Abstracts

Medicinteknikdagarna 2023

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Ulrika Sandberg, Ledningsnätverket för Medicinsk Teknik (LfMT)

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Invited Speaker

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Karin Dembrower, St. Görans hospital

Oral presentations

Artificial Intelligence

2023-10-10
11:30 - 13:00

O1 - Automatisk utvärdering av regional lungfunktion möjliggörs med datortomografi och maskininlärning

1. AI, machine learning, big data in medicine

Emelie Bäcklin[1, 2, 3]
Simone Bendazzoli[1, 2], Bryan Connolly[1, 3], Birgitta Janerot-Sjöberg[1, 3], Örjan Smedby[1, 2], Magnus Sköld[1, 3], Chunliang Wang[2]
[1] Karolinska Instituet
[2] KTH, Royal Institute of Technology
[3] Karolinska University Hospital

Abstract text*: Bakgrund
I en tidigare studie av 294 forskningspersoner har vi sett att luftvägsobstruktion kan kopplas till automatiskt beräknade funktionella mätvärden genererade från datortomografi (DT) av lungorna både vid inspiration men framförallt vid expiration. Det är av stort intresse att analysera dessa mätvärden på regional nivå och i lungans enskilda lober. Lunglober har egen tillförsel av både luft och blod, och avsaknad av segmentering för enskilda lober kan påverka utfallet av undersökningar. I vår tidigare studie presterade kommersiellt tillgänglig mjukvara för lobsegmentering dåligt för expiratoriska bilder (ca 20% misslyckade). Vi har därför gått vidare med försök att förbättra segmenteringen av lunglober.

Metod
Inspiratoriska och expiratoriska DT-bilder (n=59) från Swedish CArdioPulmonarybioImage Study (SCAPIS) annoterades manuellt för lunglober av en erfaren radiolog. Totalt 48 par DT-bilder användes för att träna algoritmerna och 11 för att testa prestanda. En djupinlärningsalgoritm tränades för lunglobssegmentering med hjälp av DT-bilder och annoteringar från radiolog (algoritm A). Utifrån en hypotes om att lungkärlens riktning i gränsskikten mellan lober kan vägleda vid segmentering så tränades ytterligare en algoritm där vi adderade information om lungkärlen (algoritm B). De två algoritmerna utvärderades med hjälp av ”Dice-koefficient” som speglar volumetriskt överlapp samt ASD (”average surface distance”) som beräknades som medelvärdet av avståndet mellan radiologens annoterade yta och den av algoritmerna segmenterade ytan.

Resultat
Bägge algoritmerna kunde automatiskt segmentera alla inspiratoriska och expiratoriska DT-bilder och resultat för ASD och Dice-koefficient beräknades som medelvärde för alla lunglober. Algoritm B gav en förbättring i ASD om 9,5% i expiration och 7% i inspiration jämfört med algoritm A. Dice-koefficienten var 0,96 för båda algoritmerna i expiration, och 0,97 respektive 0,96 för algoritm A respektive B i inspiration.

Slutsats
Med hjälp av maskininlärning har vi tagit fram en automatisk algoritm för lunglobssegmentering som möjliggör vidare studier av regional lungfunktion både på expiratoriska och inspiratoriska datortomografibilder av lunga.

O2 - Age-Related Brain Atrophy Detection in Alzheimer's Disease via Deep Learning-Based Healthy Templates: A Cross-Sectional Study

1. AI, machine learning, big data in medicine
Jingru Fu[1]
Rodrigo Moreno[1]
[1] KTH

Abstract text*: Introduction
Alzheimer's disease (AD) is a pressing public health challenge due to the aging population. Early detection and monitoring of disease progression are crucial for timely diagnosis and effective treatment. Studies have shown that healthy aging and AD are intertwined, and AD is characterized by an accelerated aging process. The normal aging morphology can be described via a deep learning-based deformable template model directly on the interested cohort. A morphological biomarker can be developed via deformation-based morphometry using magnetic resonance imaging (MRI) which is associated with accelerated normal aging progression in AD.

