Prostate Brachytherapy Techniques & Applications

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Outline

- Epidemiology
- Evidence
- History
- Technique

Epidemiology

- Globocan- Prostate Cancer in India

Year	Incidence
2018	25696
2025	32537
2030	38035
2035	43899
2040	50141

Clinical Scenario

- Aging population
- Elderly
- Advanced stages
- Emerging evidence for brachytherapy

Evidence

- The Prostate Testing for Cancer & Treatment (ProtecT)
  - Radiotherapy outcomes are similar to surgery
  - Improved toxicity & QoL
- Brachytherapy
  - Major cancer guidelines & societies worldwide

Low Dose Rate Brachytherapy (LDR-BT)

- Monotherapy for low-risk disease- established

- Prostate Cancer Results Study Group-10 Year outcomes

  - Freedom from Biochemical Failure(FFBF)- >86 %
  - Distant Metastasis Rates- <10%
  - Prostate-cancer-specific mortality (PCSM)< 5%
  - Overall survival (OS) >85%,

  - Grade 3–4 toxicities <4% (of patients)

LDR-BT monotherapy or boost for intermediate risk disease

- Prostate Cancer Results Study Group-10 Year outcomes
  - Freedom from Biochemical Failure(FFBF)- 65 – 90%
- Monotherapy compared to EBRT + LDR-BT (RTOG 0232)
  - No difference in FFBF,OS,DM or PCSM
  - Fewer late events

LDR-BT boost for high risk disease

- Accepted modality of treatment
- RTOG 0019
- CALGB 99809
- ASCENDE-RT (Androgen Suppression Combined with Elective Nodal and Dose Escalated Radiation Therapy)

ASCENDE -RT

- ^{125}I brachytherapy boost
- External Beam Radiation Therapy -78 Gy
- Twice as likely to have experienced biochemical failure (at a median follow-up of 6.5 years).

Treatment Related Morbidity

	Time (yrs.)	LDR-PB (%)	DE-EBRT (%)	P value
Cumulative Incidence Gr. 3 GU events	5	18.4	5.2	< 0.001
Prevalence of Gr. 3 GU morbidity	5	8.6	2.2	0.058
Cumulative Incidence Gr. 3 GI events	5	8.1	3.2	.124
Adequate Baseline Erections	5	45	37	.30

ASCENDE RT

- 6 year follow up
- Health related QOL
  - Similar
- Physical & Urinary Function Scales
  - Better in LDR Arm

HDR-BT

- Monotherapy
  - Low Risk & Intermediate Risk Disease

- High Risk -Clinical trials

- FFBF- > 85 % at 5 years.
- OS-> 95%
- PCSM-<4%
- LR-<4%
- DM-<4%

HDR Boost for Intermediate & High-Risk Disease

- 5 year- Better than EBRT alone
  - PCSM-99-100 %
  - OS-85-100 %
  - LR-0-8%
  - DM-0-12 %

