A Futuristic Look at The Cath Lab

Imaging and Physiology Summit 2009
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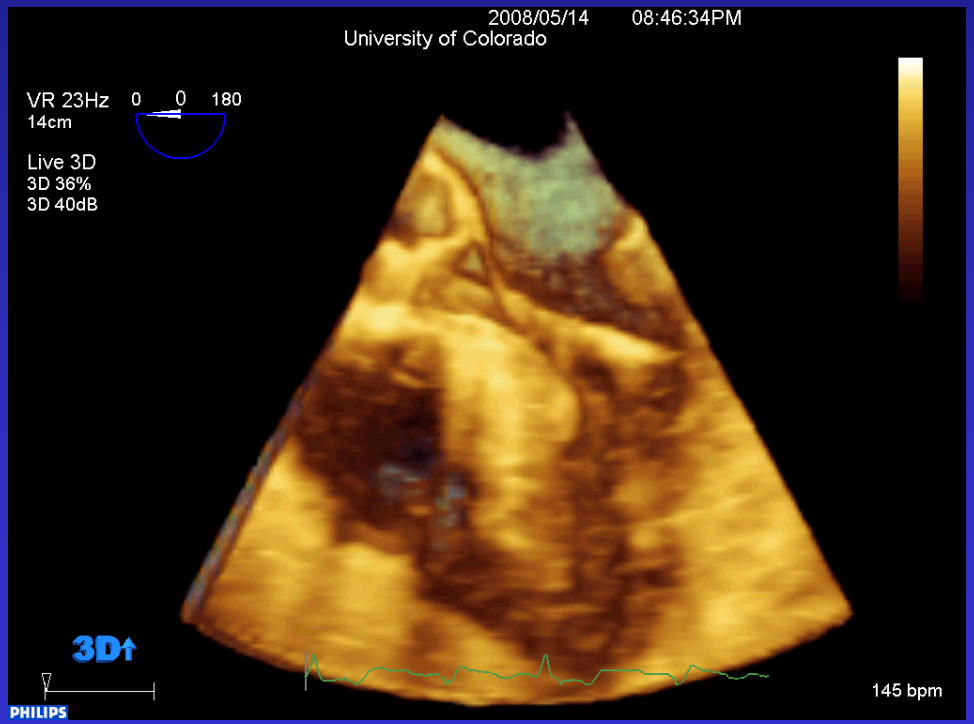
Seoul, Korea

