PERSPECTIVE STUDY

# Role of Imaging in Medical Schools of Tomorrow

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**Abstract**

CT of the cadavers and on site 3-D ultrasound imaging significantly increase the amount of visual information and improve students' understanding of anatomy leading to more efficient assimilation of the basic science knowledge. In addition to cadaveric CT and ultrasound imaging, students are provided with normal and abnormal radiographic studies of living humans. The imaging modalities in Medical Image Library of Paul L Foster School of Medicine in El Paso, TX are X-ray, computerized tomography (CT), magnetic resonance imaging (MRI) and ultrasound. Normal anatomy and pathology are demonstrated on different types of imaging studies which enables integration of the basic science material with relevant clinical examples. Recent advances in 4-D and Doppler ultrasound significantly enrich learning experience in embryology and physiology. Multidisciplinary approach using cutting edge medical imaging technology may improve students' retention of basic science knowledge throughout their medical school, residency training and beyond.

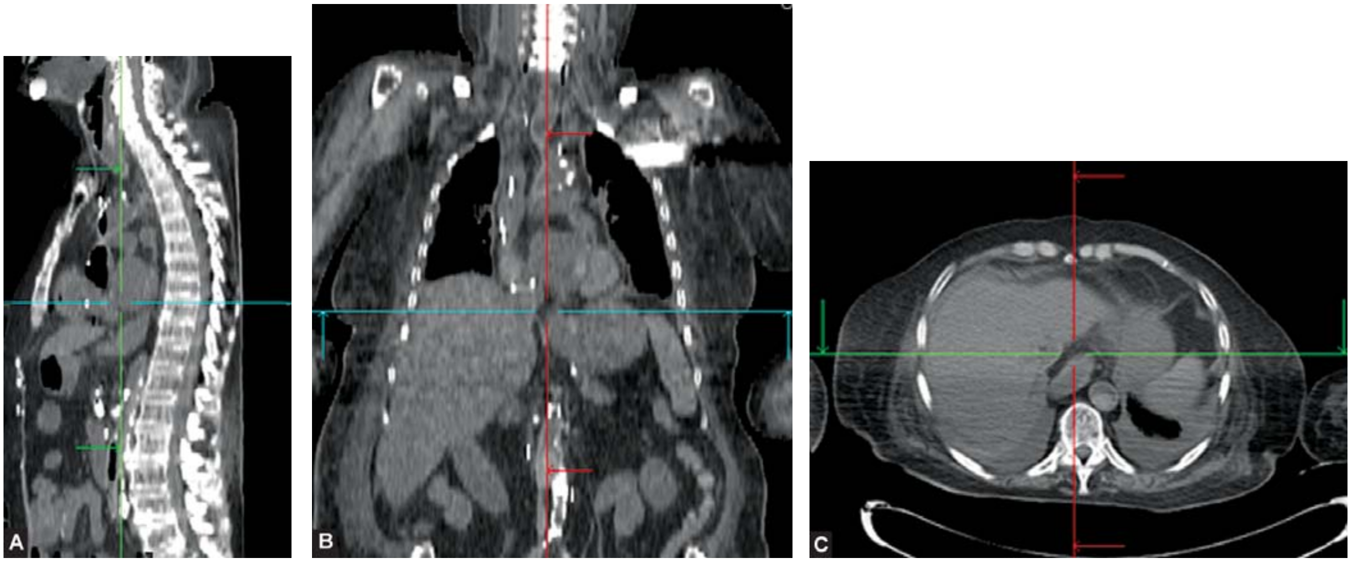
**Keywords:** Ultrasound, CT scan, cadaver, anatomy, embryology, medical education.

Nowadays patient care and health care reform are hot topics in the US. Physicians and basic scientists involved in medical education became aware that the crucial link in this chain is effective and efficient medical school curriculum. Traditional medical school training consists of two years basic science component, which focuses on classroom based courses in anatomy, embryology, physiology, histology, biochemistry, microbiology, immunology, pathology and pharmacology. The application of the basic science knowledge to diagnosis and management of real patients occurs during the two years of clinical clerkships.