- Toxicity –RTOG 0321
  - Gr 3-4 toxicity-2.6 %
  - Stricture Rates-0.7 %

Evolution of Modern Brachytherapy

- In 1911 –Pasteau

TECHNIQUE CHANGES: Open Brachytherapy Implant: 1960 to early 1980's

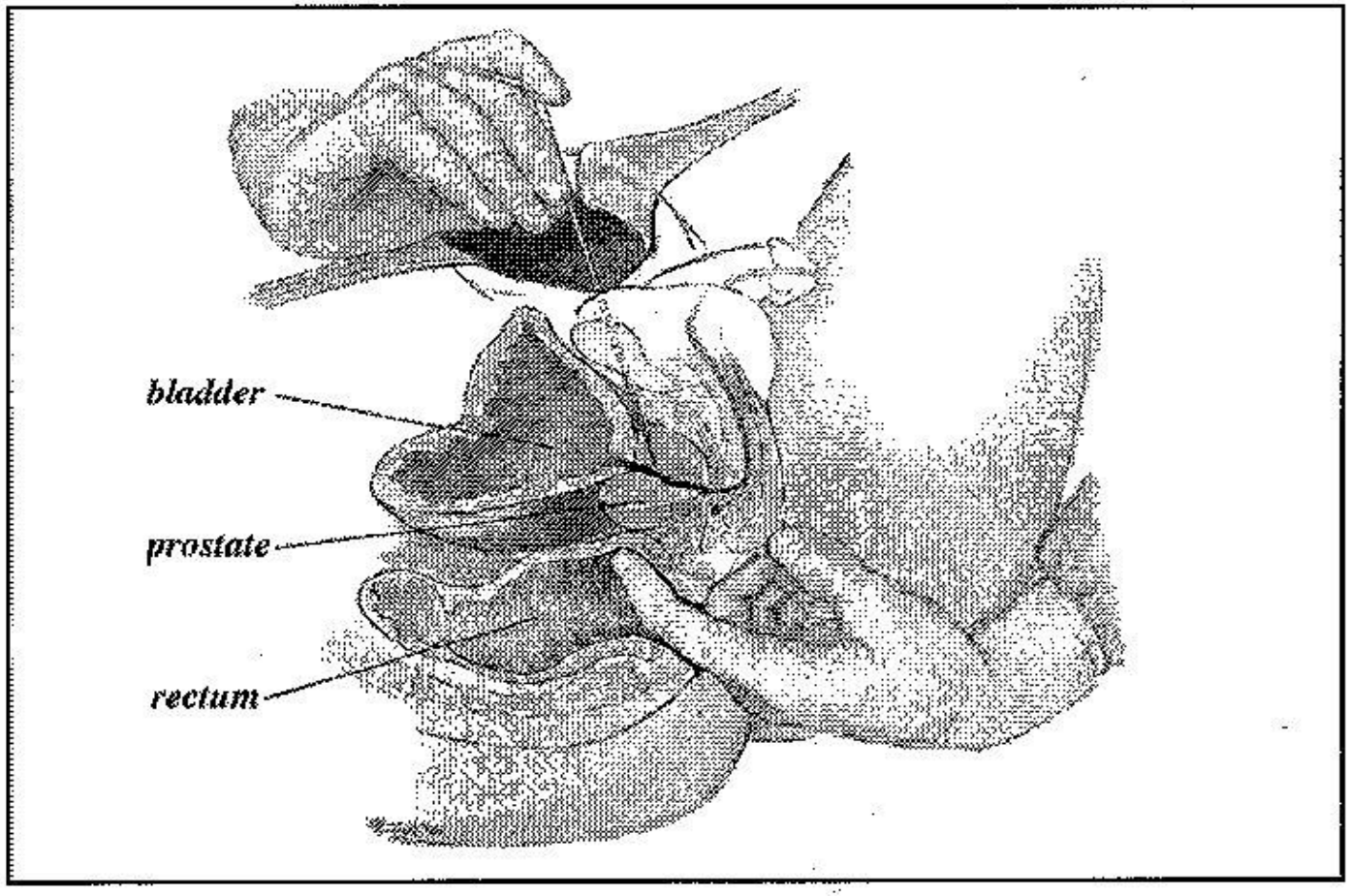
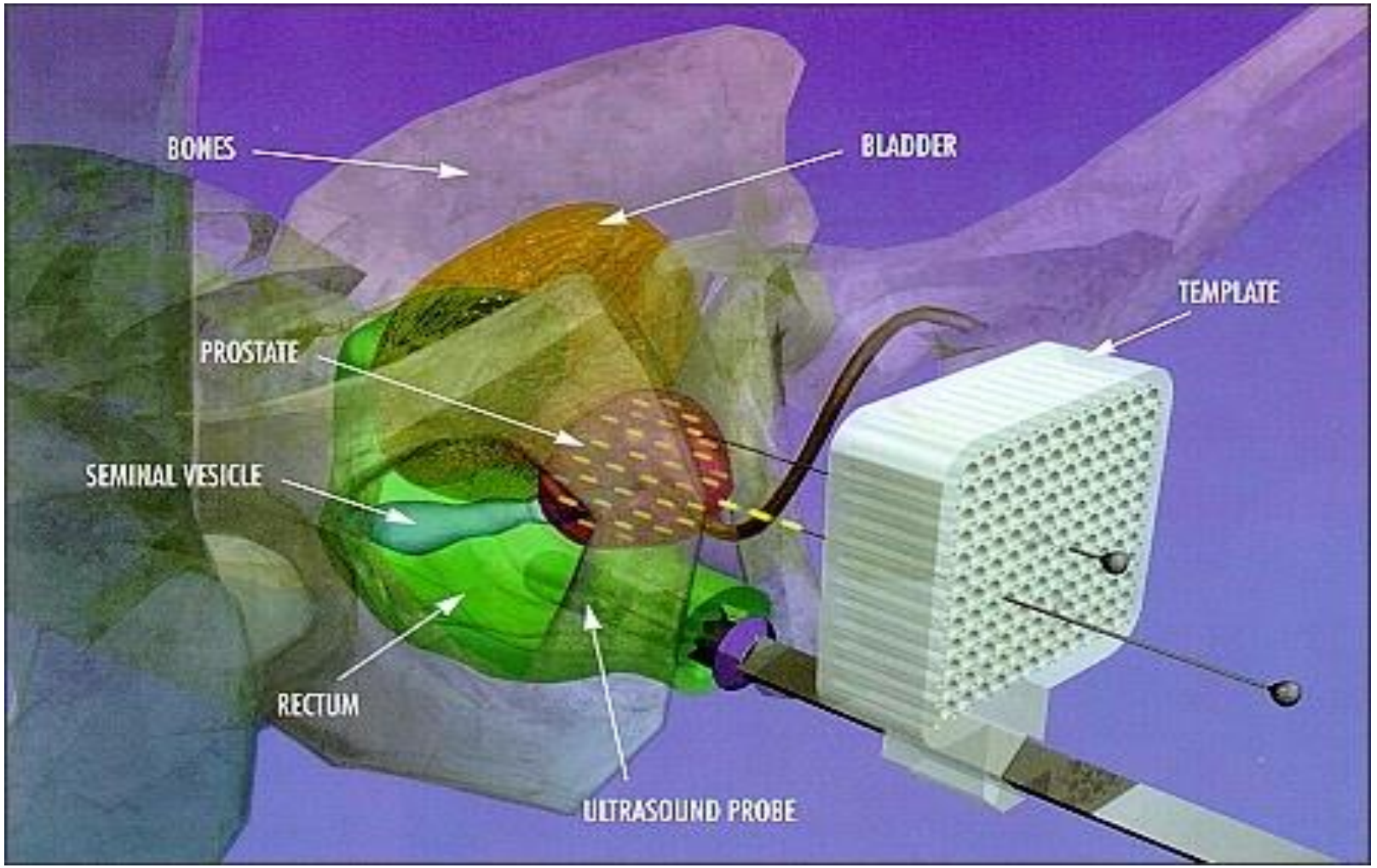


