

RISK OF SECONDARY MALIGNANCIES FROM CYBERKNIFE RADIOSURGERY

Maria R. Bellon, B.S.

D. Followill, Ph.D, G. Ibbott, Ph.D, M. Salehpour,
Ph.D, R. White, Ph.D, A. Mahajan, M.D., S. Kry,
Ph.D, C. Ding, Ph.D

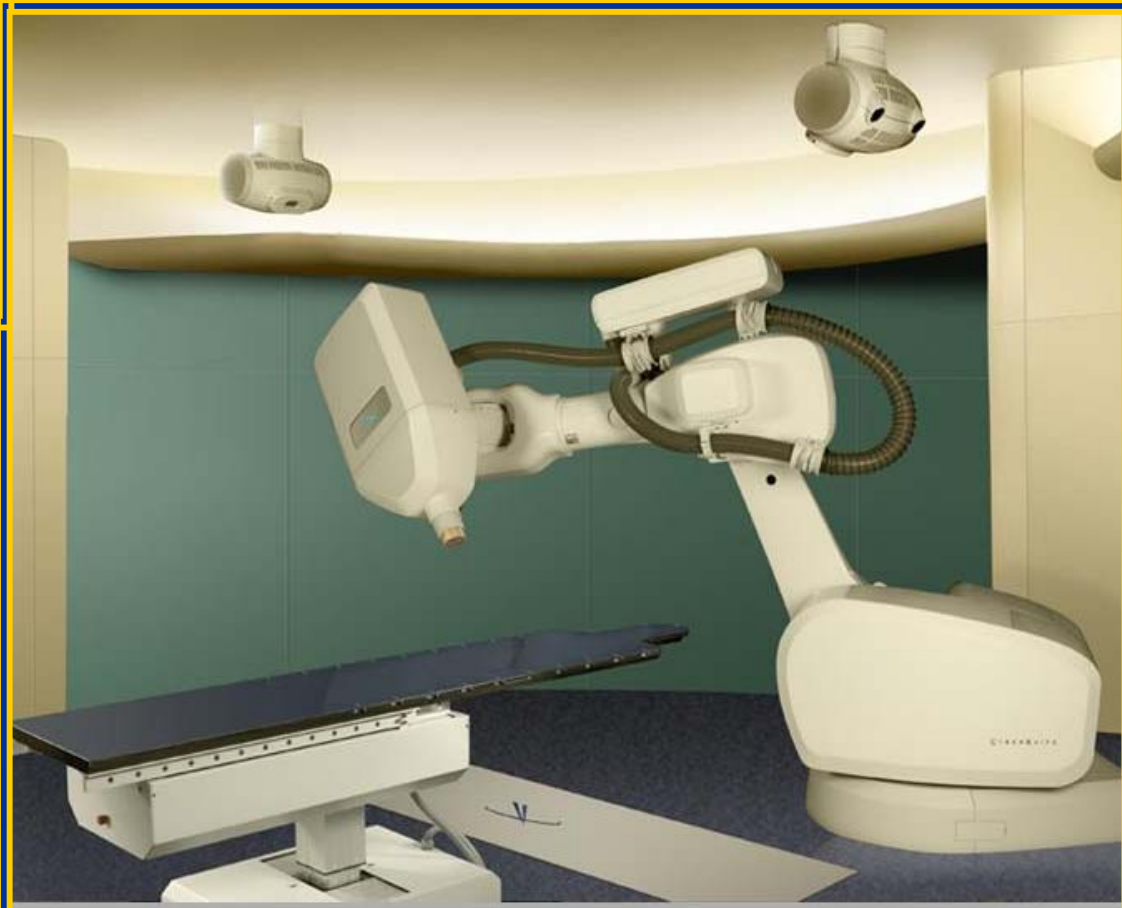
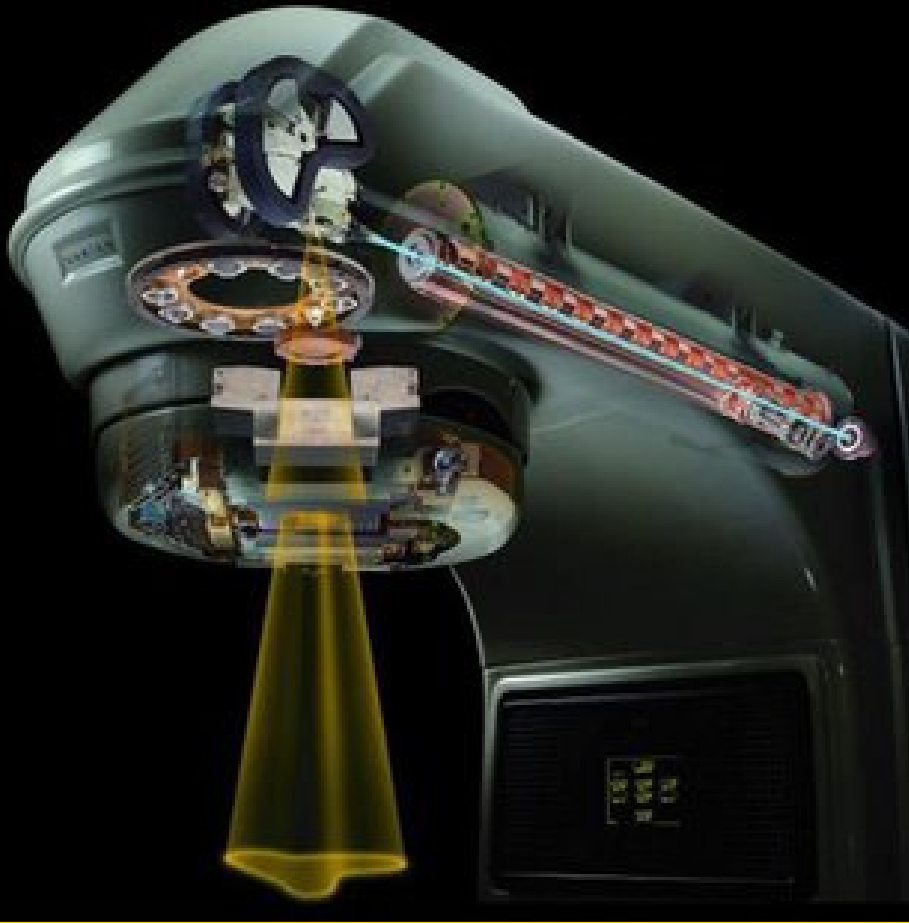


