Optimizing Treatment Planning Process in Clinical Environment with Lean Six Sigma

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Outline:

1. Introduction to Lean Six Sigma
2. Planning goal
3. Influence of upstream and downstream operations
4. Reduction of delay between planning steps
5. Optimizing planning process itself

What is the Study Subject

- Clinical Environment like community hospital
  - Routine clinical service mainly, min unusual treatment
  - Favor more towards efficiency
  - Work assignment change, like dosimetrist contour OAR
  - Min physics support, commissioning done by 3rd party
  - Min IT support, like API scripting, admin right, policy for remote desktop/remote assistant
- Paperless environment with EMR
  - data in digital format with image, plan, treatment record, RT image, etc.

What is the Study Subject

- Reality Facing
  - On Tx Patients doubled from 30+ to 60+, 3 Linac in 2 Sites,
  - HDR APBI&GYN every day
  - Plan modification required frequently
  - IMRT QA low pass rate, especially SBRT/SRT
  - Chart Check/IMRT QA till late night, even weekend
  - Postpone Tx starting date frequently

What is the Study Subject

- Tools available
  - TG-100 Risk Analysis for quality/safety
    - Process Map
    - FMEA (Failure mode and effects analysis)
    - Fault Tree
  - Lean Six Sigma for consistency/efficiency

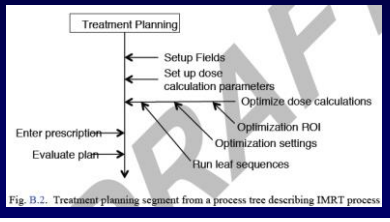

Fig. B.2. Treatment planning segment from a process tree describing IMRT process

What is Lean Six Sigma

- Lean Six Sigma is a methodology that relies on a collaborative team effort to improve performance by systematically removing waste;
- Waste is any step or action in a process that is not required to complete a process successfully (also called "Non Value-Adding")
- Same goal to seek to eliminate waste and create the most efficient system possible
- Different approaches to identify the root cause of waste.
  - Lean practitioners believe that waste comes from unnecessary steps in the production process that do not add value to the finished product
  - "We will not put into our establishment anything that is useless" by Henry Ford
  - Six Sigma proponents assert that waste results from variation within the process.

What is Lean Six Sigma

- 8 kind of wastes in Lean, acronym "DOWNTIME"

- Defects =Products or services that are out of specification that require resources to correct
- Over production = Producing too much of a product before it is ready to be sold
- Waiting = Waiting for the previous step in the process to complete
- Non-Utilized Talent = Employees that are not effectively engaged in the process
- Transportation = Transporting items or information that is not required to perform the process from one location to another
- Inventory = Inventory or information that is sitting idle (not being processed)
- Motion = People, information or equipment making unnecessary motion due to workspace layout, ergonomic issues or searching for misplaced items
- Extra processing = Performing any activity that is not necessary to produce a functioning product or service

What is Lean Six Sigma

- Identified waste/variation, agree with other's experience
  - Need for plan modifications --- Defects
    - Products or services that are out of specification that require resources to correct
  - Delays in physician contouring --- Waiting, Inventory
    - Waiting for the previous step in the process to complete
    - Inventory or information that is sitting idle (not being processed)
  - Delayed IMRT QA --- Non-Utilized Talent
  - Delays in Plan/Chart checks --- Waiting, Inventory
  - Extra Paperwork --- Extra processing
    - Performing any activity that is not necessary to produce a functioning product or service

Potters L, Kapur A; Implementation of a "No Fly" safety culture in a multicenter radiation medicine department; Pract Radiat Oncol. 2012 Jan-Mar;2(1):18-26

Planning Goal --- "Value"

- Efficient
  - Benchmarked by turn around time
  - Real working time and dead time
- High Quality
  - Benchmarked by dose constraint
  - Isodose distribution
- Error Proof
  - Benchmarked by mistakes, incident and near-miss
  - Find known error easily
    - Known error check list
    - Incident report system and periodic review
  - System wide reminder/alert on error prone scenario
    - Prone or Feet-first patient → shift direction
    - Couch kick → collision

What is the Study Range

- Simulation
  - Start from simulation scheduling
- Planning
  - All steps include physics check and patient specific QA
- Treatment
  - End after first day of treatment

What is Lean Six Sigma

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  - Delays in Plan/Chart checks --- Waiting, Inventory
  - Extra Paperwork --- Extra processing

Influence of upstream operations

- Simulation
  - Simulation request need to be clearly documented
  - Adequate personnel to cover like 4D, SRS/SBRT
  - Adequate equipment for simulation like spare vacuum bag
  - When unusual cases identified in simulation, notify physicist/dosimetrist early to be prepared.

