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Meeting Abstracts

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Keynotes Presentations

High-speed 3D Structured Light Imaging and Applications

Song Zhang

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Abstract

Advances in optical imaging and machine/computer vision could have profound impact on biomedical engineering. My research addresses the challenges in high-speed, high-resolution 3D imaging and optical information processing. My current research focuses on achieving speed breakthroughs by developing the binary defocusing techniques; effectively storing enormously large 3D data by innovating geometry/video compression methods; and automating structured light 3D microscopic imaging techniques using the recently developed electrically tunable lens (ETL). The binary defocusing methods coincide with the inherent operation mechanism of the digital-light-processing (DLP) technology, permitting tens of kHz 3D imaging speed at camera pixel spatial resolution. The novel methods of converting 3D data to regular 2D counterparts offer us the opportunity to leverage mature 2D data compression platform, achieving extremely high compression ratios without reinventing the whole data compression infrastructure. The electronically controllability of ETL lens shows promise for large Field of View (FOV) 3D imaging automation. In this talk, I will present our recent work in these areas and discuss some of the applications that we have been exploring including biomedical engineering, forensic sciences, along with others.

Mathematical Methods in Medical Image Processing

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Abstract

We will sketch some central mathematical problems in medical imaging. Much of the new software is based on certain methods utilizing geometric partial differential equations in conjunction with standard signal/image processing techniques as well as computer graphics facilitating man/machine interactions. Researchers have been trying to base biomedical engineering principles on rigorous mathematical foundations for the development of software methods to be integrated into complete therapy delivery systems. These systems support the more effective delivery of many image-guided procedures such as radiation therapy, biopsy, and minimally invasive surgery. We will show how mathematics may impact some of the main problems in this area, including image enhancement, registration, and segmentation.

Radiation Oncology

Nuclear Medicine in Japan as Seen by Me –Reminiscence and Prospects

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Abstract

Background: Since 1965 I have seen the dawn and progress of nuclear medicine (NM) in Japan. This is a good opportunity to present a historical review of NM in Japan.

Purpose: The purpose of this presentation is to trace the track of diagnostic and therapeutic applications of radiopharmaceuticals (RPs) and instruments based on radioactive tracer technology invented by Hevesy in 1913.

Methods: Uses of various instruments and RPs for diagnosis and therapy of diseases are described in accordance with chronology of my clinical experiences and research works in the past half a century.

Results: NM has been progressed by the developments of new instruments and RPs like 2 wheels of a vehicle, which has been driven by the cooperation of nuclear physicians, technologists and specialists in related fields.

In 1960th scintillation scanners and 131I-labeled RPs were used for organ imaging. After the so-called happy wedding of scintillation cameras and 99mTc, static and dynamic images of organs such as brain, heart, liver, bone, kidney, etc. have been taken using varieties of 99mTc-labeled compounds. With the introduction of X-ray computed tomography in early 1970th brain scintigraphy dramatically decreased. Newly commercialized 201TlCl rescued NM by prevailing use of myocardial perfusion images. The Single Photon Emission Tomography (SPECT) invited the prime age of nuclear cardiology during 1980th to 1990th. Radio-immunoassays boomed in 1970th to 1980th using well type scintillation counters and 125I-labeled antibodies. In 1980th radio-immuno-detection (RID) of cancers was a target of research interest, which has evolved to radio-immuno-therapy (RIT) and to theragnostic. Clinical PET was started in 1980th and was facilitated by commercially available PET/CT in early 2000th together with commercial delivery of 18F-Deoxyglucose (FDG). FDG PET has been widely used in cancer detection. The use of FDG PET for health check-up is a uniqueness in Japan. My research works included use of catheter-type semiconductor detector (CASRAD,14C- and 13C-breath tests using a liquid scintillation counter and mass-spectrometry, respectively, etc.

Conclusion: NM should continue to evolve with the developments of new instruments and RPs, which is promoted by the multidisciplinary cooperation of specialists.

Dynamic PET for Oncological Applications

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Abstract

Positron emission tomography (PET) provides functional images that demonstrate the mean activity distribution at a defined point in time. Most oncological PET examinations are performed as static studies. However, it is possible to use dynamic acquisition protocols which provide information about the radiotracer´s distribution within time and in different tissues. The most important applications of dynamic PET in oncology are: 1. Tumor diagnosis and staging 2. Pharmacokinetic studies of different tracers 3. Therapy monitoring 4. Tumor prognosis 5. Parametric imaging. Representative examples will be shown for each of these applications. Dynamic PET is for example useful for noninvasive biological grading in soft tissue sarcomas and for the differentiation between benign and malignant lesions. Pharmacokinetic studies with novel tracers, like Ga-68-PSMA-11 in metastatic prostate cancer will be presented showing different time-activity curves by tissue type. Dynamic PET with F-18-FDG is helpful for therapy monitoring showing a superiority for the use of multiparametric analysis as compared to the use of the SUV alone. Tumor prognosis can also be facilitated by dynamic PET as demonstrated in patients with multiple myeloma. Highlights of parametric imaging will also be presented. Parametric imaging is based on the use of pharmacokinetic models and visualize isolated parameters of the tracers' kinetics. They add a new dimension to the existing conventional PET images and provide more detailed information about the tracer distribution over time and space. The introduction of new PET-CT scanners with a long axial field of view which allow a faster data acquisition, higher sensitivity, higher temporal resolution, robust image-derived-input function and potentially reduction of radiation exposure as well as the development of more sophisticated evaluation software packages will probably lead to a renaissance of dynamic oncological PET and parametric maps in the whole body.

