A novel Integrated VMAT/IMRT technique for the treatment of non-small cell lung cancer

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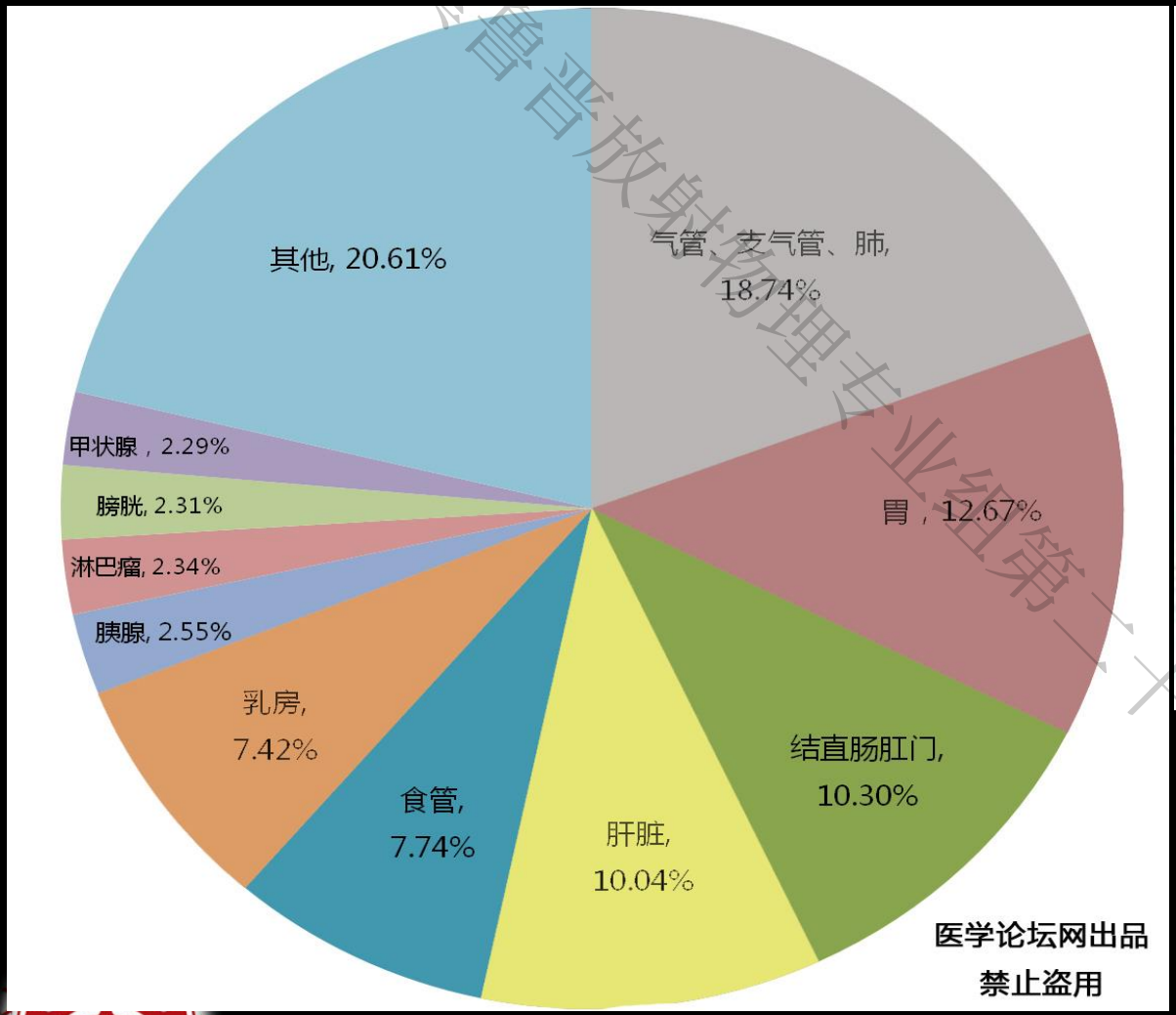
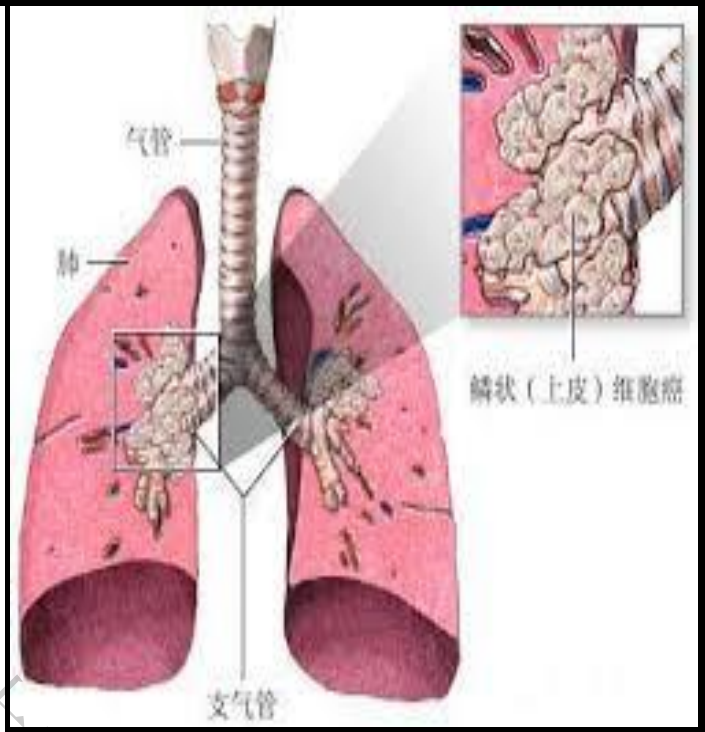
Outline