John D. Carroll, MD
University of Colorado Denver



Post MI VSD Closure

Disclosure

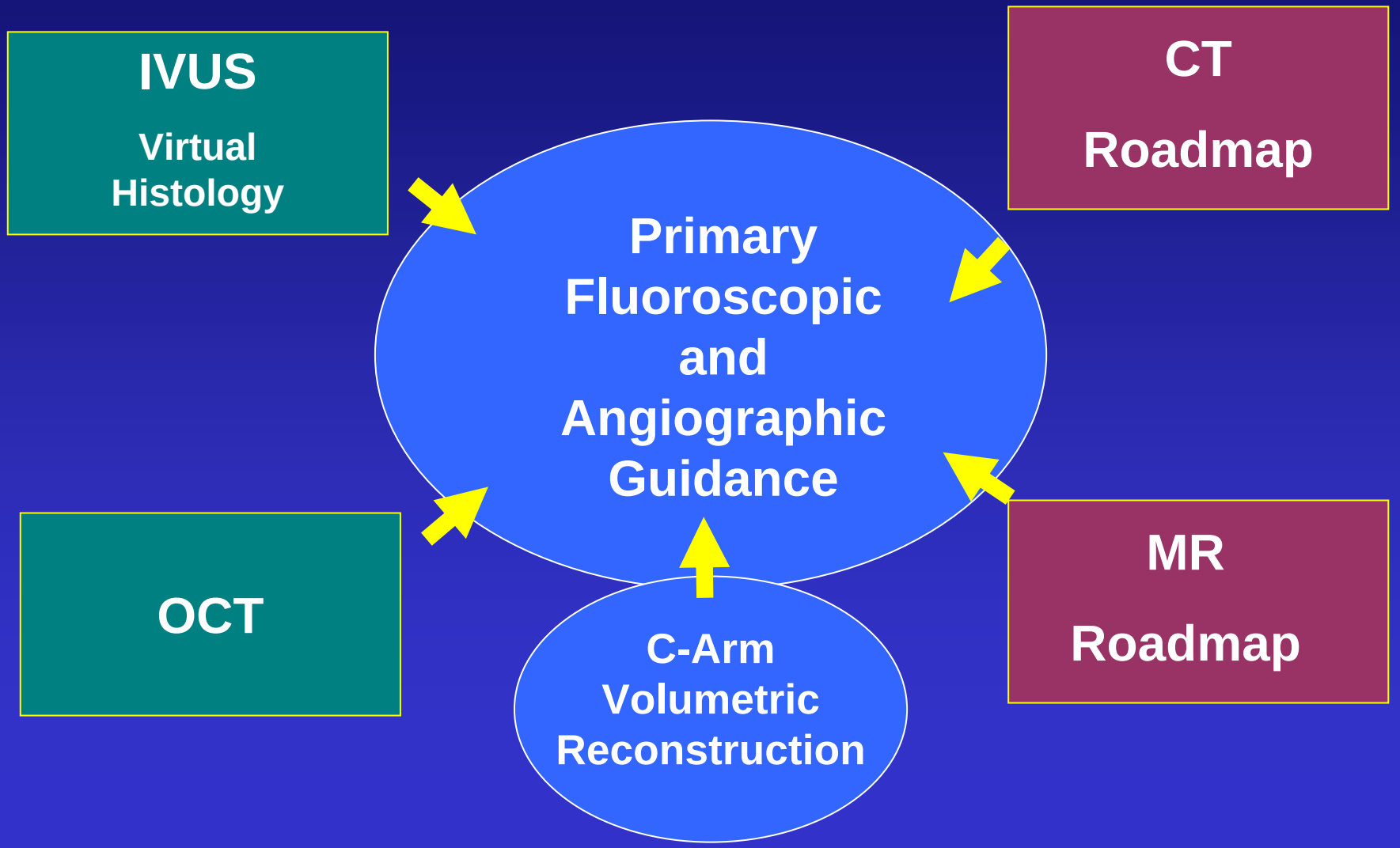
- Co-Inventor of 3-D Vascular Modeling and Analysis Software
  - Assigned to the University of Chicago and University of Colorado
- Philips Healthcare: Research grant, consultant, speaker

“Image-guidance” refers to the linkage between medical imaging and interventions.

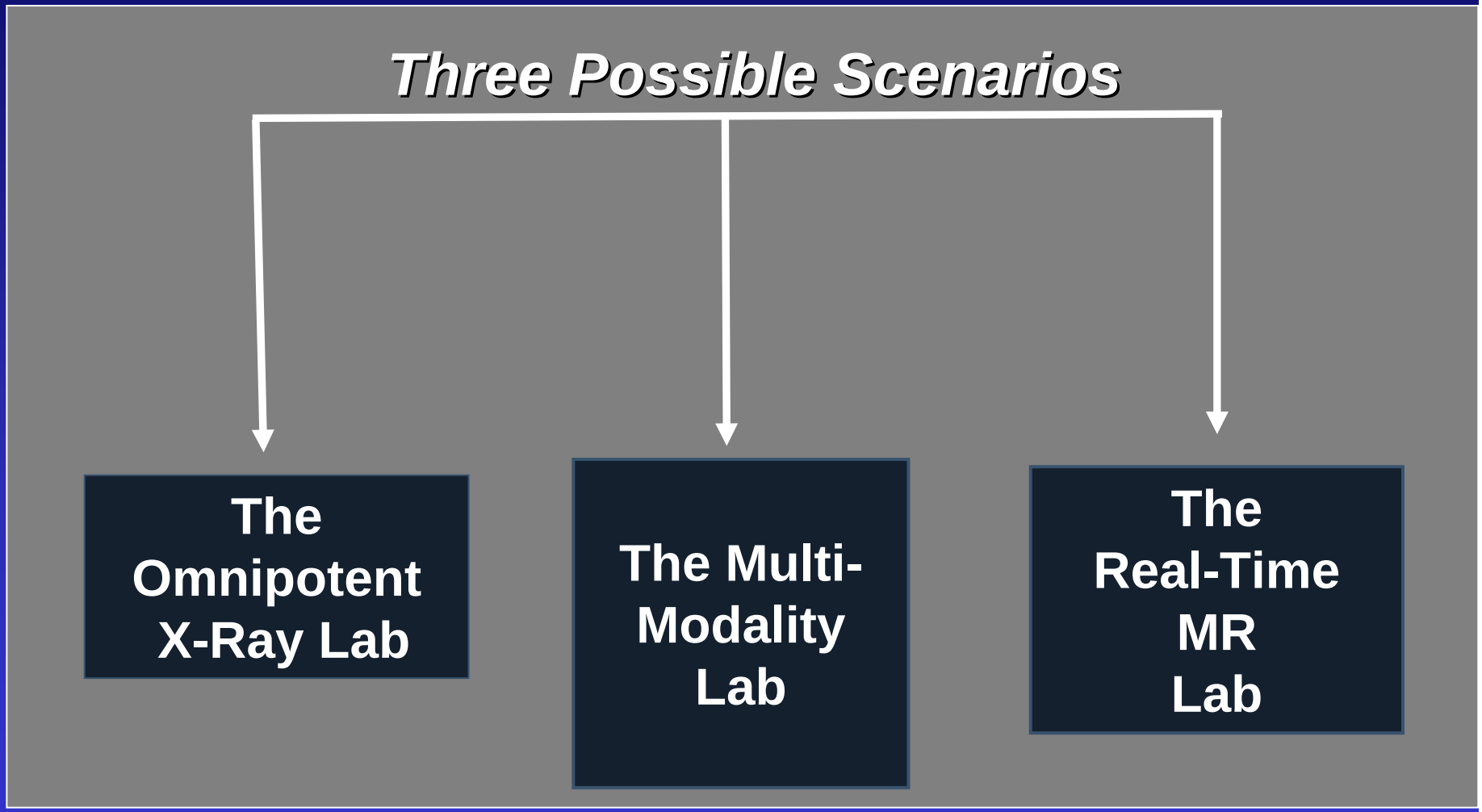
- An Image Guided Intervention is a patient encounter where images are obtained and used for guidance, navigation, and orientation in a minimally invasive procedure to reach a specified target under operator control.
- The concept of image-guidance has involved a strategic shift, and currently not completed transition, in the focus of medical imaging from diagnosis to treatment.
- Image-guidance is no longer simply a passive visual roadmap to help the physician perform a procedure but can involve active navigation systems for delivery systems within the human body.

