



The Joint Department of **MEDICAL IMAGING**

Mount Sinai Hospital • University Health Network • Women's College Hospital

The Promise of Modern Imaging

Patrice Bret

*Professor & Chair Medical Imaging at University of Toronto
Radiologist-in-Chief MSH, UHN & WCH*

Objectives

- To review the *road map* of Medical Imaging *technology*
- To reflect on the impact of technology *changes* in the “prescription” of MI examinations
- To discuss the *shift* from morphology to *function* in Medical Imaging

Disruptive Innovation

- Changes are *a way of life* not a transitional time between 2 periods of stability

Where Are We Heading?

- Information Technology
- Variables that influence the future
- Cross Sectional vs Conventional Imaging
- Computer Assisted Diagnosis
- New Probes for Imaging
- Diagnostic / Therapeutic

Quote

- *Developing the capacity to collect, analyze and distribute information to providers and consumers alike is the number one priority for improving the health system*

The Health Care Restructuring Commission of
Ontario, Canada – Forward on **2000**

The end of an era

- This is the end of *films, printed letters, printed reports, handwritten notes, analog voice dictation, faxes* that all provide a single copy of the data, often stored in the wrong place and have no potential for real time interactivity

Tools

- *Hardware*: Ability to *process display store & transfer* data
- *Software*: tools that digest the data so that it becomes usable
 - This should be simple *It is just a database*
 - It is in fact complex *There are many barriers*

Barriers

- The limiting factor is not the hardware
- The limiting factor is in part the software
- The limiting factor is the people



VARIABLES THAT INFLUENCE THE FUTURE

Variables

- Geography
 - *Various systems of reimbursement*
 - *Temporal changes in same region of the world*
 - US: unrestricted fee for service / HMO until 2000 / HMO after 2000
 - *Local expertise (US versus CT versus MRI)*

Variables

- Geography: Canada
 - Various *systems of reimbursement*
 - PET distribution and availability
 - PET reimbursement
 - “*Privatization*” of imaging centers

Differ in each province and even within each province

In Theory

- *Intuitive* medicine should be “out”
- Relationship of *diagnostic procedures* to *outcomes* should be the main criterion for prescription.
- *Clinical decision support* tools should enhance consistency and implementation of standards (**Appropriateness Criteria**)

In Practice

- The evidence is often not easy to prove
- Local variables make it difficult to demonstrate universal evidence or cost-effective strategies
- New developments are constantly challenging cost-effectiveness models
- As a rule physicians are resistant to changes even when the evidence is there

Which tests should be done?

- Appendicitis: US, CT, or none?
- Imaging vessels: CT angiography or MR angiography?
- Liver and pancreatic diseases: US, CT or MRI?

A world of correlative imaging

Which tests should be done?

- There is only value in a technique if it can be applied *across* the medical community
- Only those techniques that can be *taught* or *transferred* to the community will have an impact
- More efforts should be made to *transfer the skills* than to perfect the technique

Where Are We Heading?

- Information Technology
- Variables that influence the future
- *Cross Sectional vs Conventional Imaging*
- Computer Assisted Diagnosis
- New Probes for Imaging
- Diagnostic / Therapeutic

Conventional Radiography

Chest X-Ray, Abdominal series
Bone Surveys

Digital Radiography

- A new way to perform conventional radiography
 - New design for *patient flow*
 - Requires an integrated *network*
 - *Productivity* gains needed to offset huge capital investment
- Advanced applications: Dual Energy, Tomosynthesis,
- Digital Radiography versus Computed Radiography

The paradox of Digital Radiography

- Flat panel digital detectors (DR), or Computed Radiography systems (CR) have replaced film-screen combinations in conventional radiology

The paradox of Digital Radiography

- But in fact, Conventional Radiology is on its way out

Conventional Abdominal Imaging

- **Plain films of the abdomen**
 - Not sensitive
 - Not specific
- **Barium studies**
 - Sensitive
 - Specific
 - Knowledge to perform *and* read them is disappearing

Why Conventional Radiology*

- **No longer** the only imaging method avail.
- **No longer** less expensive than cross-sectional imaging in digital environment
- **No longer** a big saver in radiation dose
- **No longer** a higher throughput than cross-sectional

* Chest X-Ray, Abdomen, Bones ...



The main reason why we are still doing so much conventional Radiology is that we have done it for 100 years and it feels “good”

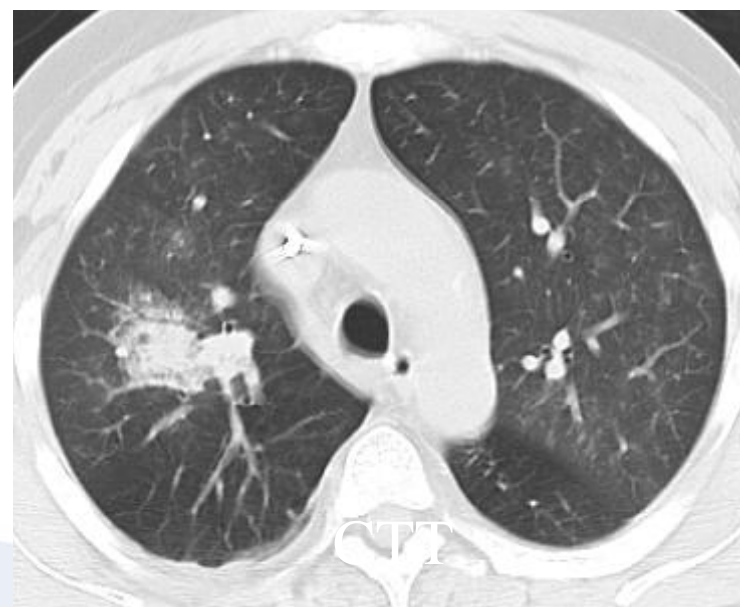
Low (Minimal) Dose CT



x Rads

3.5x Rads

19x Rads



Where Are We Heading?