Methods and Materials
Our framework (Figure 1) consists of four steps. First, T1-weighted (T1w) MRI scans from the OASIS3 dataset were collected and preprocessed. Next, a cohort comprising exclusively pure healthy subjects was created, and a deep learning model was trained to generate deformable templates of healthy brains. Subsequently, healthy templates were extracted at arbitrary ages, and unit healthy atrophy encoded in stationary velocity fields (SVFs) was extracted. Finally, a cross-sectional analysis was conducted by projecting the morphological vector onto the normal aging direction.

Results
Our findings demonstrated significant differences between cohorts (Figure 2), indicating the ability of our method to detect age-related brain atrophy in AD patients. By quantifying morphological changes, our approach holds potential as a biomarker for monitoring disease progression and evaluating treatment efficacy.

Conclusions
This study utilizes deep-learning-based healthy aging templates and models a morphological biomarker associated with accelerated aging progression in AD. By utilizing deep learning and deformable templates, our approach enables the estimation of normal healthy morphology and the detection of age-related brain atrophy more effectively. The observed significant differences among cohorts validate the effectiveness of our method in capturing disease-specific changes. This framework has the potential to enhance early detection and monitoring of AD, leading to improved clinical management and interventions.

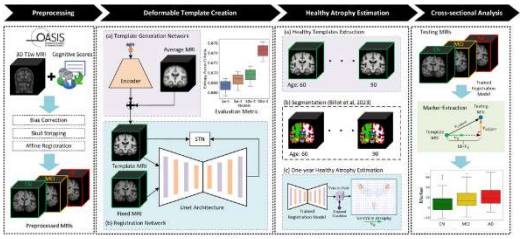

Figure 1. Workflow of the proposed method

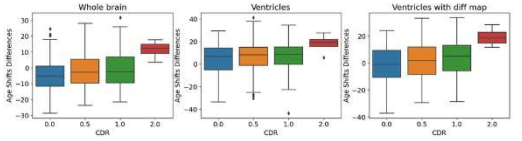

Figure 2: Boxplots illustrating group-wise differences in morphological age shift difference estimates for increasing disease stages. Three regions of interest were investigated: 1) Whole Brain: Morphological age calculations excluded the background; 2) Ventricles: Segmentation labels [4, 14, 15, 43] were included; 3) Ventricle with Difference Map: Highlighting distinctive morphological changes in the ventricles (i.e., the edges), defined by the difference map between the 50-years-old healthy template and 60-years-old healthy template. Pairwise Welch's t-tests were performed for the three regions. Significant differences were observed for all pairs in regions 1) and 3), except for CDR=0.5 vs CDR=1. For region 2), significant differences were found for the pairs CDR=0 vs CDR=0.5 and CDR=0 vs CDR=1. Morphological age shift difference showed an increasing trend with higher disease stages.

O3 - Effect of data leakage in deep learning-based image classification: A show-case on optical coherence tomography data

1. AI, machine learning, big data in medicine

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Anders Eklund[1, 2, 3], Neda Haj-Hosseini[1, 2]
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[3] Division of Statistics & Machine Learning, Department of Computer and Information Science, Linköping University, Sweden

Abstract text*: Background: Deep learning has pervaded the medical research landscape, with methods trained to solve a variety of medical imaging related tasks, such as classification, detection and segmentation. Even though capable, when blindly implemented, these methods are susceptible to biases during training, which can result in under- or over-estimated model performance.

Aim: The aim of this work was to show the effects of data leakage due to inappropriate data split on model evaluation in the context of deep learning-based classification of optical coherence tomography (OCT) images.

Methods: Three open-access OCT datasets extensively used in literature were part of this study, two ophthalmology datasets and one breast tissue dataset. A shallow convolutional neural network was trained on data split between training and testing using a per-volume/subject or per-image split strategy. Models were evaluated in terms of accuracy and Matthews Correlation Coefficient (MCC).

Results: Performance inflations from 0.07 to 0.43 MCC, from 5% to 30% accuracy, could be seen when models were trained and tested on an improper per-image split strategy, compared to a per-volume/subject split. The amount of inflation varied depending on the classification task and the dataset.

Conclusion: Data leakage due to improper dataset splitting leads to an over- optimistic classification performance. This work intends to raise awareness on a simple but overlooked problem in deep learning studies.