- Background
- Methods and Materials
- Results
- Conclusions

Background

Lung cancer has been the first killer of cancer in China.





From China Medical Tribune 2013

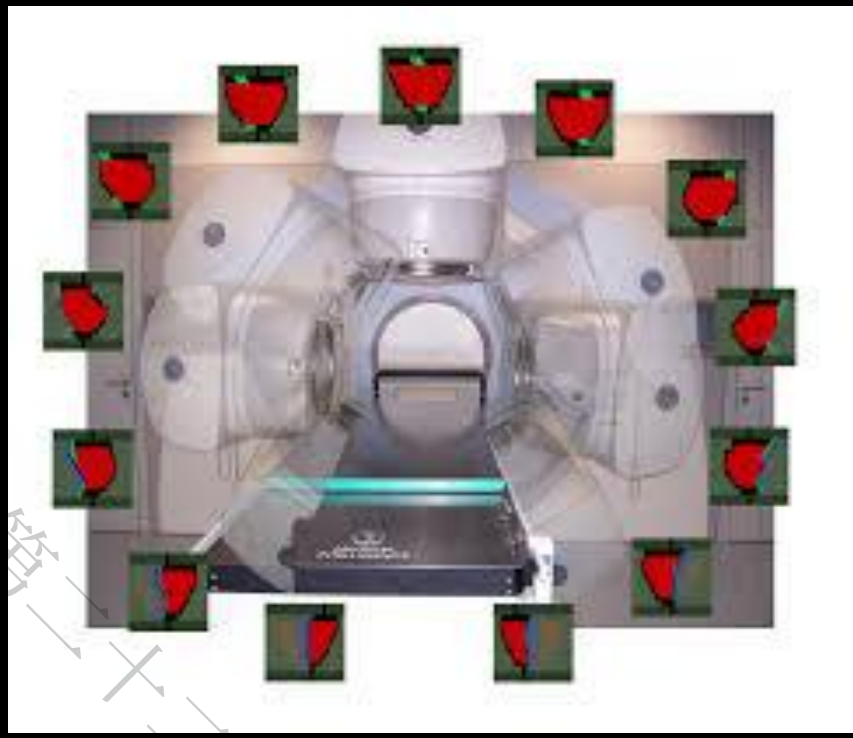
Background

- 3D-CRT has proved to be effective in NSCLC.
- Intensity-modulated radiotherapy (IMRT)
  - reduced the volume of normal lung receiving low dose
  - *longer treatment time and more MUs*
- Volumetric-modulated radiotherapy (VMAT)
  - shorter treatment time and fewer MUs
  - *larger V_5 and V_{10} of lung*

Patel RR, Mehta M. Curr Oncol Rep 2002
Murshed H, Liu HH, Liao Z, et al. Int J Radiat Oncol Biol Phys 2004
Hall EJ. Int J Radiat Oncol Biol Phys 2006
Holt A, Van Gestel D, Arends MP, et al. Radiat Oncol 2013
Jiang X, Li T, Liu Y, et al. Radiat Oncol 2011

Purpose

We developed a novel technique to treat NSCLC.