A Dedicated Pipeline to Predict Response to Neoadjuvant Chemotherapy in Breast Cancer Using MRI Acquired in Various Centres

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Abstract

To predict pathological complete response (pCR) to neoadjuvant chemotherapy (NAC) in locally advanced or aggressive breast cancer, dynamic contrast enhanced T1-weighted and T2-weighted MRI play an important role, in complement to biomarkers including breast cancer subtype (Luminal, HER2+ or Triple Negative), KI67 and Tumor Infiltrating Lymphocytes. We investigated this complementarity based on a retrospective database of 150 patients treated in our institute. Pretreatment MRI data, if mainly acquired in our center (n=120) on three different devices, came from 16 additional centers for 30 patients. First, BI-RADS descriptors were used to define tumors from pretherapeutic images, and their combination showed a predictive value of pCR higher than biological data alone. Combining the two types of data enabled us to improve the quality of the prediction. In parallel, a dedicated radiomics pipeline was proposed, compensating for the non-fully quantitative nature of MRI signal and the variability introduced by multicentric data. This machine learning pipeline included MR data preprocessing and normalization, tumor segmentation, radiomic features computation and harmonization, model definition and test of the model on external data. In addition to conventional radiomic features, the role of tumor margins was highlighted in the radiomic models, showing an excellent transfer capacity. Future works include to reinforce the robustness of the pipeline with the introduction of tumor segmentation based on deep learning approaches and to better unveil the link between radiomic features and biological data.

Combining and Analyzing Novel Multi-Parametric Magnetic Resonance Imaging Metrics for Predicting Gleason Score

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Abstract

Background: Radiologists currently subjectively examine multi-parametric magnetic resonance imaging (MP-MRI) to determine prostate tumor aggressiveness using the Prostate Imaging Reporting and Data System scoring system. Recent studies showed that modified signal to clutter ratio (SCR), tumor volume, and eccentricity (elongation or roundness) of prostate tumors correlated with Gleason score (GS). No studies combined the prostate tumor's shape, signal to clutter, tumor volume, and potential aggressiveness to predict GS.

Methods: MP-MRI (T1, T2, diffusion, dynamic contrast-enhanced images) were obtained, resized, translated, and stitched to form spatially registered multi-parametric cubes. Multi-parametric signatures that characterize prostate tumors were inserted into a target detection algorithm [adaptive cosine estimator (ACE)]. Pixel-based blobbing, and labeling were applied to the threshold ACE images. Eccentricity calculation used moments of inertia from the blobs. Tumor volume was computed by counting pixels within multi parametric MRI blobs and tumor outlines based on pathologist assessment of whole mount histology. Pathology assessment of GS was performed on whole mount prostatectomy. The covariance matrix and mean of normal tissue background was computed from normal prostate. Using signatures and normal tissue statistics, the z-score, noise corrected SCR (eigenvalue filtering, modified regularization) from each patient was computed. Eccentricity, tumor volume, and SCR were fitted to GSs. Analysis of variance assesses the relationship among the variables.

Results: A multivariate analysis generated correlation coefficient (0.60 to 0.784) and P value (0.00741 to <0.0001) from fitting two sets of independent variates, namely, tumor eccentricity (the eccentricity for the largest blob, weighted average for the eccentricity) and SCR (removing 3 eigenvectors, removing 4 eigenvectors, modified regularization, and z-score) to GS. The eccentricity t-statistic exceeded the SCR t-statistic. The three-variable fit to GS using tumor volume (histology, MRI) yielded correlation coefficients ranging from 0.724 to 0.819 (P value <<0.05). Tumor volumes generated from histology yielded higher correlation coefficients than MRI volumes. Adding volume to eccentricity and SCR adds little improvement for fitting GS due to higher correlation coefficients among independent variables and little additional, independent information.

Conclusions: Combining prostate tumors eccentricity with the magnetic resonance imaging SCR relatively highly correlates with GS.

Tailoring Imaging Phenotypes to Measure Omic Profiles for Tumors Using ImaGene

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Abstract

The potential for radiomics to support oncology decision-making has grown substantially in recent years, as scanning techniques such a CT, MRI and PET have been found to offer unique information regarding the tumor phenotype and microenvironment that is distinct from that provided by path-omics data such as histopathology, genomics and proteomics. Such imaging and omics data can be correlated with one another to identify associations between them. Imaging-omic based biopsies bear potential to yield better pathological outcomes improving treatment for cancer patients. However, the field lacks a unified software platform wherein imaging and omic features can be brought together to conduct a variety of correlational analyses and build robust and artificially intelligent (AI) models that aid the prediction of omic profiles of tumors from their radiological images or vice-versa. This also includes prediction of patient outcomes for therapies based on their omic and imaging profiles. ImaGene is publicly available as both Graphical User Interface and Command-line interface- that can be utilized by researchers and clinicians globally to conduct imaging-omic studies for a variety of cancer types, and further validate and deploy it in clinic to aid effective monitoring, diagnosis, and treatment of cancer patients.

To demonstrate the utility of ImaGene, we conducted imaging-omic studies in cancer types such as Invasive Breast Carcinoma (IBC) and Head and Neck Squamous Cell Carcinoma (HNSCC) using datasets from The Cancer Genome Atlas (TCGA) and The Cancer Imaging Archive (TCIA). Potential associations were identified between several imaging features (i.e., texture, shape, size and intensity) and expressions of WT1, LGI3, CLDN10 and SMTNL2 genes in IBC, and NR0B1, PLA2G2A, CLDN16 and VRTN genes in HNSCC. Further, we demonstrated the prediction of protein expression of genes such as EGFR and PCADHERIN using radiology imaging features and histopathology outcomes available at TCIA and The Cancer Protein Atlas (TCPA) respectively.

ImaGene serves as a knowledgebase for transparent AI-operational reports for imaging-omics studies thereby democratizing usage of well-trained and validated AI models globally leading to their convergence and staging them for their use in clinics to support decision making in cancer.

