Three-Dimensional Ultrasound Fusion of Trans-Abdominal and Trans-Rectal Images for Visualization of Gynecological Brachytherapy Applicators

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1. GLOBOCAN 2020.
2. Tanderup et al. IJROBP 2014. 88(3).

References

Background

Gynecological cancers are prevalent worldwide

- 1.4 million women diagnosed in 2020
- Often diagnosed in regions of low developmental index

High dose-rate brachytherapy is considered a necessary treatment for gynecological cancers

- Radioactive sources are placed within the patient, local to the tumor site using specialized applicators or needles
- Medical imaging is required to visualize the procedure and ensure accurate radiation placement

We investigate the use of three-dimensional ultrasound (3D US) as a cost effective, portable imaging alternative to CT and MR for applicator localization

- Must overcome US shadowing and reflection artifacts from a single trans-abdominal (TAUS) or trans-rectal (TRUS) view
- Generalizing our previously successful results to more applicator types for a comprehensive visualization method

Objective

Develop, validate, and translate an automated 3D US fusion technique to fully visualize applicators and surrounding anatomy during gynecological brachytherapy treatments

Methods

1. Image Acquisition

Motorized drivers translate any conventional US transducer

- Custom software reconstructs regularly acquired images into a volume

3D US images are acquired using both 3D TAUS and 3D TRUS mechanotronic systems

2. Phantom Study

Custom tri-modal agar female pelvic phantom with simulated internal structures and fiducials (N=4)

- Two applicator types, Vienna type including interstitial needles

3. 3D US Image Fusion

Evaluated the registration errors between all modalities and compared the 3D US fusion to gold-standard images

- 3D rendered applicator model overlaid on each 3D US image and rigidly registered

Conclusions

Target registration error (TRE): Distance between corresponding fiducial points in registered images

Fiducial localization error (FLE): Distance between the same fiducial point selected multiple times (N=5)

Values are comparable to registration accuracy of alternative fusion techniques

- Qualitative comparison showed accurate visualization of simulated internal structures and brachytherapy applicators

Ongoing clinical trial at LRCP to evaluate 3D US image fusion and examine the feasibility of dose planning using fused 3D US

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