IMRT **VMAT**

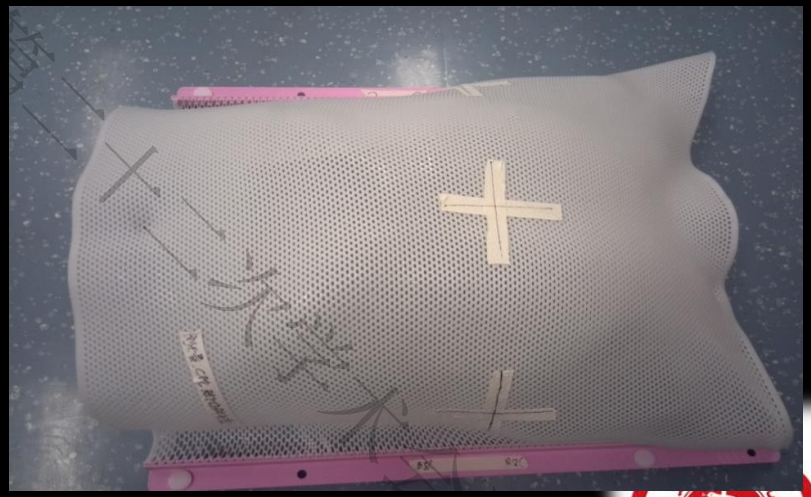
Methods and Materials

patients' characteristic

- Seventeen NSCLC patients
- Age:
  - range:26-84
  - median: 67
- Histology:
  - Adenocarcinoma: 4
  - Sqamouscarcinoma: 7
  - Not otherwise specified (NOS): 6
- PTV:
  - Range: 41.9-453.8 cm^3
  - mean: 199.3 cm^3

Methods and Materials

CT体位固定—扫描层厚3 mm



Methods and Materials

Delineation of target volumes and critical structures

- GTV: gross tumor and lymph nodes involved (>1 cm on CT)
- CTV: GTV plus a 6- to 8- mm margin
  - Adenocarcinoma: 8 mm
  - Squamous cell carcinoma: 6 mm
  - Not otherwise specified (NOS): 8 mm
- PTV: CTV plus margin
  - *Axial: 5 mm*
  - *Cranial-caudual: 10 mm*
- Normal lung: double lungs minus PTV
- Spinal cord and esophagus: from 2 cm above the superior extent of the PTV to 2 cm below the inferior extent of the PTV

Methods and Materials

Treatment planning objectives

- Prescription: *60 Gy/30 fractions*
- Target:
  - $D_{98\%}$>95% prescription dose;
  - $D_{2\%}$< 110% prescription dose
- OARs:
  - Normal lung
    - *V_5<60%; V_{10}<40%*
    - *V_{20}<30%; V_{30}<20%*
    - *Mean dose<16 Gy*
  - Spinal cord (0.03 cm^3)<50 Gy
  - Esophagus (0.03 cm^3)<60 Gy

RTOG 1106: Randomized phase II trial of individualized adaptive radiotherapy in locally advanced non-small cell lung cancer(NSCLC)

Gregoire V, Mackie T R, De Neve W, et al. ICRU Report 83: Prescribing, recording, and reporting photon-beam intensity-modulated radiation therapy (IMRT)[J]. ICRU,2010,10(1):1-106

Methods and Materials

Treatment planning

IMRT	Integrated	VMAT
5-fields IMRT (BAO)	2 partial arcs VMAT (*5-fields IMRT base plan*)	2 partial arcs VMAT

The plans were normalized to cover 95% of the PTV with 100% of the prescribed dose.

