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FUSION IMAGING AND VIRTUAL NAVIGATION

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FUSION IMAGING

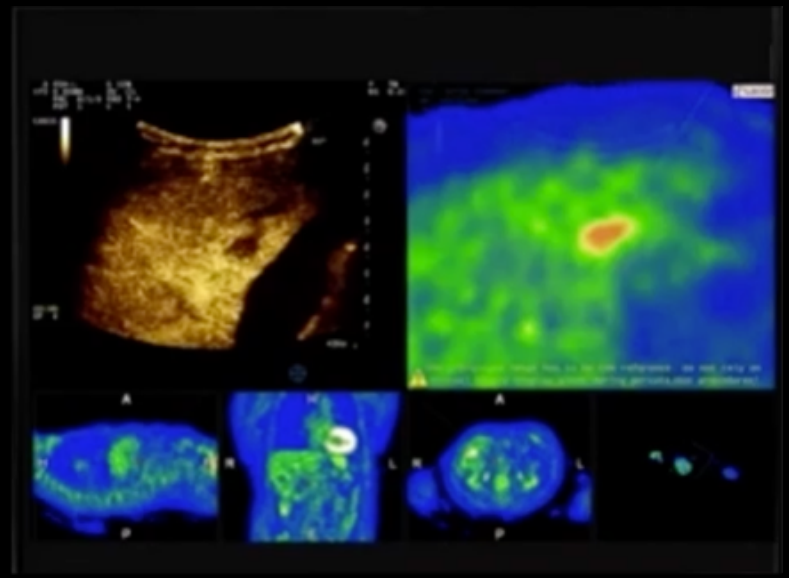
- Fusion of two (or more) imaging modalities to form a new technique. By combining the innate advantages of the fused imaging technologies synergistically, usually a new and more powerful modality comes into being.

- Existing hybrid imaging modalities comprise: PET/CT, SPECT/CT, MR/PET, MR/SPECT, ultrasound and MR, ultrasound and CT,MR and CT

PET/CT was voted "Medical Invention of the Year" in 2000.

VIRTUAL NAVIGATION

- AR-based navigation systems, patient-specific 3-D models commonly generated from preoperative images (e.g., CT, MRI) are superimposed on the real views of the field to provide operator with improved visualizations of the anatomical structures and/or to assist them throughout the procedure.



F.I. and V.N. in ENDOVASCULAR PROCEDURE

- Image fusion use was first reported in endovascular surgery in 2011

J Vasc Surg. 2011 Mar;53(3):583-90. doi: 10.1016/j.jvs.2010.09.039. Epub 2010 Dec 3.

Intraoperative C-arm cone-beam computed tomography in fenestrated/branched aortic endografting.

Dijkstra ML[1], Eagleton MJ, Greenberg RK, Mastracci T, Hernandez A.

