiation therapy
inf	inferior
INR	international normalized ratio
intraop	intraoperative
IORT	intraoperative radiation therapy
ipsi	ipsilateral
IQ	intelligence quotient
ITV	internal target volume
IVC	inferior vena cava
<i>JAMA</i>	<i>Journal of the American Medical Association</i>
<i>JCO</i>	<i>Journal of Clinical Oncology</i>
JCOG	Japan Clinical Oncology Group

JCRT	Joint Center for Radiation Therapy
JHH	Johns Hopkins Hospital
JNCI	Journal of the National Cancer Institute
JPA	juvenile pilocytic astrocytoma
KPS	Karnofsky performance status
L	lumbar (spine level)
LA	lymphadenopathy
lab	laboratory/laboratory test
LAD	lymphadenopathy
LAMP	Locally Advanced Multimodality Protocol
LAO	left anterior oblique
lat	lateral
LC	local control
LDCT	low dose computed tomography
LDH	lactate dehydrogenase
LDR	low dose rate
LE	lower extremity
LEEP	loop electrosurgical excision procedure
LF	local failure
LFT	liver function test
LGSIL	low-grade squamous intraepithelial lesion
LH	luteinizing hormone

LINAC	linear accelerator
LLL	left lower lobe
LML	left middle lobe
LN	lymph node
LND	lymph node dissection
LOH	loss of heterozygosity
LP	lumbar puncture
LPO	left posterior oblique
LR	local recurrence
LRC	locoregional control
LRF	locoregional failure
LRFS	local recurrence-free survival
LRR	locoregional recurrence
LUL	left upper lobe
LVI	lymphovascular invasion
LVSI	lymphovascular stromal invasion
MALT	mucosa-associated lymphoid tissue
max	maximal/maximum
MB	medulloblastoma
MDACC	MD Anderson Cancer Center
med	medication
MEN	multiple endocrine neoplasia
mets	metastasis/metastases

M:F	male to female ratio
MFS	metastases-free survival
MGMT	O ⁶ -methylguanine DNA-methyltransferase
MI	myocardial infarction
MIBG	metaiodobenzylguanidine
min	minimal/minimum
MLC	multileaf collimator
MLD	mean lung dose
MN	mediastinal node
mo/mos	month/months
MRC	Medical Research Council
MRCP	magnetic resonance cholangiopancreatography
MRI	magnetic resonance imaging
MS	median survival
MSKCC	Memorial Sloan Kettering Cancer Center
MTD	maximum tolerated/tolerable dose
Mtx	methotrexate
MVA	multivariate analysis
NB	neuroblastoma
N/C	nuclear to cytoplasm ratio
NCCN	National Comprehensive Cancer Network
NCCTG	North Central Cancer Treatment Group

NCI	National Cancer Institute
NCIC	National Cancer Institute of Canada
NED	no evidence of disease
<i>NEJM</i>	<i>New England Journal of Medicine</i>
neoadj	neoadjuvant
NF	neurofibromatosis
NGGCT	nongerminomatous germ cell tumor
NHL	non-Hodgkin lymphoma
NPCR	National Program of Cancer Registries
NPV	negative predictive value
NPX	nasopharynx
NR	no response
NSABP	National Surgical Adjuvant Breast and Bowel Project
NSAID	nonsteroidal anti-inflammatory drug
NSE	neuron-specific enolase
NSS	not statistically significant
NTR	near-total resection
n/v	nausea/vomiting
NWTS	National Wilms Tumor Study
NZ	New Zealand
OAR	organ at risk
OPX	oropharynx

OR	odds ratio
ORN	osteoradionecrosis
ORR	overall response rate
OS	overall survival
PA	posterior-anterior
PAND	periarotic lymph node dissection
PAP	Papanicolau
PCI	prophylactic cranial irradiation
PCNSL	primary CNS lymphoma
PCP	pneumocystic pneumonia
pCR	pathologic complete response
PCR	polymerase chain reaction
PDGFR	platelet-derived growth factor receptor
PEG (tube)	percutaneous endoscopic gastrostomy tube
periop	perioperative
PET	positron emission tomography
PF	posterior fossa
PFS	progression-free survival
PFT	pulmonary function test
PgR	progesterone receptor
Plt	platelets
pm	afternoon (post meridian)