Methods and Materials

Plan evaluation

- Target evaluation:
  - $D_{98\%}$(minimal dose delivered to the 98% of the target volume)
  - **$D_{2\%}$** (maximum dose delivered to the 2% of the target volume)
  - CN (conformation number)
  - HI (homogeneity index)
- OARs evaluation:
  - Normal lung: V_5, V_{10}, V_{20}, V_{30}, MLD
  - Spinal cord: maximum dose (0.03 cm^3)
  - Esophagus: maximum dose (0.03 cm^3) and mean dose
  - Heart: V_{40}， V_{60}， mean dose
- Treatment delivery time and MUs

RTOG 1106: Randomized phase II trial of individualized adaptive radiotherapy in locally advanced non-small cell lung cancer(NSCLC)

Results

Target

PTV	IMRT mean±SD	VMAT mean±SD	Integrated mean±SD	IMRT vs VMAT p value	IMRT vs Integrated p value	VMAT vs Integrated p value
$D_{98\%}$ (Gy)	58.3±0.5	58.4±4.1	58.8±2.1	>0.05	<0.05	<0.05
$D_{2\%}$ (Gy)	68.8±21.9	67.4±21.0	64.9±9.6	<0.05	<0.05	<0.05
CN	0.7±0.1	0.8±0.1	0.9±0.1	<0.05	<0.05	<0.05
HI (%)	16.1±3.6	13.9±3.4	9.9±1.4	<0.05	<0.05	<0.05

Results

OARs

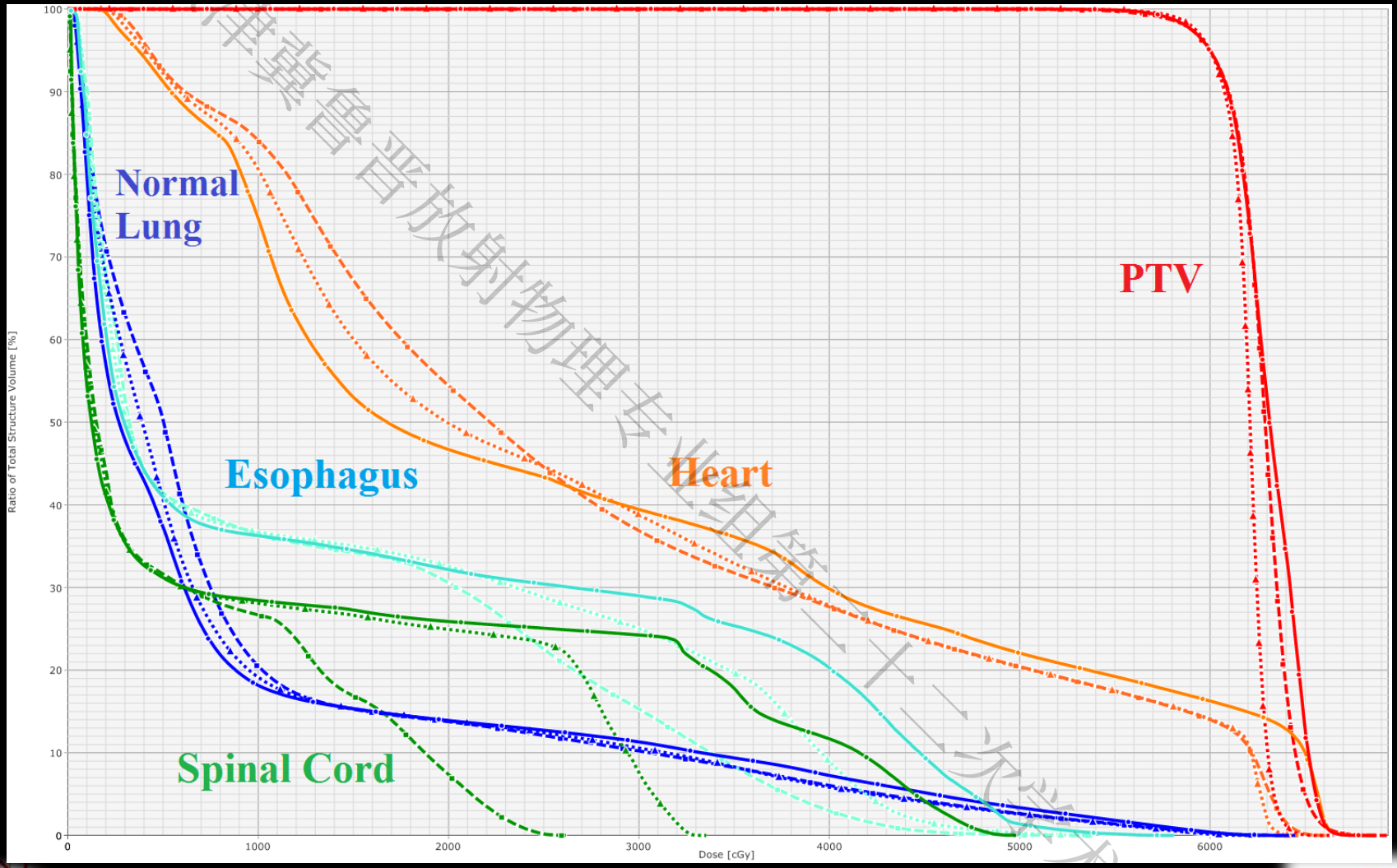
	IMRT mean±SD	VMAT mean±SD	Integrated mean±SD	IMRT vs VMAT p value	IMRT vs Integrated p value	VMAT vs Integrated p value
Normal lung						
$D_{2\%}$ (Gy)	48.7±7.9	45.3±8.1	44.7±7.9	<0.05	<0.05	<0.05
*V_{30} (%)	9.2±4.2	8.9±4.9	8.4±4.4	>0.05	<0.05	>0.05
*V_{20} (%)	14.5±6.7	14.6±7.3	14.6±6.9	>0.05	>0.05	>0.05
*V_{10} (%)	21.5±10.3	24.9±12.3	23.5±11.8	<0.05	<0.05	<0.05
*V_5 (%)	34.1±15.8	42.9±19.1	38.7±18.1	<0.05	<0.05	<0.05
Mean (Gy)	8.1±3.3	8.7±3.7	8.3±3.5	<0.05	<0.05	<0.05
Spinal cord						
D_{max}(Gy)	36.4±13.4	30.6±10.4	31.5±10.4	<0.05	<0.05	>0.05