Influence of upstream operations

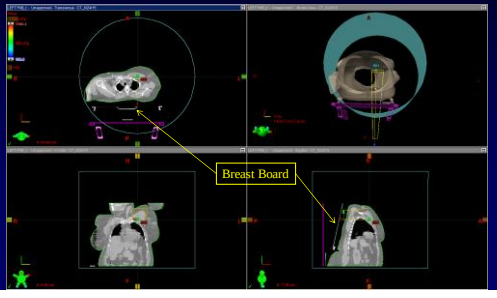
- Check list for Simulation Variations
  - Metal artifact: like prosthesis, breast expander, dental filling
  - Dose limiting: pacemaker/ICD, fetus, gonald
  - Electron: small field, large oblique angle, extended SSD, backscatter for keloid
  - Breast: Flash, breast expander
  - Nose/extremities: water, rice, bolus
  - Simulation mistake: arm in beam, non-bladder control, excessive gas in rectum, object on patient, accessory/setup error
  - Indexer, respiration belt clipper
  - Recon cutoff like heavy patient
  - Patient setup off-center: collision

Influence of downstream operations

- Treatment delivery Variation
  - Gantry clearance, especially with couch kick
  - CBCT clearance
  - Electron cone clearance
    - Schedule linac simple sim in additional CT sim
  - In-consistent setup
    - Same immobilization device between sim and treatment
  - Couch kick minimization
    - Larger PTV margin for couch kick
  - Treatment MU/Time
    - Non-SRS mode has max 999 MU limit
    - Tx time is not enough for arc patient
  - Exact Couch side rail/bar
    - Rail-in affect AP/PA KV imaging
    - Rail-in give more room for rail-free arc
  - Gantry angle sorting
    - Sort KV setup fields/CBCT, 90 deg difference
    - Sort MV treatment fields
    - 179.9 or 180.1 instead of 180.0

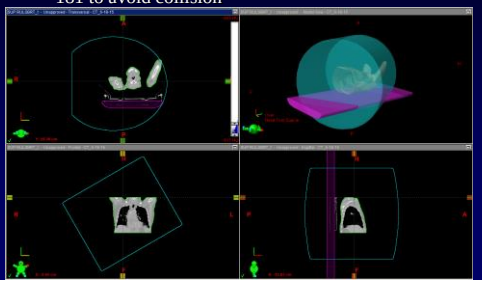
Collision Detection

- Collision free zone technique
  - Detection during planning
  - Change beam setup to avoid potential collision
    - Breast case: PAB field collide with couch.



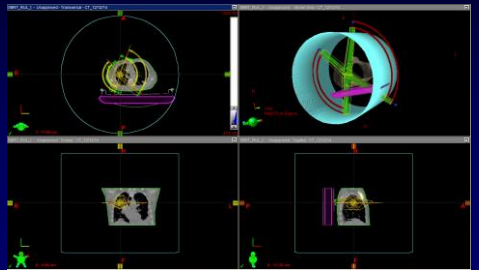
Collision Detection

- Collision free zone technique
  - Detection during planning
  - Change beam setup to avoid potential collision
    - Lung case: Couch 30, Gantry 179-181; change to Arc 0-181 to avoid collision



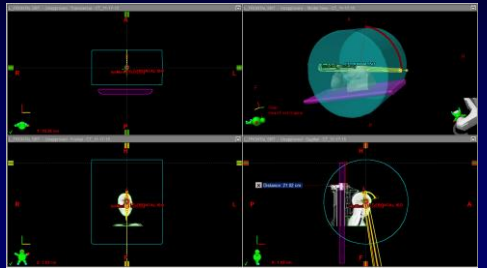
Collision Detection

- Collision free zone technique
  - Detection during planning
  - Change beam setup to avoid potential collision
    - Lung case: Couch 0, collision with couch, due to shift right in sim; reduce Arc 20-130 to 20-65



Collision Detection

- Collision free zone technique
  - Detection during planning
  - Change beam setup to avoid potential collision
    - Brain case: Couch 90, gantry 20-100; change to 20-90 to avoid collision