Reference: Tampu, I.E., Eklund, A. & Haj-Hosseini, N. Inflation of test accuracy due to data leakage in deep learning-based classification of OCT images. Sci Data 9, 580 (2022). https://doi.org/10.1038/s41597-022-01618-6

O4 - Early Characterization of Stroke Using Video Analysis and Machine Learning

1. AI, machine learning, big data in medicine

Viktor Johansson[1]
Elsa Thoreström[1], Nathalie Larsson[1], Andrei Borg[1], Marcus Lorentzon[1], Oskar Tryggvasson[1], **Stefan Candefjord**[1], Bengt-Arne Sjöqvist[1], Hoor Jalo[1]
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Abstract text*: Stroke is the second leading cause of death in the world and occurs due to an insufficient supply of oxygen to the brain caused by a blocked artery or bleeding. The outcome of a stroke patient is dependent on timely treatment which highlights the importance of an optimized prehospital assessment.

The aim of this project was to explore the possibility of using video analysis and machine learning to detect various stroke symptoms based on the National Institutes of Health Stroke Scale (NIHSS), which has the potential to improve prehospital stroke assessment. Videos (n=888) of the research group members were recorded when mimicking stroke symptoms, such as body weakness, facial palsy and dysarthria (speech disorder) based on NIHSS. Several algorithms were tested for the prediction of stroke symptoms, and their performance evaluated using accuracy, sensitivity and specificity of each algorithm.

The detection algorithm MediaPipe and Support Vector Machine (SVM) algorithm showed a 100% accuracy in the detection and classification of arm paresis. Leg paresis, on the other hand, was not successfully classified, possibly due to the angle of the camera making it hard to distinguish the leg from the rest of the body. HOG (Histogram of Oriented Gradients) features combined with SVM performed the best when detecting and classifying facial palsy, with all evaluation metrics above 97%. Google Cloud Speech-to-Text, a google supported speech recognition service, and the classification algorithms Deep Neural Network (DNN), SVM and AdaBoost showed a 100% classification accuracy for dysarthria.

The results show that various items of NIHSS have the potential to be digitalized using video analysis and machine learning. This project has several limitations such as a limited dataset and videos recorded by people with no education or experience in stroke symptoms, which suggests that more research in this area is required to confirm our results.

O5 - A CONVOLUTIONAL NEURAL NETWORK-BASED METHOD FOR THE GENERATION OF SUPER-RESOLUTION 3D MODELS FROM HIGH-RESOLUTION CLINICAL CT IMAGES

1. AI, machine learning, big data in medicine

Yijun Zhou[1]
Eva Klintström[2], Benjamin Klintström[3], Stephen Ferguson[4], Benedikt Helgason[4], Cecilia Persson[1]
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[2] Center for Medical Image Science and Visualization (CMIV), Linköping University, Sweden
[3] Dept. of Biomedical Engineering and Health Systems, KTH Royal Institute of Technology, Huddinge, Sweden
[4] Institute for Biomechanics, ETH Zürich, Zürich, Switzerland

Abstract text*: Accurately evaluating bone mechanical properties is crucial for predicting fracture risk based on clinical computed tomography (CT) images. Nonetheless, blurring and noise present in clinical CT images may compromise the accuracy of these predictions, consequently leading to inaccurate assessment of risk. To address these limitations, we developed a workflow that employs convolutional neural networks (CNN) to generate super-resolution (SR) 3D models from various clinical HR-CT images.

Available for this study were datasets of bone specimens scanned with six distinct HR-CT instruments that are accepted for clinical image acquisition in the peripheral bones. Furthermore, micro-CT datasets that served as the ground truth (GT) images of the same bone specimens were acquired. A CNN SR model was trained and utilized to generate SR versions of the clinical scanner images. The GT, HR-CT, and SR models were then compared based on three morphological parameters, namely bone volume fraction (BVF), bone-to-surface volume ratio (BS/BV), and trabecular thickness (Tb.Th). Additionally, we compared the mechanical properties using finite element (FE) simulation using Abaqus explicit solver (ABAQUS 2021, Dassault Systemes).

The SR models demonstrated superior morphological performance compared to their HR-CT counterparts (Fig. 1). Specifically, the SR models achieved average errors of only 17%, 16%, and 21% in terms of BVF, BS/BV, and Tb.Th, respectively. FE simulation also confirmed the accuracy of SR models, with stiffness and strength errors of only 10% and 9%, respectively. This represents a significant improvement over the HR-CT results, which had stiffness and strength differences of 771% and 539%, respectively, when compared to the GT results.