In Paul L Foster School of Medicine curriculum, basic science disciplines are integrated with clinically relevant information from the very first day. For example, anatomy is transformed into a course combining laboratory-based teaching, imaging technology and advanced clinical diagnostic tools. The radiology component of the course includes use of CT (computed tomography) scans of each cadaver at the dissection table (Figs 1A to C), and three-dimensional (3-D) ultrasound scanning of the cadaver prior to dissection of every region. Through 3-D ultrasound visualization of human organs, students improve their understanding of anatomy and better assimilate basic science material.

It has been reported that cadaveric CT and ultrasound imaging prior to cadaveric dissection enable better understanding of interrelationships between the anatomical structures.[1-3] Using imaging studies, radiologists and anatomists explain the structure or a particular organ and demonstrate the relationship with adjacent structures and organs. During dissection the students are expected to identify and label the structures they have visualized on cadaveric imaging studies. Dissection is facilitated by understanding the associations and landmark features which were previously explained. In addition, CT information and 3-D ultrasound enable reconstruction and navigation through the volume data of the cadaveric organs. CT slices are compared to 2-D real time ultrasound and 3-D volume studies, which are performed on site.

Application of color and power Doppler sonography allows unprecedented insight into the physiological and pathophysiological events. Hand-on ultrasound workshops using B-mode and color Doppler ultrasound performed by medical students on each other may improve their understanding of physiology and introduces them effectively to radiology imaging. This strategy enables students to understand and appreciate comparable advantages of




**Figs 1A to C:** CT of the cadaver obtained at Paul L Foster School of Medicine prior to dissection

different imaging modalities before they are exposed to clinical sciences.

Cadaveric ultrasound may also be used in training and evaluation of medical practitioners who are training in diagnostic ultrasound, and those who are entering the field of ultrasound guided procedures.[4,5] The use of imaging prior to dissection is very useful in training internal medicine, obstetrics and gynecology, anesthesiology, orthopedic and surgery residents. It has been demonstrated that this approach is useful in continuous medical education of experts in different surgical disciplines, because it improves planning process before the actual surgery.

There are multiple purposes of cadaveric CT and ultrasound. They inform prosectors about any pathology and foreign bodies (pacemaker, inferior vena cava filter, IUCD, etc) that may interfere with dissection process, or need to be further discussed in anatomy and pathology laboratory (Fig. 2). Students are gaining valuable experience in obtaining and interpreting imaging studies. Finally, students are introduced into a team work and learn how to respect the visual information in health care process. CT and ultrasound images are compared with the images of normal living subjects and images of different clinical pathology to facilitate inductive reasoning and understanding of the clinical presentations which are explained during the course of each unit.

Medical Education Department at Paul L Foster School of Medicine uses a commercially available three-dimensional (3-D) portable ultrasound system (Voluson I, GE, USA) for studying human anatomy and pathology. Portable ultrasound unit allows radiologist to scan cadavers on any dissection table. Using 2-D conventional ultrasound imaging and 3-D ultrasound abdominal organs, breast, thyroid morphology and pelvic structures are exemplary visualized. During the course of the anatomy laboratory experience, the students learn how to differentiate postmortem artifacts influenced by the gas production in the cadavers due to autolysis from real abnormalities. 3-D ultrasound images and CT of the cadavers are compared to the 3-D ultrasound images, organ volumes and CT DICOM information of the

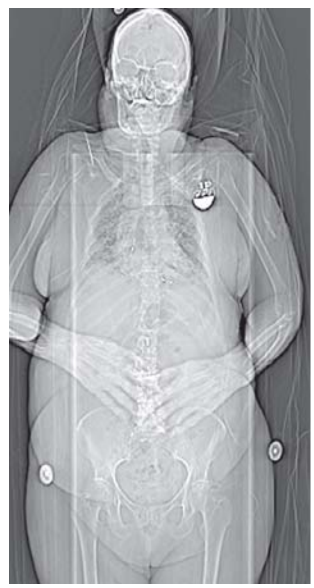


**Fig. 2:** Topogram of the same cadaver demonstrating pacemaker

living human subjects with both normal and abnormal findings.