What is Lean Six Sigma

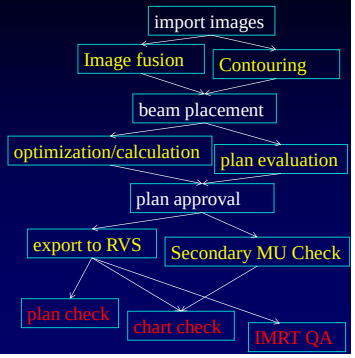
- Identified waste/variation, agree with other's experience
  - Need for plan modifications --- Defects
  - Delays in physician contouring --- Waiting, Inventory
  - Delayed IMRT QA --- Waiting, Inventory
  - Delays in Plan/Chart checks --- Waiting, Inventory
  - Extra Paperwork --- Extra processing

Planning workflow

Sequential

1. import images
2. Image fusion
3. Contouring
4. beam placement
5. dose optimization
6. plan evaluation
7. plan approval
8. export to RVS
9. Secondary MU Check
10. plan check
11. chart check
12. IMRT QA

Parallel/overlapping



Reduction of delay between planning steps

- Contour
  - Wait for image import for contour
    - 1st priority task for dosimetrist
  - Wait for Dx image for fusion
    - Most OAR can be contoured without fusion
  - No time (too much time needed)
    - Automatic contour (smart seg, model based, autoseg with SPICE)
    - Resident contour/Attending review
    - Dosimetrist OAR/Attending GTV
    - Dedicated/blocked time for MD contouring
  - Remote contour
    - Citrix
    - Remote desktop to resume work easily
  - Forgot
    - Communication/Reminder

Reduction of delay between planning steps

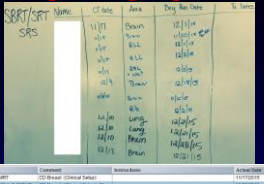
- Plan approval
  - Plan quality deficient (Constraint not met)
    - Automatic plan quality analyze with DVH
    - Communicate early, like half way of planning
  - No time (too much time needed)
    - Automatic plan quality analyze with DVH
    - Remote review anywhere
      - Citrix/Remote desktop/Remote Assistance
      - MD shares same screen with dosimetrist to evaluate and approve plan
  - Forgot
    - Communication/Reminder

Reduction of delay between planning steps

- Communication
  - QCL – limited to responsible person
  - Global patient process status like dashboard
  - in-time notification
    - EMR connect to email system, outlook
    - External script or manually to send email
    - External script or manually to send sms text message
    - Notify repeatly
  - Phone Call
  - Face to face talk to the responsible person

Reduction of delay between planning steps

- Dashboard to tracking plan status
  - Hardware On the Wall
  - 3rd party software
  - EMR/RVS



Reduction of delay between planning steps

- Dashboard to tracking plan status
  - Hardware On the Wall
  - 3rd party software
    - Tracking plan status
    - Store process information
    - Streamline workflow
    - Increase in efficiency
    - Improving patient safety by allowing more time for quality assurance processes
  - EMR/RVS
    - Care Path
    - QCL

1. D DiCostanzo, S Thompson, J Woollard, N Gupta and A Ayan, MO-F-CAMPUS-T-02: An Electronic Whiteboard Platform to Manage Treatment Planning Process; Med. Phys. 42, 3572 (2015)
2. S Laub, M Dunn, G Galbreath, S Gans and M Pankuch; MO-D-213-01: Workflow Monitoring for a High Volume Radiation Oncology Center; Med. Phys. 42, 3553 (2015)

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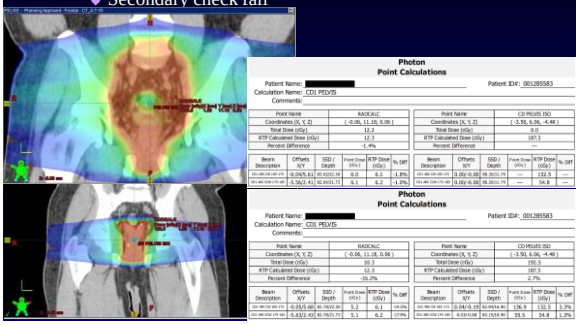
  - Extra Paperwork --- Extra processing

