Brachytherapy in Anal Cancers

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Dept of Radiation Oncology &
Tertiary Cancer Center, PGIMER, Chandigarh
Chandigarh: The City Beautiful

ROCK GARDEN
Asia’s Largest “Recycled” Sculpture Garden

ROSE GARDEN
Everyday is a Valentine Day
PGIMER:
- A 2000 Bedded Tertiary care Centre
- Patient care, Teaching, and Research

MISSION:
“Service to the community,
Care for the needy,
Research for the good of all”
Acknowledgements

- Dr. Arun S. Oinam (Chief Medical Physicist)
- And Team of Radiation Technologists
- Conflict of Interest – Nil
Uncommon tumor of the lower GI tract.
Constitutes 4% of lower GI and 1.5% of the whole digestive system malignancies.
Initial chemoradiotherapy is the standard treatment.
External RT boost or interstitial brachytherapy is used for achieving radical dose, thus avoiding the need for permanent colostomy.
Anal Cancer: anatomy

- **Anatomy:**
  - 3–4 cm anal canal
  - Anal verge to dentate line

- **Lymph node drainage:**
  - Perirectal
  - Internal iliac
  - Inguinal nodes

(Up-to-date; cancerbackup.org)
**Staging**

- **T**
  - T0
  - Tis
  - T1 < 2 cm
  - T2 > 2 cm but < 5 cm
  - T3 > 5 cm
  - T4 invades adjacent organs

- **N**
  - N0
  - N1 perirectal
  - N2 unilateral internal iliac or inguinal
  - N3 perirectal and inguinal and/or bilateral inguinal and/or internal iliac

- **M**
  - M0
  - M1 distant metastases

(Hansen and Roach, 2007)
Treatment options

- Surgery: – Abdominoperineal resection (APR)
  - Local excision

- Radiation
  - Adjuvant after Surgery
  - Definitive
    -- External beam RT (EBRT)
    -- Brachytherapy
    -- EBRT + Brachytherapy

- Combined modality – Radiation with chemotherapy
Abdominoperineal resection (APR) with colostomy was the standard surgical procedure 3-4 decades back.

Associated morbidities:
- Sphincter sacrifice—- affecting quality of life
- Permanent colostomy
- Possibility of damage to pelvic sympathetic system

**Reported outcome after APR**

<table>
<thead>
<tr>
<th>Reference</th>
<th>pts</th>
<th>Operative Mortality</th>
<th>5 yr survival</th>
<th>LRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardcastle</td>
<td>83</td>
<td>NS</td>
<td>48%</td>
<td>27%</td>
</tr>
<tr>
<td>Dillard</td>
<td>40</td>
<td>8%</td>
<td>45%</td>
<td>NS</td>
</tr>
<tr>
<td>Greenall</td>
<td>103</td>
<td>6%</td>
<td>55%</td>
<td>35%</td>
</tr>
<tr>
<td>Boman</td>
<td>125</td>
<td>2.5%</td>
<td>66%</td>
<td>28%</td>
</tr>
</tbody>
</table>
## Results of external irradiation alone

<table>
<thead>
<tr>
<th>Author</th>
<th>Radiation</th>
<th>T1</th>
<th>T2</th>
<th>T3-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newman et al</td>
<td>50 Gy/20 # / 4 wk</td>
<td>100 %</td>
<td>81 %</td>
<td>65 %</td>
</tr>
<tr>
<td>Martenson &amp; Gunderson</td>
<td>45- 50 Gy /28 #/ 5-6 wk + boost t0 33-67 Gy</td>
<td>100 %</td>
<td>100 %</td>
<td>Ns</td>
</tr>
<tr>
<td>Otim – oyet</td>
<td>60- 65Gy /30 – 33 #/ 6-7 wk + boost</td>
<td>100 %</td>
<td>73 %</td>
<td>47 %</td>
</tr>
<tr>
<td>Papillon &amp; Montbarton</td>
<td>42 Gy / 10 / 2.5 wk +boost 20 Gy</td>
<td>ns</td>
<td>74 %</td>
<td>42 %</td>
</tr>
</tbody>
</table>
What has Chemoradiation changed;

*Nigro regimen*

5FU 1000mg/m2 on days 1–4 and 28–31

+ Mitomycin C 15 mg/m2 on day 1

EBRT 30Gy/15#/3wks

3 of 3 patients showed CR
Current Standard is Definitive Chemoradiotherapy for Anal Cancer

- Radiotherapy alone vs. Chemoradiotherapy.
  - 45 Gy alone or w/ concomitant 5-FU and mitomycin
  - UKCCCR, 1996: 585 epidermoid anal cancer patients with any stage disease randomized
  - EORTC, 1997: 110 patients with stage IIIA–B anal cancer randomized

(UKCCCR, 1996; Bartelink et al., 1997)
Chemoradiation contd...