Students use 2-D and 3-D ultrasound to scan each other, which allows them to obtain basic scanning skills and experience firsthand the advantages and disadvantages of this method. Three-dimensional ultrasound enables surface and volume rendering. In case of volume rendering the students are able to visualize the structures below the surface, which facilitates understanding of the organ structure and pathology (if present). Multiplanar mode enables visualization of the same object in axial, sagittal and coronal planes. At the same time it allows better understanding of the position, spatial relationship of the structures and tracking of the movement in three-dimensional space. The students have to label the cadaveric and normal patients' organs on CT scans and ultrasound images, which facilitates learning process for a novice (Figs 3 to 4B). All these components lead to better understanding of the important principles of human anatomy.

Ultrasound is also used for volume determination of human organs in cadavers for students' scholarly projects. The volume of thyroid lobes, liver, spleen and pelvic structures is determined with 2-D and 3-D ultrasound. Each measurement is documented and stored. Manual segmentation and volume assessment is then performed by a student and an ultrasound expert. After the organs are resected, their volume is measured by submersion and compared to ultrasound measurements.

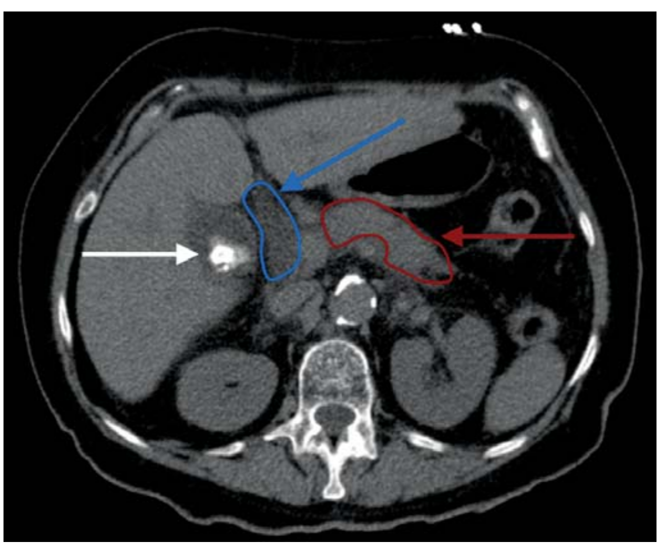
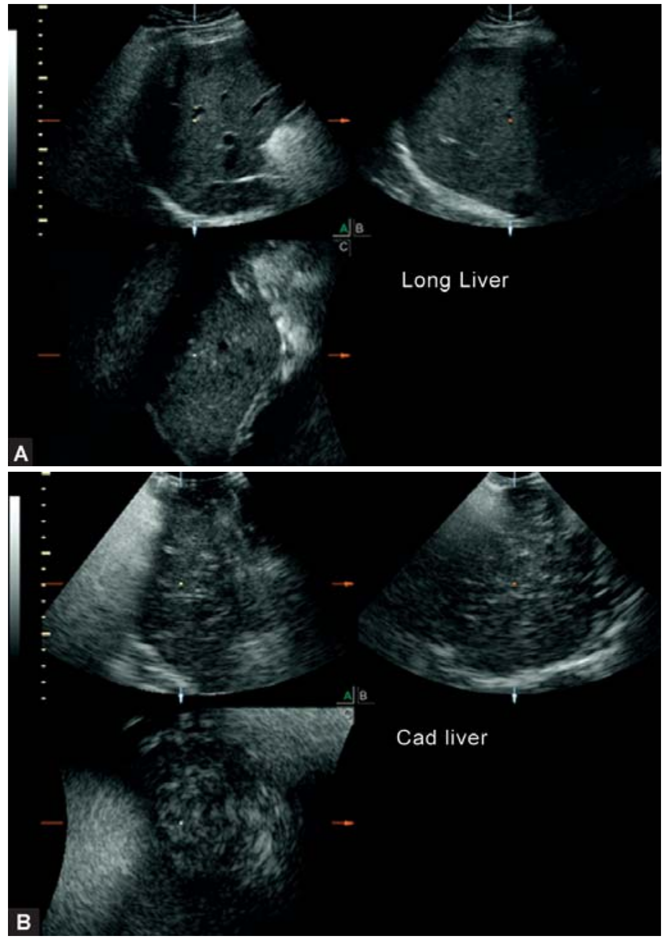