Reduction of delay between planning steps

- QA
  - Secondary check fail check list
    - Ref point outside of PTV, close to field edge or skin
    - Equivalent path length
    - High gradient area
    - Low dose region
    - Flash
    - Heterogeneity interface like lung/bone
    - Artifact
    - IMRT QA

Reduction of delay between planning steps

- QA
  - Secondary check fail



Photon
Point Calculations

Patient Name: [redacted]
Patient ID#: 00128558
Calculation Name: CDI PELVIS
Comments:

Point Name	RADCALC
Coordinates (X, Y, Z)	(-0.06, 11.18, 0.06)
Total Dose (cGy)	12.2
RTP Calculated Dose (cGy)	12.3
Percent Difference	-1.4%

Point Name	CDI PELVIS ISO
Coordinates (X, Y, Z)	(-3.50, 6.06, -4.48)
Total Dose (cGy)	0.0
RTP Calculated Dose (cGy)	187.3
Percent Difference	---

Beam Description	Offsets X/Y	SSD / Depth	Point Dose (cGy)	RTP Dose (cGy)	% Diff
001 ARC ON 185 175	-0.04/5.61	81.61/22.78	6.0	6.1	-1.8%
002 ARC CCW 175 185	-5.56/2.43	81.94/21.73	6.1	6.2	-1.0%

Beam Description	Offsets X/Y	SSD / Depth	Point Dose (cGy)	RTP Dose (cGy)	% Diff
001 ARC ON 185 175	0.00/-0.00	88.26/21.79	---	132.5	---
002 ARC CCW 175 185	0.00/-0.00	88.26/21.79	---	54.8	---

Photon
Point Calculations

Patient Name: [redacted]
Patient ID#: 00128558
Calculation Name: CDI PELVIS
Comments:

Point Name	RADCALC
Coordinates (X, Y, Z)	(-0.06, 11.18, 0.06)
Total Dose (cGy)	10.3
RTP Calculated Dose (cGy)	12.3
Percent Difference	-16.2%

Point Name	CDI PELVIS ISO
Coordinates (X, Y, Z)	(-3.50, 6.06, -4.48)
Total Dose (cGy)	192.5
RTP Calculated Dose (cGy)	187.3
Percent Difference	2.7%

Beam Description	Offsets X/Y	SSD / Depth	Point Dose (cGy)	RTP Dose (cGy)	% Diff
001 ARC ON 185 175	-0.05/5.68	81.79/22.80	5.2	6.1	-14.0%
002 ARC CCW 175 185	-5.61/2.42	81.79/21.71	5.1	6.2	-17.9%

Beam Description	Offsets X/Y	SSD / Depth	Point Dose (cGy)	RTP Dose (cGy)	% Diff
001 ARC CW 185 175	0.19/-0.08	81.15/16.90	136.9	131.5	3.9%
002 ARC CCW 175 185	-0.33/-0.08	81.15/16.90	55.5	54.8	1.3%

Reduction of delay between planning steps

- IMRT QA
  - ~20% IMRT fail with 95 pass rate with 3% 3mm criteria
    - Mostly SBRT/SRT
    - Difficult Plans
    - High modulation
  - Physicist hesitate to do IMRT QA, which cause delay
  - Even introduced different workflow
    - Export plan fields first for IMRT QA
    - If pass, plan approval, export document, chart check

Reduction of delay between planning steps

- QA
  - IMRT QA Check list
    - Check printout/GUI
      - Wrong patient, plan, QA plan, QA dose export
      - Wrong Calibration file, energy and cal date
      - Wrong criteria, Gamma/absolute, 3%, 3mm
    - 10x10 standard field
      - Wrong setup
      - Laser off
      - Output drift
    - Standard plan delivery
      - MLC calibration
      - MLC QA

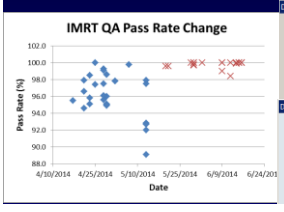
Reduction of delay between planning steps

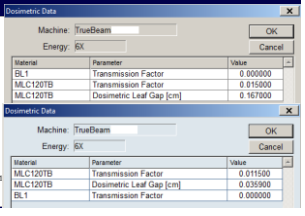
- Trouble shooting steps
  - Array cal
  - Absolute cal
  - Anglar cal

  - Arc vs. IMRT
  - Sliding window vs. step and shoot
  - Composite vs. Per beam
  - Modulation vs. Static fields
  - 10x10cm static
  - Chamber vs. diode