A modified deep SR network model based on CNN was successfully implemented to generate SR images from different clinical HR-CT scans. Our results demonstrate that the SR images outperform the HR-CT images in terms of accuracy, as confirmed by a 3D comparison to GT micro-CT scans.

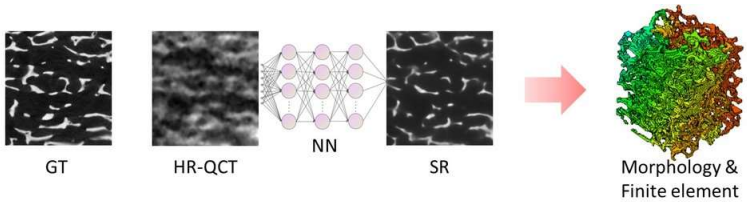


Fig. 1. The super-resolution (SR) workflow. Neural network models were trained based on ground truth (GT) images from micro-CT instrument and images from HR-QCT instrument. The generated models were analysed morphologically, and mechanically with finite element (FE) simulation.

O6 - Lesion Localization in Digital Breast Tomothsynthesis via Deformable Detection Transformer

9. Medical imaging, image processing

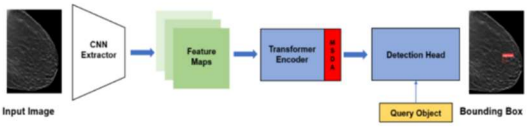
Zhikai Yang[1]
Örjan Smedby[1], Rodrigo Moreno[1]
[1] KTH Royal Institute of Technology, Department of Biomedical Engineering and Health Systems, Sweden

Abstract text*: Purpose
Manual examination of lesions in digital breast tomosynthesis (DBT) is time-consuming for radiologists. Deep learning-based automatic lesion detection has become an effective approach. The Detection Transformer (DETR) is a cutting-edge method for object detection. However, the various sizes of breast tumors pose challenges for DETR, particularly in localizing small objects within the size range. To address this issue, Zhu et al. proposed deformable DETR, which incorporates multi-scale feature information to improve the localization of objects across different sizes. In this study, we retrained the deformable DETR model specifically for localizing breast tumors in DBT. The experimental results demonstrated that deformable DETR outperforms all other methods used for comparison.

Methods and Experiments
We trained all deep learning models on an Nvidia GeForce RTX 3090 GPU with 24 GB of memory. The dataset comprised 223 breast images from the Digital Breast Tomosynthesis Cancer Detection Challenge dataset, 80% for training and 20% for validation. To ensure a fair comparison, we utilized Resnet50 as the backbone for feature extraction in the Faster RCNN, RetinaNet, DETR, and deformable DETR models. Performance evaluation was based on the metrics specified by the common objects in context (COCO) challenge, and implementation was carried out using the Detectron2 toolkit.

Table 1 presents the results, indicating that the deformable DETR achieved the highest mean average precision (mAP). Furthermore, it exhibited superior accuracy in detecting median (APm) and large-sized (APl) tumors compared to other methods.

Conclusion
In summary, we proposed to use the deformable DETR method to localize the DBT lesion. The preliminary results demonstrate that the deformable DETR could perform better than other methods. In the future, more datasets and extensive experiments with different sizes of backbone models will be used to validate the deformable DETR in DBT detection.



The framework of the deformable DETR for digital breast tomosynthesis detection. The MSDA denotes a multi-scale deformable attention module, which could capture the multi-scale feature information. First, a CNN backbone extracts feature maps from different receptive fields. Second, a multi-scale deformable attention module fuses different scale feature maps. Finally, the detection head and query object generates the bounding box for the lesion location.

Table 1: Performance of different detection models using the COCO metrics.

