Radiation Therapy in Rhabdomyosarcoma

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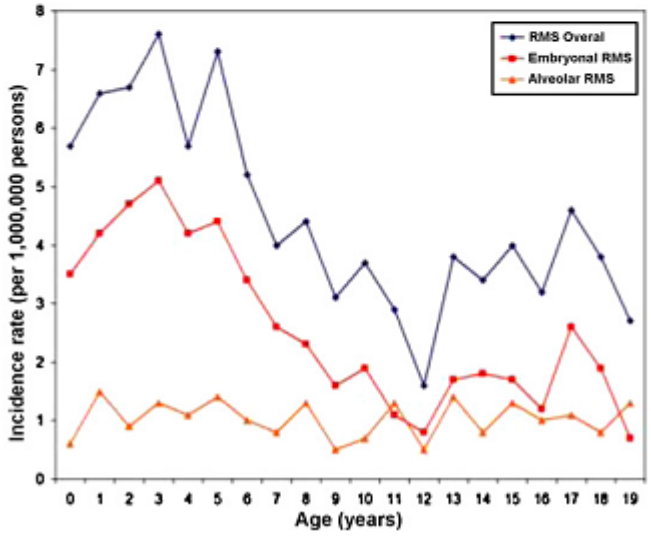
Anatomy

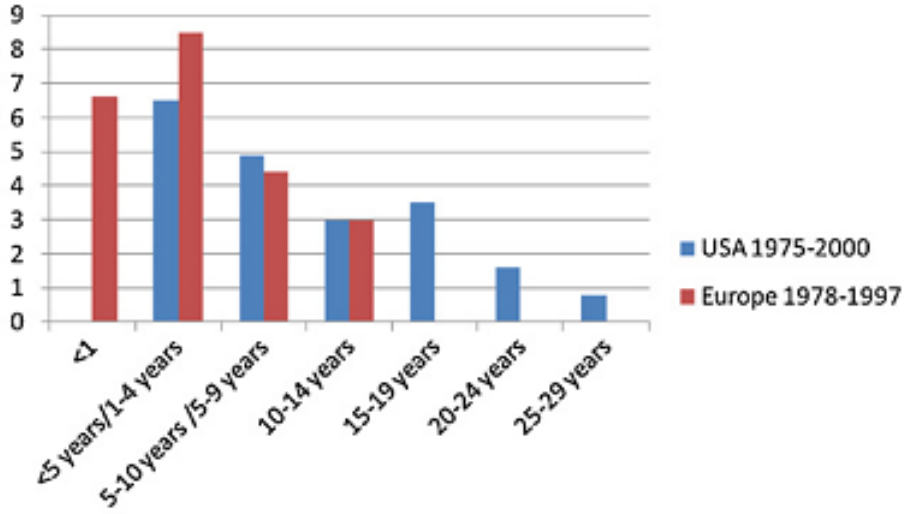
Head & Neck	39%
Parameningeal	25%
Non Parameningeal	07%
Orbit	09%
Genitourinary	31%
Extremity	13%
Retroperitoneum	07%
Trunk	05%
Other Sites	03%

Epidemiology

Annual incidence (West):
4.4 per 1 million whites
1.3 per 1 million blacks

Male: Female ratio - 1.5: 1.0





Risk Factors

- Environmental exposures:
  Paternal cigarette use, X-ray exposure, Maternal drug use

- Associated with disorders in development:
  CNS, GU, GI, CVS anomalies

- Congenital disorders:
  Congenital pulmonary cysts
  Gorlin basal cell nevus syndrome
  Neurofibromatosis

- The most frequently occurring childhood cancer in families:
  Li-Fraumeni syndrome
  Neurofibromatosis type 1
  Beckwith-Wiedemann syndrome

Natural History

- Association of site of primary, age at diagnosis and tumor histology.
  - Urinary bladder/ vagina -- Primarily infants -- Embryonal / Botryoid
  - Trunk/ Extremity -- Adolescents – Alveolar/ Undifferentiated
  - Head & Neck -- throughout childhood -- Embryonal

- Locally invasive/ pseudo-capsule

- Local spread: Fascial/ muscle planes

- Lymphatic extension (15%)
  - Paratesticular, extremity, and truncal tumors: 25%
  - Head & Neck: 15%
  - Orbit: <5%
  - Influenced by Site/ Size/ Invasiveness/ Histology

- Hematogenous dissemination (15-20%)
  - Sites of Met: Lung, Bone Marrow, Bone, Pleural effusion, Ascites
  - Higher incidence from Truncal & Head/ Neck sites
  - Alveolar (25%), Embryonal (13%)

Clinical Features

- Primary:
  - Asymptomatic mass
  - Site:
  - Orbit - Proptosis, Ophthalmoplegia.
  - Parameningeal - Nasal, aural, sinus obstruction
    Cranial nerve palsy, headache
  - Genitourinary - Hematuria, urinary obstruction, constipation

- Lymphatic:
  - Regional & distant nodal disease

- Hematogenous:
  - Lung/ Pleural effusion – Dyspnoea, cough, chest pain
  - Bone Marrow – Bone pain, weakness, low counts
  - Bone – Pain, fracture
  - Ascites – Abd. distension, discomfort

Diagnostic Workup

All sites	History Physical Exam
Lab Investigations	Haemogram • LFT • RFT • Urine Analysis
Bone Marrow Aspirate & Biopsy	All Patients
Imaging	CECT Scan - Primary & Pulmonary Met MRI Scan - Primary PET CT Scan - Primary & Met
Head & Neck	MRI Scan - Primary CSF Exam - Parameningeal
Genitourinary	MRI Scan - Primary Cystoscopy Pelvic EUA - If required
Extremity/ Trunk	MRI Scan/ CECT

Role of PET -CT

Pediatr Blood Cancer

Comparison of PET–CT and Conventional Imaging in Staging Pediatric Rhabdomyosarcoma

