2D and 3D image guidance for interventional procedures

kV, mA & filtration matter, but so do advanced applications

Aya REBET
Clinical Research Engineer
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Scope

Dose reduction can be achieved through:

- image acquisition techniques (kV, mA, filtration)
- image processing (denoising, edge enhancement, ..)
- **2D & 3D advanced planning & guidance**
Each procedure has specific needs...

Specific needs in:
- Image quality
- Image processing
- Advanced planning & guidance

2D guidance
- Fluoroscopy
- DSA
- Single shot
- Subtracted fluoroscopy
- Fluoroscopy roadmap
- DSA roadmap
- Bolus chasing
- Vascular flow imaging
- Stent visualization enhancement

3D guidance
- Cone Beam CT (CBCT)
- CBCT - CT/MR/PET/ultrasound fusion
- Planning: trajectory planning / vessels path detection
- Guidance - 3D roadmap
- Needle guidance / vessels roadmap/pedicle, CTO, embol...
- Assessment
- Needle stereotaxic assessment
- Stent 3D visualization

Diagnostic
Planning
Guidance
Assessment
Monitoring

Each step of each procedure deserves optimal imaging

2D advanced applications examples
Advanced 2D roadmap

- DSA acquisition
- Extraction of the vessels
- Sub fluoro
- Use of previously acquired DSA as a roadmap

Stent visualization

- GE: StentViz® & StentVesselViz®
- Philips: Stent Boost®
- Siemens: Clear Stent®

Bolus Chasing

- Clinical objective: assess lower limbs vessels patency with only one contrast injection
- Application: follow a single contrast injection and paste images together to visualize the entire vessels
Vascular flow imaging

- Peak Op: Shows the peak intensity reached by each pixel among time frames.
- Time to Peak: Shows the time at which each pixel reaches its peak intensity.
- Time to Peak Fusion: Color indicates Time to Peak, intensity indicates Peak Opacification value.

Stenting assessment using AngioViz

- Pre stenting
- Post stenting

3D advanced applications

- Cone Beam CT (CBCT)
- 3D/2D roadmap
- Clinical examples:
  - Endovascular procedures
  - Needle procedures

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CBCT proven clinical value vs DSA

- **Iwazawa et al. – 2009** – “Identifying Feeding Arteries During TACE of Hepatic Tumors: Comparison of C-Arm CT and Digital Subtraction Angiography”

Examined 58 possible feeding arteries in 33 patients. The sensitivity, specificity, and accuracy of CBCT (96.9%, 97.0%, and 96.9%, respectively) are significantly higher than those for DSA (77.2%, 73.0%, and 75.4%). CBCT is superior to DSA for identifying tumor-feeding arteries during superselective TACE for HCC.

- **Mao Qiang Wang et al. – 2016** – “Benign Prostatic Hyperplasia: Cone-Beam CT in Conjunction with DSA for Identifying Prostatic Arterial Anatomy”

The numbers of prostatic artery origins and anastomoses that could be identified were significantly higher with CBCT (94.7% and 97.0%) than with DSA (74.5% and 58.2%, P < .05). Cone-beam CT provided essential information that was not available with DSA in 90 of 148 (60.8%) patients.

- **Jan B. Hinrichs et al. – 2015** – “Comparison of C-Arm Computed Tomography and Digital Subtraction Angiography in Patients with Chronic Thromboembolic Pulmonary Hypertension”

Purpose: assess the pulmonary arteries diagnostic performance of CBCT compared to DSA in patients suffering from chronic thromboembolic pulmonary hypertension.

Conclusion: CBCT provides clinical information DSA cannot provide. One CBCT can avoid several DSA.

CBCT: It’s not only about the dose...