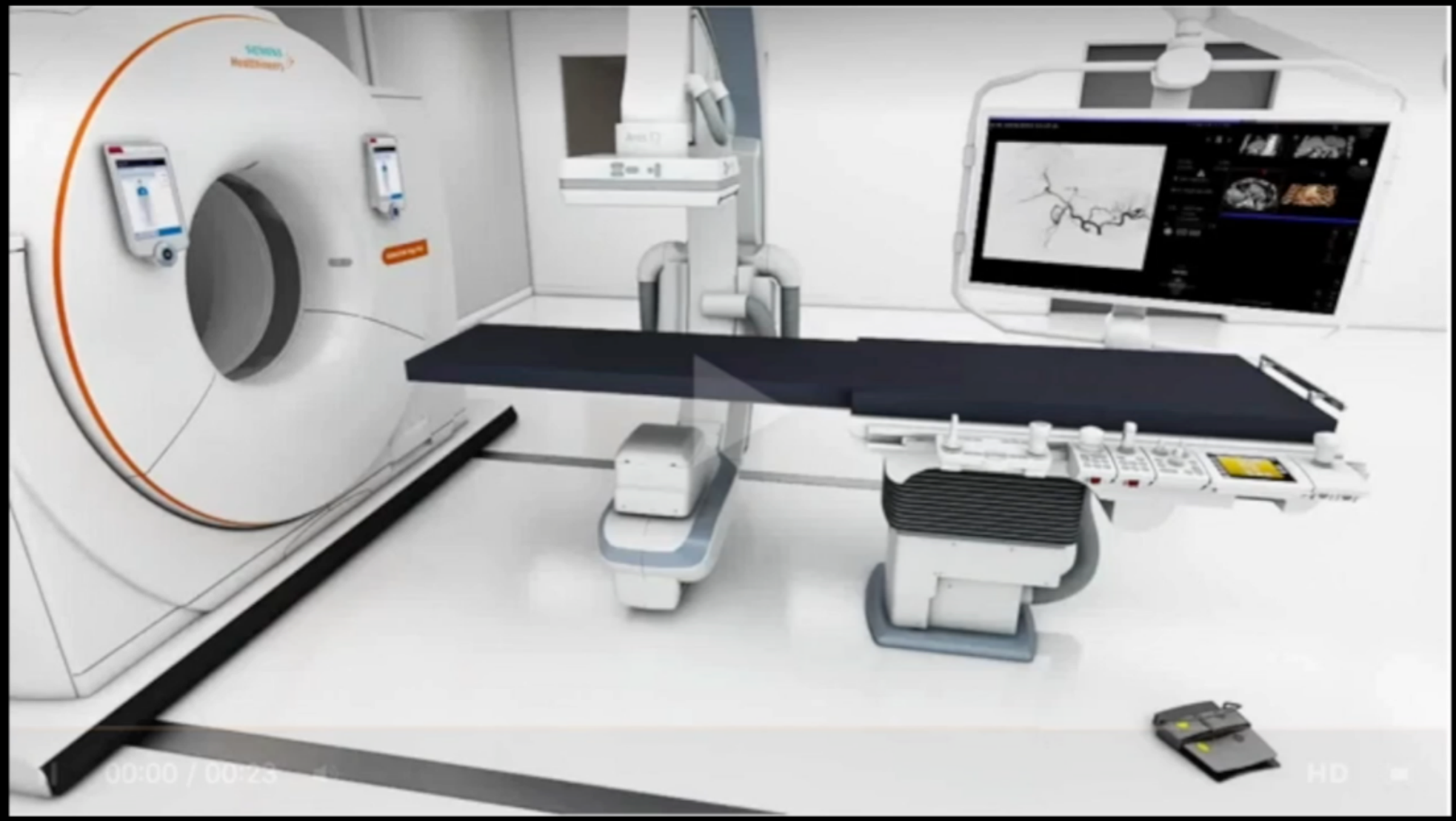
Circulation. 2011 Sep 13;124(11):e280-2. doi: 10.1161/CIRCULATIONAHA.110.014118.

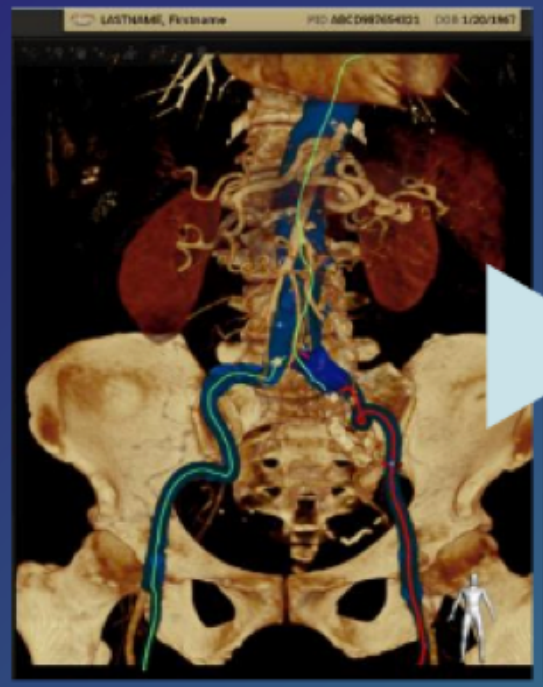
Zero-contrast thoracic endovascular aortic repair using image fusion.

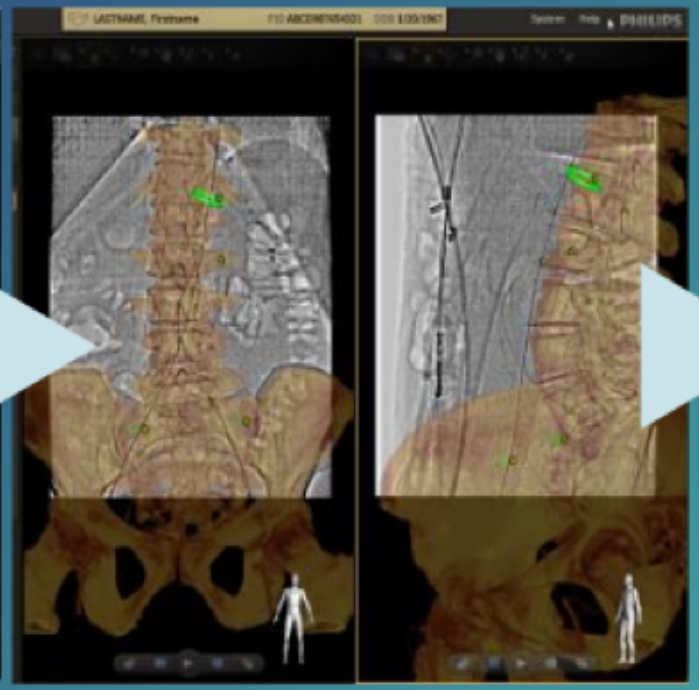
Kobeiter H[1], Nahum J, Becquemin JP.

