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**Automatic treatment planning and
quality assurance for
gynecological high dose-rate
brachytherapy**

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Department of Radiation Oncology

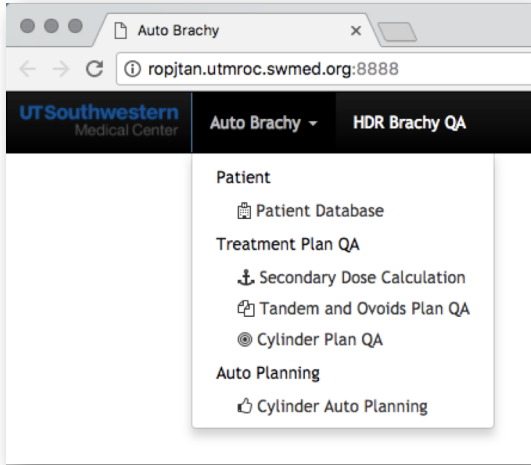
Disclosure

This work is supported by Varian Medical Systems

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Outline

- Motivation
- AutoBrachy system
 - Treatment planning
 - Treatment plan QA
 - Database
- Conclusion



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Motivation

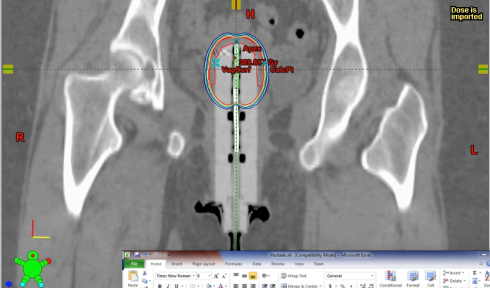
- Conventional practice
 - Treatment planning
 - Pre-treatment QA

Screen captures

~10 captures for different purposes

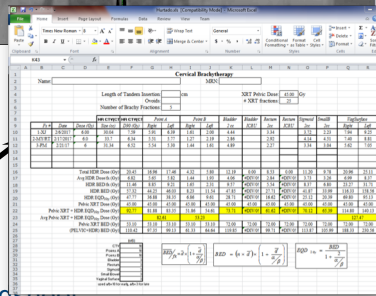
Run secondary dose calculation

A dose report



Bind to a single pdf

Upload to MOSAIQ



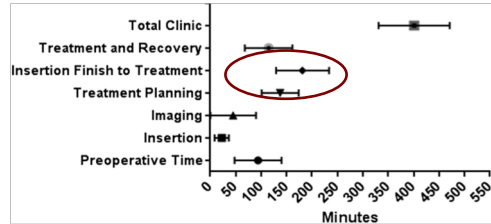
- Documentation
- Record plan information in a spreadsheet

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Motivation

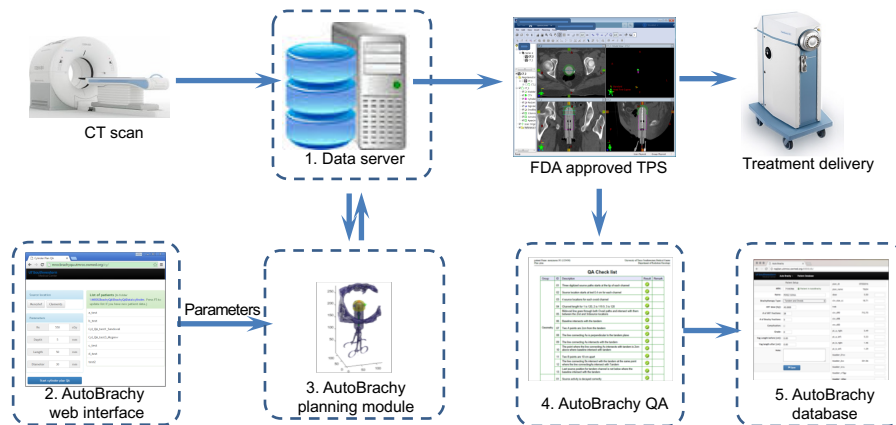
■ Problems:

- Human errors
- Low efficiency
- Plan quality variation
- Organized and comprehensive data documentation
 - Document 7 variables per minimum standard for reporting (Level 1)
 - 33 variables per advanced standard for reporting (Level 2)
 - ~100 per research-oriented reporting (Level 3)