Positron Emission Tomography (PET) Imaging - An Updated Look at Its Role in the Diagnosis and Staging of Prostate Cancer

William Yaxley

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Abstract

Positron Emission Tomography (PET) imaging for prostate cancer has seen its role rapidly change over recent years. PET imaging for prostate cancer is predominantly performed using PSMA PET/CT imaging. Whilst historically this has been utilized to identify recurrent disease after treatment, there has been a growing body of evidence to support its use in the primary diagnosis of prostate cancer, as well as further evidence to suggest it as a superior staging modality in comparison to more conventional imaging techniques such as whole-body bone scanning.

Through this talk we will explore the ever-changing landscape of positron emission tomography (PET) imaging in the diagnosis and staging of prostate cancer and provide an update on its current role in clinical practice.

CT in Radiotherapy

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Abstract

Radiotherapy (RT) has a set of phases that a patient needs to go through before the actual treatment. This workflow includes carrying out a CT-planning. Its objective is to define the patient's position, which will have to be maintained throughout all RT sessions in a reproductible way. The images that are generated during CT-planning are the images used for contour target volumes and organs at risk and subsequent treatment planning. CT in RT presents some differences when compared to CT scanners used in radiology, e.g., a flat tabletop, accessories of immobilization, external wall lasers, a virtual simulation software, a large scanner bore size and scanning protocols specifically designed for radiation oncology. Registering CT images with other imaging modalities is also common practice when additional information regarding tumors is required (CT-CT-planning; CT-planning- PET/CT; CT-planning MRI). Diagnostic Reference Levels (DRL) are dose levels in the medical practice of radiodiagnosis. In RT daily clinical practice, they can be considered in the acquisition of CT planning images and in the simulation of treatments. DRL values for diagnostic CT already exist and there are currently reference values in many countries, however in RT, the different image quality requirements and the different ranges for each pathology prevent their application. Currently, there is a growing concern about dose levels and many studies have already published DRL values for CT-planning in RT.

Neuroimaging

Neuroimage Analysis in Autism: from Model-Based Estimation to Data-Driven Learning

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Abstract

Functional magnetic resonance imaging (fMRI) has been shown to be helpful for the study of autism spectrum disorders (ASD). This talk will describe the evolution of efforts in this area within our group that carry promise for producing objective biomarkers for ASD, as well as predicting patient response to a behavioral therapy known as Pivotal Response Treatment (PRT), using task-based fMRI. Such biomarkers would provide an important step for better understanding the underlying pathophysiology of ASD that could help with objective and personalized diagnosis, provide new targets for development of new treatments, and provide a way to monitor patient progress. Initially a robust, group-wise unified Bayesian framework to detect both hyper and hypo-active communities from connectivity maps will be described. Next, more recent work will be presented that has focused on deriving ASD biomarkers from individual subject's time-series data, based on the classification of individual subjects (into ASD or typical control) and identifying spatially specific key regions using convolutional neural networks and ablation analysis of regions. In addition, a strategy based on recurrent neural networks (using long-short-term memories or LSTMs) will be presented that predicts patient response to PRT behavioral therapy from baseline imaging while incorporating subject-specific phenotypic information for network initialization. Finally, early work on the use of effective connectivity based on whole brain dynamic causal modeling will be discussed as an alternative or an adjunct to functional connectivity for classification and biomarker analysis.

Evaluation of Infarct Core and Ischemic Penumbra by Absolute Quantitative Cerebral Dynamic Susceptibility Contrast Perfusion Magnetic Resonance Imaging Using Self-Calibrated Echo Planar Imaging Sequencing in Patients with Acute Ischemic Stroke

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Abstract

Background: This study aimed to investigate the clinical value of the Self-Calibrated echo-planar imaging Perfusion-Weighted Imaging (SCALE-PWI) in offering a unique insight into ischemic stroke (IS) pathophysiology and improving the sensitivity of IS diagnosis.

Methods: A total of 14 patients with IS were prospectively recruited as a consecutive convenience sample. The quantitative cerebral blood flow (qCBF) and volume (qCBV) maps were processed immediately online after the scan. Then, 2 radiologists independently drew the region of interest of the infarct core (IC), ischemic penumbra (IP), and the contralateral normal tissues for the statistical analyses. A value of P<0.05 was considered statistically significant with 95% confidence intervals.

Results: The images for one representative subject are shown in Figure 1. All the values of qCBF and qCBV in the lesions were lower than those in the contralateral normal tissues (all P<0.05). The values of qCBF and qCBV in the IC were lower than those in the IP (mean values: 16.42 mL/100 g/min vs. 21.54 mL/100 g/min, P=0.013; 1.23 mL/100 g vs. 1.47 mL/100 g, P=0.049, respectively). The qCBF threshold of the IC was 18.18 mL/100 g/min (sensitivity, 71.40%; specificity, 64.30%) and the qCBF threshold of the IP was 28.09 mL/100 g/min (sensitivity, 78.60 %; specificity, 85.70 %).

Conclusion: Different from the previous semi-quantitative measurement, the SCALE-PWI technique has the potential to provide absolute quantitative hemodynamic information which may be used to detect the IC and IP in a relatively short scan time.