THE UNIVERSITY OF TEXAS
MD ANDERSON
CANCER CENTER

OBJECTIVE OF EXPERIMENT

- ❑ To quantify the risk of developing a secondary malignancy following an external beam radiation therapy treatment
 - Pediatric brain and adult prostate treatment

■ IMRT vs. Cyberknife Radiosurgery



MATERIALS & METHODS

Adult Rando Phantom



Adult Organs of Interest

Organ	Distance from Isocenter (cm)
Thyroid	60
Lung Center	42.5
Esophagus Center	40
Inferior Lung	30
Inferior Esophagus	27.5
Liver Center	27.5
Stomach Center	25
Inferior Stomach	22.5
Inferior Liver	22.5
Transverse Colon	20
Ascending Colon	12.5

MATERIALS & METHODS

Pediatric Organs of Interest

5 yr old Pediatric Rando Phantom



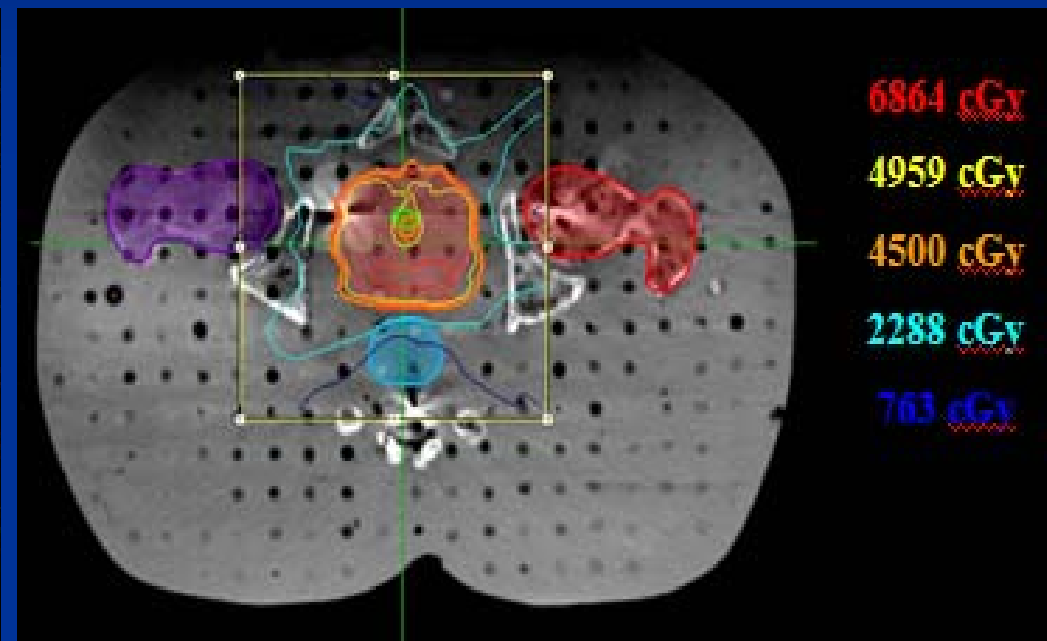
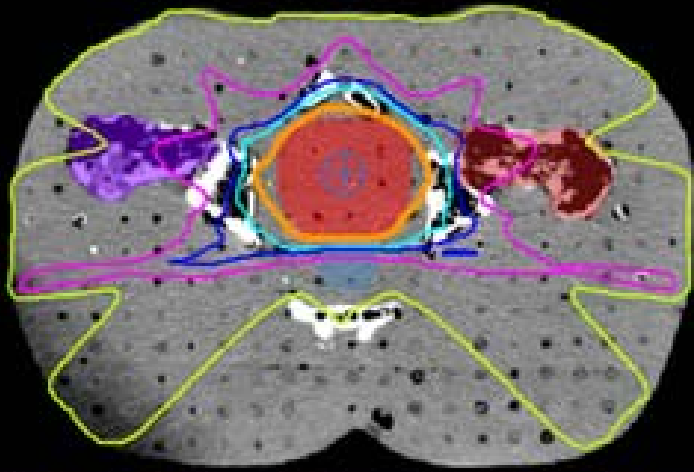
Organ	Distance from Isocenter (cm)
Thyroid	12.5
Sup. Esophagus	12.5
Sup. Lung	15
Breast Bud	20
Cnt. Esophagus	20
Heart	22.5
Cnt. Lung	22.5
Sup. Liver	25
Sup. Stomach	27.5
Cnt. Stomach	30
Cnt. Liver	30
Kidney	32.5
Trans. Colon	35
Cnt. Colon	37.5
Pelvis	42.5
Ovaries	45
Bladder	47.5