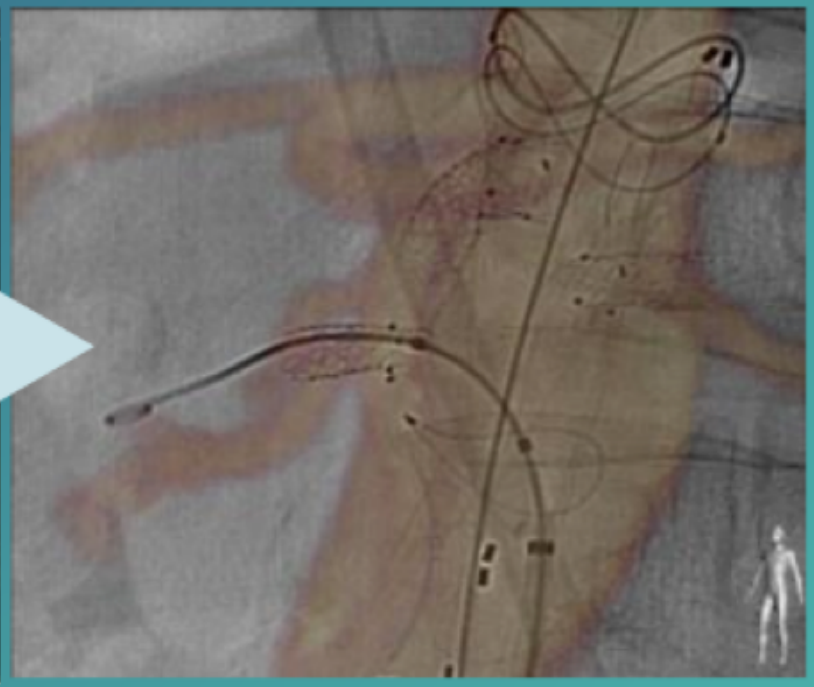
- the creation of a 3D patient-specific vascular roadmap based on preoperative imaging which aligns with intraoperative fluoroscopy, with many potential benefits