Methods	mAP $\times 10^{-2}$	AP50 $\times 10^{-2}$	AP75	APm	APl
Faster RCNN	4.6	11.3	2.2	9.1	4.1
RetinaNet	14.2	42.1	1.5	34.1	14.0
DETR	16.8	51.9	4.7	3.7	18.3
Deformable DETR	19.5	51.0	5.4	10.1	20.4

Biomechanics

2023-10-10
11:30 - 13:00

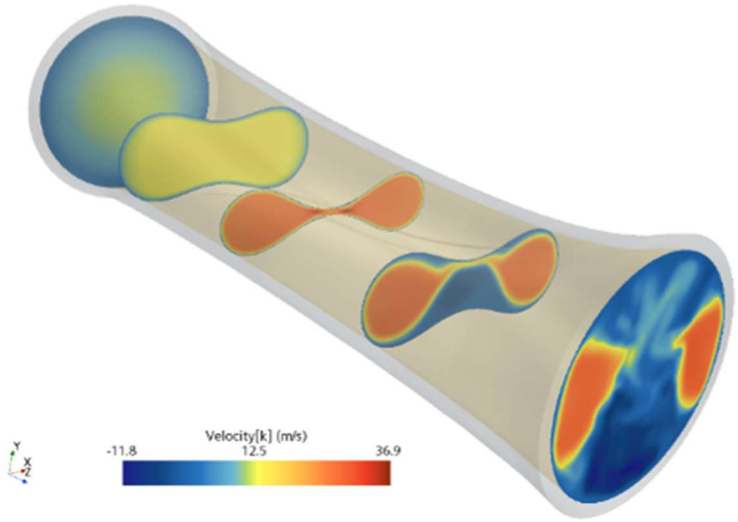
O7 - Acoustics and Fluid Structure Interaction of collapsible tubes relevant for biomedical applications

3. Biomechanics

Marco Laudato[1]

[1] KTH Royal Institute of Technology, Department of Engineering Mechanics

Abstract text*: Collapsible tubes are a simple yet powerful model for understanding the dynamics of the human vessels and airways. Despite their simplicity, indeed, their dynamics is rich enough to capture the most relevant biomedical aspects of the collapsibility, stenosis formation, thrombus formation, etc. of human vessels. Another advantage is that their simple geometry allows for reliable experimental validation. In this presentation, the complex Fluid-Structure Interaction (FSI) behaviour of a collapsible tube undergoing different physiological boundary conditions is investigated using a Computational Fluid Dynamics (CFD) numerical model. General equations for the buckling critical pressure and the contact critical pressure of a generic collapsible tube are derived. Another interesting aspect for biomedical applications is the study of the aeroacoustics of a collapsible tube and in particular the analysis of the sound generation mechanisms. The standpoint of this investigation is that the understanding of the main fundamental pathophysiological flow mechanisms and their relationship with the corresponding produced sound can be employed in the development of new diagnostic tools. Foreseeable applications of this methodology are the study of the dynamics of vocal folds, stenosis formation in the carotid, collapse of the pharynx in Obstructive Sleep Apnoea Syndrome, and mucus/air interaction in the lungs.



O8 - AN EXPERIMENTAL SETUP FOR ASSESSMENT OF TRACTION FORCE AND ASSOCIATED FETAL BRAIN DEFORMATION IN VACUUM-ASSISTED DELIVERY

3. Biomechanics

Estelle Pitti[1, 2]
Annelies Severens[1], Maria Pop[1], Lotta Herling[2, 3], Xiaogai Li[1], Gunilla Ajne[2, 3], Matilda Larsson[1]
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[2] Clinical Science, Intervention and Technology – CLINTEC, Karolinska Institutet, Stockholm, Sweden
[3] Clinical Science Pregnancy Care & Delivery, Karolinska University Hospital, Stockholm, Sweden

Abstract text*: Vacuum-assisted delivery (VAD) consists of placing a vacuum cup on the scalp of the fetus and applying traction to assist complicated vaginal deliveries. Despite its common use, VAD presents higher neonatal morbidity compared to natural vaginal delivery and biomechanical evidence for safe VAD traction forces is still limited (Romero et al. 2022). Furthermore, accurate methods to evaluate VAD are lacking, which hinders development of VAD safety. The aim of this study was to develop an experimental VAD testing setup and to investigate the impact of traction forces on fetal brain deformation. A patient-specific fetal head phantom was developed based on segmentation of the brain, skull, fontanelles and sutures in CT scans of a newborn using Slicer 3D 5.0.3. The brain phantom was cast in a 3D-printed mold using a composite hydrogel (6% PVA and 0.85% PHY in a 1:1 ratio) (Fig. 1a) and sonomicrometry crystals were used to measure the brain deformation. The skull phantom was 3D printed using multi-material Polyjet technology to print in one prototype different materials with realistic mechanical properties (Fig. 1b) (Jones M et al.2017). A metal Bird cup was placed on the skull using a vacuum pump and a digital force gauge (FH 1K, Sauter) was attached to record traction forces during simulated VAD (Fig. 1c) with a maximum force of 10-100N. The strain of the brain increased with increasing traction force, and at 100N a vertical strain of 3.4% was obtained (Fig. 1d). The experimental setup allows further investigation of the relationship between traction force and brain deformation to establish biomechanical evidence for safe VAD.