Image Guidance Techniques

PCI and Other Vascular Interventions

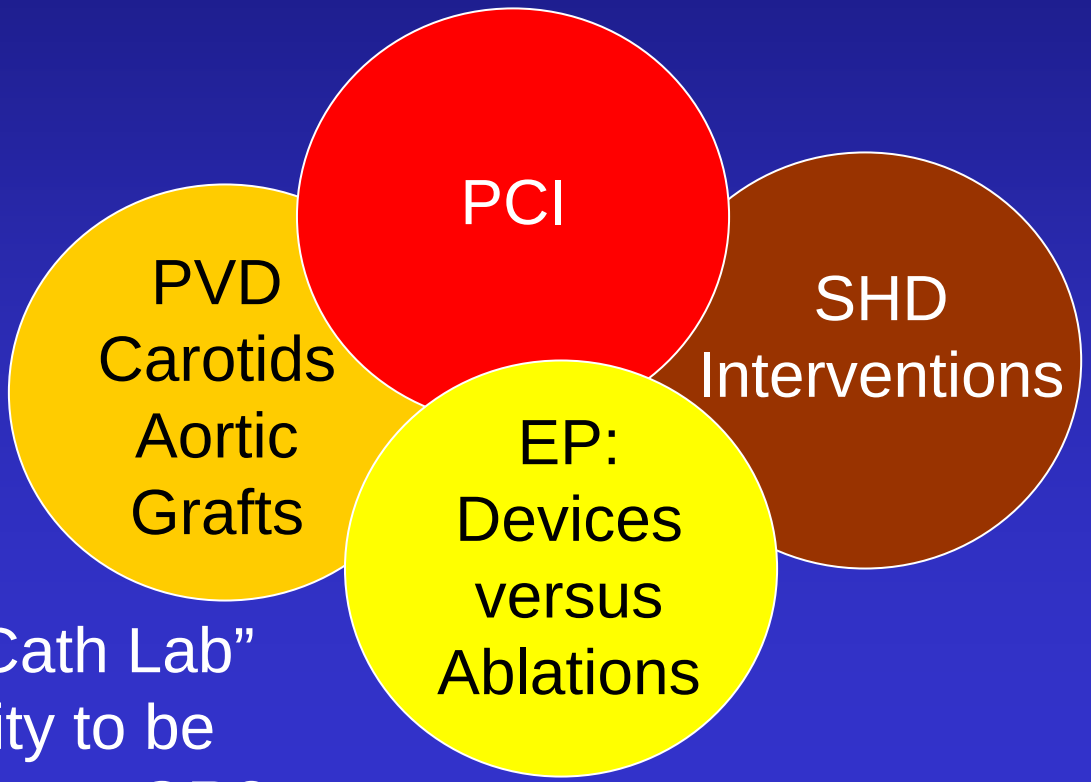


How Will The Cath Lab Evolve In The Next Ten Years?