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Background. Over the past decade, PET–CT has been used to assess rhabdomyosarcoma (RMS) in children. However, the role of PET–CT in staging RMS is unknown. ***Procedure.*** Thirty subjects with RMS, median age 7.3 years, underwent PET–CT before therapy. PET–CTs and conventional imaging (CI) were independently reviewed by two radiologists and two nuclear medicine physicians to determine the presence of metastases. Accuracy, sensitivity, and specificity of PET–CT for detecting metastases were compared to CI using biopsy and clinical follow-up as reference standards. Maximum standardized uptake values (SUV_{max}) of primary tumors, lymph nodes, and pulmonary nodules were measured. ***Results.*** Primary tumors had an average SUV_{max} of 7.2 (range, 2.5–19.2). Accuracy rates for 17 subjects with nodal disease were 95% for PET–CT and 49% for CI. PET–CT had 94% sensitivity and 100% specificity for nodal disease. Of seven pulmonary nodules detected by CI, three were not identified by PET–CT, two were indeterminate, and one was malignant with a SUV_{max} (3.4) > twice that of benign nodules. Two subjects had bone disease; both were identified by PET–CT but only one by CI. Four subjects had bone marrow disease, two had positive PET–CTs but none had positive CI. Two subjects had soft tissue metastases detected by PET–CT but not CI. ***Conclusions.*** PET–CT performed better than CI in identifying nodal, bone, bone marrow, and soft tissue disease in children with RMS. CI remains essential for detection of pulmonary nodules. We recommend PET–CT for staging of children with RMS. CI with Tc^{99m} bone scan can be eliminated. Pediatr Blood Cancer

Key words: conventional imaging; diagnosis; PET–CT; rhabdomyosarcoma; staging

Conventional Imaging (CI) = CT Chest + CT/MRI Primary + Bone Scan

PET Ct Scan: Better detection of Nodes/ Bone Marrow/ Bone/ Soft Tissue

PET-CT in Prognostication

Contribution of PET/CT to Prediction of Outcome in Children and Young Adults with Rhabdomyosarcoma

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J Nucl Med 2011; 52:1535–1540

Significantly shorter overall survival in primary tumors visually rated as highly metabolically active or with a ratio of SUV(max) to SUV of the liver above 4.6

Metabolically active lymph node and distant site involvement was indicative of significantly lower survival rates

Multivariate Cox regression analysis: impact of SUV(max) of primary tumor on outcome failed to attain significance, although PET performed better than some of the prognostic factors (P = 0.081)

Pathologic Classification

INTERNATIONAL CLASSIFICATION OF RHABDOMYOSARCOMA

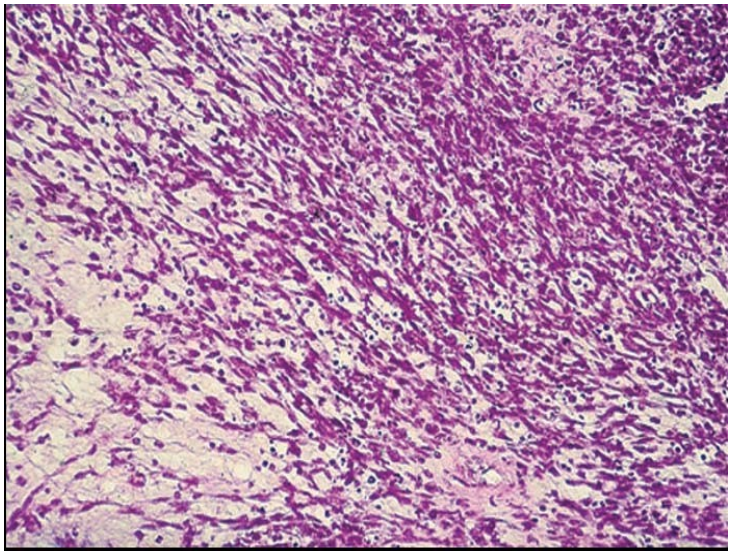
	5 Yr. Survival
I. Superior prognosis	
a. Botryoid rhabdomyosarcoma	88 – 95%
b. Spindle cell rhabdomyosarcoma	
II. Intermediate prognosis	
a. Embryonal rhabdomyosarcoma	80 – 85%
III. Poor prognosis	
a. Alveolar rhabdomyosarcoma	60 – 65%
b. Undifferentiated sarcoma	
c. Anaplastic rhabdomyosarcoma	
IV. Subtypes whose prognosis is not presently evaluable	
a. Rhabdomyosarcoma with rhabdoid features	50 – 55%

Pathology

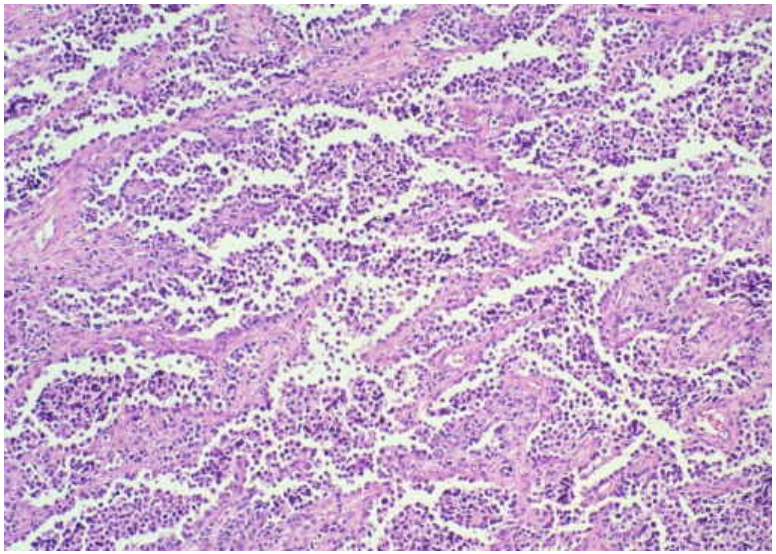
Small round blue cell tumors with cross striations/ characteristic Rhabdomyoblast