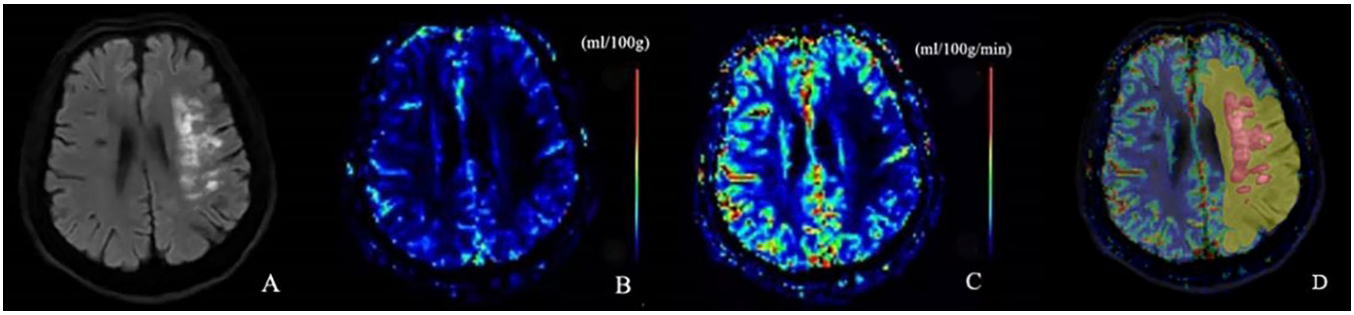

Figure 1: A 62-year-old male patient with cerebral IS. The DWI-qCBF fusion image (D) shows the IC (red zone) and the IP (yellow zone).

Vascular and Interventional Radiology

Retrograde as an Alternative to Antegrade Approach in Peripheral Arterial Angioplasty

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Abstract

Background: Critical Limb Ischemia (CLI) is a Peripheral arterial disease in which severe perfusion insufficiency threatens limb vitality. The burden of CLI is rising as the prevalence of diabetes mellitus and hyperlipidemia increases, causing ischemic rest pain and chronic tissue loss. Therefore, endovascular management is preferred over surgical approaches considering these patients' higher risks of surgery. Arterial access for angioplasty is traditionally obtained through a proximal artery such as the common femoral artery. However, this is sometimes challenged by the inability to visualize the arterial ostium or the creation of a subintimal flap preventing re-entry to the target artery. In such cases obtaining distal access for retrograde angioplasty may be the only limb salvaging option.

Objective: This study aims to interrogate the utility of retrograde revascularization as the solution in technically challenging antegrade angioplasties.

Methods: This prospective study included 25 patients with CLI who underwent a retrograde approach to angioplasty due to technical difficulties with the antegrade approach. Data describing the study cohort, the procedural technique, and arterial

access were collected. In addition, patients' outcomes, complications and recurrence rates were collected over six months and compared to antegrade angioplasties.

Results: The access site chosen for retrograde angioplasty was the posterior tibial artery in 48%, the popliteal artery in 28%, and the anterior tibial artery in 24% of patients. No significant acute or late complications were observed. Patients who presented with rest pain described post-procedural resolution of symptoms, and those with tissue loss witnessed improvement to complete healing of their wounds with no observed recurrence. These findings were comparable to the antegrade approach to revascularization.

Conclusion: Retrograde angioplasty is feasible, safe, and successful in treating critical arterial stenosis with comparable results to the antegrade approach.

Hepatic Vein Waveform Index (HVWI) and Portal Vein Velocity (PVV) in Covid-19 Patients: The Hepatic Involvement from an Ultrasound Point of View. A Cross-Sectional Study

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Abstract

Abnormalities in liver biochemistry are common in patients with COVID-19, occurring in approximately 15– 65%, but the prognostic significance of elevated liver enzymes in these patients is controversial (1,3).

In this study we sought to investigate liver ultrasound (US) features in COVID patients and correlated hepatic vein Doppler waveform and the velocity of portal vein with patients' inflammatory indexes and clinical outcome. Fifty-five patients with SARS-CoV-2 infection were recruited in a cross-sectional study and examined at bedside. All participants underwent a preliminary conventional diagnostic US evaluation (B-mode and color Doppler). Hepatic vein Doppler waveforms records were classified as triphasic, biphasic and monophasic as previously described. HVWI was calculated as (maximum velocity – minimum velocity)/maximum velocity. The mean portal vein velocity (PVV) was calculated automatically after the waveform trace for three cardiac cycles.

All patients showed steatosis and sludge in the gallbladder. Patients with low HVWI and high PVV had high serum LDH, ALT, D-dimer and ferritin values ($p < 0.05$). D-dimer and ferritin were higher ($p<0.05$) in patients with mono or biphasic than in patients with triphasic waveform. High PVV and large spleen diameter were associated with a worse respiratory outcome (cPAP and tracheal intubation) ($p< 0.05$). Optimal cut-off values for PVV (21.7 cm/s) and spleen diameter (9.84 cm) allowed to maximize sensitivity and specificity in predicting cPAP and tracheal intubation. Both cut-off values significantly predicted cPAP and tracheal intubation ($p<0.05$).

COVID patients showed changes of intrahepatic hemodynamics. Abnormal hepatic vein Doppler waveform in these patients could reflect liver inflammation and fibrosis.

Large Thigh Tuberculous Abscess Mimicking a Femoral Pseudoaneurysm: A Case Report

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Abstract

A cold abscess refers to an abscess that lacks the intense inflammatory. Musculoskeletal tuberculosis (TB) typically originates in bones and joints due to the lack of lymphatics and poor blood supply. The primary involvement of soft tissues is rare. This report represents a case of TB cold abscess that was diagnosed as a pseudoaneurysm initially.

A 93-year-old male, with a history of bladder cancer which was treated with BCG vaccine, presented with a left mid-thigh soft tissue swelling without systematic symptoms, and without history of pulmonary TB infection. Ultrasound scan (USS) imaging and CT angiography (CTA) has shown a left SFA aneurysm in the adductor hiatus with an overlying large fluid collection and multi-level aneurysms and perivascular fluid collections. USS-guided aspiration revealed negative routine cultures, but pos-

itive Mycobacterium collection (TB abscess). Anti-TB treatment was initiated. Due to increasing pain and size of the swelling, and developed skin breakdown over the swelling, surgical excision was the next option. Intraoperatively, SFA was eroded and SFA stent was visible, and this raised concerns about long-term freedom from infection. The Sartorius flab for exterior cover and proximal extension of the existing SFA stent was performed to ensure the stent would not migrate out of the eroded vessel and prevent prospective life-threatening haemorrhage.