Reduction of delay between planning steps

- QA
  - IMRT QA fail
    - Limit segment size, MU
    - Tune-up commissioning model
      - Optimize dosimetric leaf gap
      - Make up missing output factor for small field size





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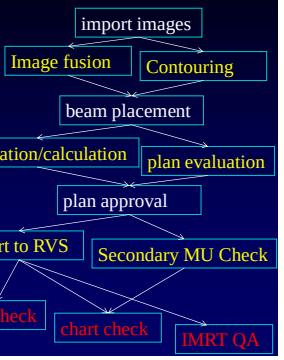
  - Extra Paperwork --- Extra processing

Reduce Treatment Planning Overall Time

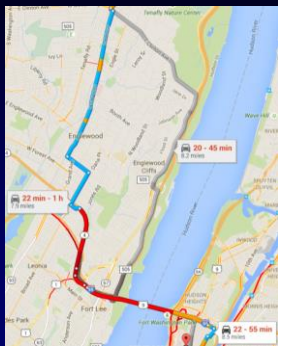
Work flow

- Reduce repeat
  - Catch mistake early
  - Communicate efficiently
- Reduce bottle neck
  - Overlap steps
  - Prioritize the process
    - Import image/fusion asap to start contour process
    - Use VMAT primarily to avoid beam placement variation
- Reduce bottle neck
- Reduce paperwork



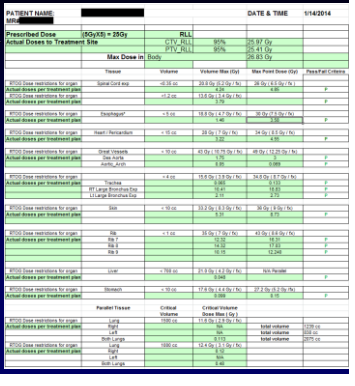
Reduce Treatment Planning Overall Time

- Reduce repeat
  - Catch mistake early
  - Communicate efficiently
- Overlap steps
- Prioritize the process
  - Import image/fusion asap to start contour process
  - Prioritize the process
- Reduce bottle neck
- Reduce paperwork



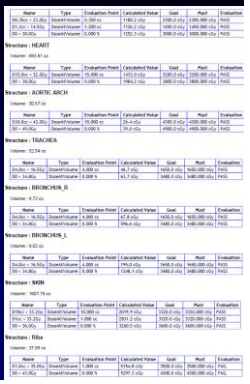
Reduce Treatment Planning Overall Time

- Plan/DVH Check
  - Manual DVH Check
  - Time consuming
    - 15-30min
  - Error prone
    - 1-2 error/sheet



Reduce Treatment Planning Overall Time

- Plan Check --- DVH check tool
  - Homemade software with Excel
  - Commercial Plan quality software
  - Script of Pinnacle/Eclipse
    - <30Sec to run



Reduce Treatment Planning Overall Time

- Plan Check --- DVH check tool
  - Homemade software
  - Commercial Plan quality software
  - Script of Pinnacle/Eclipse
  - Plan Objectives in Eclipse
    - 5-10Sec
    - Can be used by dosimetrist after each optimization cycle
    - Can be used by Physician to review before plan approval
    - Plan meet minimum standard before Physicist chart check
    - Permanent Record included in plan printout

Reduce Treatment Planning Overall Time

- Chart Check
  - Minimum standard clearly outlined
  - Check list with mandatory/optional item
    - Couch position wrong
    - Rail in/out mismatch
    - Artifact override and density assignment wrong
    - Contour name mismatch
    - Contour PTVsum does not include all PTVs
    - Contour PTV CTV mismatch with multiple targets
    - Contour not enough in SI direction
    - Gantry 180.1 for right side target
    - Bolus Custom unselected, Bolus thickness not defined
    - Treatment Time 0.0 or too short
    - No DRR, DRR not associated, DRR association mismatch
    - Field no tolerance table, mismatch
    - CBCT wrong structure set
    - Patient orientation wrong
    - Shift wrong
    - Field ID not match with gantry angle
    - Port film, MU=0, Delta=8
    - Field size < 3cm
    - Dose rate < 600 MU/min for SBRT/SRT
    - MU >= 1000 MU for non-SRS mode