IHC: Actin, Myosin, Desmin, Myo-D 1

EMBRYONAL



ALVEOLAR



ARMS

80% harbor translocations resulting in PAX 3/FOXO or PAX 7/FOXO fusion gene

Fusion negative ARMS (20%) are similar to patients with ERMS

ERMS

LOH at 11p15 locus

Better prognosis than ARMS

Staging & Prognostication

A. Clinical group

Surgicopathologic staging developed by IRSG in 1972

B. TNM System

A. Takes into account tumor size & lymph node burden

B. Site of disease included

C. Incorporated IRS-IV onwards

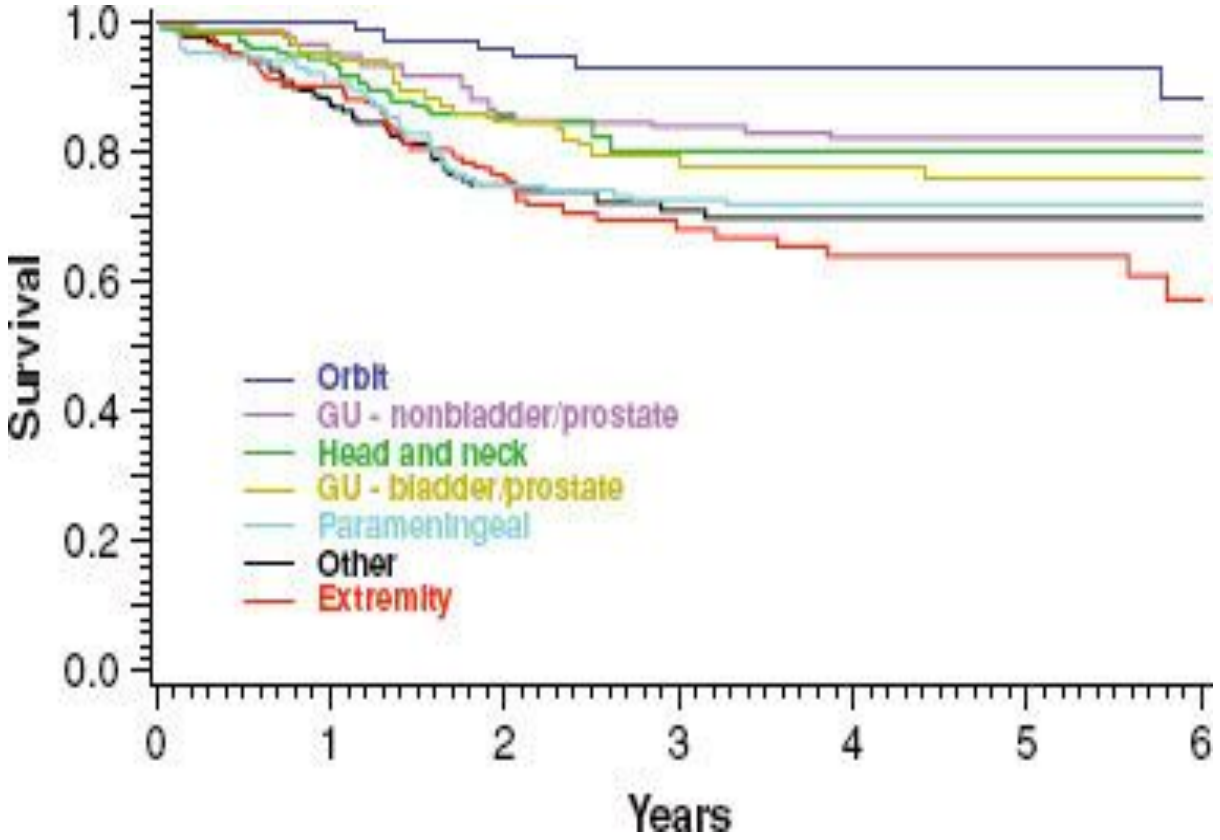
Intergroup Rhabdomyosarcoma Study Clinical Grouping

Clinical Group		Extent of disease/ Surgical Resection
I (Localized)	A	Localized tumor, confined to site of origin, completely resected
	B	Localized tumor, infiltrating beyond site of origin, completely resected
II (GTR)	A	Localized tumor, gross total resection, but with microscopic residual disease
	B	Locally extensive tumor (spread to regional lymph nodes), completely resected
	C	Locally extensive tumor (spread to regional lymph nodes), gross total resection, but microscopic residual disease
III (Incomplete resection)	A	Localized or locally extensive tumor, gross residual disease after biopsy only
	B	Localized or locally extensive tumor, gross residual disease after major resection (≥50 percent debulking)
IV (Metastatic)		Any size primary tumor, with or without regional lymph node involvement, with distant metastases, irrespective of surgical approach to primary tumor

The Intergroup Rhabdomyosarcoma Study: Objectives & Clinical Staging Classification
J Pediatr Surg 1980;15:371-372

Prognostic Factors

Site of Disease



J Clin Oncol 2001;19:3091–3102

Staging

Stage	Sites	Tumour stage invasiveness	T	N	M
1	Orbit Head & Neck (Non PM) GU (Non Bladder/ Prostate) Biliary tract	T_1 or T_2	a or b	Any N	M_0
2	Bladder/prostate Extremity H&N (Para-meningeal)	T_1 or T_2	a	N_0 or N_x	M_0
3	Bladder/prostate Extremity Cranial Para-meningeal	T_1 or T_2	a	N1	M_0
			b	Any N	
4	All	T_1 or T_2	a or b	N_0 or N_1	M_1

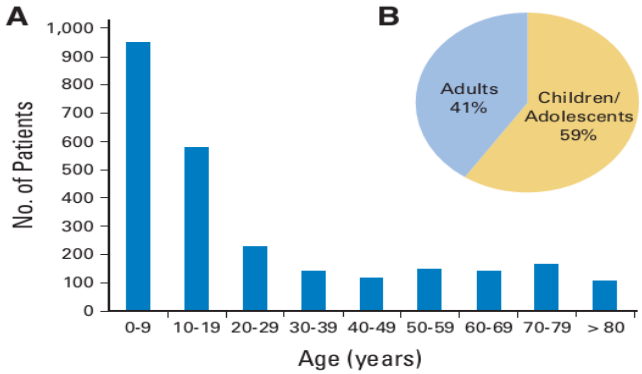
T1: Confined to anatomic site
T2: Extension
a: ≤5 cm in diameter
b: >5 cm in diameter

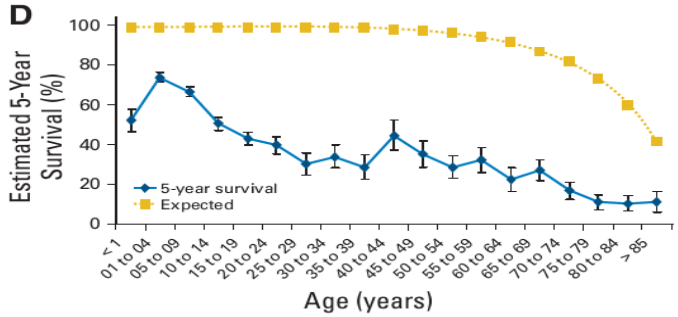
N0: Not clinically involved
N1: Clinically involved
NX: Clinical status unknown