HYBRID ROOM









Segmentation

- Select vasculature of interest

Planning

- Add ring markers
- Plan optimal angle

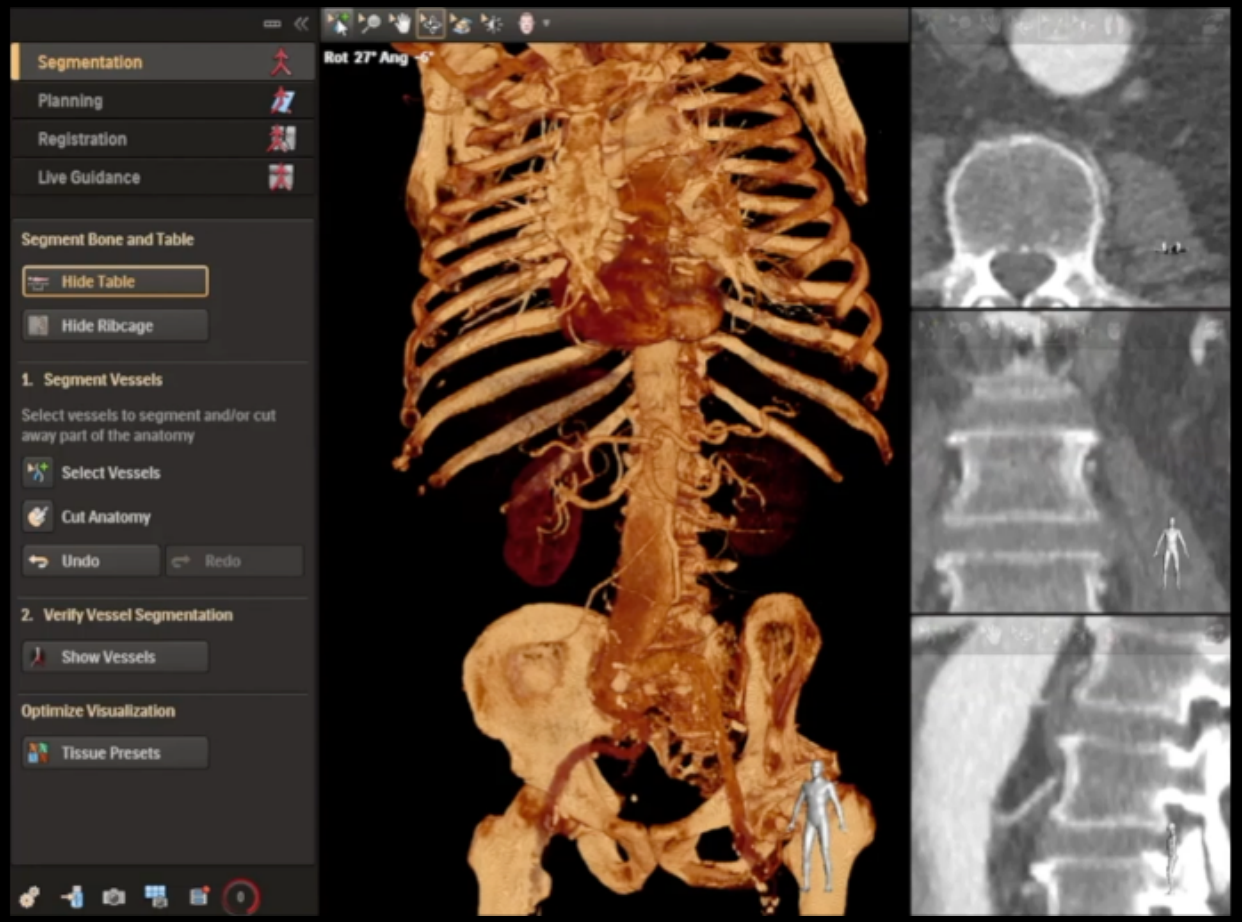
Registration

- 2D-3D: bony landmarks
- 3D-3D: calcifications

Live Image Guidance

- Select preferred visualization
- Follow C-arm and table movements

SEGMENTATION



Segmentation = select vasculature of interest

Contrast-enhanced MDCT images are uploaded to the image fusion workstation

During the segmentation process, the user selects (or ‘‘paints’’) the relevant anatomy to be included in the intraoperative model

With available software it is possible to select vessel with a one-click vessel segmentation

Jones D et al. Image Fusion and 3-Dimensional Roadmapping in Endovascular Surgery. Ann Vasc Surg 2018; 52: 302–311

PLANNING

Accurately identify vessel origins, and then the their's ostia (ring markers) can be positioned on the fusion mask to aid cannulation

Mark the planned proximal and distal landing zones of the endograft or to underline the anastomosis of a surgical graft

Landmarks are used during the procedure to identify (without the need for x-ray) the gantry positions perpendicular to each target vessel ostium or the best working angles to accurately deploy the endograft.