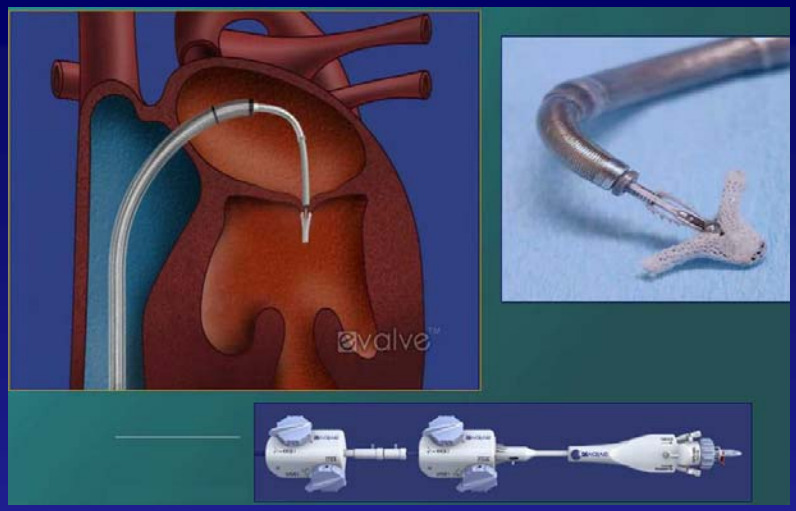


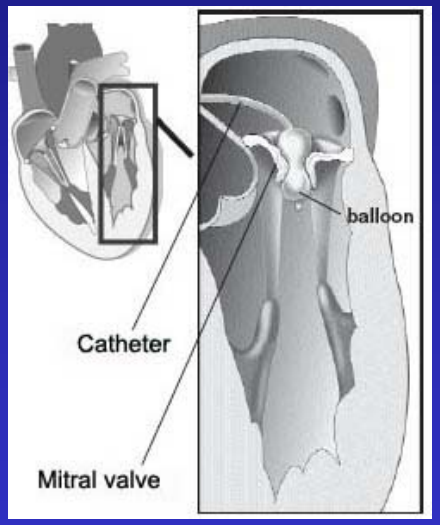
The Future Imaging Suite

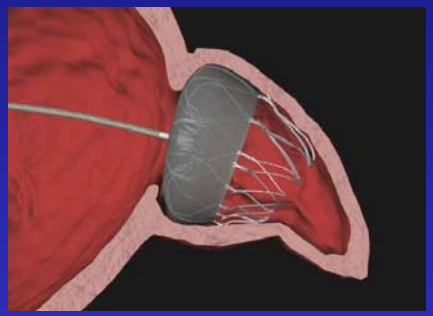
What Type of Procedures will be Performed?



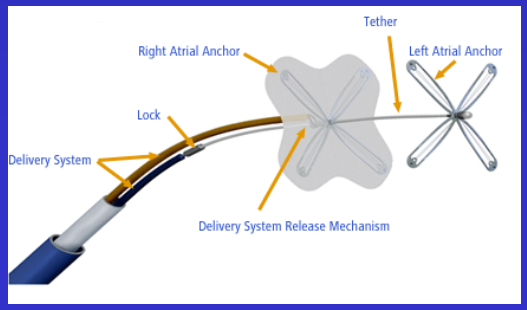
Should the “Cath Lab” have the ability to be converted into an OR?

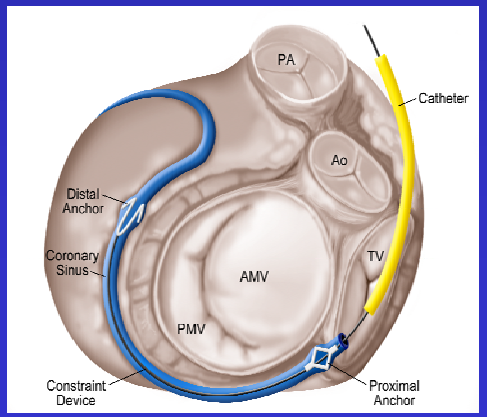

evalve


balloon
Catheter
Mitral valve




Amplatzer Septal Occluder
Amplatzer Muscular VSD Occluder
Amplatzer Duct Occluder
Amplatzer Vascular Plug
Vascular Coils