<table>
<thead>
<tr>
<th></th>
<th>RT</th>
<th>CRT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UKCCCR</strong></td>
<td>n 285</td>
<td>n 292</td>
</tr>
<tr>
<td>Complete response</td>
<td>76 (30%)</td>
<td>100 (39%)</td>
</tr>
<tr>
<td>Partial response</td>
<td>157 (62%)</td>
<td>138 (53%)</td>
</tr>
<tr>
<td>Minimal response</td>
<td>22 (9%)</td>
<td>21 (8%)</td>
</tr>
</tbody>
</table>

- The phase III UKCCCR and EORTC studies established combined chemoradiation as superior to radiation alone for LRC and colostomy-free survival unfortunately neither study was able to provide difference in overall survival

<table>
<thead>
<tr>
<th></th>
<th>RT</th>
<th>CRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 yr local failure</td>
<td>164 (61%)</td>
<td>101 (39%)</td>
</tr>
<tr>
<td>3yr OS</td>
<td>65%</td>
<td>72%</td>
</tr>
</tbody>
</table>
Current Standard is Definitive Chemoradiotherapy for Anal Cancer

- **UKCCCR**
  - Significantly decreases local recurrence
    - 59% → 36% local failure rate, Relative risk of 0.54
  - Decreases cancer related risk of death after 3 years
    - 39% → 28% anal cancer mortality, Relative risk 0.71
  - No significant overall survival benefit after 3 years
    - Radiotherapy 58% and Chemoradiotherapy 65%

- **EORTC**
  - No significant difference in acute toxicity
    - Diarrhea and skin reaction most common
  - Better complete remission rates
    - 54% → 80%
  - 18% improvement in locoregional control
  - 32% improvement in Colostomy-free survival at 5 years

(EORCT, Bartelink et al., 1997)
Rates of Locoregional Recurrence with Definitive Chemoradiotherapy

- UKCCCR: 36% at 3 years
- EORTC: ~32% at 5 years
- M.D. Anderson: 14% at 3 years

  - Study of 167 patients treated with definitive chemoRT for anal cancer.

(Das et al., 2007)
## Results - Chemoradiation

Local control and overall survival are comparable with surgery.

Local control at 5 yrs: 60–70%. Failure is predominantly locoregional. Most recurrences occur by 18 months.

Prognosis with nodal involvement is better: 5 yrs OS ~ 50%

### Why chemoradiation?

- Excellent CR rates without surgery
- Long term colostomy-free survival.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>CR</th>
<th>LC</th>
<th>CFS</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UKCCCR</td>
<td>577</td>
<td>90%</td>
<td>61%</td>
<td>72%</td>
<td>65%</td>
</tr>
<tr>
<td>EORTC</td>
<td>103</td>
<td>80%</td>
<td>65%</td>
<td>73%</td>
<td>70%</td>
</tr>
<tr>
<td>RTOG</td>
<td>291</td>
<td>92%</td>
<td>67%</td>
<td>89%</td>
<td>67%</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>70-95%</td>
<td></td>
<td></td>
<td>65-80%</td>
</tr>
</tbody>
</table>
Brachytherapy or XRT as boost?

**Brachytherapy:** Highly conformal dose distribution with high dose to the tumor and minimal dose to surrounding normal tissue.

<table>
<thead>
<tr>
<th>Study</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papillon et al (276)</td>
<td>64% 5yr DFS</td>
</tr>
<tr>
<td>Gerard et al (95)</td>
<td>89% CR, 84% 5yr OS, 72% 5yr CFS</td>
</tr>
<tr>
<td>Sandhu et al (79)</td>
<td>91% CR, 75% 3yr OS, 71% 3yr CFS</td>
</tr>
</tbody>
</table>

Overall results are similar to XRT by boost but with significantly less skin toxicity, reduced treatment time and lesser treatment breaks.