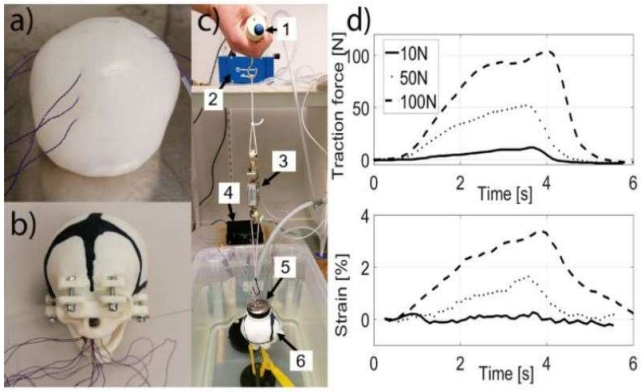

Figure 1:a) Fetal brain phantom (purple sonomicrometry crystal cables), b) Fetal head phantom, c) VAD setup, 1; VAD handle, 2; vacuum pump, 3; force gauge, 4; sonomicrometry, 5; VAD cup, 6; head phantom. d) Sample traction force and vertical strain curves.

O9 - Fat-IBC(Intra-Body Communication) based 3D printed Bionic Arm with multiple degrees of Freedom

3. Biomechanics

Arvind Selvan Chezhian[1]
Emil Bennedicks[1], Bobinis Augustine[1], Mauricio D Perez[1], Robin Augustine[1]
[1] Microwaves in Medical Engineering Group, Division of Solid State Electronics, Department of Electrical Engineering, Uppsala University, Sweden

Abstract text*: Bionic arms have witnessed remarkable advancements in restoring functional independence to persons with upper limb amputations. However, existing prosthetic solutions lack replicating the human arm's natural/full range of motion and dexterity. In this abstract, we present an innovative 3D-printed bionic arm design that embodies multiple degrees of Freedom, aiming to provide versatility with enhanced control to users.

The 3D-printed bionic arm comprises an advanced robotic platform augmented with a wireless communication module and a BCI system. The designed hand with multiple degrees of Freedom can perform a wide range of natural movements, including flexion, pronation, supination, rotation, and individual finger articulation. This extensive range of motion closely mimics the full functionality of the human arm, empowering users to perform their daily tasks with increased efficiency. The arm combines mechanical linkages, motors, and sensors to achieve these functionalities. The linkages are designed following the human anatomical structure of the arm to enable smooth, coordinated movements in multiple joints. High-performance precision motors are used to derive the necessary torque and speed required for each joint. At the same time, the integrated sensors give essential feedback on position, force, and grip.

The BCI system plays a pivotal role in wireless brain interface and uses non-invasive techniques to detect and decode the human neural signal linked with specific motor intentions. These signals are then processed and translated to trigger specific movements or actions in the bionic arm, fostering a more seamless and natural control without invasive surgical procedures.

This proposed system uses Fat-IBC(Intra-Body Communication) as a transmission medium for electric signals. Fat is used as a medium to provide seamless and real-time communication between the brain and the external component (bionic arm). This way, we eliminate the need for bulky batteries or wired connections, significantly enhancing the bionic arm's user mobility and comfort.