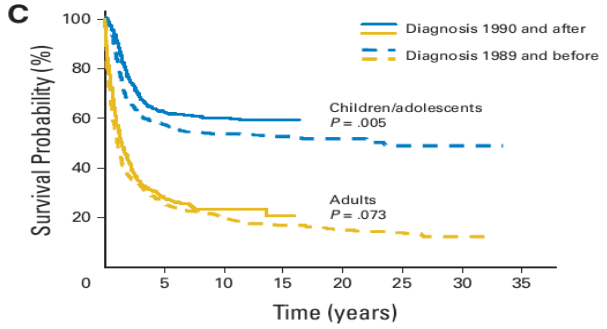
M0: No distant metastases
M1: Distant metastases present

Children vs Adults

	Adults	Children
Histology	Pleomorphic	Emryonal
Site	Trunk & extremities	HN, urogenital
Prognosis	• Worse • Unfavorable location • Invasive tumors • Propensity for loco-regional & distant spread • Higher rates of metastases	

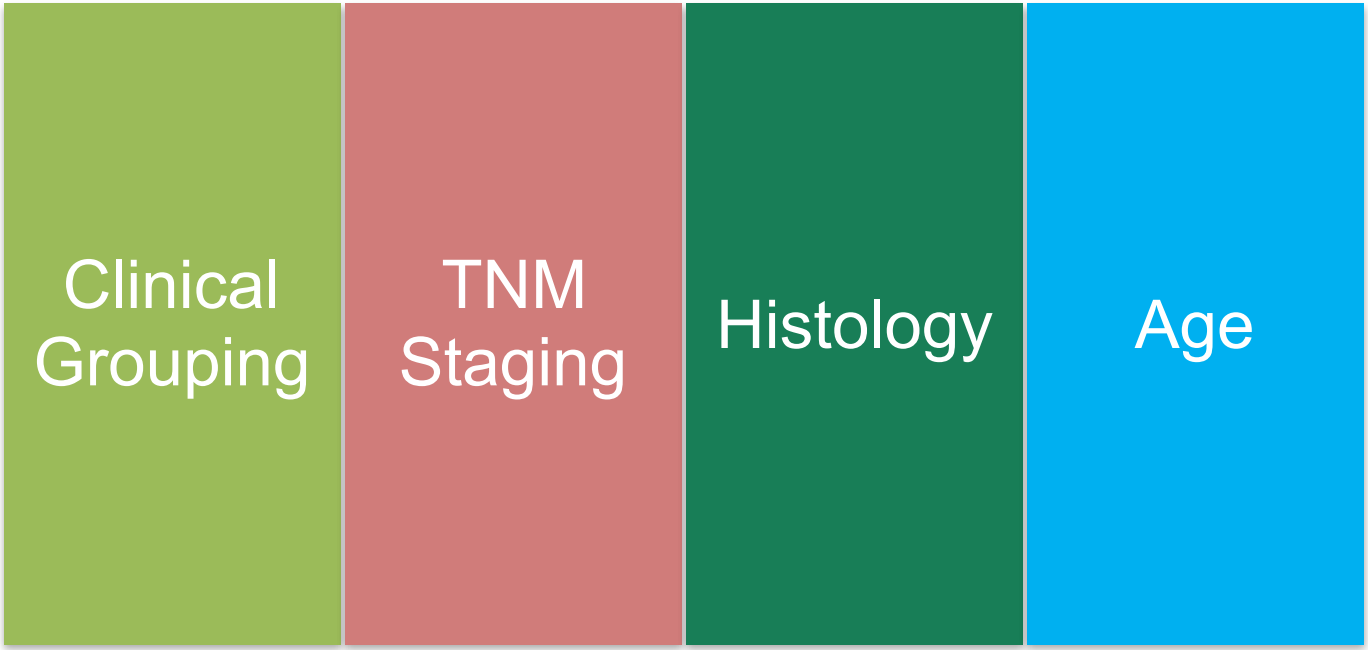






Stout et al, JCO 1967

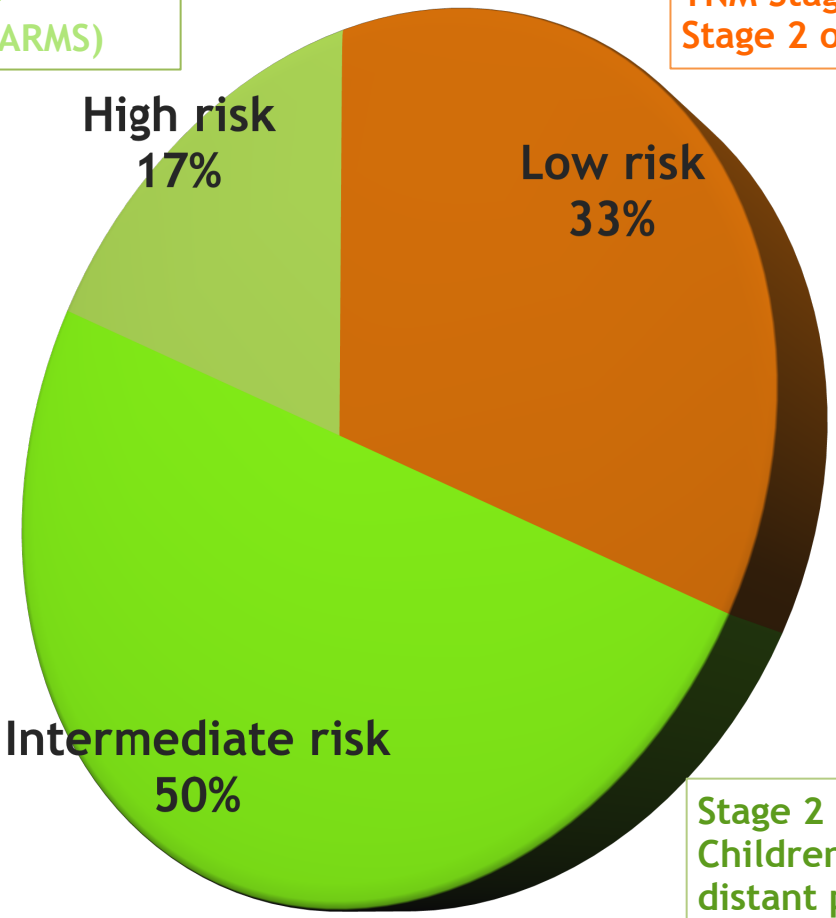
Risk Stratification



Risk Stratification

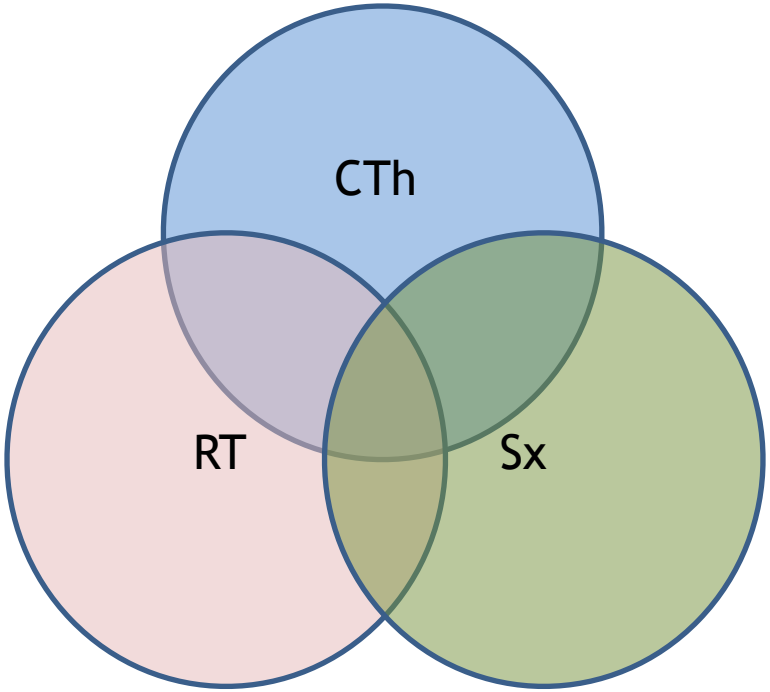
TNM Stage 4
RMS (ERMS/ ARMS)

TNM Stage 1 ERMS clinical groups I, II, or III
Stage 2 or 3 ERMS clinical groups I or II



Stage 2 or 3 ERMS clinical group III
Children with ARMS that has not spread to distant parts of the body (Stage 1, 2, or 3)

General Management



Optimal Sequence & Intensity

Disease Control, Organ & Function Preservation, Minimize Morbidity

Chemotherapy

- Chemotherapy is necessary in all cases

- Drugs demonstrating response as single-agent measured as a percentage response rate:

Ifosfamide	(86%)
Vincristine	(59%)
Cyclophosphamide	(54%)
Topotecan	(46%)
Mitomycin-C	(36%)
Dactinomycin	(24%)
Etoposide	(15% to 21%)
Irinotecan	(23%)
Cisplatin	(15% to 21%)
Dacarbazine	(11%)

- Commonly used combination chemotherapy:
  VAC or VAC + doxorubicin (VACA)
  VACA + IE - Unfavorable histology/unfavorable site/ extensive tumor burden

Intergroup Rhabdomyosarcoma Study Group

5 year OS

• IRS I (1972 – 1978)	55%
• IRS II (1978 – 1984)	63%
• IRS III (1984 – 1991)	71%
• IRS IV (1991 – 1997)	71%
• IRS V (1998 – 2005)	

Chemotherapy

- Initial intensive CTh: Used for pharmacologic debulking, potentially allowing for a more conservative surgical approach or less-aggressive radiation therapy.

  IRS I&II .Cancer 1990;66:2072–2081
  German COS .Cancer 1992;70:2557–2567
  SIOP MMT 89, *J Clin Oncol* 2005;23:2618–2628