Some small series have reported moderate rates of anal necrosis, but not corroborated in these larger studies in experienced hands.
Earliest work of brachytherapy - Papillon

<table>
<thead>
<tr>
<th></th>
<th>No brachy</th>
<th>brachy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local control</td>
<td>61 %</td>
<td>79-83 %</td>
</tr>
<tr>
<td>5 yr DFS</td>
<td>76 %</td>
<td>82 %</td>
</tr>
</tbody>
</table>
Eligibility Criteria For Brachytherapy

- Lesion length $\leq 6$ cm and thickness $\leq 3$ cm (preferably 2 cm)

- Initial lesion less than 1/2 circumference.

- Located within 8 cm from anal verge.

- No fixation to pelvic bones or visceral invasion.

- Without extreme ulceration.
Target volume
- Palpable & visible tumor with a margin of at least 5 mm
  EUA: To exactly localise the target volume, and clinical drawing done.

Timing of brachytherapy: 2 – 8 weeks after EBRT

Source and dose rate: Earlier: Cs137 preloaded needles
  Now, afterloading Ir 192 source, HDR

Preop instructions
  laxatives 4–6 hrly, light low fiber diet, Overnight fasting

Technique (Guide needle technique)
- Lithotomy position
- Under G.A. / spinal / epidural anaesthesia
- Foley’s catheter
Brachytherapy

- Earlier (Preloading era): Cs137 needles were used, without use of template.
  
  Implantation done blindly with Cs needles while palpating the tumor and canal.

- Presently (Afterloading era):
  - Blind ending steel guiding needles used; 15cm long and 1.7–1.9mm dia.
  - Needles inserted about 5mm beneath the anorectal mucosa.
  - Parallelism between needles is maintained by use of templates.
    - Papillon’s template
    - Syed Neblett template
    - MUPIT

- Template obturator also prevents the collapse of anal mucosa and implanted needles.
**Technique**

- The first needle is placed approximately at the centre of the tumor on the longest extension of its vertical axis.

- The tip of the needle should be advanced at least 2–3 cm beyond the palpable lesion.

- The template is held against the perineum in a fixed position with sutures and needles implanted.

- Orthogonal X-rays with dummy sources in all guide needles are taken.
Brachytherapy

- Orthogonal X rays are scanned and catheter reconstructed.
- Computer dosimetry according to rules of Paris system for curved planar implant is done
- The number, position and dwell time of Ir192 seeds to be loaded in each guide needle is decided
- The patient should be advised to take sitz baths once or twice a day for the first week to 10 days after implant removal.
Procedure for doing HDR brachytherapy in anal canal cancer
Image Acquisition

- DICOM 3
- DICOM RT
- TIFF
- BMP
- JPG
- Digitizer
- Film scanner
Features of Brachytherapy Planning Systems

- Possible of HDR, LDR and PDR treatments
- Integration of Treatment Planning System with HDR machine
- Standard plans with 2D films and 3D volumetric images.
- Direct data import from planning system for real time HDR treatment
- Direct data export to all HDR treatment units.
Standard Loading
Standard Funnel Shaped
CT Based Treatment Planning
CT Based Treatment Planning
Loading
Dosimetric and clinical outcome in image-based high-dose-rate interstitial brachytherapy for anal cancer

Rakesh Kapoor¹, Divya Khosla¹*, Arvind K. Shukla¹, Ritesh Kumar¹, Rajesh Gupta², Arun S. Oinam¹, Suresh C. Sharma¹

Image based Brachytherapy
Optimization of Dwell Time

- Set Dwell Time + Dose Shaper
- Geometric Optimization (Edmundson) \( t_i \approx \sum_{j}^{N} d_{ij}^2 \)
- Volume Optimization (DVH based)
- Dose calculation carried out in accordance with AAPM TG43
Plan of Anal Implant on Oncentra TPS

- Doses calculated at the position of TLDs

| Name | X [mm] | Y [mm] | Z [mm] | Coord. | Act. Dos... | Act. ...
<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>tld 2</td>
<td>8.0</td>
<td>-56.5</td>
<td>-53.5</td>
<td>Patient</td>
<td>518.84</td>
<td>172.95</td>
</tr>
</tbody>
</table>
Optimization
Optimization
How good is the implant??