Reduce Treatment Planning Overall Time

- Chart Check
  - Minimum standard clearly outlined
  - Check list with mandatory/optional item
  - Script assisted check
    - Critical to check --- check with script for each plan
      - Prescription including site, Fx, dose/fx, fx#, total dose
      - Fields including Energy, MU, control point etc
      - Isocenter/shift
      - DRR iso
      - CBCT iso
    - Prone to miss --- check with script for each patient
      - approval all fields
      - approval all documents
    - Prone to miss --- check with script for every day
      - Complete QCL due, Chart check OK/Note
      - Complete scheduled task, Chart check OK/Note

Reduce Treatment Planning Overall Time

- Initial Chart Check
  - Critical to check
    - Prescription including site, Fx, dose/fx, fx#, total dose

cGy_Dose	NoFractions	FxDose	RxDose	RadiationId	RadiationName	ControlPoint	MachineId	MachineScale	MeV	RadiationType	DoseRate	GantryRtn	GantryRtnDirection	StopAngle
0.0	3.0	700.0	2100.0	5	ARC CW 270-90	114.0	TrueBeam:SN1154	VAR_EC	6.0 X		600.0	270.0	CW	90.0
349.0	3.0	700.0	2100.0	5	ARC CW 270-90	114.0	TrueBeam:SN1154	Photon:SMALL	6.0 X		600.0	270.0	CW	90.0
0.0	3.0	700.0	2100.0	6	ARC CCW 90-270	98.0	TrueBeam:SN1154	VAR_EC	6.0 X		600.0	90.0	CC	270.0
351.0	3.0	700.0	2100.0	6	ARC CCW 90-270	98.0	TrueBeam:SN1154	Photon:SMALL	6.0 X		600.0	90.0	CC	270.0
0.0	3.0	700.0	2100.0	CBCT		1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	0.0		0.0
0.0	3.0	700.0	2100.0	KVAP	AP SETUP		TrueBeam:SN1154	VAR_EC	6.0 X		600.0	0.0	NONE	
0.0	3.0	700.0	2100.0	KVAP	AP SETUP	1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	0.0		
0.0	3.0	700.0	2100.0	KVLT	LT LAT SETUP		TrueBeam:SN1154	VAR_EC	6.0 X		600.0	90.0	NONE	
0.0	3.0	700.0	2100.0	KVLT	LT LAT SETUP	1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	90.0		
0.0	3.0	700.0	2100.0	KVPA	PA SETUP		TrueBeam:SN1154	VAR_EC	6.0 X		600.0	180.0	NONE	
0.0	3.0	700.0	2100.0	KVPA	PA SETUP	1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	180.0		
0.0	3.0	700.0	2100.0	KVRT	RT LAT SETUP		TrueBeam:SN1154	VAR_EC	6.0 X		600.0	270.0	NONE	
0.0	3.0	700.0	2100.0	KVRT	RT LAT SETUP	1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	270.0		

Reduce Treatment Planning Overall Time

- Initial Chart Check
  - Critical to check
    - Fields including Field ID, Field name, Machine, Control Point, Energy, Energy type, Dose Rate, Gantry start, Gantry stop, Gantry direction
    - Collimator, couch, Jaw, SSD, MU, Treatment Time, Addon, etc

cGy_Dose	NoFractions	FxDose	RxDose	RadiationId	RadiationName	ControlPoint	MachineId	MachineScale	MeV	RadiationType	DoseRate	GantryRtn	GantryRtnDirection	StopAngle
0.0	3.0	700.0	2100.0	5	ARC CW 270-90	114.0	TrueBeam:SN1154	VAR_EC	6.0 X		600.0	270.0	CW	90.0
349.0	3.0	700.0	2100.0	5	ARC CW 270-90	114.0	TrueBeam:SN1154	Photon:SMALL	6.0 X		600.0	270.0	CW	90.0
0.0	3.0	700.0	2100.0	6	ARC CCW 90-270	98.0	TrueBeam:SN1154	VAR_EC	6.0 X		600.0	90.0	CC	270.0
351.0	3.0	700.0	2100.0	6	ARC CCW 90-270	98.0	TrueBeam:SN1154	Photon:SMALL	6.0 X		600.0	90.0	CC	270.0
0.0	3.0	700.0	2100.0	CBCT		1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	0.0		0.0
0.0	3.0	700.0	2100.0	KVAP	AP SETUP		TrueBeam:SN1154	VAR_EC	6.0 X		600.0	0.0	NONE	
0.0	3.0	700.0	2100.0	KVAP	AP SETUP	1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	0.0		
0.0	3.0	700.0	2100.0	KVLT	LT LAT SETUP		TrueBeam:SN1154	VAR_EC	6.0 X		600.0	90.0	NONE	
0.0	3.0	700.0	2100.0	KVLT	LT LAT SETUP	1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	90.0		
0.0	3.0	700.0	2100.0	KVPA	PA SETUP		TrueBeam:SN1154	VAR_EC	6.0 X		600.0	180.0	NONE	
0.0	3.0	700.0	2100.0	KVPA	PA SETUP	1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	180.0		
0.0	3.0	700.0	2100.0	KVRT	RT LAT SETUP		TrueBeam:SN1154	VAR_EC	6.0 X		600.0	270.0	NONE	
0.0	3.0	700.0	2100.0	KVRT	RT LAT SETUP	1.0	TrueBeam:SN1154	Photon:SMALL	KV		0.0	270.0		