PM	parameningeal (for rhabdomyosarcoma)
PMH	Princess Margaret Hospital
PMRT	post-mastectomy radiotherapy
pN0	pathologically node negative
PNET	primitive neuroectodermal tumor
PNI	perineural invasion
PNS	paranasal sinuses
PORT	postoperative radiation therapy
post	posterior
posterolat	posterolateral
postop	postoperative
PPV	positive predictive value
PR	partial response
P-A	para-aortic (for lymph nodes)
PrT	paratesticular (for rhabdomyosarcoma)
preop	preoperative
PS	performance status
PSA	prostate-specific antigen
pt/pts	patient/patients
PTHr	parathyroid hormone–related peptide
PT	prothrombin time
pT	pathologic tumor stage
PTV	planning target volume

PUVA	psoralen and long-wave ultraviolet radiation
q	every
qd	daily
QOL	quality of life
QUANTEC	quantitative analysis of normal tissue effect in the clinic
RAO	right anterior oblique
RASSF1A	Ras Association (RalGDS/AF-6) domain family member 1A
RB	retinoblastoma
RBE	relative biologic effectiveness
RCC	renal cell carcinoma
RCT	randomized controlled trial
rcv	receive/received
RFS	relapse-free survival
RLL	right lower lobe
RML	right middle lobe
RMS	rhabdomyosarcoma
r/o	rule out
ROM	range of motion
RPLND	retroperitoneal lymph node dissection
RPO	right posterior oblique
RR	relative risk
RT	radiation or radiation therapy

RTOG	Radiation Therapy Oncology Group
RUL	right upper lobe
RUQ	right upper quadrant
Rx	prescription/prescriptions
S	sacral (spine level)
SABR	stereotactic ablative radiotherapy
SAD	source-axis distance
SBO	small bowel obstruction
SBRT	stereotactic body radiation therapy
SCs	spinal cord
SCC	squamous cell carcinoma
SCV	supraclavicular
SEER	surveillance epidemiology and end results (data)
SFOP	French Society of Pediatric Oncology
Sg	surgery
SIADH	syndrome of inappropriate secretion of antidiuretic hormone
SIB	simultaneous integrated boost
SIL	squamous intraepithelial lesion
SLNB	sentinel lymph node biopsy
SMA	superior mesenteric artery
SQ	subcutaneous
s/p	status post

SPECT	single photon emission computed tomography
SRS	stereotactic radiosurgery
SS	statistically significant
SSD	source to skin distance
ST	soft tissue (as in sarcoma)
STD	sexually transmitted disease
STR	subtotal resection
STS	soft-tissue sarcoma
sup	superior
SUV	standard uptake value
SVC	superior vena cava
Sx	symptom/symptoms
T	thoracic (spine level)
TBI	total body irradiation
TD	tolerance dose
TFT	thyroid function test
tid	three times a day
TKI	tyrosine kinase inhibitor
TMZ	temozolomide
TNM	tumor/node/metastasis
trilat	trilateral
TRUS	transrectal ultrasound
TSH	thyroid-stimulating hormone

Tx	treatment/treatments
UA	urinalysis
UCSF	University of California at San Francisco
UE	upper extremity
UH	unfavorable histology
UK	United Kingdom
unilat	unilateral
US	ultrasound
U.S.	United States
USPSTF	United States Preventive Services Task Force
UV	ultraviolet
VALCSG	Veterans Administration Lung Cancer Study Group
VCE	vincristine, carboplatin, etoposide (chemo regimen)
VMA	vanillylmandelic acid
vs.	versus
WBC	white blood cell
WBI	whole breast irradiation
WBRT	whole brain radiation therapy
WHO	World Health Organization
wk/wks	week/weeks
WLE	wide local excision
yo	year old/years old

yr/yrs year/years

Symbols

+ meaning *with* or *and* (as in Surgery + RT)