MATERIALS AND METHODS

Adult Prostate Treatment Plans

Hypofractionated IMRT

CyberKnife



45 Gy/ 5 Fx to 99% IDL

45 Gy/ 5 Fx to 59% IDL

8 coplanar beams

168 beams, 20mm collimator

13,400 MU

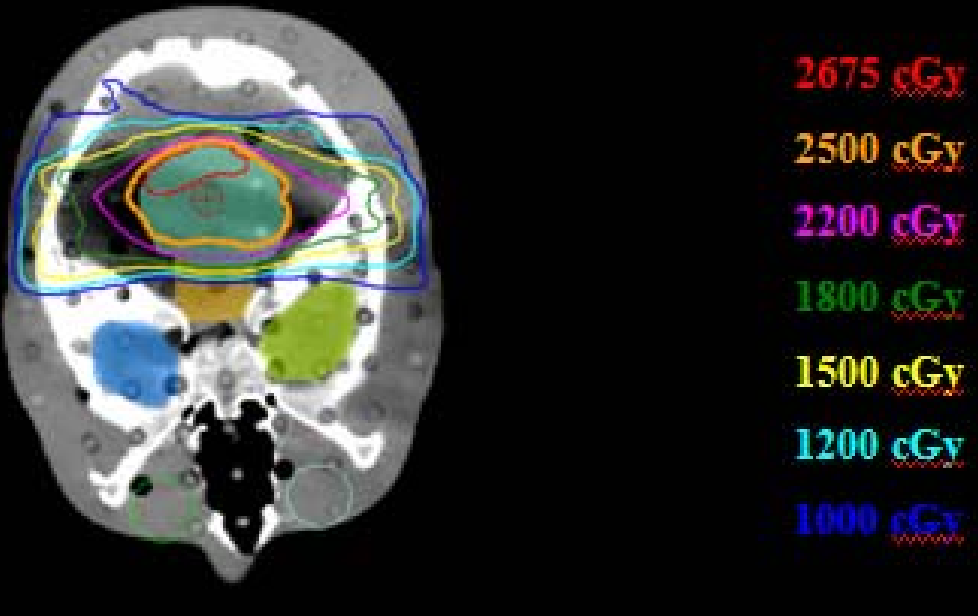
72,099 MU

MATERIALS AND METHODS

❑ Pediatric Brain Treatment Plans

IMRT

CyberKnife



25 Gy/5 Fx to 98% IDL

25 Gy/ 5 Fx to 50% IDL

8 coplanar beams

117 beams, 20 mm collimator

5,765 MU

21,606 MU

RESULTS

□ Adult Prostate Dose Results

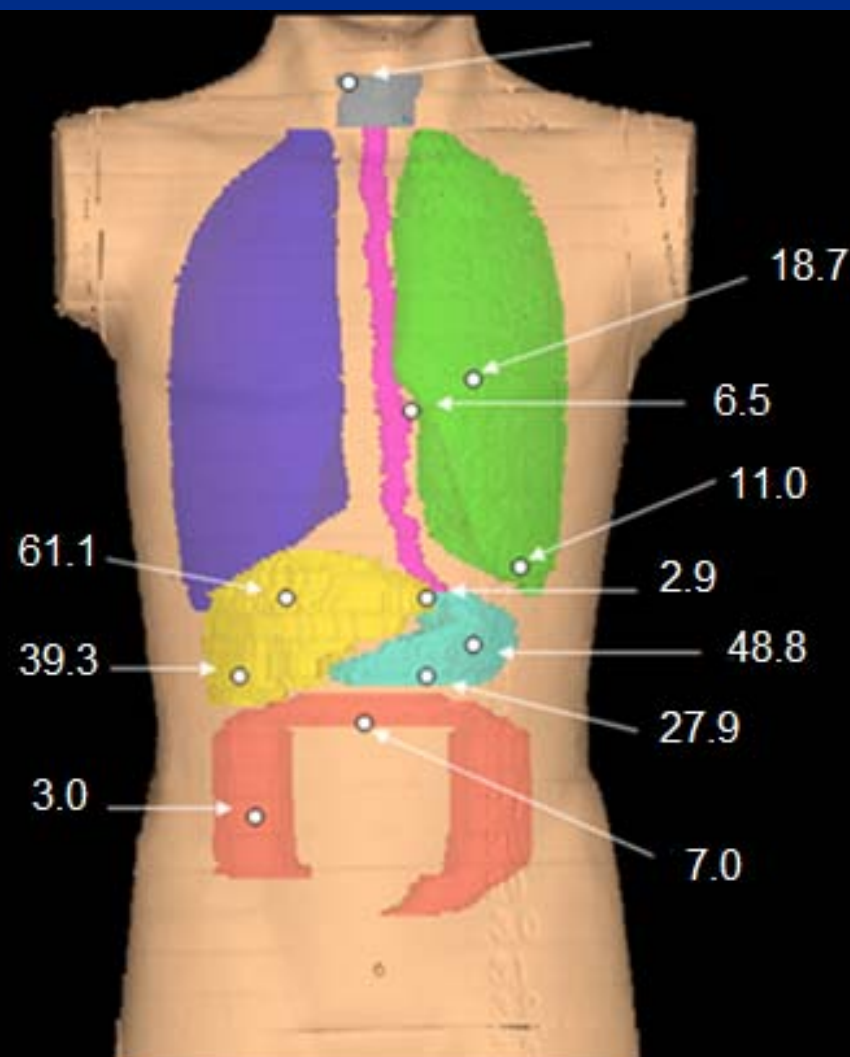
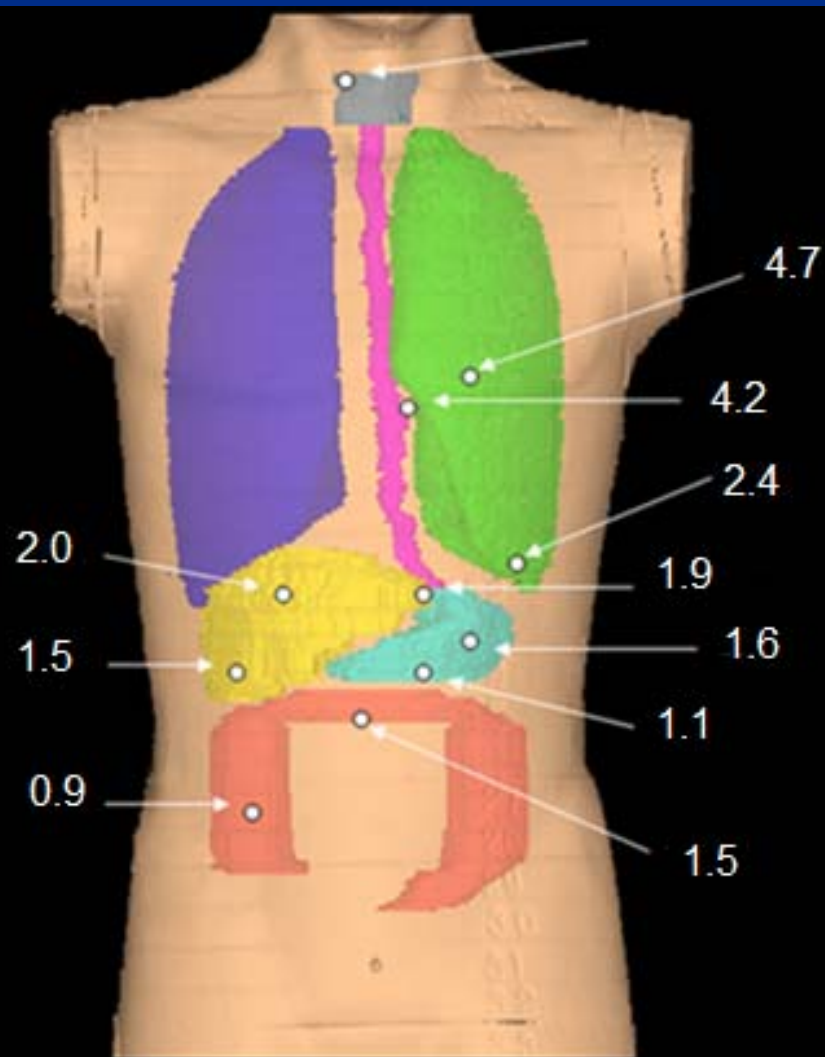
Organ	<u>CYBERKNIFE</u>		<u>IMRT</u>		<u>HYPOFRAC IMRT</u>	
	Average Dose (cGy)	95% CI	Average Dose (cGy)	95% CI	Average Dose (cGy)	95% CI
Thyroid	34.4	0.8	5.2	0.0	3.4	0.1
Lung Center	27.0	0.4	5.8	0.0	3.7	0.0
Esophagus Cnt	25.4	0.3	6.0	0.0	3.9	0.0
Inf. Lung	23.7	0.1	9.8	0.1	6.3	0.1
Inf. Esophagus	25.0	0.2	13.5	0.1	8.7	0.1
Liver Center	27.7	0.2	13.6	0.8	8.6	0.1
Stomach Center	30.3	0.1	18.6	0.1	11.8	0.1
Inf. Stomach	36.6	0.4	32.6	0.4	20.8	1.2
Inf. Liver	32.2	0.5	21.2	0.0	14.2	0.2
Trans. Colon	42.8	1.2	29.3	0.2	19.0	0.1
Asc. Colon	60.5	1.5	67.3	0.4	42.6	0.1