Recovery was uneventful and was discharged home under the cover of anti-TB treatment. This report highlights the importance of maintaining a high suspicion index to diagnose extrapulmonary TB abscesses, especially when standard microbiology tests are non-conclusive.

Medical Physics & Bioengineering

Bubbles-Enhanced Ultrasound Mechanotherapy for Noninvasive Cancer Surgery

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Abstract

Ultrasound is a widely used medical imaging and therapeutic modality due to its safety, noninvasiveness, high penetration depth and cost effectiveness. In my talk I will present our recent developments in the field of ultrasound mechanotherapy for applications of noninvasive cancer surgery. Taking microbubbles contrast agents into the nanoscale, holds the promise for noninvasive cancer therapy. Two types of contrast agents, nanobubbles and nanodroplets, will be presented. We show that coupled with low energy insonation at a center frequency below 250 kHz, well below the resonance frequency of these agents, nanoscale bubbles can serve as noninvasive therapeutic warheads that trigger potent mechanical effects in tumors following a systemic injection. As a result, low-energy, bubbles-enhanced ultrasound surgery could be performed, reducing the required energy for standard ultrasound surgery by over an order of magnitude. These capabilities will be demonstrated in tissue mimicking phantoms, in cell cultures and in vivo where bubble-mediated low frequency insonation of breast cancer tumors resulted in effective mechanical tumor ablation and tumor tissue fractionation. The presented approaches provide a unique theranostic platform for safe, noninvasive and low energy tumor mechanotherapy.

The Assessment of Pancreas Stiffness Using Point Shear Wave Elastography (pSWE)

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Abstract

Introduction: Point shear wave elastography (p-SWE) is an emerging imaging technique. Studies assessed SWE confirmed that p-SWE has a higher rate of reliability and accuracy for measuring liver fibrosis and cirrhosis. Although it has been validated for some clinical applications such as liver and breast studies regarding its feasibility in pancreas stiffness assessment is still limited. Stiffness estimates offer an opportunity to better characterize the biomechanical properties of pancreas and hence, allow early detection of changes in pancreas tissue.

Methodology and Materials: This prospective study was approved by local biomedical research ethical committee No 483-21. This study includes 62 participants (31 diabetic patients and 31 healthy control). The pancreas head, body, and tail stiffness measurements in meters per second were obtained using Epic 9 Philips Ultrasound system using curvilinear transducer with frequency of 5- 1 MHz (C5-1). The scanning was performed by two certified sonographers at the diagnostic radiology department, king Abdul-Aziz university hospital, Jeddah, Saudi Arabia.

Results: The mean shear wave velocities (SWVs) of the entire pancreas parenchyma of the patients and control were significantly different with 1.1 ±0.3 vs 0.7 ± 0.29 m/s, p =<0.001. A significant difference was found between SWVs of pancreatic segments in both patients and controls. The mean (SD) velocities of pancreatic segments in patients and controls are as follows: head (1.0±0.4 vs 0.7 ±0.3 m/s, p = 0.04), body (1.1 ± 0.5 vs 0.7 ± 0.3, p = 0.01), and tail (1 ± 0.3 vs 0.7 ± 0.2, p =<0.001).

Conclusion: This study revealed that quantifying pancreas tissue stiffness using pSWE is feasible. Diabetic patients showed higher pancreas tissue stiffens compared to healthy volunteers. Further studies are required to determine the potential value of pSWE as a screening tool in the prediabetic stage.

Reference Phantom Method for Ultrasonic Imaging of Thin Dynamic Constructs

Andres Ruland[1], James H. Hill[2] and Gordon G. Wallace[1]

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Abstract

Quantitative ultrasound is a widely used technique in clinical and preclinical areas because it provides an objective and accurate evaluation of inner tissue properties. An interesting application of ultrasound is the monitoring of biodegradable hydrogels laden with mesenchymal stem cells and their chondrogenic differentiation to produce neocartilage tissue. The formation of parametric quantitative ultrasound images of backscatter intensity and local attenuation can be achieved with the use of the reference phantom method (RPM). However, such procedure may not be accurate when the specimen experiences great changes in its physical and biological properties over time, as it occurs during the formation of neocartilage in biodegradable hydrogels. In this work we have validated the use of the RPM for the evaluation of dynamic constructs with varying mismatch properties with respect to the phantom (sound speed, attenuation, thickness). It was found that the RPM was accurate for detecting large attenuation changes, and valid when using a small focal mismatch with respect to the phantom. However, the backscatter intensity resulted markedly reduced as a function of the sound speed mismatch with respect to the phantom. An empirical equation for correcting for such diffraction effect was developed. In this talk we will also present a brief demonstration on the use of RPM for the volumetric interrogation and quantification of neocartilage bio scaffolds as well as native articular cartilage. These results pave the way towards the standardization of quantitative ultrasound by enabling the use of a generic phantom independently of the specimen's sound speed.

Artificial Intelligence and Machine Learning

Simple and Cost-effective Medical Imaging Solution Setup in Combination with Cloud Technology as an Alternative to Conventional RIS-PACS

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Abstract

Introduction: Conventional RIS-PACS systems are expensive, bulky and require extensive security setup. 'The Envelope' was developed to liberate such constraints. This is achieved by combining selected hardware, PACS storage repository and cloud technology, creating an affordable yet powerful solution for medical image archiving and communication.