- Information Technology
- Variables that influence the future
- *Cross Sectional vs Conventional Imaging*
- Computer Assisted Diagnosis
- New Probes for Imaging
- Diagnostic / Therapeutic

ULTRASOUND

- Spread of *miniature* machines
- *Contrast agents* might provoke a breakthrough for tumor characterization, or response to treatment.
- The challenge for ultrasound remains the inconsistency of results because of the operator's dependence (*standards of quality*)



Computed Tomography

- 70s EMI, Hounsfield years
- 80s 2nd, 3rd generations
- 90 - 95 Spiral CT
- 95 - 2000 *The MRI years*
- 99 - ... Multi detector CT
- 2007 ... The new generation of MDCT

Computed Tomography

- Exquisite spatial resolution (<1mm) / limited contrast resolution
- MDCT → 3D imaging
 - CTA (contrast ← contrast medium)
 - *Co-registration* with functional imaging
- **High spatial resolution allows CAD models**

Computer Assisted Diagnosis

- Computing power is now available
- Multiple models in development
 - Mammography analysis
 - Detection of lung nodules
 - Polyp detection in virtual colonoscopy
- Can be automated to optimize workflow

However,

CT still remains a modality associated
with a *low contrast resolution*



High Contrast Resolution

- MRI
 - *Morphology* real-time interactive scanning
 - *Functional* - Molecular imaging
- Nuclear Medicine
 - PET and PET-based technology

Where Are We Heading?

- Information Technology
- Variables that influence the future
- Cross Sectional vs Conventional Imaging
- Computer Assisted Diagnosis
- *New Probes for Imaging*
- Diagnostic / Therapeutic

Angiogenesis

- Tumor angiogenesis is a critical event in the switch from *hyperplasia* to *neoplasia*
- Tumor secretes both *promoters* (vefg) and *inhibitors* of angiogenesis (endostatin).
- *Hundred of agents* are in clinical trials

Angiogenesis

- Vascular density at histology may predict likelihood of metastasis
- Antiangiogenic agents are a challenge for morphologic imaging: Even when effective **they do not shrink the tumor so dimensional measurements wont predict response** therefore a need to measure tumor blood flow, vascular permeability

Angiogenesis

- Imaging in angiogenesis need functional perfusion blood volume *Ultrasound micro bubbles, PET, SPECT F18FDG, Water oxygen sestamibi for blood flow*
- **MRI** is the most investigated technique so far

New Paradigm In Imaging

- Morphology imaging has limitations
 - No tissue characterization
 - Malignant versus benign
 - Evaluation of response to treatment
- Medical imaging looking into the molecular aspect of tissues
 - Understanding of biology
 - Imaging effectiveness of cancer treatment
 - Mapping gene therapy

Co-registration Image Fusion

- *Spatial* resolution → CT
- *Contrast* resolution
 - MRI, PET, contrast-enhanced US



CT PET

Where Are We Heading?

- Information Technology
- Variables that influence the future
- Cross Sectional vs Conventional Imaging
- Computer Assisted Diagnosis
- New Probes for Imaging
- *Diagnostic / Therapeutic*

New Goals for Imaging

- Diagnosis is shifting from invasive to non invasive techniques
- Treatment is shifting from surgical to minimally invasive image-guided therapy

From invasive to non invasive

- **Biliary tract**
 - Diagnosis with MRCP
 - Treatment with endoscopic techniques
- **Colon**
 - Diagnosis virtual coloscopy
 - Treatment with endoscopic techniques
- **Coronary**
 - Diagnosis with CT angiography
 - Treatment with cath-lab techniques

Tumor Ablation

- Chemoembolization
- Thermal Tumor Ablation
 - *Radiofrequency / Microwaves*
 - *Cryoablation*
 - Photocoagulation: *Laser*
 - High intensity focused *sonography*
 - Heated fluids: *saline, alcohol, contrast*
- Targets: HCC, Mets (liver, brain) RCC, Breast, Bone.

How to monitor results

- Morphology
- Other parameters **Molecular imaging**
 - Enhancement
 - Blood flow
 - Measuring temperature: Heat-sensitive sequences

Summary

Change is the key work

Summary

- Exquisite *spatial resolution* now available with “conventional” techniques
- *Functional and Molecular* imaging is gaining acceptance
- *Combining* the information of morphological and functional imaging is the current challenge
- There is a new level of understanding of *image guided therapy*

Conclusion

The future does not come from technological advancements, but from those ***individuals*** who provoke, or at least endorse the changes necessary to their implementation