Tether
Right Atrial Anchor
Left Atrial Anchor
Lock
Delivery System
Delivery System Release Mechanism


PA
Catheter
Ao
Distal Anchor
Coronary Sinus
AMV
TV
PMV
Constraint Device
Proximal Anchor

The move to incorporate ultrasound into SHD intervention guidance is driven by the facts:

1. The target of the intervention is often not seen by fluoroscopy.

   Soft-tissue imaging needed

2. Many interventions are complex.

   Precision of guidance & placement needed

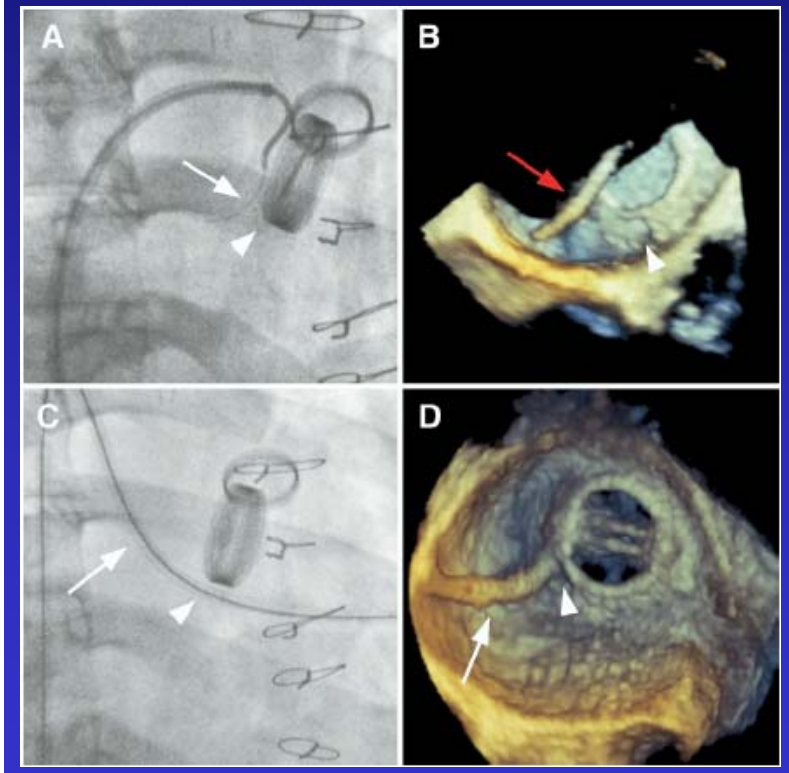
3. Navigating in 3-D space using 2-D projection or cross-sectional images is challenging.

   Real-time 3-D images needed

4. The risks of fluoroscopy are not insignificant for complex interventions especially in young patients

   Reduction of x-ray dose needed

Image Guidance



STATE-OF-THE-ART PAPER

J Am Coll Cardiol Intv 2009;2:81–90)

Percutaneous Transcatheter Closure of Prosthetic Mitral Paravalvular Leaks

Are We There Yet?

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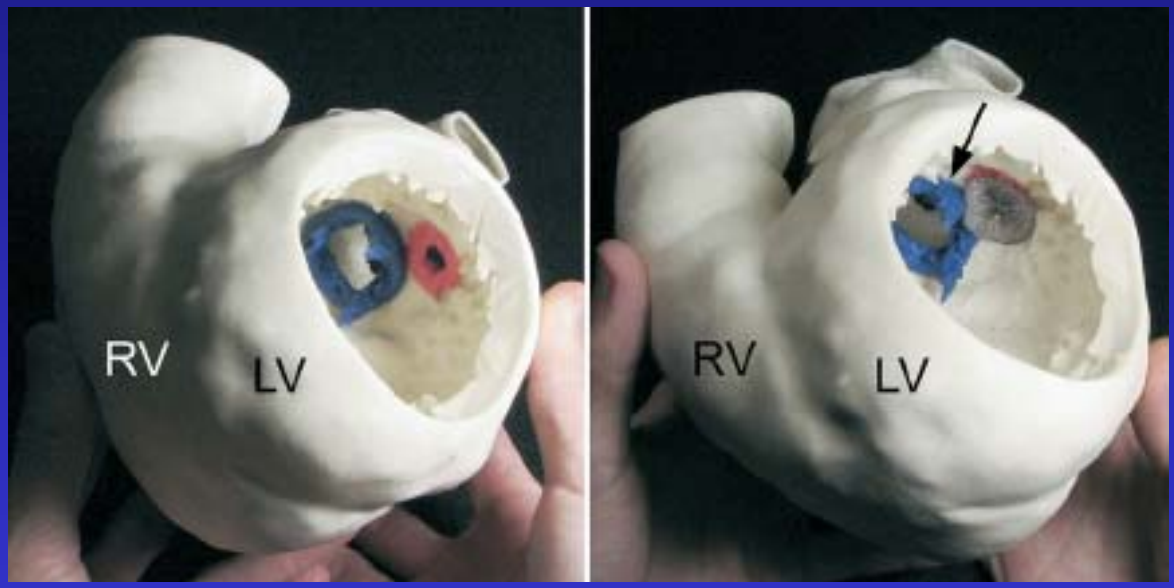
Andrew J. Klein, MD,* Ernesto E. Salcedo, MD, FACC,* John D. Carroll, MD, FACC*