Findings and/ or Procedure Details: DICOM images from modalities are transmitted to a local DICOM respository (Osirix MD) via port 11118. Images are then automatically forwarded to a gateway (Ambra) through port 104. HL7 messages if present, are parsed via port 12000. For external transmission via WAN connection, port 443 with TLS 1.2 end-to-end encryption are utilized to ensure integrity and privacy. Subsequently, images are further processed and stored via Ambra's patent split-mergetechnology.

A registered user would then login to Ambra via a secured channel. At the backend, Ambra would combine anonymized DICOM data with respective metatags in its computer memory andtransmit via encrypted means to the user's browser.

Conclusion: Recent advances in information technology have enabled a RIS-PACS setup to be less complex and easily accessible without compromise of security and privacy. This in turn, decreases setupcost, time and space. RIS-PACS administrators and decision makers should therefore consider this alternative, which has been proven functional and practical.

**'The Envelope', an alternative medical imaging solution to conventional RIS-PACS was designed by DCM MedicalCentre incorporating Ambra Health cloud technology and in collaboration with Quantum Medical Imaging.*

Diagnostic Accuracy of Computer Aided Reading of Chest X-ray in Screening for Pulmonary Tuberculosis in Comparison with Gene-Xpert

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Abstract

Background & Objectives: Pakistan ranked fifth amongst 22 high-burden TB countries, and its epidemic in Pakistan, hence screening is performed nationally, as part of the ambitious ZERO TB drive. To assess the diagnostic accuracy of Computer Aided Detection (CAD4TB) software on chest X-ray in screening for pulmonary tuberculosis in comparison with geneXpert.

Methods: The study was conducted by Radiology Department Lady Reading Hospital Peshawar in affiliation with Indus Hospital network over a period of one year after ethical review board approval. Screening was done by using mobile X-ray unit equipped with CAD4TB software with scoring system. All of those having score of more than 70 and few selected cases with strong clinical suspicion however score of less than 70 were referred to dedicated TB clinic for Gene-Xpert analysis.

Results: Among 26,997 individuals screened, 2617 (9.7%) individuals were found presumptive for pulmonary TB. Sputum samples for Gene-Xpert were obtained in 2100 (80.24%) individuals, out of which 1825 (86.9%) were presumptive for pulmonary TB on CAD4TB only. Gene-Xpert was positive in 159 (8.7%) patients and negative in 1,666(91.3%). Sensitivity and specificity of CAD4TB and symptomatology with threshold score of ≥70 was 83.2% and 12.7% respectively keeping Gene-Xpert as gold standard.

Conclusion: Combination of chest x ray analysis by CAD4TB and symptomatology is of immense value to screen a large population at risk in a developing high burden country. It is significantly a more effective tool for screening and early diagnosis of TB in individuals, who would otherwise go undiagnosed.

Medical Imaging and Analysis

Mitigating Shortcut Learning of Deep Neural Networks in Medical Image Analysis

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Abstract

Deep learning has emerged as the leading machine learning tool in the domain of image analysis. Deep learning tools have been recently applied to healthcare problems, including computer-aided detection/diagnosis, disease prediction, image segmentation, etc. However, translation of deep learning technology from research to actual clinical use is highly challenging. Deep learning models need to be not only highly accurate but scalable and robust. Shortcut learning is when a deep learning model finds and follows a "shortcut" strategy to achieve astonishing results under familiar circumstances but fails under slightly different settings. Solutions to avoid shortcut learning are crucial to prove the clinical utility and maturity of the developed models. Thus, leading to more fair, reliable, robust and transparent deep learning based clinical decision support systems.

99mTc-Sulfur Colloid SPECT/CT in Diagnosis of Splenogonadal Fusion

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Abstract

A congenital abnormal connection between an accessory spleen and a gonad is called splenogonadal fusion. The parent of a 3-y- old boy brought him to King Saud Medical City because he had left scrotal swelling that had begun 1 y previously. 99mTc-sulfur colloid (SC) imaging has superior sensitivity and specificity in targeting the liver, spleen, and bone marrow, in that these are the only organs that 99mTc-SC can visualise. Furthermore, if these tis- sues appear anywhere other than their usual

locations, such as in the case of an accessory spleen, 99mTc-SC imaging can identify them even without biopsy or—in the case of splenogonadal fusion—orchiectomy. In the current case, the patient underwent laparoscopy, the masses were removed, and orchiectomy was avoided. Histopathologic examination confirmed normal splenic tissue, matching the imaging results.

Less Intense Focused Ultrasound

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Abstract

High-intensity focused ultrasound (HIFU) is a therapeutic technique that concentrates a high-power sound wave over a small area. The highly focused and intense beam produces heat and can be directed at benign or malignant tumors for local ablation without harming the surrounding tissues. This nonionizing, nonchemical, and noninvasive procedure promotes faster recovery times for patients. Despite the advantages, HIFU has several drawbacks, including a high-power requirement, prolonged treatment time, and unablated malignant tissues left at the tumor site. Researchers have enhanced HIFU with nanoparticles (NPs) – materials with length of 1 nm to 1000 nm in at least 1 dimension—to address some of the limitations of HIFU. This NP-enhanced synergistic HIFU provides less intense focused ultrasound to better modulate its power and target lesions more precisely.

4-D Imaging of Beating Tissues using Optical Coherence Tomography

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Abstract

An imaging technique which reconstructs structure and flow in tissue with repetitive motion was developed using Optical Coherence Tomography (OCT). The demonstrated technique can accurately image both host tissue and flow at different time points during a cyclic motion, such as a cardiac cycle. Using tissue-mimicking phantoms, a phase-sensitive spectral-domain OCT system was combined with a cyclic-motion simulator to demonstrate the feasibility of the method. 3-D flow information at different time points in the cyclical motion was reconstructed in the temporal domain thus generating the 4-D imaging of the target tissue. This method could expand OCT-based studies such as those with cyclic motions in tissues and open the door to 4-D vascular imaging of periodically moving tissues such as beating heart using OCT techniques.