Results

OARs

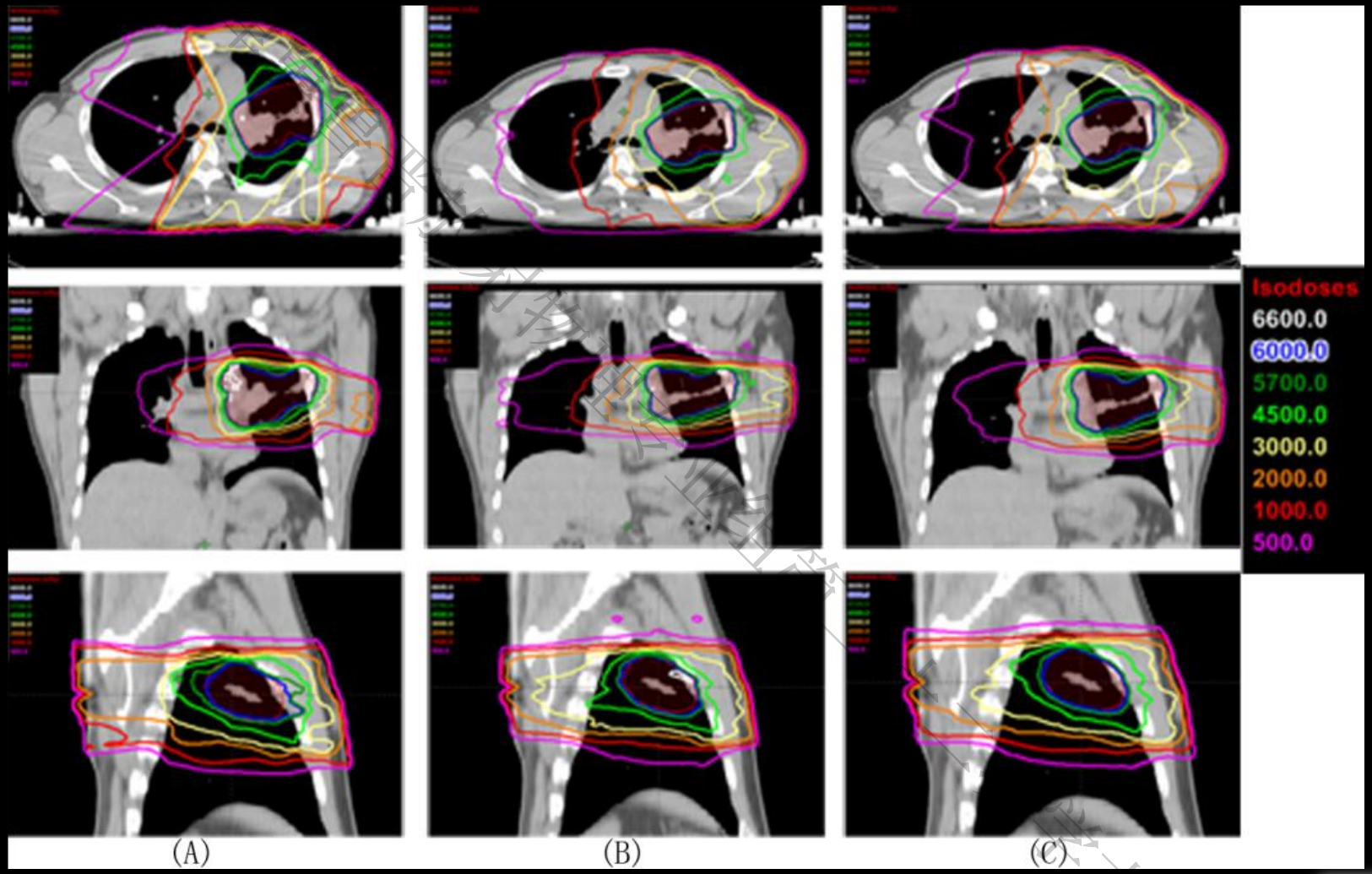
	IMRT mean±SD	VMAT mean±SD	Integrated mean±SD	IMRT vs VMAT p value	IMRT vs Integrated p value	VMAT vs Integrated p value
Esophagus						
D_{max} (Gy)	51.2±16.1	51.8±14.9	50.6±13.9	>0.05	>0.05	<0.05
Mean (Gy)	14.0±10.3	15.2±9.8	14.6±9.8	<0.05	>0.05	<0.05
Heart						
$D_{2\%}$ (Gy)	27.5±27.1	24.1±23.1	24.4±23.3	>0.05	>0.05	>0.05
Mean (Gy)	7.1±8.9	6.4±8.0	6.5±8.0	>0.05	>0.05	>0.05
*V_{60} (%)	1.7±3.9	1.2±3.4	1.2±3.4	<0.05	<0.05	>0.05
*V_{40} (%)	5.2±8.7	2.9±6.9	3.2±7.1	<0.05	<0.05	>0.05

Results



IMRT: solid lines VMAT: dashed lines Integrated: dotted lines

Results



A: IMRT B: VMAT C: Integrated

Results

Delivery time and MUs

	IMRT mean±SD	VMAT mean±SD	Integrated mean±SD	IMRT vs VMAT p value	IMRT vs Integrated p value	VMAT vs Integrated p value
Delivery time (s)	280±52	114±7	327±39	<0.05	<0.05	<0.05
MU	933±222	512±35	737±98	<0.05	<0.05	<0.05

Discussions

- Chan et al reported a Hybrid-RapidArc technique utilizing two arcs with additional static conformal fields
  - produce lower V_5 , V_{10} and MLD of normal lung
  - *fail to meet the challenge cases (highly irregular PTV)*
- Martin et al reported a IMRT&ARC technique consisted of 4-field IMRT in conjunction with a conformal arc.
  - Improve the therapeutic ratio
  - *forward planning for conformal arc as well as manual IMRT beam arrangement*

Chan OS, Lee MC, Hung AW, *et al. Radiother Oncol* 2011
Martin S, Chen JZ, Rashid DA, *et al*. *Radiother Oncol* 2011

Conclusions

- Compared with IMRT
  - *Integrated VMAT/IMRT significantly improved both the target dose conformity and homogeneity.*
  - Integrated VMAT/IMRT significantly reduced the irradiated volume of the OARs and normal tissue receiving medium to high dose and MUs.
- Compared with VMAT
  - Integrated VMAT/IMRT significantly improved both the target dose conformity and homogeneity.
  - *Integrated VMAT/IMRT reduced the volume of normal lung receiving dose higher than 10 Gy,5 Gy and MLD significantly*

谢谢