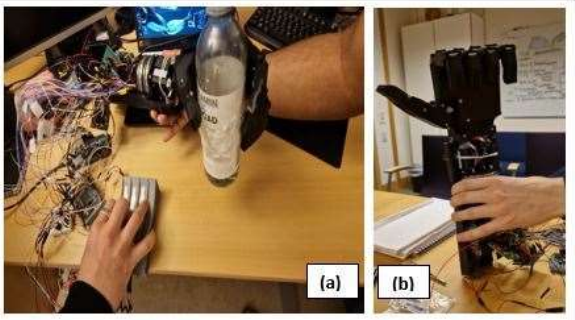

Figure a: Image depicting Bionic Arm holding the bottle with water.
Figure b: Bionic Arm showing flexion of fingers

O10 - Geometrical influence on backflow in centrifugal blood pumps in low flow conditions

3. Biomechanics

Federico Rorro[1]
Francesco Fiusco[1], Lars Michael Broman[2, 3], Lisa Prahl Wittberg[1]
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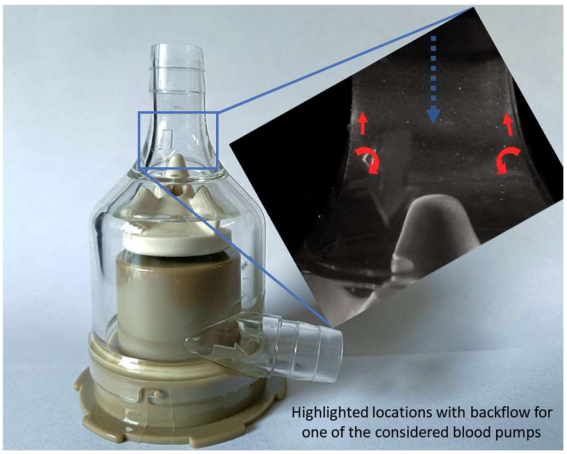
[2] ECMO Centre Karolinska, Astrid Lindgren Children's Hospital, Karolinska University Hospital, Stockholm, Sweden
[3] Department of Physiology and Pharmacology, Karolinska Institutet, Stockholm, Sweden

Abstract text*: Extracorporeal life support (ECLS) today clinically offered around the world includes support in a wide range of flow for applications of extracorporeal membrane oxygenation (ECMO) and carbon dioxide removal ($ECCO_2R$). Although lifesaving, complications of ECLS include bleeding, clotting, hemolysis or circuit components exchange (Combes et al. 2020). The circuit contains a blood pump, cannulae, oxygenator, tubing and connectors. Blood pumps available can deliver flow rates of 0-8 L/min and operate up to 10000 rpm depending on design. At low flow rates, computational fluid dynamics have reported blood pumps to have increased fluid residence time (Fiusco et al. (2022), Gross-Hardt et al. (2019)) and linked it to increased risk of hemolysis (Schöps et al. (2021)). Additionally, Fiusco et al. (2022) found a counter current flow in the pump inlet tubing.

In this study, experiments and simulations were used to investigate the backflow at the inlet of different certified ECLS pumps. Experimentally, both water and a more viscous blood analogue fluid were seeded with titanium dioxide particles, illuminated with a continuous laser and recorded with a high-speed camera (@ 10000 fps). Simulations were used to investigate the fluid structures developing in the pumps and mechanisms causing backflow at the inlet. At low flow all shrouded pumps presented stable recirculation zones resulting in a counter current flow at pump inlet (continuous red arrows). The shroud, a cover over the impeller blades, separated the flow domain into two regions. The region between shroud and pump case ceiling experienced reverse flow that, driven by the pressure gradient between pump outlet and inlet, reached the inlet tubing. Thus, pump geometrical features and low flow operations enhance the development of backflow at pump inlet.



Highlighted locations with backflow for one of the considered blood pumps

O11 - Motor performance after treatment of pilocytic astrocytoma in childhood - A study if motor performance is affected during different balance tests.

3. Biomechanics
Fredrik Öhberg[1]
Ilker Coskun[1], Gunilla Elmgren Frykberg[2], Ingela Kristiansen[3]
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[2] Department of Medical Sciences, Rehabilitation Medicine, Uppsala University
[3] Department of Women's and Children's Health, Pediatric oncological and neurological research, Uppsala University

Abstract text*: Pilocytic astrocytoma is a central nervous tumor, generally affecting children. It is a type of glioma, most found in the cerebellum. The treatment is mainly surgery and the prognosis after treatment is favorable. The cerebellum is complex, and it is involved in different functions such as balance and movements. The aim of this study was to study the balance performance of patients that during childhood went through surgical treatment after pilocytic astrocytoma.