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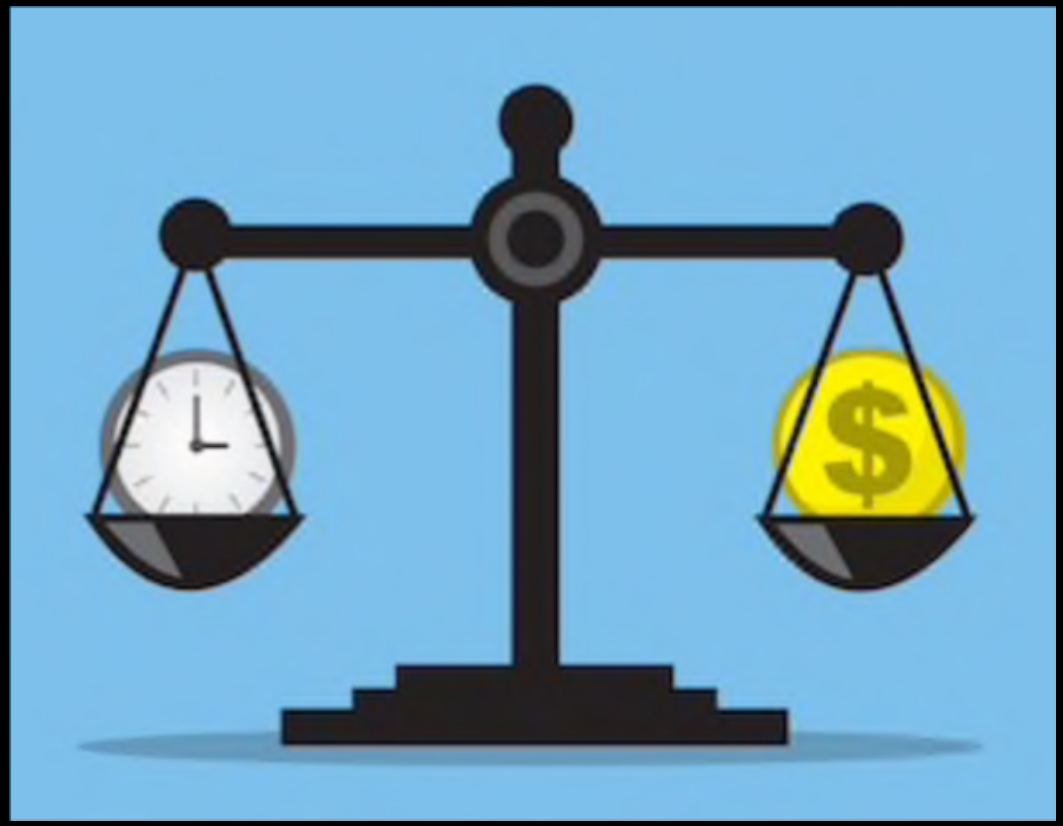
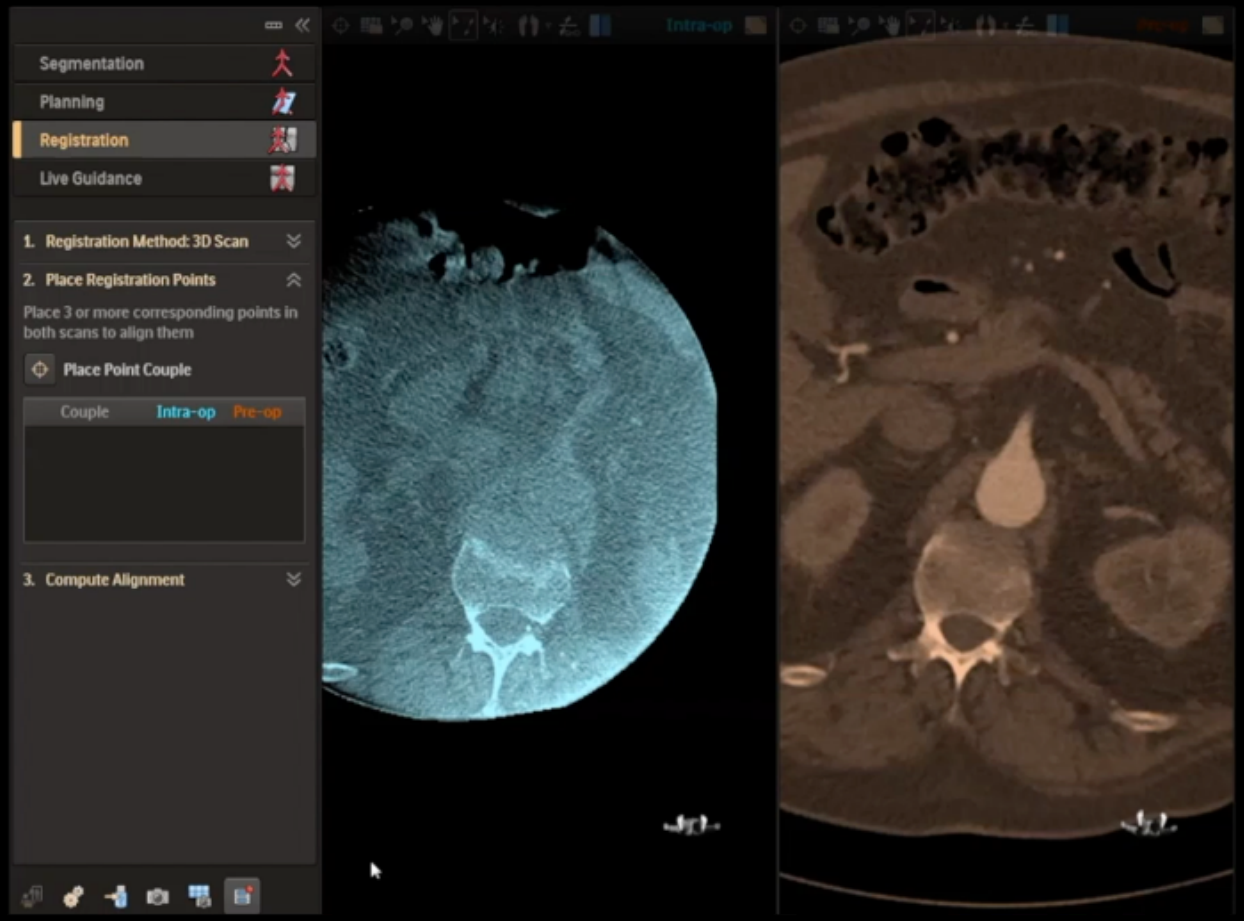
IS IT TIME CONSUMING?