Aurora and Denver, Colorado



Large Flat Monitors Justification?

- What is the clinical or economic value that justifies the higher cost?
- Possibilities:
  - we need to see finer detail
  - more efficient than multiple monitors
  - allows image integration
  - preset configurations help workflow
  - maximizes physician performance and comfort

Finer Detail is Needed

- Medical grade screen of 56 inch size
- Resolution: 3840 x 2160 pixels (8.2 Mpixel).
- Brightness: 350 cd/m2 (stabilized) and 450 cd/m2 (max)

“I have found the FlexVision to be a great help as it allows me to enlarge images, giving me the level of detail that I need during complex neuroradiology procedures..” Professor Moret, director of Neuroradiology at the Foundation Rothschild in Paris, France

No Bad Seats

Courtesy BCVI Miami

Bigger But Still 2-D Monitor

Two Technologies That Are Emerging and Change the Landscape

3-D Visualization

Some solutions are not acceptable

Holographic Display

Rendering for an Interactive 360° Light Field Display

Andrew Jones Ian McDowall* Hideshi Yamada† Mark Bolas‡ Paul Debevec

University of Southern California
Institute for Creative Technologies

*Fakespace Labs

†Sony Corporation

‡University of Southern California
School of Cinematic Arts

Physical Models of Imaging Data

University of Colorado 3-D Lab Rapid Prototyping Project

New Drugs and Technologies

Rapid Prototyping

A New Tool in Understanding and Treating Structural Heart Disease

Michael S. Kim, MD; Adam R. Hansgen, BS; Onno Wink, PhD;
Robert A. Quaife, MD; John D. Carroll, MD

***Circulation* 2008;117:2388-2394.**

Advantages of Physical Models

- Planning –TCT 2007
  - Faster comprehension of 3-D relationships
  - Patient-specific simulation of procedure