Figure 3 • Schematic illustration of the freehand technique of prostate seed implantation. (Adapted from CA-A Cancer Journal for Clinicians [1995], A T Porter, et al, with permission from Lippincott-Raven Publishers, Philadelphia)

Template Guided Implants
Late 1980's onwards



Pre- Plan System (1990s)

- Dose -144 Gy (I 125)
- Seeds & Needles
- US Guidance
- Preplanned needle positions
- CT after 4 weeks for post-planning

Intra-operative Technique (2000's)

- Computerized Image Capture in 3 D
- Computerized "Live" Planning
- Computer "Guided" Needle Implant
- Computerized delivery of Seeds/HDR Source

Techniques

- CT Based
- Real time US based

Patient Selection-For Monotherapy

Low-risk disease

- Gleason score <6,
- PSA <10 ng/ml,
- Clinical tumour classification T1, T2a)

Favourable intermediate-risk disease

- Gleason score 7,
- or PSA 10–20 ng/ml
- or clinical tumour classification of T2b, T2c
- Primary Gleason score 3 + 4,
- <50% positive biopsy cores,
- and only a single intermediate-risk feature.

For Brachytherapy Boost-High-risk disease

High-risk disease

- Gleason score 8–10
- PSA >20 ng/ml,
- Clinical tumour classification of T3a

For Brachytherapy Boost

Unfavourable intermediate-risk disease

- Gleason score 7
- PSA 10–20 ng/ml
- Clinical tumour classification of T2b, T2c
- Primary Gleason score 4+3
- > 50 % positive biopsy cores
- Multiple intermediate risk features

Absolute Contraindications

- Ataxia telangiectasia
- Pre-existing rectal fistula
- Medically Unsuitable
- Distant metastases
- Absence of rectum such that TRUS guidance is precluded
- Large TURP defects

Relative Contraindications

- Moderate-to-severe urinary symptoms (AUA Score <20)
-
- Patient peak urinary flow rate <10 cm^3/s
- Postvoid residual volume before brachytherapy >100 cm^3
- Large prostate (>60 cm^3)
- Pubic Arch interference

Table 3 Properties of radionuclides and quality planning constraints

Table 3 | **Properties of radionuclides and quality planning constraints**

Radionuclide	$t_{1/2}$ (days)	Average energy (keV)	Prostate (CTV)			Urethra	Rectum	
			D90	V100	V150			
^{125}I	59.4	28.4	>100% of dose	>90–95%	<50–60%	• UV150 ~0 (in volume) • *UV*5 <150% • *UV*30 <125%	• *RV*100 • <1 cc on day 0 and <1.3 cc on day 30	D2cc < prescribed dose and D0.1cc <200 Gy
^{103}Pd	17.0	20.7						
^{131}Cs	9.7	30.4						
^{192}Ir	73.8	380		>90–95% of dose		• D0.1 ≤120 Gy EQD2 • D10 ≤120 Gy EQD2 • D30 ≤105 Gy EQD2	D2cc ≤75 Gy EQD2	
						No normal tissue constraints from ABS owing to wide range of fractionation options[9]		

ABS, American Brachytherapy Society; CTV, clinical target volume; EQD2, equivalent dose in 2 Gy fractions.

Zaorsky, N. G. *et al.* (2017) The evolution of brachytherapy for prostate cancer
Nat. Rev. Urol. doi:10.1038/nrurol.2017.76

LDR BT fractionation

ABS & GEC ESTRO

- Monotherapy with ^{125}I – 145 Gy

- EBRT- 41.4 to 50.4 Gy at 1.8-2 Gy /#
- Before BT-Gap of 2-8 weeks
- LDR Boost-108-110 Gy
- Optimal implant-
  - D90 of 140 -180 Gy

- ^{103}Pd is 125 Gy,

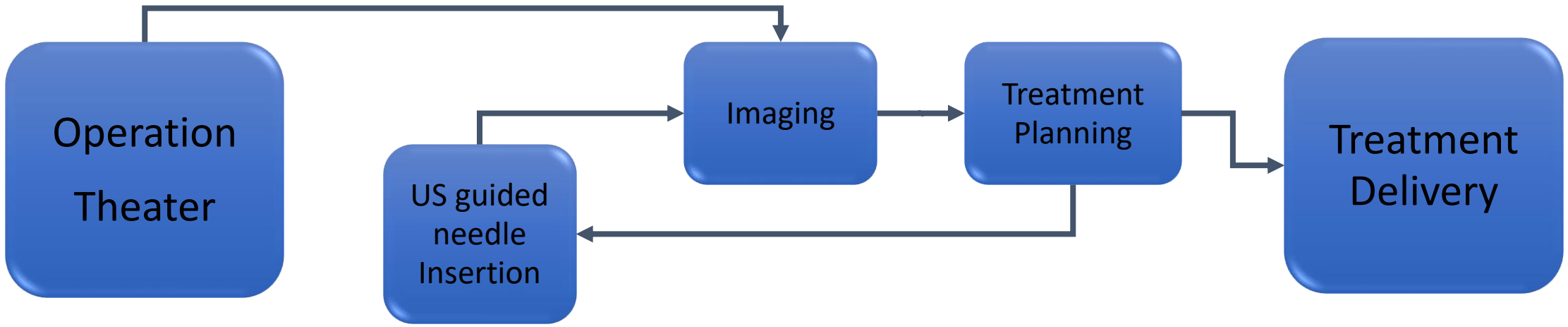
- ^{131}Cs is 120 Gy

HDR-BT fractionation and sequencing

15 Gy in three fractions at 5 Gy per fraction
11–22 Gy in two fractions, at 5.5–11 Gy fractions,
12–15 Gy in a single fraction