- The segmentation and procedure planning steps can be completed at any time before the procedure and saved for later use.
- It has been reported that these steps take <5 min for standard EVAR and can either be performed the day before surgery or just before patients' arrival to the operating room.



REGISTRATION



Registration for these two different data sets is usually performed using bony structures and/or vascular calcifications or a previously implanted endograft.

Registration can be either

- 2D/3D, which is performed by superimposing the 3D bone model obtained from the CTA on to the bony structures on 2D fluoroscopic images
- 3D/3D by superimposing the CTA 3D bone model and aortic calcifications on to a 3D bone model obtained from an on-table cone-beam CT.

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LIVE GUIDANCE

The fusion model is automatically codisplayed with fluoroscopy, and the modeled femoral bifurcation serves as additional confirmation of the level of arterial puncture.

An important feature of the fusion model is that it remains displayed and is actively adjusted even when fluoroscopy is not active.

These steps are efficient at orienting the imaging system in optimal positions while minimizing radiation

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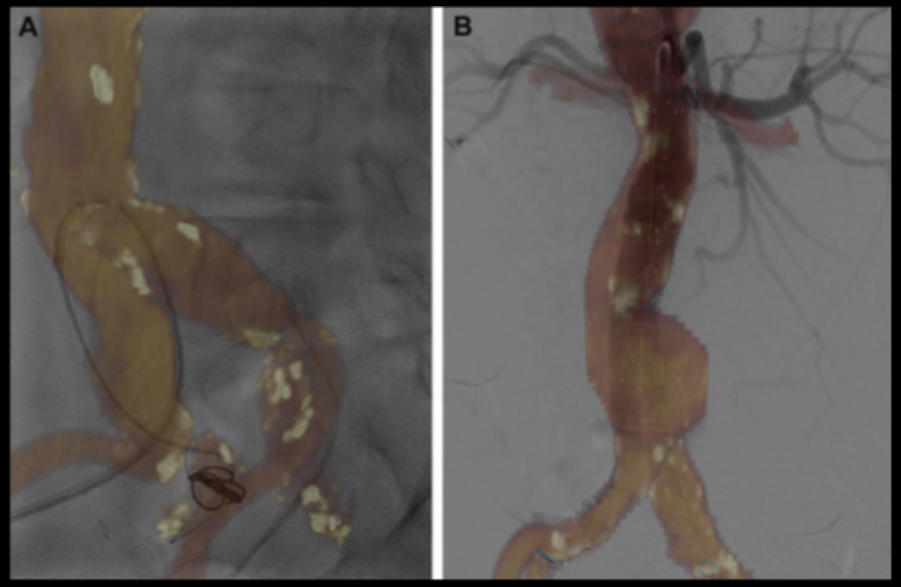
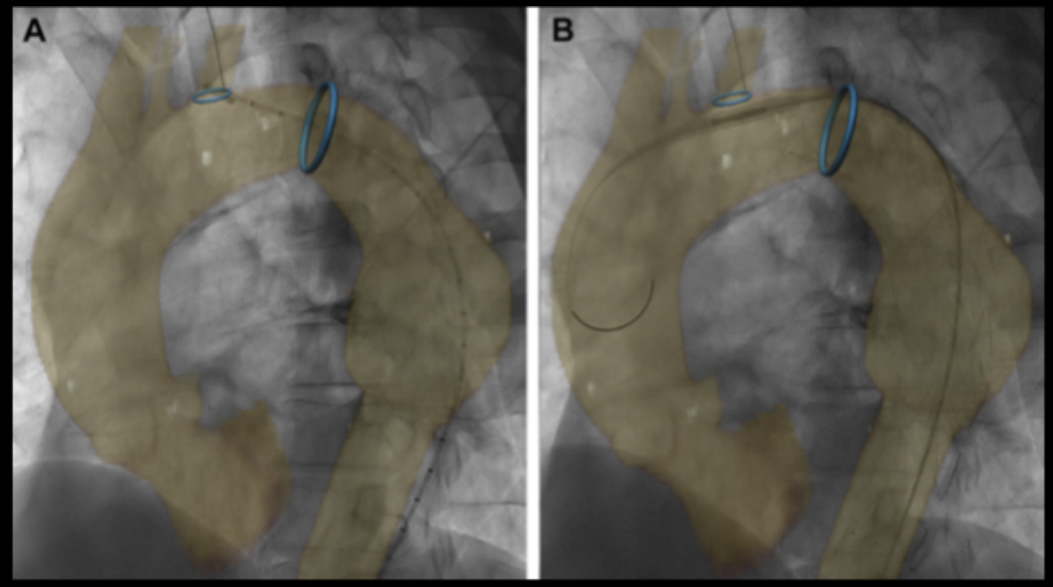
PROCEDURE – EVAR and TEVAR