Poster Presentations

Assessing if FMRI has a place in Predicting Suicidal Behaviors in High-Risk Adolescents

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Abstract

Suicide is the second leading cause of death among people in the age group of 15 to 24 in the United States. Risk factors include unstable family environment, mental health conditions, gender dysphoria, childhood trauma and lack of other protective factors. While existing screening tools for suicide are widely used for their feasibility, their sensitivity and specificity to screen for suicidal ideation are sub-par. It is known that the pre-frontal cortex is one of the last areas to mature in the brain and plays a role in the increased suicide risk. Our goal was to explore the role of brain imaging in suicide screening.

Multiple studies have shown evidence of imaging abnormalities including decreased volume and metabolic activity in regions of pre-frontal cortex in people with previous suicide attempt. Additionally, fMRI studies have shown abnormalities in functional connectivity between neural pathways involved in impulsivity and emotional regulation as possible pathways mediating increased risk for suicide.

Brain imaging studies have potential to serve as supplemental screening tools in the sphere of suicide prevention. Current data mostly focuses on adult population and anatomic variants make it challenging to quantify absolute suicide risk based off

imaging findings. There is a need for future studies exploring structural and functional brain changes in adolescent population. Early identification of adolescents at increased suicide risk can help unburden our health system that is inundated with patients with mental health challenges, especially with the ongoing COVID-19 pandemic.

Volumetric Segmentation in the Context of Posterior Fossa Related Pathologies: A Systematic Review

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Abstract

Background and Aim: Segmentation tools continue to evolve from manual methods to automated contouring technologies utilizing artificial and convolutional neural networks. These techniques have been used extensively to evaluate volumes of the ventricular system, tumors, and hemorrhages. Studies of the posterior fossa utilizing some methods of volumetric measurement have investigated pathologies including Chiari malformations, tumors, trigeminal neuralgia, cerebellar mutism syndrome, and Crouzon syndrome. Herein, we present a summary of the current literature pertaining to segmentation/volumetric analysis of the posterior fossa. This review highlights the various imaging and segmentation techniques along with objectives and outcomes of the studies conducted.

Method: A literature search was carried out in PubMed, Embase, Cochrane, and Web of Science.

Results: The search identified 2205 articles. 77 articles were selected for full text review after screening of abstracts, titles, and methods sections. Further screening based on relevance and availability identified 70 articles for inclusion in the review article. Segmentation techniques ranged from manual to automated approaches employing a variety of open source/custom software including convolutional neural networks. Most common pathologies investigated were Chiari malformations and tumors. Increased posterior fossa volume following suboccipital craniectomy was associated with symptomatic improvement in patients with Chiari malformation type I. However, posterior fossa volume/crowdedness failed to significantly differ between Chiari patients and controls in several studies.

Conclusions: Various forms of segmentation techniques have been used and each has its own advantages and disadvantages. We discuss these nuances and summarize the current state of literature in the context of posterior fossa associated pathologies.

Anatomic Contributions of Predictive Modeling in Chiari Malformation

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Abstract

Objective: Predictive modeling of Chiari I malformation patients has not yielded clinical data to determine baseline measures for optimal clinical outcomes. Measurements of the posterior fossa have yielded some promise in this regard; however, the data is sparse. We explore the correlation of foramen magnum areas (FMA), posterior fossa volumes (PFV), and a novel look at occipital Keel thickness (KT) to determine any association with postoperative outcomes in Chiari patients.

Materials and Methods: Retrospective chart analysis of 107 patients with CM was conducted. Data on patient clinical and surgical data, outcomes, as well as anatomic measurements were collected. A logistic regression model was used to predict symptomatic recovery controlling for age, KT, FMA, surgery type, and time to surgery.

Results: KT was lower in the Chiari patients under 25 ($p < 0.001$) than those older and did not differ from controls. There was a trend toward repeat surgery with larger KT. Larger FMAs were more likely to be associated with early symptomatic improvement. There was no association between PFVs and symptom improvement or need

for revision surgery. Logistic regression analyses determined the odds of symptomatic improvement was heavily reliant upon age.

Conclusion: Anatomical measurement and perioperative data are starting to be utilized in predictive models of outcomes in Chiari patients. KT and FMA may contribute to the development of symptoms in Chiari patients. Patients under 25 and with bony decompressions had higher odds of their symptoms improving within 30 days. Further work may yield stronger predictive models in the future.

A Rare Twin Pregnancy with Congenital Pulmonary Airway Malformation Type II

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Abstract

Introduction: Congenital pulmonary airway malformation (CPAM) is a lung mass that develops when abnormal alveoli are replaced by an overgrowth of disorganized pulmonary tissue. It occurs once per 25000–35000 pregnancies. The pulmonary artery supplies blood to the majority of CPAMs. Circulatory supply throughout the body suggests pulmonary sequestration (PS). Hybrid lesions (HLs) combine CPAM and PS histologic and imaging characteristics, indicating that these two entities have an embryologic origin. 20% below the hemidiaphragm, the descending aorta normally provides the arterial flow. CPAM has been classified by Stocker into five kinds based on the location or degree of involvement with the tracheobronchial tree. Small cysts (less than 2 cm) bordered by cuboidal or columnar epithelial cells are a hallmark of type 2 CPAM, which makes up 15%–20% of all CPAMs. It is closely related to other congenital abnormalities. Up to 50% of instances with type 2 CPAM are said to include SP. If not detected antenatally, HLs typically show up as respiratory distress or recurring infections throughout the newborn era. HLs can sometimes be unintentionally found on chest radiographs in older pediatric patients who are asymptomatic. Type 2 CPAM can be recognized on prenatal ultrasounds as an echogenic mass with several tiny cysts. Fetal MR imaging could help characterized it.