EBRT- 36-54 Gy in 1.8-2 Gy
Gap-1-6 weeks

Real-time US-based planning



- Average total time from theater start to treatment delivery is approx. 1.5 – 2 hours
- 3D US based planning in treatment room
- Nonstop real-time procedure, all in one room, requires no couch shifts and minimizes implant shift
- Requires a shielded Operating Room or availability of anesthesia in the brachytherapy suite

Template

Prostate Stepper Template

Needles

Stepper

OncoSelect® Stepper

Afterloader

Flexitron®

Real-time prostate clinical workflow

Patient into operating room

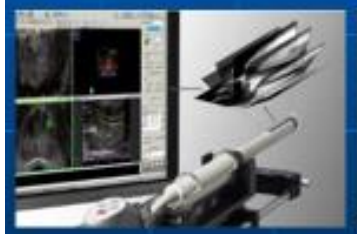
Imaging with TRUS

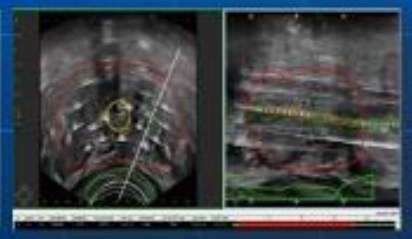
Pre-planning

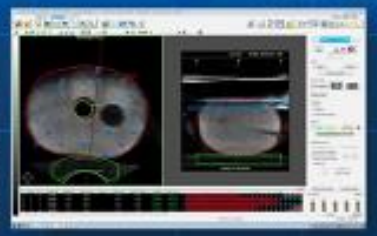
US guided needle insertion

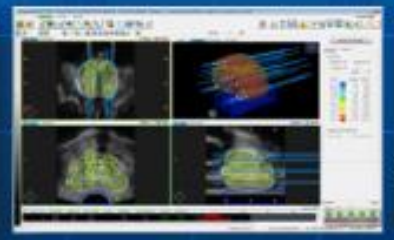
Treatment planning