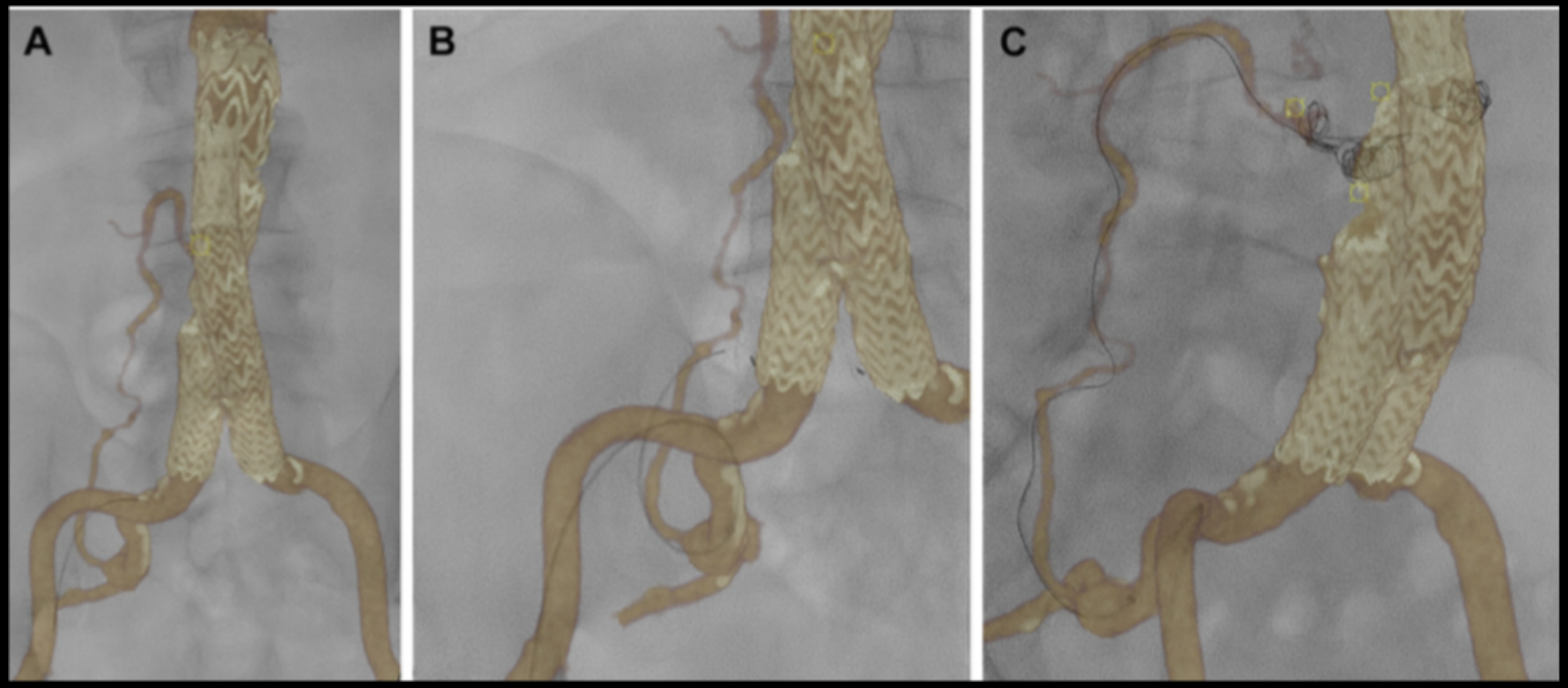
- Precise 3D visualization of the proximal aortic neck and predetermination of optimal C-arm angles
- Fenestrated and branched: accurate model alignment has been sufficient such that a fenestrated device can be introduced and branch vessels cannulated before any contrast administration





