Advances in radiotherapy techniques for prostate cancer

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Radiotherapy and Prostate Cancer

• Radical treatment with intention of cure or long term control – treatment given to the prostate gland and immediate surrounding areas
  ▫ May be given as external beam radiotherapy or brachytherapy (internal radiotherapy)
  ▫ Large doses, long courses (weeks)

• Palliative treatment with intention of helping control symptoms
  ▫ Usually external beam radiotherapy
  ▫ Lower doses, shorter courses (days)
External beam radiotherapy—what we used to do

- Rectangular fields
  - No MLC
  - High rectal dose
External beam radiotherapy-what we do now

- 3D Conformal radiotherapy
External beam radiotherapy-what we do now

• 3D Conformal radiotherapy
  ▫ MLC
  ▫ Reduced rectal dose
Evidence for conformal radiotherapy

- Comparison of radiation side-effects of conformal and conventional radiotherapy in prostate cancer: a randomised trial
  David P Dearnaley, Vincent S Khoo, Andrew R Norman, Lesley Mey, Alan Nahum, Diana Tait, John Yarnold, Alan Horwich

_Lancet_ 1999; 353:267-272
Evidence for conformal radiotherapy

- 225 patients
- 64Gy 32#
- Conventional vs conformal RT
- Radiation proctitis
  - 37% vs 56% RTOG grade 1
  - 5% vs 15% RTOG grade 2
- No difference in bladder function
Advanced radiotherapy techniques

- Intensity modulated radiotherapy (IMRT)
- Image guided radiotherapy (IGRT)
- Brachytherapy
  - LDR
  - HDR
- Fiducial markers
- (Proton therapy)
Intensity modulated radiotherapy (IMRT)

- What can IMRT do?
  - Produce concave treatment volumes
  - Closely conform to PTVs
  - Reduce normal tissue doses
  - Allow dose escalation
Intensity modulated radiotherapy (IMRT)

Conventional 3 field plan

95% isodose
Intensity modulated radiotherapy (IMRT)
Intensity modulated radiotherapy (IMRT)

- Disadvantages
  - dose heterogeneity within the target (many beams)
  - inefficiency of beam delivery and beam leakage that may result in a total body dose that is significantly higher
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  - time-consuming and expensive
Intensity modulated radiotherapy (IMRT)

- Delivery of IMRT on a conventional LINAC
  - Step-and-shoot (segmented delivery)
  - Dynamic delivery
IMRT-the evidence

• Clinical experience with intensity modulated radiation therapy (IMRT) in prostate cancer.

Radiother Oncol. 2000;55:241-249
IMRT-the evidence

• compared the acute and late toxicities of patients with T1c-T3 prostate cancer receiving high-dose (81 Gy) 3D-CRT (n=61) and IMRT (n=171)
• IMRT significantly reduced the incidence of acute mild to moderate rectal toxicity compared with 3D-CCRT
• fewer cases of moderately severe late rectal toxicity with IMRT than 3D-CRT
IMRT-the evidence

- First results of a phase III multicenter randomized controlled trial of intensity modulated (IMRT) versus conventional radiotherapy (RT) in head and neck cancer (PARSPORT: ISRCTN48243537; CRUK/03/005)

C Nutting

J Clin Oncol 27:18s, 2009 (suppl; abstr LBA6006)
IMRT-the evidence

- 94 patients (47 RT; 47 IMRT)
- Twelve month LENT-SOMA ≥G2 xerostomia scores were observed in 74% (25/34) of RT and 40% (15/38) of IMRT patients ($p=0.005$)
- Conclusions: Sparing the salivary glands through use of IMRT significantly reduces the incidence of xerostomia in patients with pharyngeal tumours
Image-Guided Radiotherapy (IGRT)

- Combines imaging and treatment capabilities on the same machine
- Tumour position can move during treatment
- Tumour movement can be tracked during treatment
- Fine adjustments can be made to treatment plan
Image-Guided Radiotherapy (IGRT)

• What can IGRT do?
  ▫ Closely conform to target volume
  ▫ Reduce normal tissue doses
  ▫ Allow dose escalation
Image-Guided Radiotherapy (IGRT)

- Disadvantages
  - Cost
  - Higher exposure to radiation
  - Less patients per hour per machine
Brachytherapy

• Low dose rate brachytherapy
  ▫ Permanent radioactive seed implant

• High dose rate brachytherapy
  ▫ Afterloading
Low dose rate (LDR) brachytherapy

- Permanent implant of $^{125}$I seeds within the prostate
- Mean energy 25KeV, half life 59.4 days
- Accuracy ensured by using TRUS
- Short range of radiation allows high doses to prostate with sparing of normal tissue (minimum 145Gy to prostate with 2-3mm margin)
Low dose rate (LDR) brachytherapy

- What can LDR brachytherapy do?
  - Closely conform dose to tumour volume
  - Reduce normal tissue doses
  - Allow dose escalation
  - Can be done outside radiotherapy centre
Low dose rate (LDR) brachytherapy

• Disadvantages
  ▫ No way to vary dosing once seeds implanted
  ▫ Early stage, low risk disease only
  ▫ Critics say all these patients could be managed with active surveillance
LDR brachytherapy-the evidence

- Biochemical disease-free survival following 125I prostate implantation.
  Beyer DC, Priestley JB

LDR brachytherapy - the evidence

- 489 patients
- Biochemical disease-free survival at 5 years was
  - 94% for T1
  - 70% for unilateral T2
  - 34% for T2c tumours
High dose rate (HDR) brachytherapy

- Used as a boost to external beam RT
- Catheters placed in situ and post implant dosimetry undertaken
- Treatment delivery follows afterwards in the HDR afterloading room with Ir\textsubscript{192}
High dose rate (HDR) brachytherapy

- What can HDR brachytherapy do?
  - Closely conform dose to tumour volume
  - Reduce normal tissue doses
  - Allow dose escalation
  - Treat more advanced tumours than LDR brachytherapy
Fiducial markers

- Fiducial markers may be inserted to aid localisation of the prostate
  - Gold grains/visicoil
  - Usually 3 markers inserted
  - Insertion via TRUS
- Used in association with IGRT or IMRT
Fiducial markers

- What can fiducial markers do?
  - Better localisation of target tissue
  - Allow delivery of closely conformal RT to target volume
  - Reduce normal tissue doses
  - Allow dose escalation
Conclusion

• Options for advanced RT techniques are:
  ▫ IMRT
  ▫ IGRT
  ▫ Brachytherapy
  ▫ Fiducial markers

• All are means of:
  ▫ Conforming treatment more closely to target volume
  ▫ Escalating doses to tumour
  ▫ Sparing normal tissue toxicity
Conclusion

- Aims of advanced radiotherapy techniques have been shown to improve conformality and reduce normal tissue doses.

- Too early to demonstrate improved outcomes for most techniques at present.