Treatment delivery in the OR

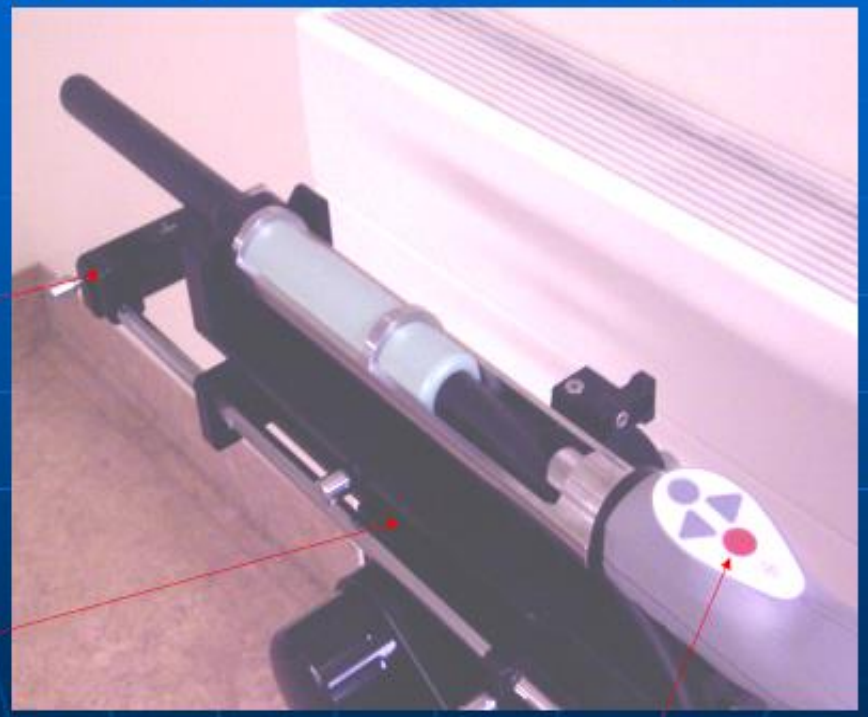




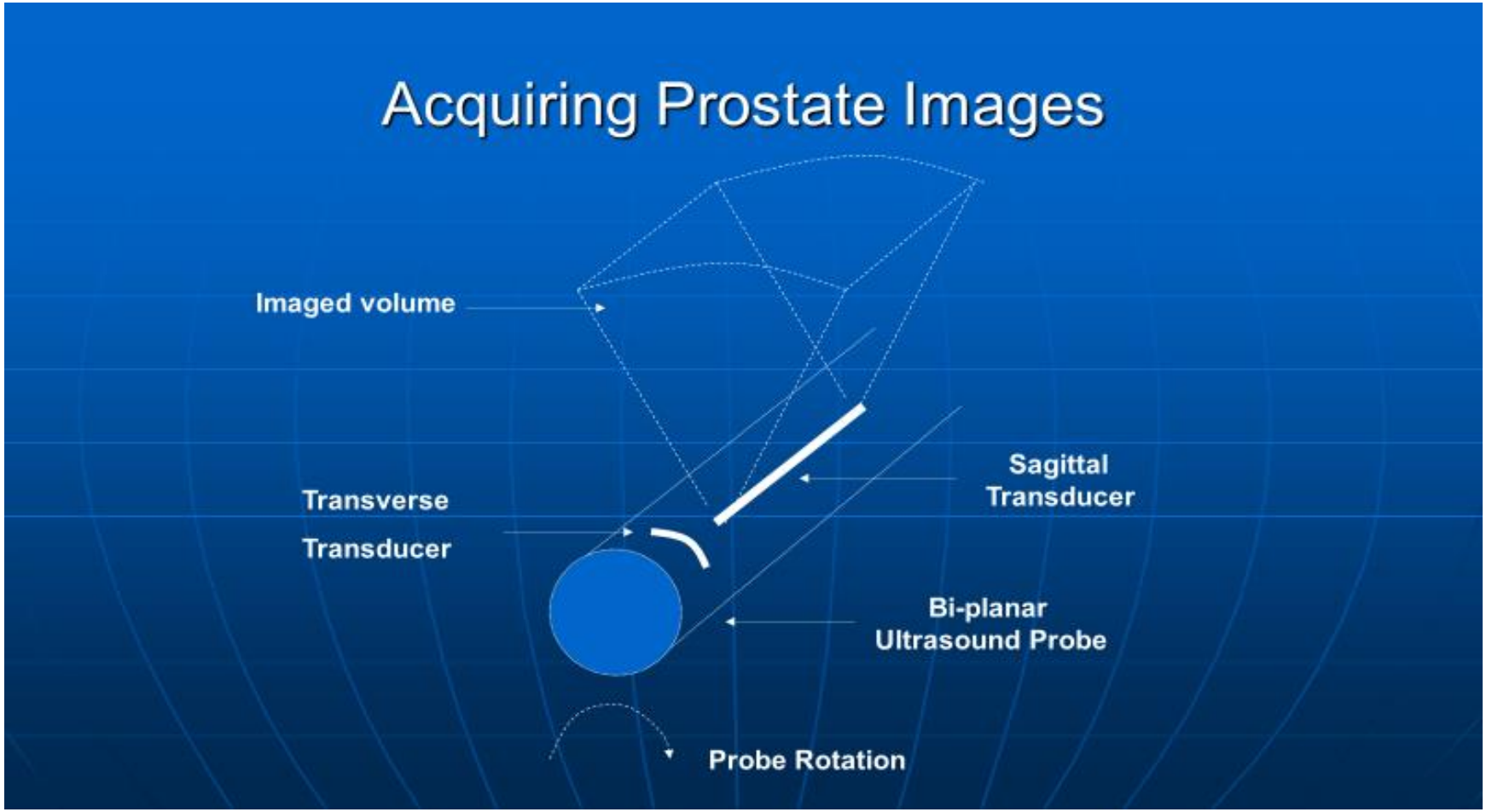




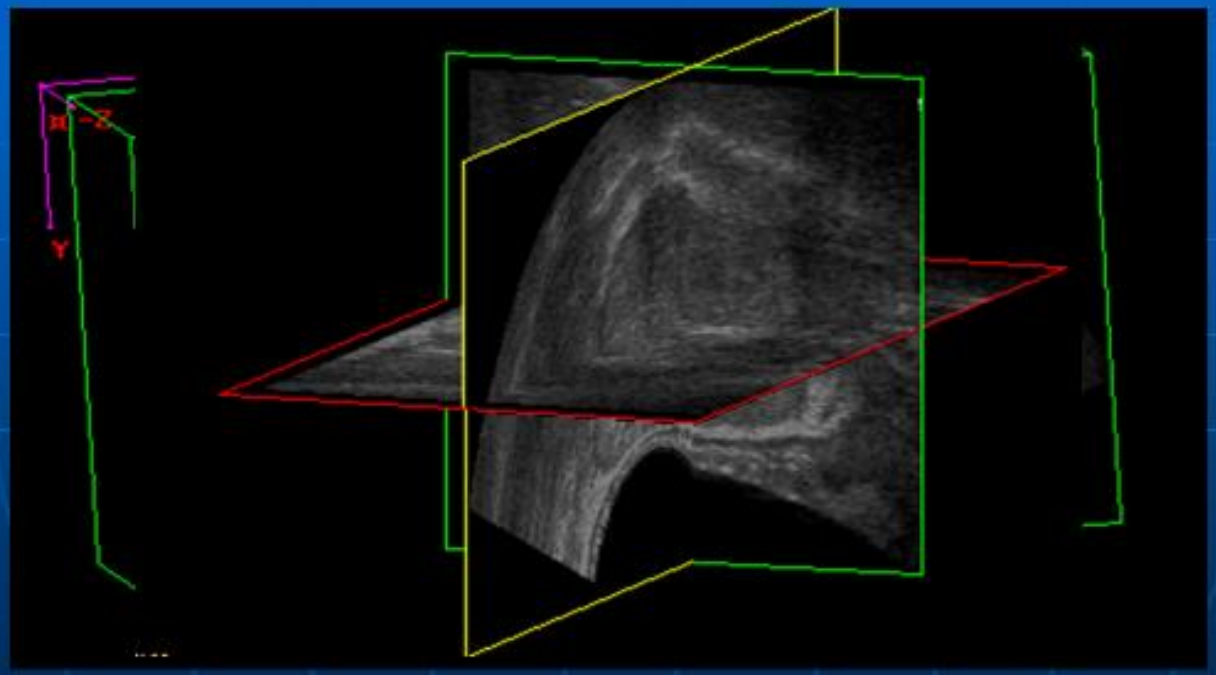
Acquiring Prostate Images



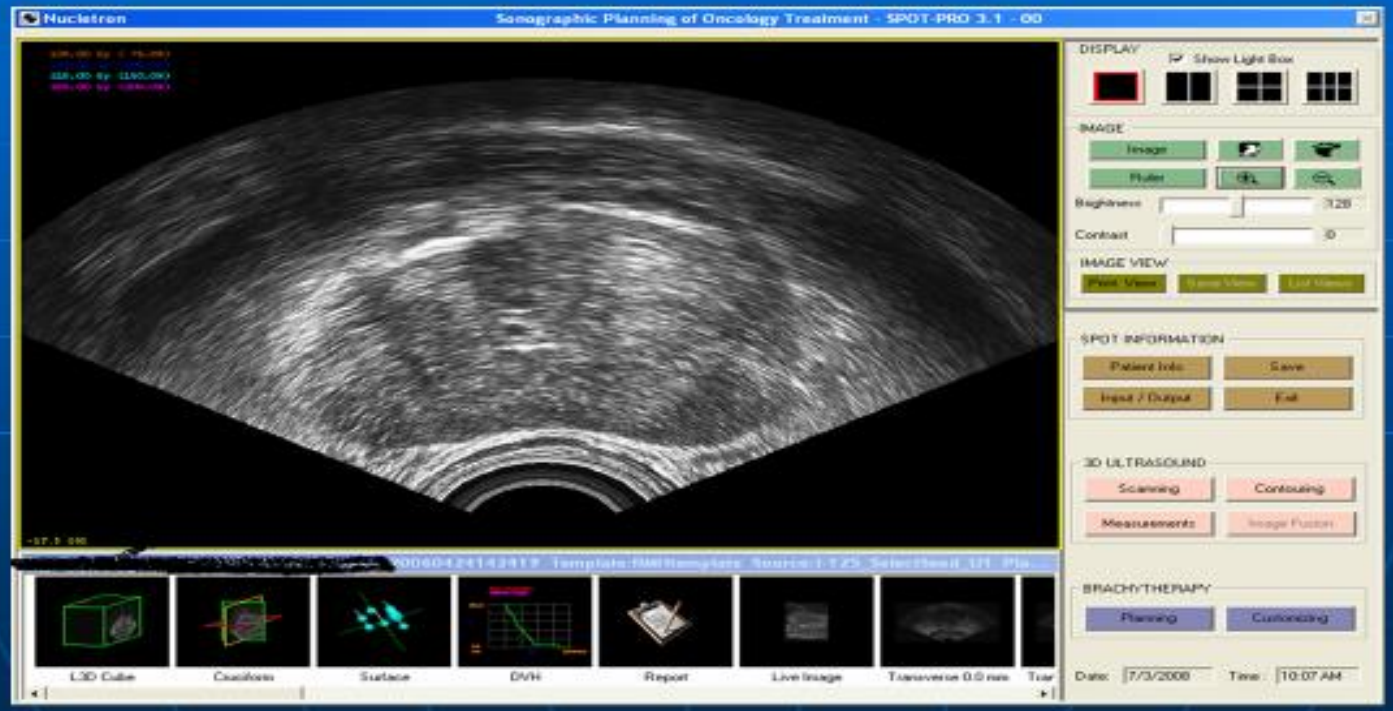
Acquiring Prostate Images



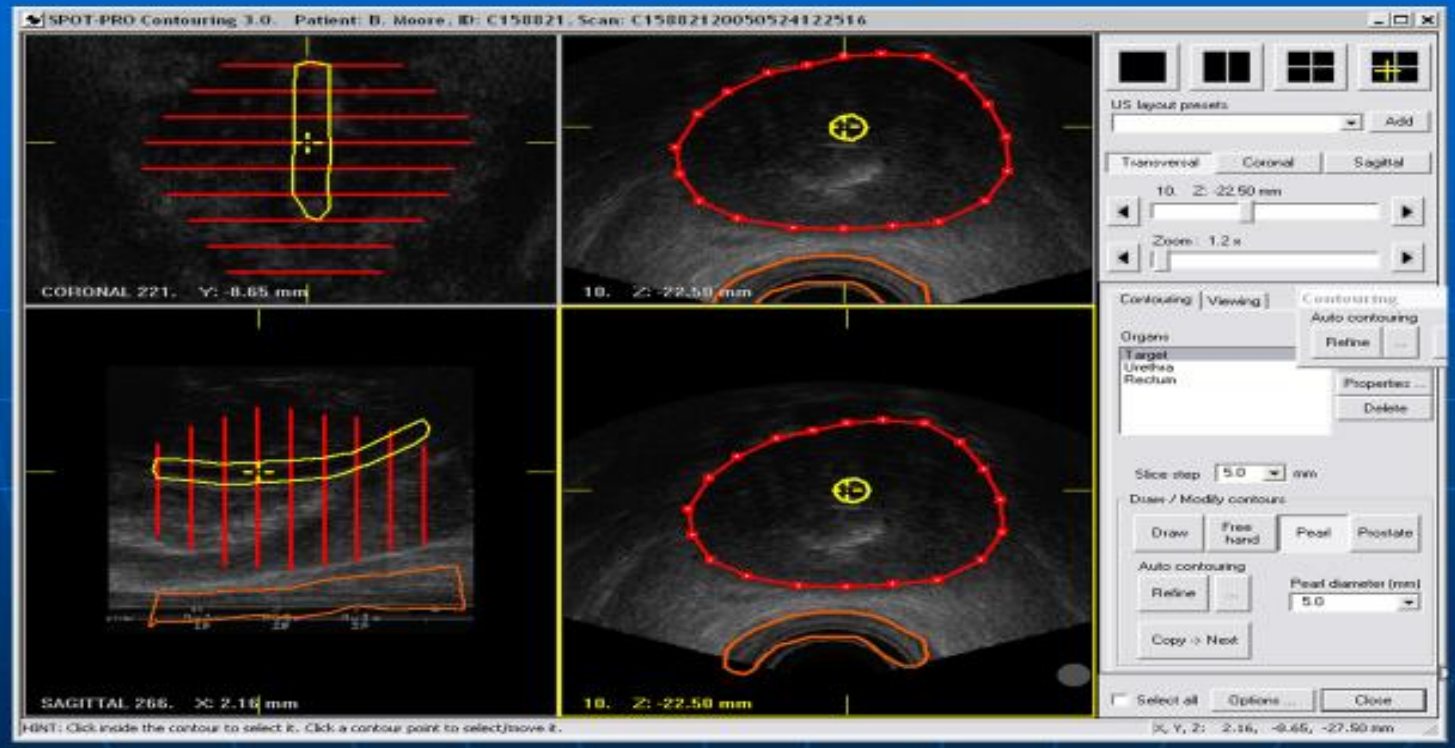
3D Ultrasound: Image captured in approximately 10 seconds, with creation of a 3D model