- Quality indices: Developed to evaluate the quality of LDR & HDR interstitial implants
- CI, DHI, ODI, DNR and COIN
- Calculated from CT based dosimetric data obtained using dose calculation algorithms

<table>
<thead>
<tr>
<th>Volumetric quantifiers</th>
<th>Mean ± standard deviation (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI</td>
<td>0.94 ± 0.07 (0.74–1)</td>
</tr>
<tr>
<td>DHI</td>
<td>0.83 ± 0.13 (0.55–0.98)</td>
</tr>
<tr>
<td>ODI</td>
<td>0.21 ± 0.07 (0.07–0.34)</td>
</tr>
<tr>
<td>DNR</td>
<td>0.37 ± 0.22 (0.21–0.45)</td>
</tr>
<tr>
<td>COIN</td>
<td>0.88 ± 0.15 (0.55–0.94)</td>
</tr>
</tbody>
</table>

CI = coverage index; DHI = dose homogeneity index; ODI = overdose volume index; DNR = dose non-uniformity ratio; COIN = conformal index.
Uncertainties in Dosimetry!!

- CT imaging quality
- Accuracy of volume delineation
- Accuracy of the reconstruction of the catheters
- Accuracy of the treatment planning system algorithm in dose calculations
- Source calibration uncertainty
- Accuracy of planned source dwell position and dwell times during delivery
- Dose received during source transit time
- Needle shifting or anatomy changes during the fractionated treatment
Thermo-luminescence dosimetry (TLD) has been established as a suitable system for dosimetry in brachytherapy. We used TLDs for in vivo dosimetry of anal implants, and compared them to the CT based dosimetry, as a prospective study.

References:

TLD Calibration

- Dose linearity of TLD 100: 1 mGy – 1000 cGy
- Beyond this ranges TLD 100 is supralinear
- A calibration curve was generated which is fitted with a polynomial curve with 1 Standard Deviation error of 5 %.
- This calibration curve works in the supralinear region upto the dose of 3000 cGy
TLD Calibration
In vivo dosimetry: Rexon

Annealing

Dose Reading
Glow curve – Rexon TLD systems–UL 300
Literature Review
26 patients

Chemotherapy: 5FU (1,000 mg/sqm, continuous infusion over the first 4 days) and Mitomycin C (10 mg/sqm on day 1, bolus administration).

Radiation: split into two cycles, dose for each cycle was 23.4 Gy, @ 1.8 Gy per fraction.

Four-six weeks after the end of cycle 2, the patients received a boost of interstitial brachytherapy.

Median follow up: 45 months

CR: 81%
PR: 19%

Five year actuarial local control: 88%
Five year actuarial survival: 75%
Five year sphincter conservation: 77%
1988 to 1997
52 patients with carcinoma anal canal
39 patients (75%) had squamous cell carcinoma and 13 patients (25%) had adenocarcinoma.

After external radiation with concurrent chemotherapy, a boost with brachytherapy was performed for squamous cell carcinomas of the anal canal, while the adenocarcinomas were referred for surgery.

5 year Sphincter preservation: 64% (69% for squamous cell; 45% for adenocarcinomas)
5 year Overall survival was 62% (69% for squamous cell carcinoma vs 36% for adeno carcinoma)
Clinical and manometric effects of combined external beam irradiation and brachytherapy for anal cancer.

Broens P¹, Van Limbergen E, Penninckx F, Kerremans R.

8 patients
External radiation : 44 Gy
Brachy therapy boost: 20 +/- 4 Gy by interstitial implantation.
Median follow up: 43 months.
Maximum anal basal pressure, squeeze pressure, and squeeze increment were significantly lower in patients than in control subjects.
Decreased anal elasticity was not observed.
Four patients were perfectly continent.
Four patients were incontinent for gas and presented urgency in case of liquid stools.
Three of them also had urgency for solid stools.
Defecation frequency was increased but regular in most patients.
Enough reserve sphincter function was maintained to preserve a clinically acceptable degree of anal continence in all the patients.
19 patients

**EBRT:** 44–50 Gy @ 2 Gy per fraction

**Chemotherapy:** one or two cycles of fluorouracil & cisplatinum.

After a gap of 2–3 weeks, **PDR interstitial brachytherapy** was performed with a **rigid needles** technique. The dose was between 10–25 Gy (**PARIS system**).