- Response to induction chemotherapy—whether complete, partial, or no response—does not predict ultimate outcome

- CTh alone without Sx/ RT (H&N, pelvis): poor local control.

  Med Pediatr Oncol 1991;19:89–95
  SIOP MMT 84 Clin Oncol 1994;12:516–521,

- Omission of radiotherapy in partial responders result in inferior survival.

  Pediatr Blood Cancer 2008;51:593–597
  J Clin Oncol 2005;23:2586–2587

- Patients with only microscopic disease after initial resection (group II) require RT

  J Clin Oncol 2004;22:143–149

- No improvement in outcome of high risk disease with High Dose CTh/ TBI + BMT

  SIOP MMT-98. Eur J Cancer 2010;46:1588–1595.

Surgery

- Ablative Surgery only: 20% long-term survival rate

- Concept of reasonable surgery: Complete removal of tumor + maximal conservation of anatomic structures. E.g.:
  - Preservation of bladder, bowel, and sexual function in patients with tumors of genitourinary origin
  - Limb function in patients with extremity tumors
  - Vision, voice, deglutition, and appearance in patients with head and neck tumors

- Primary surgical excision:

Removal of tumor + 5mm normal tissue	(IRS Gp I)	– 20%
Compromised surgical procedures (R1)	(IRS Gp II)	– 20%
Unresectable without morbidity	(IRS Gp III)	– 40%
Present with metastatic disease	(IRS Gp IV)	– 20%

- Amputation, orbital exenteration, mutilating surgery for H&N, RND etc. reserved for failure of initial therapy

Surgery

Second-look surgery (delayed primary excisions): Useful for converting partial responses after chemotherapy into complete responses – may improve survival.

IRS-V: If second-look surgery might allow a reduction in the amount of radiotherapy that is necessary to provide local tumor control.

Preliminary results: only select primary sites are appropriate for this approach

Second-look surgery to avoid RT: Inferior local control and survival.