RESULTS

Adult Prostate Risk

CK risk / IMRT risk

CK risk / Hypo IMRT risk



RESULTS

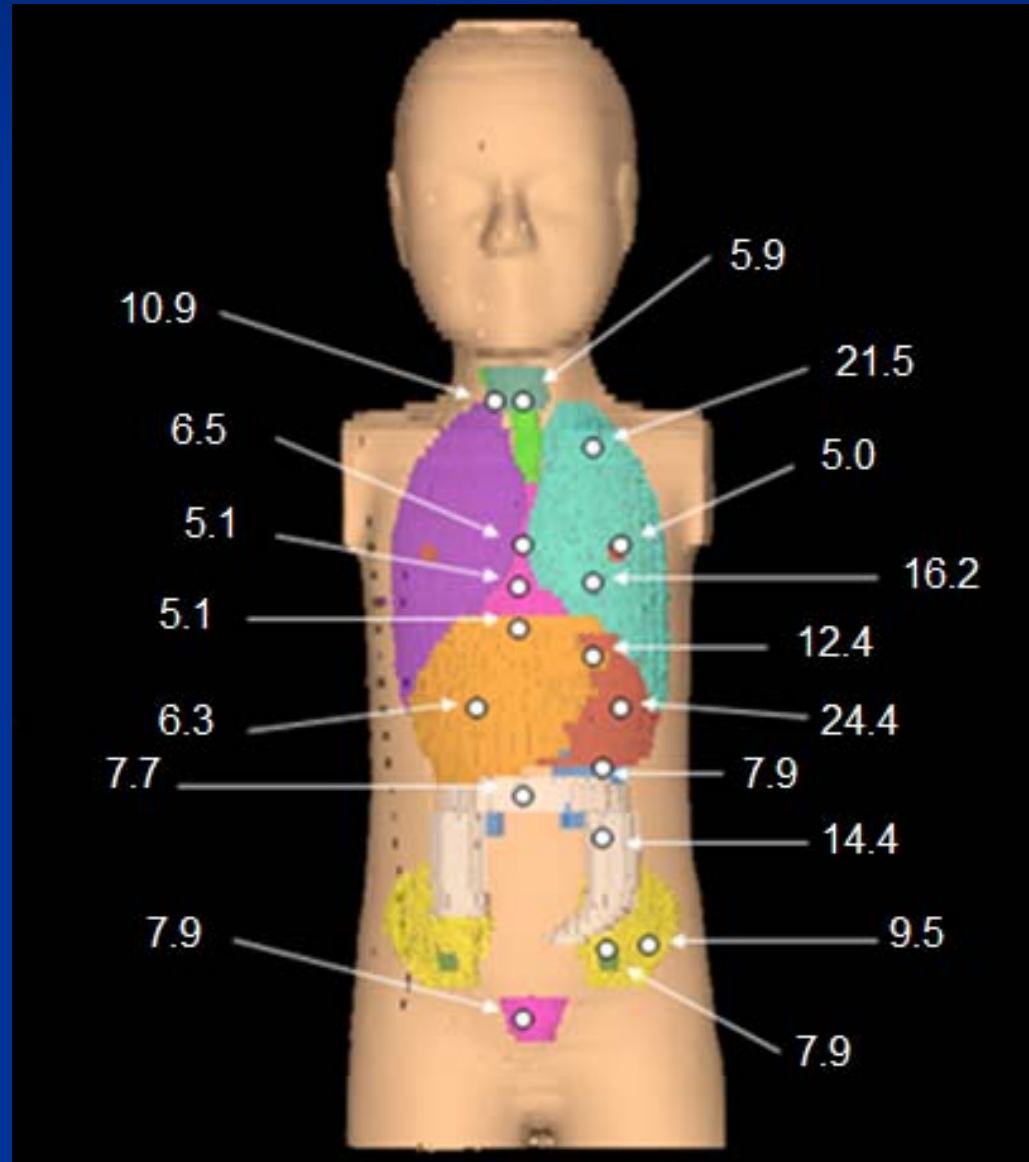
□ Pediatric Brain Dose Results

Organ	<u>CYBERKNIFE</u>		<u>IMRT</u>	
	Average Dose (cGy)	95% CI	Average Dose (cGy)	95% CI
Thyroid	32.2	11.8	5.5	0.1
Sup. Esophagus	63.8	8.9	5.9	0.0
Sup. Lung	92.1	11.9	4.3	0.0
Breast Bud	12.3	0.1	2.5	0.0
Cnt. Esophagus	16.3	0.0	2.5	0.0
Heart	14.1	0.2	2.8	0.0
Cnt. Lung	60.2	8.2	3.7	0.1
Sup. Liver	10.4	0.1	2.0	0.1
Sup. Stomach	20.5	5.9	1.7	0.0
Cnt. Stomach	36.9	1.8	1.5	0.0
Cnt. Liver	9.2	0.2	1.5	0.0
Kidney	11.4	0.2	1.4	0.0
Trans. Colon	8.5	0.3	1.1	0.0
Cnt. Colon	16.1	2.6	1.1	0.1
Pelvis	10.1	0.2	1.1	0.1
Ovaries	8.1	0.2	1.0	0.0
Bladder	7.2	0.1	0.9	0.0

RESULTS

□ Pediatric Brain Risk

CK risk / IMRT risk



DISCUSSION

- ❑ CyberKnife risk was higher due to the greater number of MU's delivered with this treatment modality

- ADULT

Conv. IMRT	Hypo. IMRT	CK
21,126	13,400	72,099

- PEDIATRIC

IMRT	CK
5,765	21,606

DISCUSSION

- ❑ CyberKnife treatments re-planned using a more updated version of treatment planning software

	Original CK Prostate Plan	CK Prostate Re-Plan	% Change
Prescription	45 Gy to 59% IDL	45 Gy to 75% IDL	16% increase
No. Beams	138	98	30% decrease
Total MU	72,099	31,984	56% decrease

DISCUSSION

❑ Modified CK results—Adult Prostate