GantryVarian	CollRtn	CollVarian	CouchRtn	CouchVarian	CollX1	CollX2	CollY1	CollY2	SSD	MURounded	TreatmentTime	SetupTechnique	AddOnId	AddOnName	AddOnType
270.0	20.0	160.0	0.0	180.0	1.9	1.9	1.9	91.7	643.0		1.6	0.0 ISOCENTRIC	0076	MLC120TB	MLC
279.0	20.0	20.0	0.0	0.0	1.9	1.9	1.9	91.7	643.0		2.0		None		
90.0	340.0	200.0	0.0	180.0	1.9	1.9	1.9	95.9	648.0		1.6	0.0 ISOCENTRIC	0076	MLC120TB	MLC
90.0	340.0	340.0	0.0	0.0	1.9	1.9	1.9	95.9	648.0		2.0		None		
90.0	0.0	0.0	0.0	0.0				93.9	0.0		0.0				
180.0	0.0	180.0	0.0	180.0	5.0	5.0	5.0	93.9				1.0 ISOCENTRIC			
90.0	0.0	0.0	0.0	0.0				93.9	0.0		0.0				
90.0	0.0	180.0	0.0	180.0	5.0	5.0	5.0	95.9				1.0 ISOCENTRIC			
180.0	0.0	0.0	0.0	0.0				95.9	0.0		0.0				
0.0	0.0	180.0	0.0	180.0	5.0	5.0	5.0	92.2				1.0 ISOCENTRIC			
270.0	0.0	0.0	0.0	0.0				92.2	0.0		0.0				
270.0	0.0	180.0	0.0	180.0	5.0	5.0	5.0	91.7				1.0 ISOCENTRIC			
0.0	0.0	0.0	0.0	0.0				91.7	0.0		0.0				

Reduce Treatment Planning Overall Time

- Initial Chart Check
  - Critical to check
    - Patient orientation,
    - Setup Isocenter/shift
    - DRR isocenter/gantry angle, association for Tx

TxOrient	ToleranceId	Verification	CouchLatDelta	CouchLngDelta	CouchVrtDelta	TblAngle	TblPitch	TblRoll	IMG_TxDef	IMG_Assoc	MachineId	RadiationId	RadiationName	GantryRtn	CollRtn	Iso_X	Iso_Y	Iso_Z
HFS	PS	Verify	1.65	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	5	ARC CW 270-90	270.00	20.00	1.49	-5.84	2.00
HFS	PHOTON_St	Verify	1.70	2.00	1.50	0.00	0.00	0.00										
HFS	PS	Verify	1.65	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	6	ARC CCW 90-270	90.00	340.00	1.49	-5.84	2.00
HFS	PHOTON_St	Verify	1.70	2.00	1.50	0.00	0.00	0.00										
HFS	PHOTON_St	Verify	1.70	2.00	1.50	0.00	0.00	0.00										
HFS	PS	Verify	1.65	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	KVAP	AP SETUP	0.00	0.00	1.49	-5.84	2.00
HFS	PHOTON_St	Verify	1.70	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	KVAP	AP SETUP	0.00	0.00	1.49	-5.84	2.00
HFS	PS	Verify	1.65	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	KVLT	LT LAT SETUP	90.00	0.00	1.49	-5.84	2.00
HFS	PHOTON_St	Verify	1.70	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	KVLT	LT LAT SETUP	90.00	0.00	1.49	-5.84	2.00
HFS	PS	Verify	1.65	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	KVPA	PA SETUP	180.00	0.00	1.49	-5.84	2.00
HFS	PHOTON_St	Verify	1.70	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	KVPA	PA SETUP	180.00	0.00	1.49	-5.84	2.00
HFS	PS	Verify	1.65	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	KVRT	RT LAT SETUP	270.00	0.00	1.49	-5.84	2.00
HFS	PHOTON_St	Verify	1.70	2.00	1.50	0.00	0.00	0.00	1.00	1.00	TrueBeamSN1154	KVRT	RT LAT SETUP	270.00	0.00	1.49	-5.84	2.00