**Most Common Improvement Opportunities**

Set up:
- Remove objects that may cause artifacts: cables, ...
- Center the anatomy
- Adopt the reconstruction filter

Patient:
- Patient breathing instructions
- Internal metallic structures

**Injection parameters**

- Injection rate: from 0.5 cc/s to 5 cc/s
- Inject during full spin for vessels visualization
- Optimized delay depends on catheter position
CBCT Respiratory motion compensation

Motion compensation, avoiding redo

Avoids retakes, saves dose

Metallic Artifacts Reduction

Extends range of CBCT-visible anatomies

Clinical example

Hepatic radioembolization

Main objectives: understand the anatomy, tumor location, and injection point, risk for extrahepatic perfusion

Main objectives: understand tumor supply (will I treat the expected lesions? Can I be more selective?), extrahepatic perfusion
Clinical example
Renal aneurysm

CBCT before coiling

Diagnostic measurements, shape, etc.

CBCT after coiling

Assessment: coil position, remaining aneurysm filling, etc.

Intraprocedural 3D planning & assessment

Clinical example
Neuro advanced 3D planning & assessment

Aneurysm stenting

3D advanced applications

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3D Roadmap techniques

Overlay of 3D information on live fluoroscopy

- User needs:
  - Ease of use
  - Accuracy
- Sources:
  - X-ray radiation
  - Iodine injection

Overlaying any 3D image to ease 2D guidance, reduce dose & contrast

Biview registration

3D = intraoperative CBCT
3D = preoperative CT/MR/PET/CBCT

Leveraging any 3D image to ease 2D guidance, reduce dose & contrast

Accuracy matters

Accuracy needs depend on clinical application:

- Liver procedures
- Neuro-radiology
- Cardiac

Safe feature to show live misregistration (patient motion, ..) & provide table side capability to manually adjust the registration when needed

3D advanced applications

- Cone Beam CT
- 3D/2D roadmap
  - Clinical examples:
    - Endovascular procedures
    - Needle procedures
CT/MR guidance for complex catheterizations

Step 1: Arterial tree automatic segmentation from preoperative CT

Step 2: Fluoro/CT registration using two views only (No spin)

Step 3: 3D live guidance under fluoro, automatic registration with table and gantry motion, dynamic adjustment

TIPS guidance

Step 1: Automatic liver, portal and hepatic system segmentation from preoperative CT

Step 2: Fluoro/CT registration using two views only (No spin)

Step 3: 3D live guidance under fluoro, automatic registration with table and gantry motion, dynamic adjustment

CBCT guidance for complex catheterizations

Use of fusion with CBCT for complex case
Multimodality fusion

- Procedure objective: embolize the vessel responsible for the extra-hepatic enhancement seen on pre-op SPECT-CT before Y90 treatment.

- Vessel suspected on DSA for the extra-hepatic enhancement.

- CBCT fused with the SPECT imaging to confirm the diagnosis.

Liver transarterial embolization

- TACE procedure principle:
  - Embolic agent to suppress arterial blood supply
  - Drug to kill the tumor cells

- Patients with primary liver cancer often have a poor liver function.
  - Important to be super-selective during the drug delivery.

- CBCT offers:
  - Superior 3D visualization of the vasculature with a single injection
  - Better tumor feeders sensitivity & visibility of extra-hepatic perfusion
  - Reduced need for DSA runs
  - Assessment of post-embolization contrast retention

- But image analysis takes time...
  - Need for an easy to use & automated tool to improve transcatheter liver interventions and gain time.

Liver transarterial embolization
Liver embolization guidance - clinical value

Comparison of the number of image acquisitions and procedural time between a transarterial chemoembolization (TACE) procedure with and without tumor feeder detection software.

**Use of CBCT with automated feeder vessel detection software in TACE of HCC helped to reduce the number of total image acquisitions and the overall procedural time while maintaining a comparable treatment efficacy, as compared to that of TACE without software assistance.**

- **Iwazawa et Al. – 2013**: Comparison of the Number of Image Acquisitions and Procedural Time Required for Transarterial Chemoembolization of Hepatocellular Carcinoma with and without Tumor Feeder Detection Software.