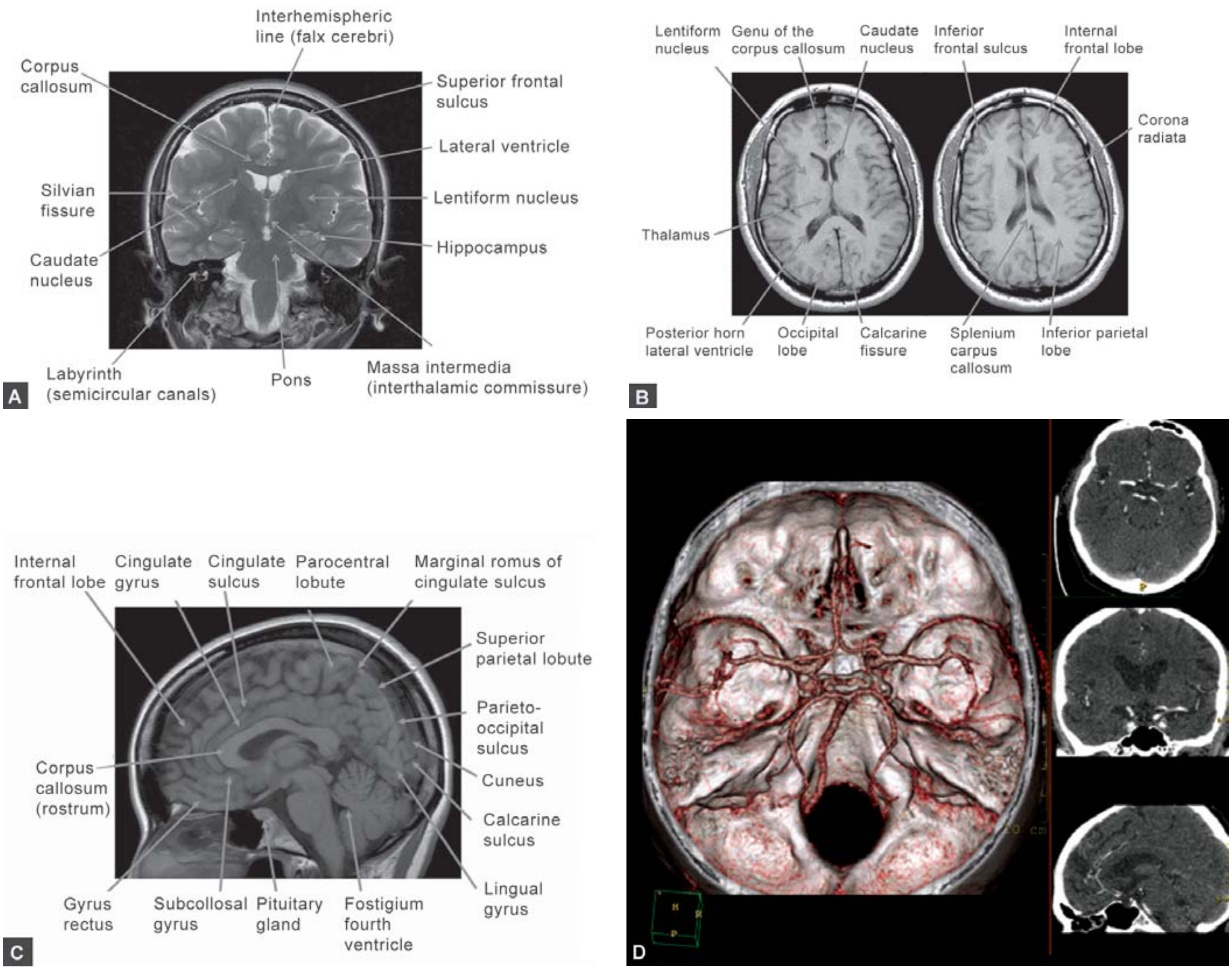
**Fig. 3:** CT of cholelithiasis. White arrow: Large gallstone in a distended gallbladder; Blue arrow: Dilated common bile duct coursing from anterior to posterior on its way inferiorly to the duodenum; Red arrow: Body of the pancreas appears edematous and thickened