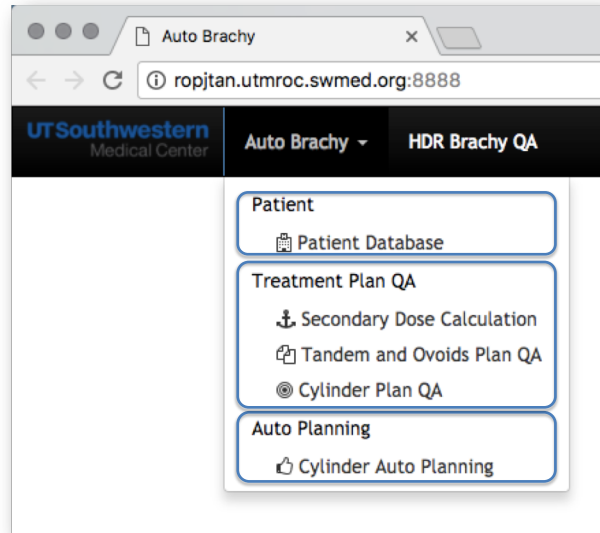


[1] Allan et al., 1995 Human Factors Evaluation of Remote Afterloading Brachytherapy vol NUREG/CR-6125(1-3)
 [2] Mayadev et. al., 2014 Implant time and process efficiency for CT-guided high-dose-rate brachytherapy for cervical cancer, Brachytherapy 13, 233
 [3] ICRU REPORT 89, Prescribing, Recording, and Reporting Brachytherapy for Cancer of the Cervix, 2016

An automated workflow

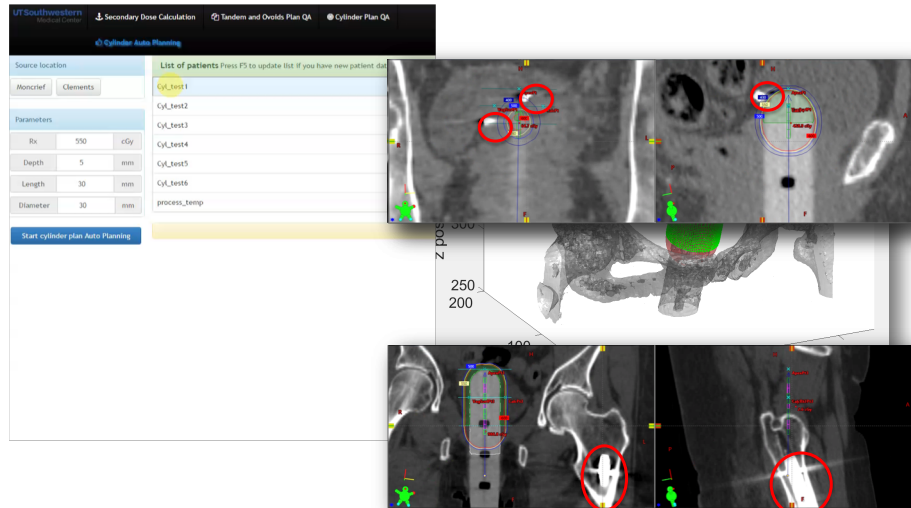


AutoBrachy



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Cylinder



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Tandem and Ovoid

The screenshot displays the Tandem and Ovoid software interface. On the left, a control panel includes a 'Source location' dropdown set to 'Mancrief Clements', a 'List of patients' table with three entries (T_and_o_testCase1, T_and_o_testCase2, T_and_o_testCase3), and a 'Start tandem and ovoid plan auto planning' button. On the right, a CT scan image shows a brachytherapy plan with various colored markers and lines indicating the placement of sources and ovoids. The UT Southwestern Medical Center logo is visible in the bottom right corner.

AutoBrachy

The screenshot shows a web browser window titled 'Auto Brachy' with the URL 'ropjtan.utmroc.swmed.org:8888'. The application header includes the UT Southwestern Medical Center logo and navigation tabs for 'Auto Brachy' and 'HDR Brachy QA'. A dropdown menu is open, listing the following options: 'Patient' (with a sub-option 'Patient Database'), 'Treatment Plan QA' (with sub-options 'Secondary Dose Calculation', 'Tandem and Ovoids Plan QA', and 'Cylinder Plan QA'), and 'Auto Planning' (with a sub-option 'Cylinder Auto Planning'). The UT Southwestern Medical Center logo is also present in the bottom right corner.