AIEOP Study.Pediatr Blood Cancer 2008;51:593–597

Major Clinical Trials

Intergroup Rhabdomyosarcoma Studies (IRS)	International Society of Pediatric Oncology (SIOP)	Co-operative Weichteilsarkom Studiengruppe Studies (CWS)
USA	Europe	German
IRS I – V COG	RMS – 75 MMT – 84 MMT – 89	CWS – 81 CWS – 86 CWS – 91
Evaluated efficacy of Chemotherapy & Radiotherapy as a function of surgical stage	To develop strategies to minimize local therapy by using risk adapted intensification of Chemotherapy & salvage pts with local failure	More frequent use of local therapy compared to the MMT studies. Tried to develop strategies to reduce doses of radiation therapy but not eliminate its use

Radiotherapy

Indications

- Un-resectable primaries at diagnosis (IRV Gp III)
- Microscopic residual disease (IRS Gp II)
- Completely resected alveolar histology or lymph node involvement

Wolden SL et al. Indications for radiotherapy and chemotherapy after complete resection in rhabdomyosarcoma:a report from the Intergroup Rhabdomyosarcoma Studies I to III.

J Clin Oncol 1999;17(11):3468-75

Can Radiotherapy be Avoided?

- No direct head to head comparison in IRSG trials (RT vs. No RT)

- Elimination of RT in para-meningeal RMS patients < 3 yrs age in the MMT trials reduced OS from 62% to 44%.

  Defachelles AS. Treatment of nonmetastatic cranial parameningeal RMS in children younger than 3 years old: results from SIOP MMT 89 and 95. J Clin Oncol 2009;27(8):1310-5.

- Improved outcomes in Group II disease in IRS-III& IV

  Smith LM. Which patients with rhabdomyosarcoma (RMS) and micro-scopic residual tumor (Group II) fail therapy? A report from the Intergroup Rhabdomyosarcoma Study Group (IRSG) [abstract 2273B]. Proc Am Soc Clin Oncol 2000;19:577a

De- Escalating Therapy

Pediatr Blood Cancer 2011;57:76–83

Local Control and Outcome in Children With Localized Vaginal Rhabdomyosarcoma: A Report From the Soft Tissue Sarcoma Committee of the Children's Oncology Group

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RMS Vagina

41 Pts

D9602 & ARST0331

Outcomes after Delaying/ Avoiding RT based on CTh Response & Delayed Surgery

5 Yr FFS (ARST0331): 42%

5 Yr FFS (D9602): 70%

Inferior outcome in ARST0331 attributed to: Avoidance of RT & Low Cumulative Cyclophophamide Dose (4.8g/m2)

RT Timing

INFLUENCE OF RADIATION THERAPY PARAMETERS ON OUTCOME IN CHILDREN TREATED WITH RADIATION THERAPY FOR LOCALIZED PARAMENINGEAL RHABDOMYOSARCOMA IN INTERGROUP RHABDOMYOSARCOMA STUDY GROUP TRIALS II THROUGH IV

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SUZANNE L. WOLDEN, M.D.,†‖ FRAN LAURIE,†¶ MARYANN JODOIN,†¶ BEVERLY RANEY, M.D.,†#
MOODY D. WHARAM, M.D.,†** AND SARAH S. DONALDSON, M.D.†††

- Early RT within 9 weeks preferable
- Delayed RT feasible without compromising OS in a subset (bladder & prostate)
- Meningeal involvement- RT preferably within 2 weeks (LR increase from 18% to 33%)
- WBRT not necessary

Int. J. Radiation Oncology Biol. Phys., Vol. 59, No. 4, pp. 1027–1038, 2004

RT Timing

S.No	RT On Day 0	RT On Day21 (Wk 3)	RT On Day 62 (Wk 9)
1	Intra-cranial extension	Para-meningeal sites Nasopharynx PNS (maxilla/ethmoid/sphenoid) Middle ear Mastoid Pterygopalatine fossa Infra Temporal Fossa	All others
2	Skull base erosion		
3	Cranial nerve palsy		

RT Volumes

GTV –	All visible disease prior to starting CTh
CTV –	Pre CTh extent + 2 cm margin (except sites like Orbit/ Pelvis/ Thorax etc)
	Surgical sites/ Biopsy tracts
	Clinically suspicious or involved lymph nodes should be included
	Prophylactic lymph node irradiation not necessary
PTV -	Pt/ Site/ Institute specific – Usually 5mm beyond CTV

- Parameningeal sites (middle ear, paranasal sinuses, nasopharynx, nasal cavity, infratemporal fossa, and parapharyngeal area): Portals should cover the adjacent meninges

IRS III, J Clin Oncol 1995;13:610-630,
IRS II-IV, Int J Radiat Oncol Biol Phys 2004;59:1027-1038

- Whole Brain RT not indicated

RT Dose

Traditionally used RT dose:

Microscopic disease – 41.4Gy/ 23#/ 5Wks @ 1.8Gy/ fraction
Gross Disease – 50.4Gy/ 28#/ 6Wks @ 1.8Gy/ fraction

Dose reduction:

IRS-V, D9602 – Suggest 45Gy for gross tumor at orbital sites, especially if cyclophosphamide is included in the systemic therapy regimen

Raney R. Results of the Intergroup Rhabdomyosarcoma Study Group D9602 protocol, using vincristine and dactinomycin with or without cyclophosphamide and radiation therapy, for newly diagnosed patients with low-risk embryonal rhabdomyosarcoma: a report from the Soft Tissue Sarcoma Committee of the Children's Oncology Group. J Clin Oncol 2011;29:1312-1318.

Breneman J. Local control with reduced dose radiotherapy for low-risk rhabdomyosarcoma: a report from the Children's Oncology Group D9602 study. Int J Radiat Oncol Biol Phys 2012;83(2): 720-726.

RT Dose Reduction

Local Control With Reduced-Dose Radiotherapy for Low-Risk Rhabdomyosarcoma: A Report From the Children's Oncology Group D9602 Study

John Breneman, M.D.,* Jane Meza, Ph.D.,† Sarah S. Donaldson, M.D.,‡ R. Beverly Raney, M.D.,§,¶ Suzanne Wolden, M.D.,‖ Jeff Michalski, M.D.,** Fran Laurie, B.S.,†† David A. Rodeberg, M.D.,‡‡ William Meyer, M.D.,§§ David Walterhouse, M.D.,¶¶ and Douglas S. Hawkins, M.D.‖‖

International Journal of Radiation Oncology biology • physics

Volume 83 • Number 2 • 2012

COG D9602

Table 2 Radiotherapy (RT) doses

Group	RT dose (Gy)
I	No RT
IIA	36
IIB/C	41.4
III orbit	45
III nonorbit*	50.4

* These patients were eligible for second-look operation after Week 12 chemotherapy. If tumor was completely resected, radiotherapy was reduced to 36 Gy for lymph-node negative tumors, and 41.4 Gy was given for lymph-node positive tumors. Girls with vaginal tumors received RT only if there was gross or microscopic tumor after chemotherapy with or without second-look operation.