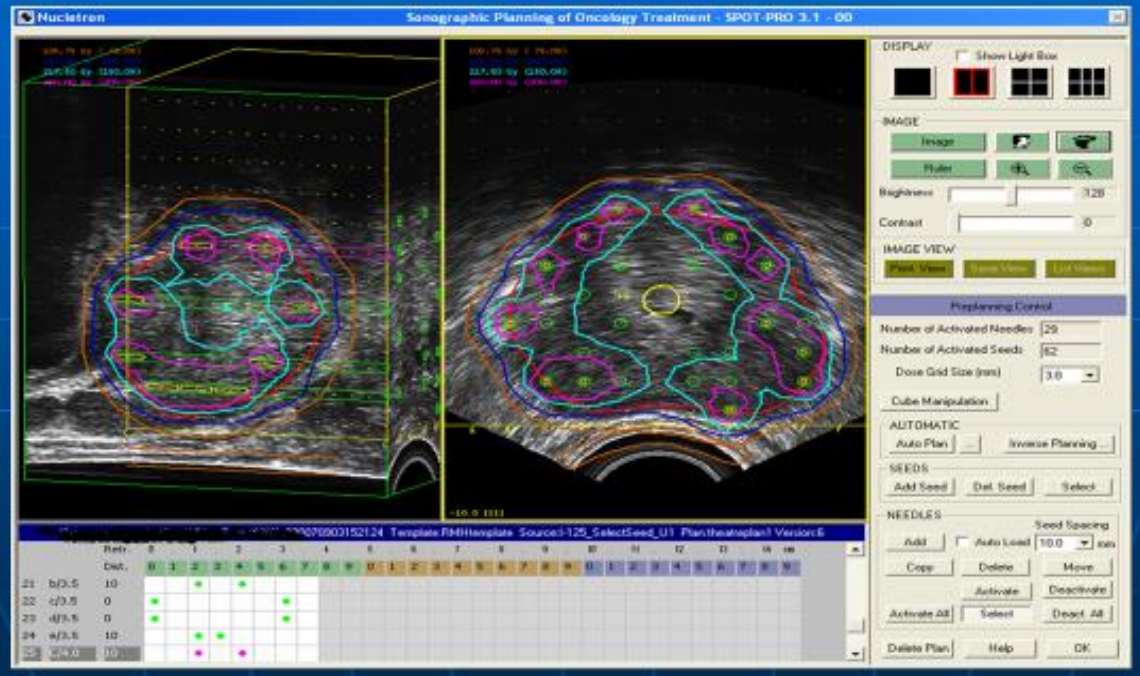
Transverse Ultrasound Image



Prostate Mapping: Contouring live in 3D

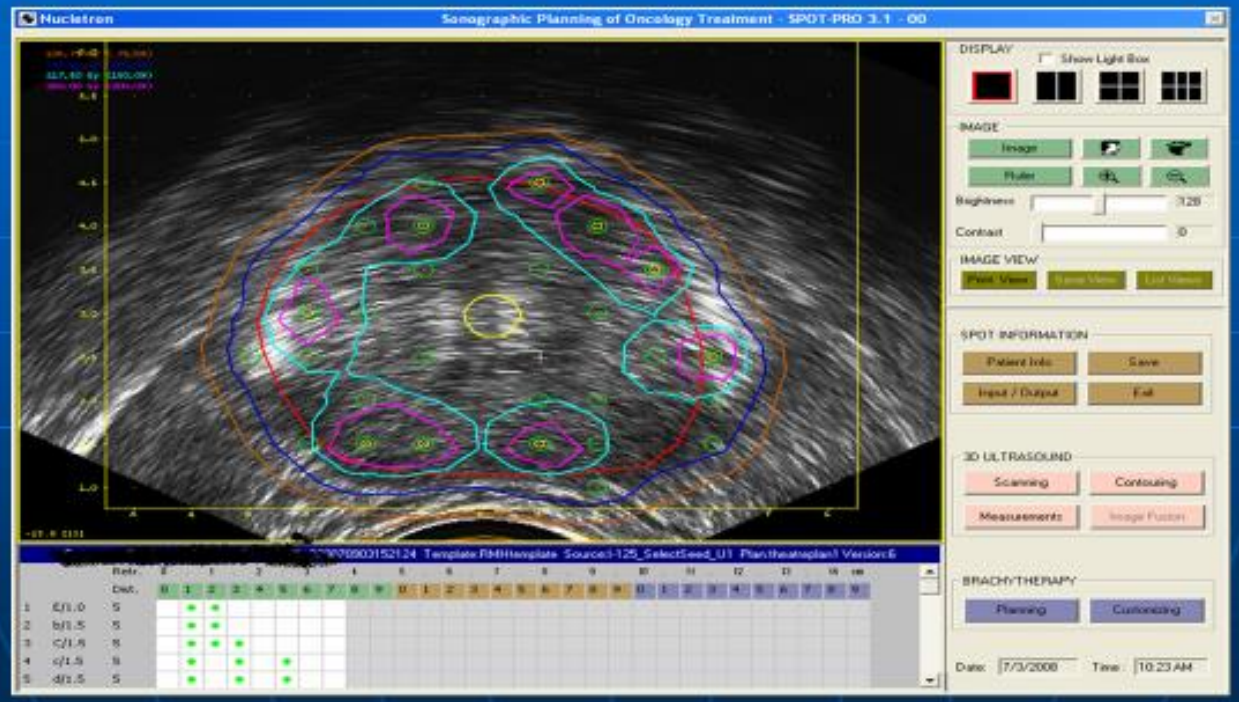


Planning

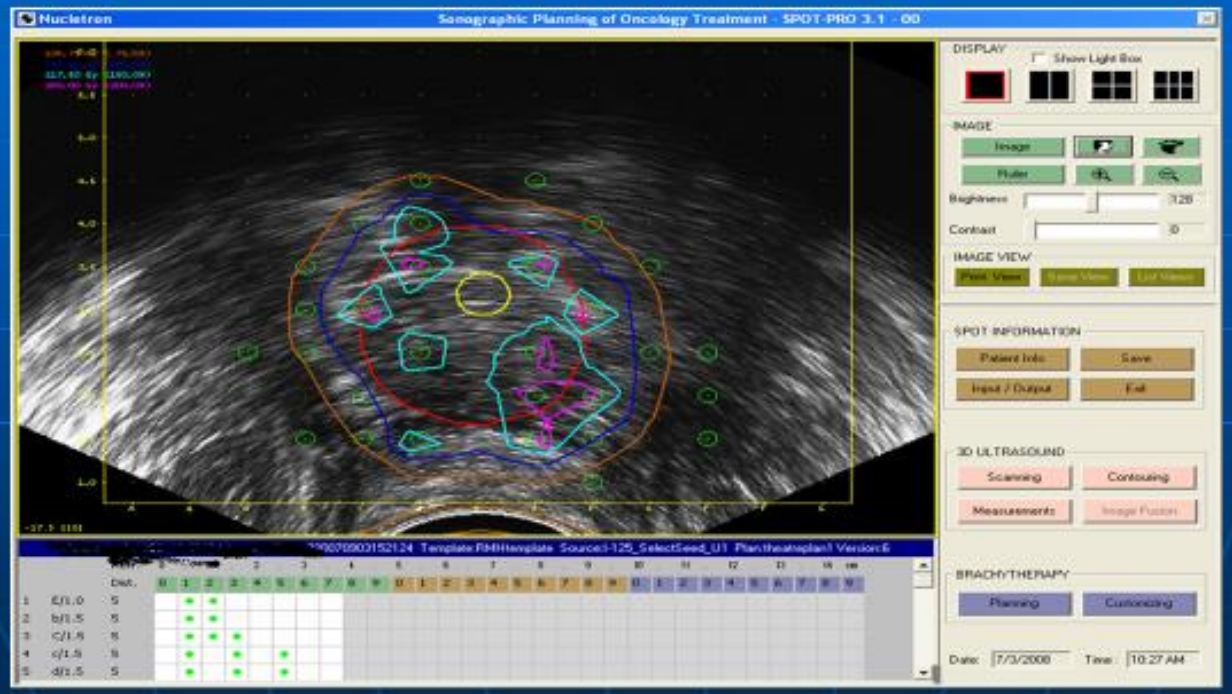

Nucletron
Sonographic Planning of Oncology Treatment - SPOT-PRO 3.1 - 00
DISPLAY
Show Light Box
IMAGE
Image
Ruler
Brightness
128
Contrast
0
IMAGE VIEW
Preplanning Control
Number of Activated Needles
29
Number of Activated Seeds
62
Dose Grid Size (mm)
3.0
Cube Manipulation
AUTOMATIC
Auto Plan
Inverse Planning...
SEEDS
Add Seed
Del. Seed
Select
NEEDLES
Seed Spacing
Add
Auto Load
10.0
mm
Copy
Delete
Move
Activate
Deactivate
Activate All
Select
Deact. All
Delete Plan
Help
OK

Viewing the plan in 3D

Plan Evaluation - Central Slice



Plan Evaluation - Apex Slice




IMPLANT: OR Setup with Computer Screens

Conclusion

1. Prostate Brachytherapy is indicated for almost all stages of the disease
2. Brachytherapy Boost to be considered after EBRT for advanced stages
3. Newer Technology is user friendly & efficient
4. Patient selection is key to avoid severe toxicity