Report: A 32year old female with G2P1L1, 24 weeks 0 days twin pregnancy presented at radiology department for routine obstetric ultrasonography. Routine prenatal ultrasonography (US) revealed hyperechoic tubular small cystic regions with solid tissue in the lower lobe of the right lung of one of the twins, however the diaphragmatic rent could not be ruled out. So further evaluation was done with fetal MRI which revealed a large T2 hyperintense lesion in right lung possibly involving lower lobe which is characterized by a mixture of solid tissue and small cysts largest of size 9x8mm with an enlarged and T2 hyperintense right lung minimally displacing the heart towards left side noted with compensatory hypertrophy of left lung. No evidence of any obvious diaphragmatic defect noted. However, possibility of pulmonary sequestration could not be ruled out. Above imaging features suggestive of Type 2 CCAM/CPAM. The other Twin reported no anomaly and so pregnancy was continued till third trimester. Postnatal follow up Xray after supportive treatment showed diffuse opacification in right lower zone. However, as the twin is asymptomatic is kept under close follow-up.

Conclusion: Post antenatal USG, Fetal MRI evaluation helped in specifically diagnosing Type 2 CCAM/CPAM. giving more detailed view of site, extent of the lesion and helped in early diagnosis, follow up, postnatal prognosis and treatment saving the anomalous twin and giving positive clinical outcome by active postnatal management& resuscitation preventing further complications.

Sub-pericardial Hematoma Following Coronary Angiography

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Abstract

A rare case demonstrates the occurrence of sub-pericardial hematoma following percutaneous coronary intervention (PCI) in an individual presenting with symptoms of a myocardial infarction. A non-contrast CT chest was obtained to determine any evidence of significant hematoma. A focus of contrast was identified which was concerning due to the non-contrast setting. Therefore, the contrast was determined to likely be extravasated fluid from the PCI. Due to the appearance of this hyperdense focus, diagnosis of a hematoma due to perforation of the vein graft was made. The sub-pericardial location was determined due to the anatomical position close to the right ventricle. It is essential to recognize the focal nature and unique location of the

hematoma, positioned between the pericardium and the myocardium. Sub-pericardial hematomas of this nature do not usually lead to pericardial effusions or cardiac tamponades, making this complication specific to recognize for early and adequate treatment measures. However, long-term complications are still a possibility and therefore proper management, and monitoring is required. CT in this emergent context holds its merits in being a quick, convenient, and precise imaging modality, with the capacity to visualize an area of interest in multiple planes Hematoma was deemed stable following serial CT scans.

Comparison of Two Ultrasonography Operating Methods Used in Acupuncture to Avoid Risk of Pneumothorax

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Abstract

Ultrasound detection acupuncture (UDA) is an innovative acupuncture technique that uses ultrasonography to detect the depth of the pleura before performing acupuncture to avoid puncturing the lungs. For acupuncturists to appropriately use UDA, a good operating method to identify the pleura by ultrasonography is crucial. This study aimed to compare two ultrasound operating methods using active learning in a "flipped classroom" setting for acupuncture students. Students and interns were recruited to complete the UDA flipped classroom course and evaluate the operations of two ultrasound methods: the single B-mode with high echo reflex and the combined mode with high echo reflex and the "seashore sign" ("sand on the beach") in the M-mode. (Figure 1) Participants then completed satisfaction surveys. A total of 37 participants (19 students, 18 interns) completed the flipped classroom course and evaluations. The combined mode had better measurement accuracy, acupuncture safety, and shorter operating time ($p < 0.05$), and no pneumothorax occurred. Among both participant groups, the combined mode allowed the student group to learn quickly and the intern group to become proficient. The use of UDA in the combined mode can greatly reduce the measurement failure rate and improve learning efficiency. High satisfaction with the flipped classroom setting was also observed. These results show that the combined mode is helpful for the learning and promotion of UDA.

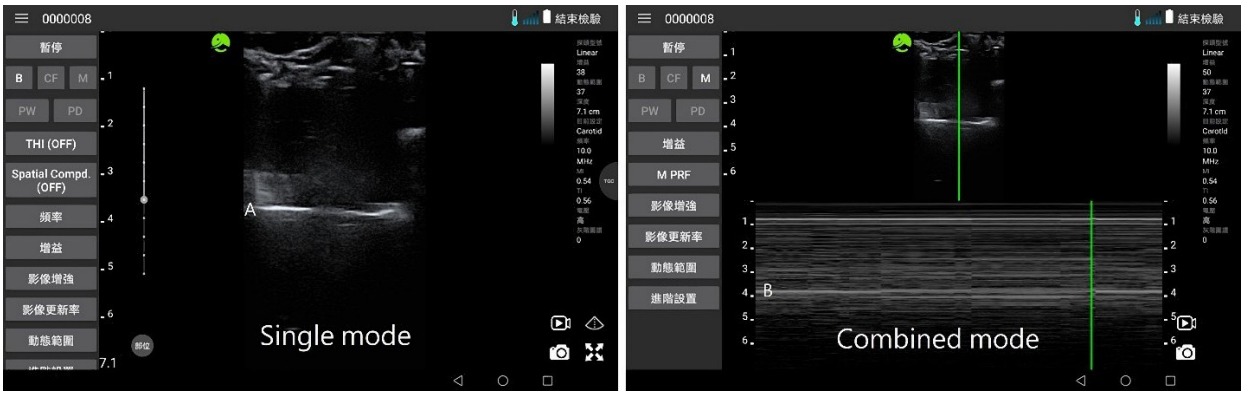

Figure 1: Ultrasound images in the single mode and combined mode. Left: B-mode (A: high echo reflex); Right: B-mode and M-mode (B: seashore line).

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