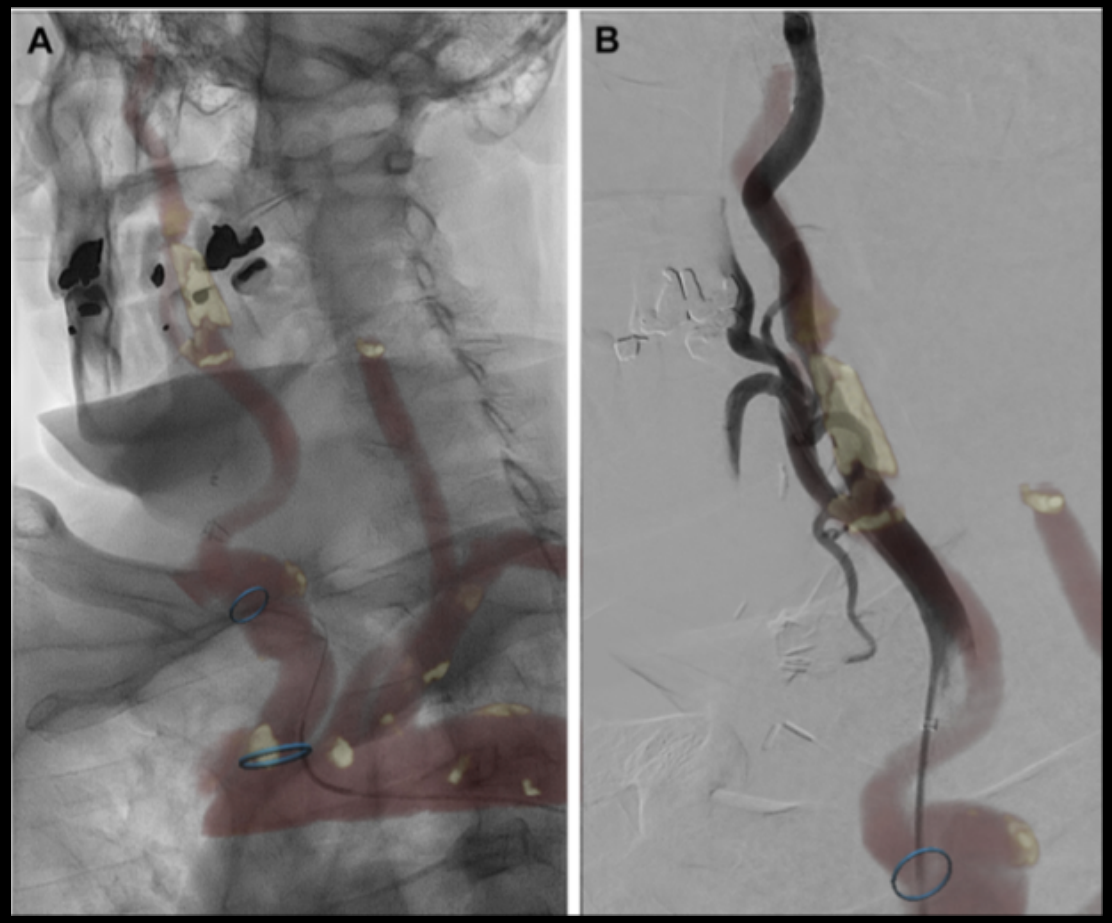
PROCEDURE – ENDOLEAKS

- Type 2 endoleak: image fusion can illustrate the area of residual flow, guiding the operator to focus on embolization efforts in these areas.



PROCEDURE – CAROTID STENTING

- Delineate the aortic arch and guide common carotid artery catheterization
- Facilitates arch vessel cannulation and minimizes catheter manipulation without an arch aortogram and decreases the need for DSAs, again potentially decreasing the risk of operative stroke



BENEFITS

- Increased diagnostic/therapeutic accuracy
- Further step towards individualized medicine
- Precise monitoring of interventional procedures
- Reduced radiation exposure and iodine contrast medium

FUTURE DIRECTIONS

- Recent reports have shown that automated systems for model segmentation and registration may be feasible.
- Computerized algorithms may be able to produce fusion masks that predict and display vessel deformation caused by the introduction of stiff devices, which would further improve on intraoperative model accuracy
- If the advantages of image fusion technology become more clearly evident, as we expect them to be, then this should lead to wider adoption and, potentially, a reduction in cost