Co-Registration
Modalities and Process

Pre-Procedure MSCT 3-D Image

Intra-Procedure Real-Time 2-D Fluoroscopy

Intra-Procedure C-Arm CT 3-D Image

Study Design

Image Reconstruction

Geometric Calibration

↓

Adaptive noise filtering of projections

↙ Non-gated reconstruction

↘ ECG R-peak detection & gating

↓

Gated reconstruction

↓

Artifact reduction strategies

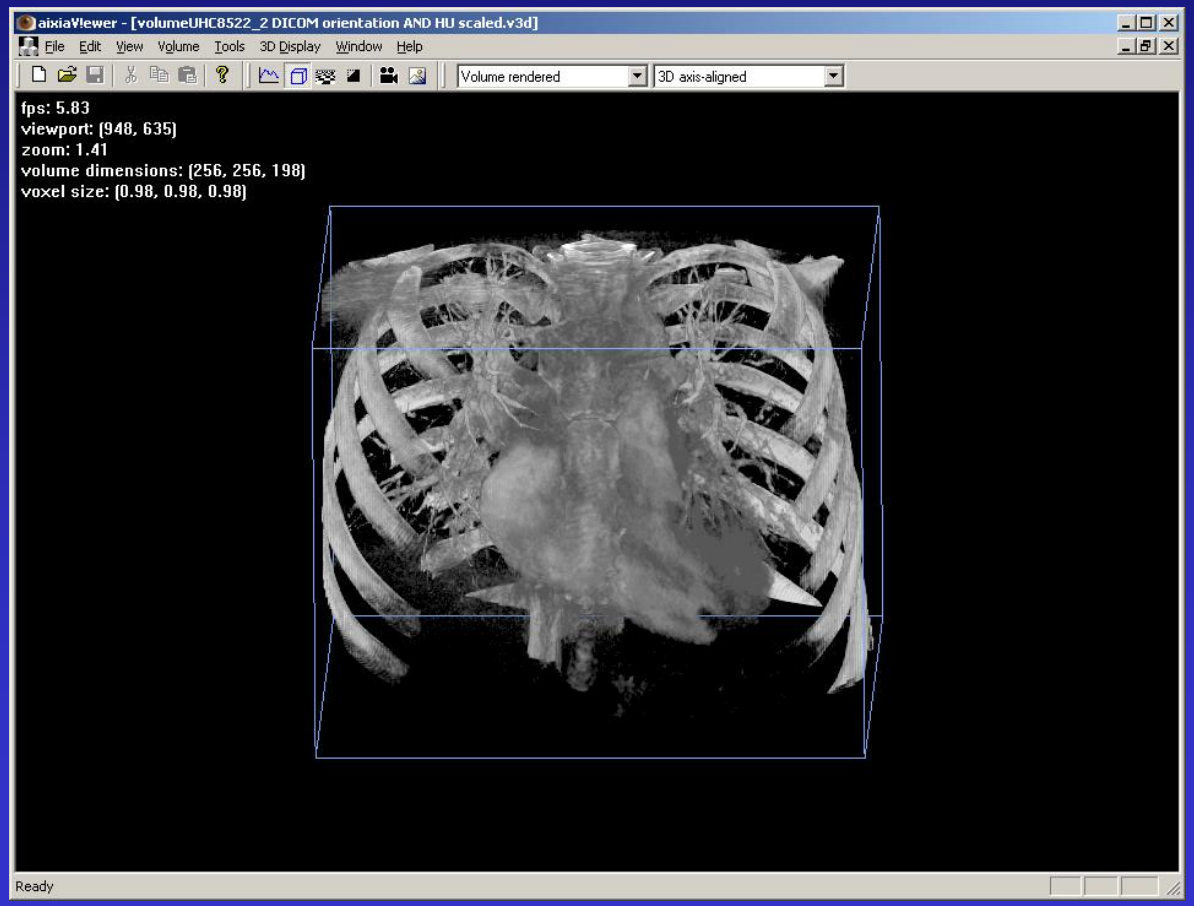
Original projections

Adaptively filtered line integral images

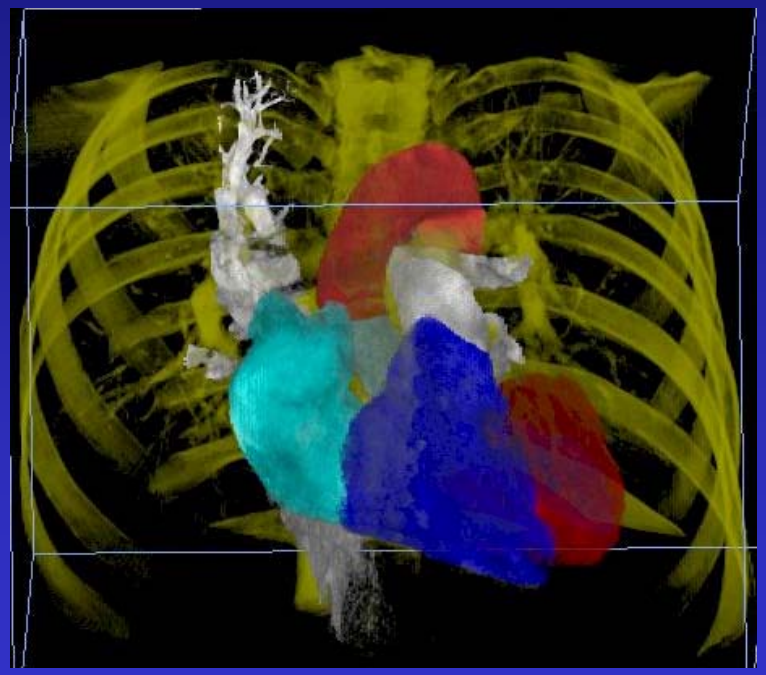
[1]Feldkamp, Davis, and Kress. J Opt Soc Am 1984.