- **Cornelis et Al. – 2018**: Hepatic Arterial Embolization Using Cone Beam CT with Tumor Feeding Vessel Detection Software: Impact on Hepatocellular Carcinoma Response.

**Automatic tumor feeders detection in 3D**
- Finds additional feeder(s)
- VS DSA, improving treatment response
- Increases confidence during procedure
- Saves procedure planning time
- Overlay of the 3D embolization plan on top of fluoro
- Helps reduce the number of DSA runs required, i.e. dose & contrast
- Helps determine the optimal view, easing catheterization

**EVAR guidance**

- Planning on pre-op CTA/MRA:
  - Vessel/bone extraction
  - Ostium marking
  - Marking of planes of interest

**EVAR guidance - Clinical Value**

- **Haulon, et al. - 2015**: Endovascular Today
  - Using image fusion during EVAR. Experience from a high-volume aortic center shows a reduction in radiation exposure when image fusion is used.
  - Significant x-ray dose & contrast reduction

- **Haulon, et al. - 2015**: Endovascular Today
  - Automatic tumor feeders detection in 3D
    - Helps determine the optimal view, easing catheterization
  - Use of liver ASSIST was the only factor predictive of CR (p=0.04) on univariate analysis.

- **EVAR ASSIST © GE Proprietary**
  - Combination of:
    - Image fusion for CT roadmapping with no need for a intra-op CBCT for registration
    - ALARA principle (x-ray techniques, Collimation, II distance to the patient, etc.)
    - Imaging system controlled by the operator

- **EVAR ASSIST © GE Proprietary**
  - Clinical Value
  - Radiation Dose Reduction During EVAR: Results from a Prospective Multicentre Observational Study (The REVAR Study).
  - By following ALARA principle in modern hybrid rooms with radiation and contrast volume use were adjusted compared with the published literature by 60% in the REVAR Study.
  - The median dose area product (DAP) was 227.8 Gy.cm² vs. 149.7 Gy.cm² for EVAR ASSIST and non-EVAR ASSIST, respectively.

- **EVAR ASSIST © GE Proprietary**
  - Clinical Value
  - Significant x-ray dose & contrast reduction
3D advanced applications

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Vertebroplasty

Liver tumor ablation
Needle guidance clinical value

Tselikas et Al. – CVIR 2015
"Percutaneous bone biopsies: comparison between flat-panel cone-beam CT and CT-scan guidance"

Conclusion:
- Better accuracy using Needle ASSIST guidance (3 mm, p=0.003).
- Patient & operator radiation doses lower with Needle ASSIST vs CT (p<.0001).
- All biopsies technically successful.
- No significant difference in puncture time nor in pathological results.

Martin et Al. – RSNA 2017
"New Needle Guidance Technology in the Angiography Room: From Cone Beam CT to Stereotaxic Reconstruction From Two Fluoroscopic Views"

Conclusion:
Stereo3D (Needle ASSIST, GE) could allow verifying probes position in the 3D anatomy with a 1-2mm accuracy while reducing each probe guidance DAP and Air Kerma by 77% and 64% on average, respectively.

Multi modality fusion for liver ablation in IR

Liver cryoablation guidance using fusion of preop CT on live US (Logiq E9 Ultrasound, GE) - CBCT used as a bridge for automatic preopCT to live US fusion (INTERACT Active Tracker, GE). Needle tip is virtually tracked.

Portal vein embolization guidance using fusion of preop CT with live US (Logiq E9 Ultrasound, GE) - CBCT used as a bridge for automatic preopCT to live US fusion (INTERACT Active Tracker, GE).
Conclusion

Each procedure has specific needs & deserves optimal imaging.

Dose reduction can be achieved through:
- image acquisition techniques
- image processing
- 2D & 3D advanced planning & guidance

2D & 3D advanced applications can help:
- better understand anatomy
- better plan treatment
- increase operator confidence
- decrease number of DSAs, dose & contrast
- ease guidance
- decrease procedure time
- improve treatment outcome

Thank you!
Any comment / question?
ayarebet@ge.com