COG D9602

Table 4 Five-year cumulative local control for Group IIA: favorable site tumors

Protocol	RT dose (Gy)	Chemotherapy	Local failure rate (%)
D9602 ($n = 62$)	36	VA	15*
IRS III ($n = 52$)	41.4	VA	11
IRS IV ($n = 43$)	41.4	VAC/VAI/VAE	2

COG D9602

Table 5 Five-year cumulative local control for Group IIA: unfavorable site tumors

Protocol	RT dose (Gy)	Chemotherapy	Local failure rate (%)
D9602 ($n = 16$)	36	VAC	0
IRS III ($n = 38$)	41.4	VA	14
IRS IV ($n = 28$)	41.4	VAC/VAI/VAE	7

COG D9602

Table 6 Five-year cumulative local control for Group III orbital tumors

Protocol	RT Dose (Gy)	Chemotherapy	Local failure rate
D9602 (n = 77)	45	VA	14%
IRS III (n = 71)	41.4–50.4	VA	16%
IRS IV (n = 50)	50.4–59.5	VAC/VAI/VAE	4%

Conclusions: In comparison with Intergroup Rhabdomyosarcoma Study Group III and IV results, reduced-dose radiotherapy does not compromise local control for patients with microscopic tumor after surgical resection or with orbital primary tumors when cyclophosphamide is added to the treatment program. Girls with unresected nonbladder genitourinary tumors require radiotherapy for postsurgical residual tumor for optimal local control to be achieved.

Hyperfractionation
(Dose Escalation)

RESULTS FROM THE IRS-IV RANDOMIZED TRIAL OF HYPERFRACTIONATED RADIOTHERAPY IN CHILDREN WITH RHABDOMYOSARCOMA—A REPORT FROM THE IRSG

SARAH S. DONALDSON, M.D.,* JANE MEZA, PH.D.,† JOHN C. BRENEMAN, M.D.,‡ WILLIAM M. CRIST, M.D.,§ FRAN LAURIE, M.S.,‖ STEPHEN J. QUALMAN, M.D.,¶ AND MOODY WHARAM, M.D.,# FOR THE CHILDREN'S ONCOLOGY GROUP SOFT TISSUE SARCOMA COMMITTEE (FORMERLY INTERGROUP RHABDOMYOSARCOMA GROUP) REPRESENTING THE CHILDREN'S ONCOLOGY GROUP AND THE QUALITY ASSURANCE REVIEW CENTER

Arm A: 59.4 Gy/ 1.1-Gy fractions twice daily at 6-hour intervals for gross disease
Arm B: 50.4 Gy/ 1.8 Gy once daily.

Result: No difference in LRC, FFS, OS

Int. J. Radiation Oncology Biol. Phys., Vol. 51, No. 3, pp. 718–728, 2001

RT Techniques

- 3D CRT
- IMRT
- Proton beam therapy
- Brachytherapy

IMRT for H&N RMS

CLINICAL INVESTIGATION **Head and Neck**

INTENSITY-MODULATED RADIOTHERAPY FOR HEAD-AND-NECK RHABDOMYOSARCOMA

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MICHAEL P. LAQUAGLIA, M.D.,‡ ERIC LIS, M.D.,§ AND PAUL A. MEYERS, M.D.†

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GTV	The gross tumour volume was defined as the extent of disease at diagnosis (pre-chemotherapy volume).Modified to reflect change in anatomy after tumour shrinkage
CTV	1 cm margin beyond GTV
PTV	0.5cm

Int. J. Radiation Oncology Biol. Phys., Vol. 61, No. 5, pp. 1432–1438, 2005

H&N IMRT

Results (3 Years):

OS –	65%
LC (Primary) –	95%
LC (Node) –	88%
Dist Met Free Survival –	80%

Orbit: No failures

DFS inferior in Alveolar

Acute/ Late toxicities: Similar to previous IRS studies without IGRT

IMRT with reduced margins: Excellent outcomes

IMRT for H&N RMS

LOCAL CONTROL AFTER INTENSITY-MODULATED RADIOTHERAPY FOR HEAD-AND-NECK RHABDOMYOSARCOMA

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4 Year LC (92.9%) , OS (76%)

Overall Survival:

Parameningeal: 42.9%

Other Sites: 100%

I. J. Radiation Oncology ● Biology ● Physics Volume 73, Number 1, 2009

3D-CRT vs IMRT

EFFECT OF RADIOTHERAPY TECHNIQUES (IMRT VS. 3D-CRT) ON OUTCOME IN PATIENTS WITH INTERMEDIATE-RISK RHABDOMYOSARCOMA ENROLLED IN COG D9803—A REPORT FROM THE CHILDREN'S ONCOLOGY GROUP

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	3D-CRT	IMRT
Median FU	5.7 Yrs	4.2 Yrs
5 Yr Local Rec Free Survival	18%	15%
5 Yr Failure Free Survival	72%	76%
Target Coverage	Inferior	Superior

Parameningeal sites: More likely treated with IMRT
Doses >50Gy more frequently with IMRT

Int. J. Radiation Oncology Biol. Phys., Vol. 82, No. 5, pp. 1764–1770, 2012

Proton Beam Therapy

- Sharp fall off
- Superior dose distribution
- Greater sparing of normal structures
- Advantageous especially in H&N (para-meningeal)locations

FRACTIONATED, THREE-DIMENSIONAL, PLANNING-ASSISTED PROTON-RADIATION THERAPY FOR ORBITAL RHABDOMYOSARCOMA: A NOVEL TECHNIQUE