C-Arm CTA

Immediate Un-gated Reconstruction Images



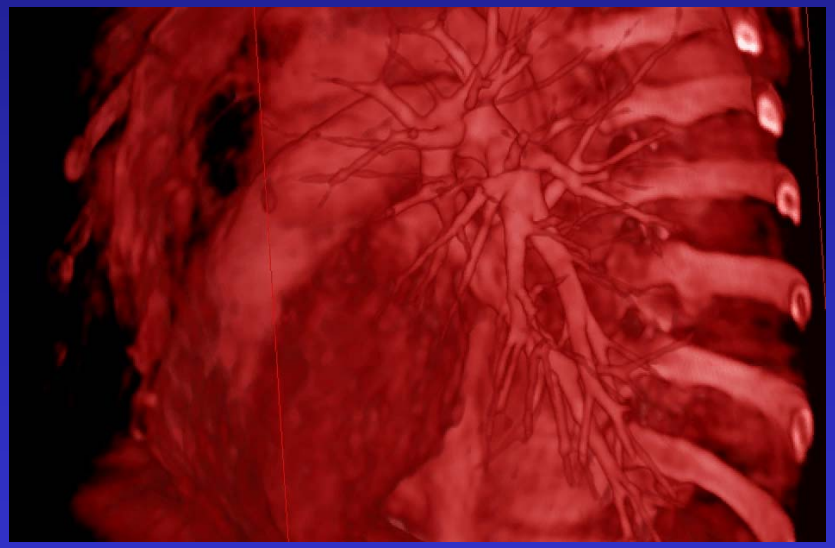
C-Arm CTA
Subsequent Segmented Images



- Segmentation for CAD, Structural Heart Disease Interventions and EP Procedures

The Future of Image Guidance for Interventions? *4-D Road-Mapping*

- **Images acquired at University of Colorado Hospital with 220 degree rotation.**
  - **Anne Neubauer, PhD**
- **Advanced Image Processing performed at Philips Research in Hamburg**
  - **Michael Grass, PhD and team**

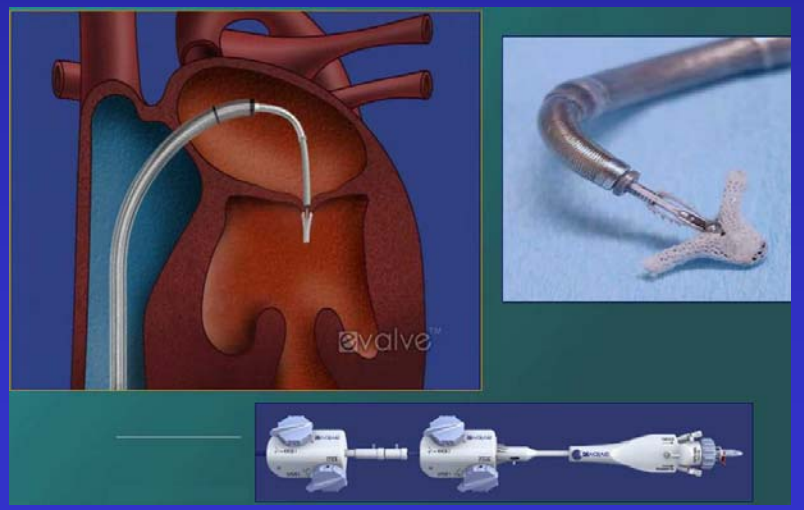


New Contrast Agents and New Injection Systems

- Gold nanoparticles: a new X-ray contrast agent. Hainfeld et al. British Journal of Radiology (2006) 79, 248-253
  - **Excreted in the urine (save – do not flush!)**

Robotic Guidance?

- The transition to robust 3-D imaging systems is a key enabling step.
- Small incremental steps will occur.
- Some procedure are “ripe” and some are not.
- Enhanced clinical outcomes is a huge barrier to justify cost and change of procedure room.
  - The comfort and safety of the operator will come second.



Conclusions

- Image guidance of interventional procedures is evolving in parallel with the development of new procedures and new devices.
- Ultrasound is undergoing a profound transition as the technology adapts to interventional rather than purely diagnostic use.
- X-ray based guidance is not dead – it remains vital for all interventions.
- X-ray based guidance is not a stationery technology
  - Rotational angiography using a FD C-arm has been developed to optimize the acquisition of images that subsequently can be rapidly and automatically processed in-room to yield 3-D and 4-D reconstructions.
- 3-D Imaging, in general, is now technologically feasible in multiple modalities and barriers to its adaptation are falling to its routine clinical use. Real-time 3-D is possible with ultrasound.
- Image display is a next frontier for technological development.