Reduce Treatment Planning Overall Time

- Initial Chart Check
  - Critical to check
    - CBCT isocenter, structure set, iso set flag

Iso_X	Iso_Y	Iso_Z	IsoSet	StructureSetId	StructureSetUID
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047
1.49	-5.84	2.00	1.00	CT_12-18-15	1.2.246.352.71.4.882283254716.31562.20151220095047

What is Lean Six Sigma

- Identified waste/variation, agree with other's experience
  - Need for plan modifications --- Defects
  - Delays in physician contouring --- Waiting, Inventory
  - Delayed IMRT QA --- Waiting, Inventory
  - Delays in Plan/Chart checks --- Waiting, Inventory
  - Extra Paperwork --- Extra processing

Reduce Spike of Patient Load

- Patient Load Spike
  - Weeks even months
    - Increase man power
    - Increase working time
  - Last a couple of days
    - No more than 2 FTE*Day for each starting day, the cases over 2 need to be postponed automatically during scheduling right after simulation
    - Quick turnaround will be handled case by case, since it is hard to change the start date of previously scheduled patient
    - Re-treat will be handled case by case, since it takes longer time to figure out the vicinity of the previous dose to current Tx, on which planning difficulty depend.

3D	FTE*Day
Breast 4F	0.50
Breast Tang	0.25
Lung	0.25
Spine	0.25
Brain	0.25
Pelvic	0.25
Extremity	0.25
Electron	0.25
Other	0.25
IMRT	Day
Head Neck	1
Prostate with CD	1
Prostate	0.5
Lung	0.5
Spine	0.5
Brain	0.5
Other	0.5
SRS/SBRT	Day
Lung	1
Spine	1
Brain	1
Other	1

Reduce Paperwork

- Option 1
  - Plan Check
    - MD approve the plan
    - Dosimetrist lock the plan
  - Chart Check
    - dosimetrist generate plan printout and load to EMR
    - MD approve the plan printout
    - Physicist approve the plan printout
- Option2
  - Plan Check
    - MD approve the plan
    - MD lock the plan
  - Chart Check
    - dosimetrist generate plan printout and load to EMR and dosimetrist approve printout
    - Physicist check plan printout approval date/time matching with TPS
    - Physicist approve the plan printout

Reduce Paperwork

- Prostate patient,
  - Plan 0, prostate+SV+LN
  - CD1, prostate+SV
  - CD2, prostate
- Option1
  - Plan and approve 3 plans at the beginning,
  - QCL to export fields and plan printout/document 3 times at different dates
  - IMRT QA, Physics chart check, approve fields and plan printout 3 times,
- Option2
  - Plan and approve 3 plans at the beginning,
  - Export Fields, plan printout/document once for all 3 plans
  - IMRT QA and Physics chart check once for all 3 plans
  - Physicist approve fields and printout once for all 3 plans
  - QCL dosimetrist to approve plan printout at different dates, and bill on corresponding date

Future Work

- Standardize the protocol
  - Prescription
  - Dose Constraints
  - Contour naming
  - Field naming
- Automatic Contour
  - Smart segmentation does not work well
  - Might need to create our own expert case library
- Automatic Planning
  - Rapid Plan evaluation and license
- Treatment Delivery Monitoring and process optimization
  - Weekly Chart Check
  - Catch error early

Acknowledgement

- Vendor
  - Varian
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  - SNC
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  - Song Wang
  - Zhiqiu Li
- Dosimetrist in BHS
  - Michael Maille
  - Johnny Michel
- Facilities
  - Columbia
  - Cornell
  - William Beaumont
  - Wayne State U
  - LIJ
  - Duke
  - UPenn
  - U Maryland
  - NYU