At 3 yrs of follow up,

1/19 pts (5 %) had **local recurrence**;
1/19 pts (5 %) had **metastatic disease**. 

**Treatment of squamous cell anal canal carcinoma with pulsed dose rate brachytherapy. Feasibility study of a French cooperative group**

Jean-Pierre Gerard, Florana Mauro, Luc Thomas, Bernard Castelain, Jean-Jacques Mazeron, Jean-Michel Ardiet, Didier Peiffert

Received 23 September 1998; received in revised form 13 February 1999; accepted 8 March 1999.
22 colostomy–free survivors
chemoradiation +/- brachytherapy
Gastrointestinal Quality of Life Index (GIQLI)
anorectal manometry to determine anal sphincter length (SL), resting pressure (RP), maximum squeeze pressure (MSP), rectal compliance (RC) and relaxation of the internal anal sphincter (RIAS).
SL, RP and MSP were significantly lower in anal carcinoma patients than in healthy volunteers. Complete continence was detected in 56% of patients.
Brachytherapy and local excision for sphincter preservation in T1 and T2 rectal cancer.

Grimard L¹, Stern H, Spaans JN.

1989 and 2007
32 patients
Median follow up: 6.2 yrs
5 year local control: 76%
Median time for local recurrence: 14 months
5 year DSS: 85%
5 year OS: 78%
Sphincter preservation@ 5 years: 27/32 pts (84%)
1989 to 2009
38 patients
22/38 patients received chemoradiation
10/38 patients received radiotherapy alone

**Radiation dose**: 45 Gy to the pelvis followed by a **brachytherapy boost** of 15–35 Gy to the anal canal using **LDR (26 pts)** or **PDR (12 pts)**

6/10 patients received brachytherapy alone @ till 60–65 Gy

Median follow-up: 30 months
2 year local control rate: 91%
5 year local control: 87%
Sphincter preservation @ 5 yrs: 84%
84 patients
3D CRT with concurrent chemotherapy (5-fluorouracil and mytomycin C), followed by **brachytherapy** or **external beam boost**.
Median follow up: 53 months (range: 16–105 months).
5 year loco regional control (LRC) : 71 %
5 year disease–free survival (DFS) : 68 %
5 year disease–specific survival (DSS) : 81 %
5 year overall survival (OS) : 67 %
5 year colostomy–free survival (CFS) : 85 %

*In patients with brachytherapy boost a trend of less late side effects was observed compared to patients with external beam boost (P=0.066).*
High-dose-rate endorectal brachytherapy in the treatment of locally advanced rectal carcinoma: Technical aspects

Té Vuong¹,* , Slobodan Devic², Belal Moftah², Michael Evans², Ervin B. Podgorsak²

¹Division of Radiation Oncology, McGill University Health Centre, Montreal, Canada
²Medical Physics Department, McGill University Health Centre, Montreal, Canada

ABSTRACT

PURPOSE: In this era of new radiation technologies and tumor imaging, a high-dose-rate endorectal brachytherapy has been developed and tested in a phase I/II study of advanced rectal tumors. In this article, we report technical aspects of the treatment modality.

METHODS AND MATERIALS: Forty-nine patients underwent staging with endoscopic rectal ultrasound, and the tumor dimensions were determined with MRI of the pelvis. Patients with resectable rectal cancer (staged T2, T3, or early T4) were treated with preoperative high-dose-rate endorectal brachytherapy followed by surgery 6–8 weeks later. Under direct rectoscopy, radiopaque clips were used to mark the tumor margins. The treatment planning was done with the use of a CT simulator, and the treatment was delivered using a flexible endorectal applicator with eight catheters arranged around the circumference of the applicator and a high-dose-rate brachytherapy remote afterloading system with an Iridium-192 source. Isodose distributions were generated by the Plato planning system (Nuclotron B.V., Veenendaal, The Netherlands) and digitally reconstructed radiographs were used as references for daily treatment. A tumor dose of 26 Gy in four fractions was prescribed, and intramesorectal deposits were documented on the magnetic resonance images.