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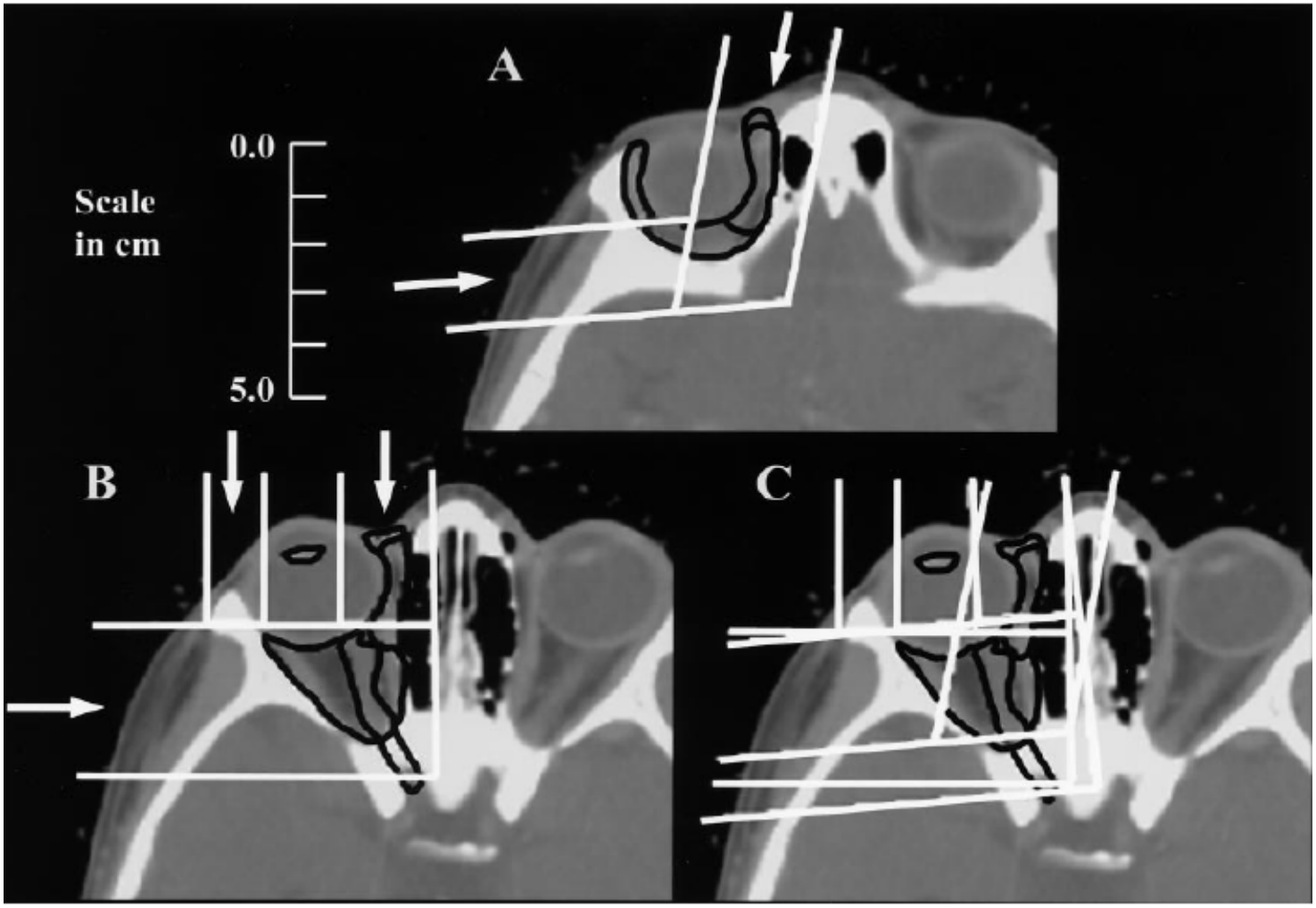
- Excellent sparing of lens & orbit
- Conformal target dose coverage

Int. J. Radiation Oncology Biol. Phys., Vol. 47, No. 4, pp. 979–984, 2000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PROTON RADIOTHERAPY FOR ORBITAL RHABDOMYOSARCOMA: CLINICAL OUTCOME AND A DOSIMETRIC COMPARISON WITH PHOTONS

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Table 4. Average dose and percent savings to CNS structures

Structure	X-ray dose average (%)*	Proton dose average (%)*	Difference (%)	Percent savings†
Hypothalamus	6.3	0.7	5.6	88.7
Pituitary	21.7	1.3	20.4	94.1
Brain	10.4	1.2	9.1	88.1
Temporal lobe (contralateral)	6.3	0.7	5.6	88.6
Temporal lobe (ipsilateral)	18.1	3.3	14.8	81.8
Chiasm	19.8	1.9	17.9	90.4

Int. J. Radiation Oncology Biol. Phys., Vol. 63, No. 4, pp. 1161–1168, 2005

PROTON RADIOTHERAPY FOR PARAMENINGEAL RHABDOMYOSARCOMA: CLINICAL OUTCOMES AND LATE EFFECTS

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Table 2. Incidence of recorded toxicities in patients with parameningeal rhabdomyosarcoma: Comparison of proton data with previously published studies

	Protons: MGH ($n = 10$) Median f/u: 5 y		IRS II-III* ($n = 213$) Median f/u: 7 y		IMRT: MSKCC† ($n = 21$) Median f/u: 2 y		University of Iowa‡ ($n = 17$) Median f/u: 20 y	
Toxicity	*n*	%	*n*	%	*n*	%	*n*	%
Decreased growth velocity	3/10	30	92/190	48	NR		9/15	60
Growth hormone replacement	2/10	20	36/190	19	1/21	5	6/15	40
Other endocrinopathies	1/10	10	17/213	8	NR		1/15	7
Facial hypoplasia	7/10	70	74/76	97	1/21	5	11/15	73
Visual complications	0		45/213	21	2/21	10	9/11	82
Auditory complications	0		36/213	17	NR		6/8	75
Dentition	3/10	30	NR		NR		7/7	100
Chronic nasal and sinus congestion	2/10	20	35/71	49	4/21	19	NR	
Secondary malignancies	0		4/213	2	2/21	10	1/17	6

Int. J. Radiation Oncology Biol. Phys., Vol. 82, No. 2, pp. 635–642, 2012

SUMMARY

- Radiation therapy forms an important component in combined modality treatment of RMS
- Improves local disease control in high risk patients
- Conformal techniques can reduce toxicities without compromising outcomes
- Brachytherapy us a useful tool for radiotherapy in young children
- Quality assurance & compliance to guidelines is essential for optimal disease control
- Avoidance or Delaying RT should be done with caution