**Figs 4 A and B:** 3-D ultrasound of a normal (A) and cadaveric liver (B)

In addition to cadaveric CT and ultrasound imaging, students are provided with normal and abnormal radiographic studies of living humans. Presently medical image library (MIL) of Paul L Foster School of Medicine includes three thousand original images provided and explained by Radiology faculty at Texas Tech University in El Paso, TX. The imaging modalities in this databank are X-ray, X-ray fluoroscopy (digital radiography equivalent), CT, MRI and ultrasound. Normal anatomy and pathology are demonstrated on different types of studies and enable integration of the basic science material with relevant clinical examples (Figs 5A to D). Radiological studies are also discussed in a Medical Skills setting.

Obstetrical 2-D and 3-D ultrasound images and videos are used to make educational points and provide important clinical information related to embryology component of the curriculum (Fig. 6). Prenatal and postnatal imaging studies enable better understanding of normal and abnormal human development.[6]




**Figs 5 A to D:** Few examples from Medical Image Library at Paul L Foster School of Medicine (courtesy of Jose Gavitto, MD) Normal brain anatomy demonstrated by MRI. (A to C) Coronal, axial and sagittal views. (D) Normal intracranial structure

**Fig. 6:** Three-dimensional ultrasound image of a fetus at 11 weeks gestation demonstrating physiologic herniation. This type of images facilitates students' understanding of the embryology portion of the curriculum (From Embryology Image Library, Editors: Sanja Plavsic Kupesic, MD, PhD and Guillermo Azumendi, MD)

We believe that our multidisciplinary approach using modern imaging technology will improve students' retention of basic science knowledge throughout their medical school, residency training and beyond. We hope that innovative medical education incorporating cutting edge medical imaging into anatomy, embryology, physiology and pathology courses during the first and second years of medical school will help our students to practice efficient and cost-beneficial medicine of tomorrow.

## REFERENCES

1. Teichgraber UKM, Meyer JMA, Nautrup CP, von Rautenfeld DB. Ultrasound anatomy: A practical teaching system in human gross anatomy. Medical Education 2009;30:296-98.
2. Chew FS, Relyea-Chew A, Ochoa ER. Postmortem computed tomography of cadavers embalmed for use in teaching anatomy. J Computed Assisted Tomography 2006;30(6):949-54.
3. Lothe VA. Virtual cadaver navigation system: Using virtual reality for learning human anatomy. (Master of Science Thesis in Computer Science, Department of Computer Science and Engineering, University of South Florida, USA); June 2005;9.
4. Luyet C, Eichenberger U, Greif R, Vogt A, Szucs Farkas Z, Moriggl B. Ultrasound guided paravertebral puncture and placement of catheters in human cadavers: An imagin study. British J Anesthesia 2009;102(4):534-39.
5. Clendene SR, Riutort K, Ladlie BL, Robards C, Franco CD, Greengrass A. Real time three-dimensional ultrasound assisted axillary plexus block defines soft tissue planes. Anesth Anest 2009;108:1347-50.
6. Kupesic S, Hafner T, Bjelos D. Events from ovulation to the end of first trimester studied by three-dimensional ultrasound. J Perinat Med 2002;30:84-98.