RESULTS: Forty-nine patients received planned treatment, and all but 2 patients underwent planned surgery. The pathology specimens showed a complete macroscopic response in 64% of the patients and tumor downstaging in 67% of the patients.

CONCLUSIONS: Advances in tumor imaging and 3D treatment planning systems allow for better tumor mapping and dose planning. The use of a multichannel flexible endorectal applicator leads to tumor downstaging before surgery in patients with resectable locally advanced rectal carcinomas. The technique used in our center was practical and validated by this study. © 2005 American Brachytherapy Society. All rights reserved.
Dosimetric and clinical outcome in image-based high-dose-rate interstitial brachytherapy for anal cancer

Rakesh Kapoor¹, Divya Khosla¹,*, Arvind K. Shukla¹, Ritesh Kumar¹, Rajesh Gupta², Arun S. Oinam¹, Suresh C. Sharma¹

¹Department of Radiotherapy and Oncology, Regional Cancer Centre, Post Graduate Institute of Medical Education and Research, Chandigarh, India
²Department of Surgery, Post Graduate Institute of Medical Education and Research, Chandigarh, India

ABSTRACT

PURPOSE: To evaluate dosimetric and clinical outcome in patients of anal cancer treated with image-based interstitial high-dose-rate brachytherapy following chemoradiation.

METHODS AND MATERIALS: Sixteen patients with anal cancer were treated with chemoradiation followed by brachytherapy boost with image-based high-dose-rate interstitial brachytherapy from January 2007 to June 2011. Two brachytherapy dose schedules were used: 21 Gy in seven fractions and 18 Gy in six fractions depending on response to chemoradiation. CT scan was done after placement of needles for confirmation of placement and treatment planning. Target volume was contoured on CT scans. Volumetric quality indices and dose parameters were calculated.

RESULTS: The mean clinical target volume was 17.7 ± 4.98 cm³, and the median overall tumor size was 4.2 cm (3.4–5 cm). The mean values of coverage index, dose homogeneity index, overdose volume index, dose non-uniformity ratio, and conformal index were 0.94, 0.83, 0.21, 0.37, and 0.88, respectively. With a median followup of 41 months (range, 20–67.2 months), preservation of the anal sphincter was achieved in 14 patients. The 1- and 2-year local control rates were 93.8% and 87.5%, respectively. Treatment was well tolerated and none of the patients developed Grade 3 or higher late toxicity.

CONCLUSIONS: The combination of external beam radiotherapy with interstitial brachytherapy increases the dose to the tumor volume and limits the volume of irradiated normal tissue, thereby decreasing late toxicity. The use of image-based treatment planning provides better dose conformality with reduced toxicity and helps to prevent a geographic miss. © 2013 American Brachytherapy Society. Published by Elsevier Inc. All rights reserved.
Updated Results Brachytherapy

- N = 42 patients
- T2–3 N0,M0
- All had Brachy boost after con chemoRT
- Dose of ext RT – 40–45 Gy/ 20–25 #/ 5 wks
- Dose of brachy – 18–21 Gy @ 3 Gy / # twice daily
- Sphincter preservation – 33 patients (78.57 %)
- Residual disease, sent for salvage sx – 9
RESULTS

- Only grade I and II acute reactions noted in all patients.
- None had necrosis/ ulceration as late term sequela.
- In suppl. XRT Boost(Historic Deptt Data) group sphincter preservation of 63% was achieved.
Toxicity:
- Acute side effects are seen in a majority of patients, but are nearly always self-limiting.
- Late or chronic toxicity is uncommon at doses $\leq 60\text{Gy}$ and # size $<2.5\text{Gy}$.
- Anal necrosis & small bowel damage requiring surgery: 3-6%.
- Genitourinary complications are seen in 1-2% cases.
- Treatment mortality is extremely rare.

Prognostic Factors:
- Nodal status
- Tumor size
- Overall treatment time
- Tumor differentiation
- Age
- Sex
Chemoradiotherapy with HDR brachytherapy boost is an accepted modality of treatment.

Patient selection is important for long term results (colostomy-free survival).

HDR boost brachytherapy is advantageous over XRT boost (in terms of less skin reactions, sparing of part of the anal canal circumference).
Thank you