Decision Support in Radiation Therapy

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Summary

- Overview of Clinical Decision Support
  - Decision support for radiation therapy
  - Introduction to informatics methods
    - Ontology
    - User interface

Clinical Decision Support

- To improve clinical decision making
  - “Characteristics of individual patients are matched to a computerized knowledge base, and software algorithms generate patient specific recommendations.” (Garg et al. 2005)
  - “Providing clinicians or patients with computer-generated clinical knowledge and patient-related information, intelligently filtered or presented at appropriate times, to enhance patient care.” (Jaspers et al. 2011)
Clinical Decision Support
Applications
- Diagnosis
- Disease management
- Drug dosing and prescribing
- Preventive care
- Healthcare utilization

Clinical Decision Support
Mechanisms
- Alert
- Advice
- Recommendation
- Critique
- Suggestion

Clinical Decision Support Modes
- Passive (recommendations)
- Active (predictions, alerts)
- Collaborative (iteratively refine)
Effects of Clinical Decision Support

- Practitioner performance
- Patient outcome

- Systematic Review (Jaspers 2011)
  - Increased practitioner performance
    - Strong evidence
  - Improved patient outcome
    - Little evidence

Decision Support for Oncology

- Diagnosis and staging
- Prognosis prediction
- Treatment guideline and personalization
- Patient decision aid

Decision Support for Radiation Therapy

- Target and OAR delineation
- Dose prescription
- Treatment plan/dose parameter generation
- Treatment plan evaluation/selection
- Treatment verification and delivery
- Treatment response and injury effects
RT Decision Support Examples

- RT decision support system
  - “Image-assisted knowledge discovery and decision support in radiation therapy planning”, by Brent J. Liu et al. CMIG 2007

- Target and OAR delineation
  - Web-based atlas

- Target and OAR delineation
  - “Decision support system for localizing prostate cancer based on multiparametric magnetic resonance imaging” by Vijay Shah et al. Medical Physics 2012
  - Cancer Probability Maps
RT Decision Support Examples

- Dose prescription

RT Decision Support Examples

- Treatment plan/parameter generation
  - “Simultaneous navigation of multiple Pareto surfaces, with an application to multicriteria IMRT planning with multiple beam angle configurations,” by David Craft and Michael Monz, Medical Physics 2010

RT Decision Support Examples

- Treatment plan/parameter generation
  - “Data-driven approach to generating achievable dose–volume histogram objectives in intensity-modulated radiotherapy planning” by Binbin Wu et al. Int. J. Radiation Onc. 2010
RT Decision Support Examples

- Treatment plan evaluation/selection
  - "A decision aid for intensity-modulated radiation-therapy plan selection in prostate cancer based on a prognostic Bayesian network and a Markov model" by Wade P. Smith et. al. in Medicine 2009

RT Decision Support Examples

- Treatment plan evaluation/selection
  - "A planning quality evaluation tool for prostate adaptive IMRT based on machine learning", by Xiaofeng Zhu et al. Medical Physics 2011

RT Decision Support Examples

- Treatment verification and delivery
  - "Automated radiotherapy treatment plan integrity verification" by Deshan Yang and Kevin L. Moore, 2012
RT Decision Support Examples

- Treatment verification and delivery
  - "Clinical development of a failure detection-based online repositioning strategy for prostate IMRT—Experiments, simulation, and dosimetry study" by Liu Wu et al. Medical Physics, 2010

RT Decision Support Examples

- Treatment response and injury effects
  - "Investigation of the support vector machine algorithm to predict lung radiation-induced pneumonitis", Shifeng Chen et al, Medical Physics 2007

RT Decision Support Examples

- Treatment response and injury effects
  - "Nomograms for Predicting Local Recurrence, Distant Metastases, and Overall Survival for Patients With Locally Advanced Rectal Cancer on the Basis of European Randomized Clinical Trials", Vincenzo Valentini et al, 2011
Effects of RT Decision Support

- Provider performance
- Patient outcome

Knowledge Sources in Radiation Therapy

- Past data
  - Plans, quality assessment, patient anatomy, machine characteristics, calibration, treatment outcomes
- Published knowledge
  - Guidelines, clinical trials, peer reviewed papers, normal tissue complication models
- Experience
  - In the head of physicians, physicists, dosimetrists, therapists

Informatics Methods for Decision Support

- Data management and curation
- Data modeling and mining
- Decision theory
- Terminology standardization
- Knowledge representation and reasoning
- Visualization and human computer interface
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Ontology (not Oncology)
- Formal knowledge representation
  - Concepts
  - Relationships
- Ontology and rules
  - Clinical trials publications
  - Guidelines
  - Experience
- Sophisticated queries
- Automated reasoning

Modeling RT Guidelines Knowledge
Example: Endpoints in Clinical Trials

CTCAE – Many Tables

CTCAE (cont.)
CTCAE Endpoints in RT Ontology

Renal Genitourinary Endpoints

Urinary Frequency 5 Grades

The Studies

Other Endpoints

Rectal Bleeding Grade 3

Rectal Bleeding Grade 5
RT Decision Support User Interface

- Integrated
  - All sources of knowledge
- Individualized
  - Specific patient
- Intuitive and visual
  - Minimal cognitive burden (e.g. nomograms)
- Interactive
  - Zoom in and out, trade-off

Integrated, Individualized, Intuitive, and Interactive DSS

Example
RT Decision Support Examples

- Treatment plan evaluation/selection
  - “Evolving treatment plan quality criteria from institution-specific experience” by D. Ruan et al. Medical Physics 2012