<u>60 YR OLD MALE</u>				
Organ Site	Lifetime Attributable Risk of Cancer Mortality (%/Sv)	Cyberknife Risk (%)	IMRT Risk (%)	Hypofrac IMRT Risk (%)
Thyroid*	0.003	0.00	0.00	0.00
Lung Center	0.93	0.11	0.05	0.01
Esophagus Cnt	0.58	0.06	0.03	0.02
Inf. Lung	0.93	0.10	0.09	0.02
Inf. Esophagus	0.58	0.06	0.08	0.05
Liver Center	0.12	0.01	0.02	0.00
Stomach Center	0.11	0.01	0.02	0.00
Inf. Stomach	0.11	0.02	0.04	0.00
Inf. Liver	0.12	0.02	0.03	0.00
Trans. Colon	0.49	0.21-0.09	0.14	0.03

DISCUSSION

❑ Modified CK results—Pediatric Brain

5 YEAR OLD FEMALE

Organ Site	Cyberknife Risk (%)	IMRT Risk (%)
Thyroid*	0.88	0.23
Sup. Esophagus	1.19	0.17
Sup. Lung	3.20	0.23
Breast Bud	0.17	0.05
Cnt. Esophagus	0.31	0.07
Heart	0.26	0.08
Cnt. Lung	2.09	0.20
Sup. Liver	0.01	0.00
Sup. Stomach	0.07	0.01
Cnt. Stomach	0.12	0.01
Cnt. Liver	0.01	0.00
Kidney	0.21	0.04
Trans. Colon	0.05	0.01
Cnt. Colon	0.09	0.01
Pelvis	0.19	0.03
Ovaries	0.03	0.00
Bladder	0.03	0.00

CONCLUSION

- ❑ The risk of developing a secondary malignancy is higher for a CyberKnife Radiosurgery treatment than a gantry-based IMRT treatment, but overall, the risks associated with both treatment modalities are minimal.
- ❑ Keep the total MU's as low as possible in order to minimize patient risk.
 - $\text{IMRT risk} = \text{CK risk}$

QUESTIONS?