Secondary dose calculation

- Export Dicom-RT data to QA server
- Launch dose calculation in web and generate a pdf report

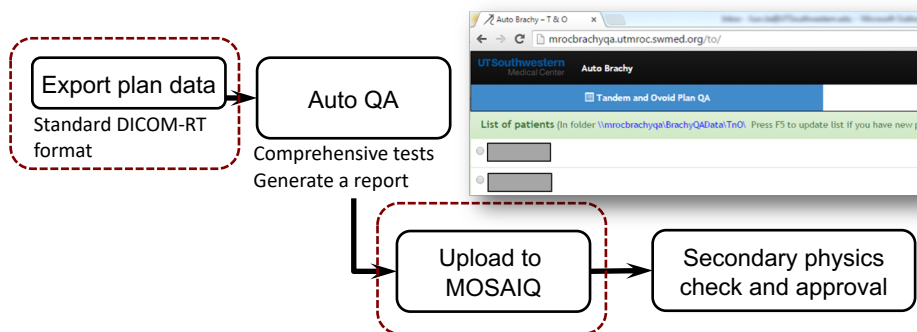
UTSouthwestern Medical Center Secondary Dose Calculation Report **Auto Brachy**

Patient Name	ID	Birthdate	Sex	Plan	QA Date		
				SAVI 6-1 Mini	01/30/2017		
Treatment Type	Isotope Name	Half Life [days]	Tx Strength [cGy cm ² /h]				
HDR	VariSource 5 mm source	73.83	18115.16				
Point Name	x [cm]	y [cm]	z [cm]	Planned dose [cGy]*	Calculated dose [cGy]	Diff [cGy]	Diff [%]
CalcPt	11.42	4.38	12.88	339.0	337.0	-2.0	-0.6

*Planned dose is from interpolation of 3D dose matrix in the DICOM RD file. It may not be identical to the reported value in TPS.

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QA



- Comprehensively validate the plan from over 20 dosimetric and geometry aspects
- Summarize QA results with suspicious issues highlighted
- A streamlined work flow with ~3 min

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Tandem and Ovoid

patient: Tandem anonymous N1 (123456)
Plan: plan

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QA Check list

QID	Description	Result	Remark
Q1	Three digit lead source paths, starts at the tip of each channel	Pass	
Q2	Source location checks at least 5 cm for each channel	Pass	
Q3	A separate connection for each source channel	Pass	
Q4	Channel length for 1 to 100, 2 to 100, 3 to 100	Pass	
Q5	Minimum the gaps through both Channel paths and returned with them between the 2nd and 3rd channel bundles	Pass	
Q6	Relative intersects with the bundles	Pass	
Q7	Two A points are 2cm from the bundles	Pass	
Q8	The line connecting the 2 points perpendicular to the tandem plane	Pass	
Q9	The line connecting the 2 points parallel to the tandem	Pass	
Q10	The point where the line connecting the 2 points with tandem is 2cm distance from tandem channel and bundle	Pass	
Q11	Two B points are 10 cm apart	Pass	
Q12	The line connecting the 2 points with the tandem at the same point when the line connecting the tandem with tandem	Pass	
Q13	Two points parallel to the tandem channel is not visible when the bundles intersect with the tandem	Pass	
Q14	Source activity is decayed correctly	Pass	
Q15	The source strength is correct as calculated based on source activity	Pass	
Q16	If there is a cable used it should be connected	Pass	
Q17	Distance of points in the plan is correct	Pass	
Q18	Manometry sample is in the correct location	Pass	
Q19	CTV Ovoid 4.5 Gy	Pass	
Q20	Rectum, Signoid 4.5 Gy	Pass	

patient: Tandem anonymous N1 (123456)
Plan: plan

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QA report for "plan"

Patient: anonymous N1
Ref: 123456
Sex: O
ID: 123456

Plan

Plan ID: plan
Channel ID: 1
Prescribed dose: 500.00 cGy
Source wire model: 6121-6889-001-10213-106148
Source cable: Source cable
Source calibrated activity: 11661.00 mCi
Treatment date: 19070101
Total air kerma strength: 1066.00 cGy cm²
Plan created: 19010101
Plan last no:

General

Name	x(cm)	y(cm)	z(cm)	dose [cGy]
OutDose-p1	21.37	28.34	6.58	206.04
OutDose-p2	30.20	26.28	9.03	211.54
Bladder5	25.28	30.00	10.25	251.66
ConstRect5	23.30	27.76	6.65	509.36
PAL6	27.42	27.87	6.95	503.80
PR6	36.43	27.60	6.91	164.78
UtagLut-FUL	28.26	26.11	9.73	194.09
MAR6-Linet-p1	20.32	27.96	9.33	164.74
MAR6-Linet-p2	30.30	24.54	9.95	103.10
Rectum5	25.29	25.33	9.63	472.95
PALRS	23.41	27.55	6.65	507.89
PRRS	26.43	27.51	6.59	166.58
BRtagLut-bC	22.38	27.48	9.43	891.49

Reference points

Name	x(cm)	y(cm)	z(cm)	dose [cGy]
OutDose-p1	21.37	28.34	6.58	206.04
OutDose-p2	30.20	26.28	9.03	211.54
Bladder5	25.28	30.00	10.25	251.66
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patient: Tandem anonymous N1 (123456)
Plan: plan

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patient: Tandem anonymous N1 (123456)
Plan: plan

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patient: Tandem anonymous N1 (123456)
Plan: plan

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Structure	Volume [cc]	Min Dose [cGy]	Max Dose [cGy]	Mean Dose [cGy]
Bladder	102.1	11.3	92.0	27.5
Rectum	49.2	6.4	94.8	30.7
Signoid	127.0	3.5	92.1	24.5
SmallBowel	53.2	5.0	65.3	21.2
BODY	22060.3	0.0	7765.6	6.8
CTV	35.4	64.7	4102.2	219.4

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AutoBrachy

Auto Brachy

ropitan.utmroc.swmed.org:8888

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Auto Brachy ▾ HDR Brachy QA

Patient

- 📄 Patient Database
- Treatment Plan QA
 - ⚙️ Secondary Dose Calculation
 - 📄 Tandem and Ovoids Plan QA
 - 📄 Cylinder Plan QA
- Auto Planning
 - 📄 Cylinder Auto Planning

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HDR database

- A database
- Patient name
- External ID
- Treatment plan
- Estimate HDR

The screenshot shows a web application window titled "Auto Brachy - Patient Database". It is divided into two main sections: "Patient" and "Fractions Outcome".

Patient Section:

- Brachytherapy Type: Tandem and Ovoids
- XRT dose [Gy]: 45.0000
- # of XRT fractions: 0
- # of Brachy fractions: 5
- CTV [Gy]: 45.0000
- Point A [Gy]: 45.0000
- Point B [Gy]: 45.0000
- Bladder [Gy]: 45.0000
- Rectum [Gy]: 45.0000
- Sigmoid [Gy]: 45.0000
- Small Bowel [Gy]: 45.0000
- Vag Surface [Gy]: 45.0000
- PIBS [Gy]: 45.0000

Fractions Outcome Section:

Parameter	Fx # 1	Fx # 2	Total
plan_dt	11072016		
plan_name	TB01		
dose	5.50		
ctv_size_cc	0.52		
trak			
ctv_d90	5.66		81.92
ctv_d98			45.00
ctv_d50			45.00
pt_a_right	6.24		87.26
pt_a_left	6.03		85.27
pt_b_right	1.68		53.16
pt_b_left	1.75		53.55
bladder_01cc			45.00
bladder_2cc	5.18		87.31
bladder_1cru			45.00
bladder_v15gy			45.00
bladder_v25gy			45.00

HDR database

- Automatically document dosimetric results, when QA report is generated

The screenshot shows a dropdown menu with various dosimetric parameters. The parameters listed include:

- bladder_v25gy
- bladder_v35gy
- bladder_v45gy
- rectum_01cc
- rectum_2cc
- rectum_1cru
- rectum_v15gy
- rectum_v25gy
- rectum_v35gy
- rectum_v45gy
- sigmoid_01cc
- sigmoid_2cc
- sigmoid_1cru
- sigmoid_v15gy
- sigmoid_v25gy
- sigmoid_v35gy
- sigmoid_v45gy
- small_bowel_01cc
- small_bowel_2cc
- small_bowel_1cru
- small_bowel_v15gy
- small_bowel_v25gy
- small_bowel_v35gy
- small_bowel_v45gy
- vag_surface_right
- vag_surface_left
- pibs
- pibs_plus_2cm
- pibs_minus_2cm

The background shows a form with the following fields:

- Complication: Vaginal stricture
- Complication: 3
- before [cm]: 5
- th after [cm]: 4
- Note: (empty text area)

Ongoing works

■ New (AI-based) modules

- Syed and Y-tandem treatment planning
- Syed preplanning
- Automatic organ contouring