→ meaning *followed by*

↑ meaning *increasing, high(er), or elevated*

↓ meaning *decreasing or low(er)*

Section Editors

Updating Authors

Acknowledgments

Preface

Abbreviation Key

Part I Pediatrics

1 Rhabdomyosarcoma

Updated by Shane R. Stecklein

2 Ewing Sarcoma

Updated by Amy Catherine Moreno

3 Wilms Tumor

Updated by Jennifer Logan

4 Neuroblastoma

Updated by Tommy Sheu

5 Retinoblastoma

Updated by Vincent J. Lee

6 Langerhans Cell Histiocytosis

Updated by Harvey B. Wilds

7 Medulloblastoma

Updated by Shane R. Stecklein

8 Ependymoma

Updated by Penny Fang

9 Intracranial Germ Cell and Pineal Tumors

Updated by Harvey B. Wilds

10 Craniopharyngioma

Updated by Amy Catherine Moreno

11 Hemangioblastoma

Updated by Harvey B. Wilds

12 Brainstem Glioma

Updated by Harvey B. Wilds

Part II Central Nervous System

13 General Central Nervous System

Updated by Jennifer Logan

14 Low-Grade Glioma

Updated by Tommy Sheu

15 High-Grade Glioma

Updated by Penny Fang

16 Optic Pathway Glioma

Updated by Hubert Pan

17 Primary Central Nervous System Lymphoma

Updated by Jennifer Chen Ho

18 Meningioma

Updated by Jennifer Logan

19 Pituitary Tumor

Updated by Jason T. Hayes

20 Primary Spinal Cord Tumor

Updated by Jennifer Chen Ho, Boris Hristov, William Kempton
Jeffrey Skinner and Timothy Chan

21 Choroid Plexus Carcinoma and Papilloma

Updated by Boris Hristov

22 Arteriovenous Malformation

Updated by Jason T. Hayes

23 Vestibular Schwannoma/Acoustic Neuroma

Updated by Jennifer Logan

Part III Eye

24 Ocular Melanoma

Updated by Vincent Lee and Gopal K. Bajaj

25 Orbital and Intraocular Primary Eye Lymphomas

Updated by Tommy Sheu and Gopal K. Bajaj

26 Thyroid Ophthalmopathy

Updated by Boris Hristov

27 Orbital Pseudotumor

Updated by David Eastham and Gopal K. Bajaj

Part IV Head and Neck

28 Nasopharyngeal Cancer

Updated by Brian Deegan

29 Sinonasal/Paranasal Sinus

Updated by Courtney Pollard, III and Gopal K. Bajaj

30 Oral Cavity Cancer

Updated by Brian Deegan

31 Oropharyngeal Cancer

Updated by Hubert Pan and Gopal K. Bajaj

32 Salivary Gland Cancer

Updated by Hubert Pan

33 Laryngeal and Hypopharyngeal Cancers

Updated by Brian Deegan

34 Thyroid Cancer

Updated by Boris Hristov

35 Head and Neck Cancer of Unknown Primary

Updated by Amy Catherine Moreno

36 Neck Management and Postoperative Radiation Therapy for Head and Neck Cancers

Updated by Lauren Colbert and Gopal K. Bajaj

Part V Thorax

37 Early-Stage (I–II) Non–Small Cell Lung Cancer

Updated by Lauren Colbert and Steven H. Lin

38 Advanced-Stage (III–IV) Non–Small Cell Lung Cancer

Updated by Jennifer Chen Ho and Steven H. Lin

39 Small Cell Lung Cancer and Bronchial Neuroendocrine Tumor

Updated by Jennifer Chen Ho and Steven H. Lin

40 Thymoma and Thymic Carcinoma

Updated by Dario Pasalic and Steven H. Lin

41 Pleural Mesothelioma

Updated by Penny Fang and Steven H. Lin

Part VI Breast

42 General Breast Cancer

Updated by Shane R. Stecklein

43 Ductal and Lobular Carcinoma In Situ

Updated by Penny Fang

44 Early-Stage (I–II) Breast Cancer