A total of 19 patients and 38 matched controls were included. All the participants performed static balance tests based on mini balance evaluation systems test. Inertial sensors were used to collect data and measure angular velocity and joint angle. A linear mixed model was used to obtain estimated mean and 95% confidence intervals.

Adults with pilocytic astrocytoma had a higher angular velocity in the sagital plane (2.9 deg/s vs 2.1 deg/s) and frontal plane (2.4 deg/s vs 1.4 deg/s), compared to healthy controls, when performing one leg stance on their dominant leg. Children with pilocytic astrocytoma had higher angular velocity in the sagital plane (6.2 deg/s vs 3.7 deg/s) compared to healthy controls, when performing one leg stance on their dominant leg.

The motor performance was affected in patients with pilocytic astrocytoma. This was mainly showed by a reduced balance control when performing on their dominant leg. Therefore, this should be taken in consideration in clinical practice, and early treatment should be recommended for these patients.

O12 - Numerical investigation of fluid-structure interaction of simplified three-dimensional human soft palate in unsteady airway flow

3. Biomechanics

Peng Li[1]
Marco Laudato[1], Susann Boij[2], Mihai Mihaescu[1]
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[2] Marcus Wallenberg laboratory for Sound and Vibration Research (MWL), KTH Royal Institute of Technology, Teknikringen 8, Stockholm, 10044, Sweden

Abstract text*: Obstructive sleep apnea syndrome (OSAS) is a common breathing disorder, referring to partial or complete cessation of airflow during sleep due to upper airway collapse. One common symptom of patients with such sleep-induced apnea is the vibration or collapse of the flexible tissue of the upper airway. The knowledge of the tissue behavior subject to a particular airway flow is relevant for realistic clinic applications. However, in-vivo measurements are usually not practical. The goal of the present study is to develop a 3D fluid-structure interaction model for the human uvula-palatal system relevant to OSAS based on simplified geometries. Numerical simulations are performed to assess the influence of the different breathing conditions, the rigidity of the soft tissue and the variation of its length on the self-oscillation and obstruction dynamics. Meanwhile, the vortex dynamics is investigated for the coupled fluid-structure system as well.

Education and Experiences from Industry

2023-10-10
11:30 - 13:00

Näringslivets erfarenheter-Innovationsjakten: En vindlande resa från idé till färdig produkt

Hannes Hultgren, RaySafe/Fluke

Sammanfattning: Vi berättar om äventyren på Fluke & RaySafe som lett fram till nya metoder och ny teknik för testning av medicinteknisk utrustning. Först ut i vår nya produktserie är IDA-6, nästa generations infusionstestare. Vi delar med oss av våra viktigaste mättekniska insikter såväl som några av de misstag och lyckokast som skett under utvecklingen.
Det har varit en vindlande resa och det är så här sann innovation ser ut.

Experience from Industry-Safeguarding Healthcare: the role of data in medical device cybersecurity

Arno van der Heijden, Philips

O13 - Digital lärplattform för Sveriges medicintekniska avdelningar

4. Biomedical engineering education
Lars Carlsson[1, 2]
Elina Broman[1, 2], Leo Lantz[1, 2], Johan Olsson[1, 2], Katie Wu[1, 2]
[1] MTPodden
[2] Nerality

Abstract text*: Efter ett identifierat kompetensutvecklingsbehov har vi utfört en förstudie under våren 2023 där de tillgängliga utbildningarna inom branschen har utvärderats utifrån hur anpassade de är för ingenjörer på medicintekniska avdelningar. Resultatet från förstudien visade att ingen kurs är specifikt riktad mot ingenjörer på medicintekniska avdelningar, utan att innehållet är mer anpassat till tillverkare.

Via en undersökningsenkät som skickades ut till Sveriges medicintekniska avdelningschefer under sommaren 2023 har behov och önskemål för en utbildningslösning anpassad för medicintekniska avdelningar bekräftats. Enkäten identifierade även ett kartläggningsbehov av den kompetens som avdelningen besitter, vilken kompetens som behöver införskaffas samt vilka ämnen som avdelningarna ser störst behov av.

Ett koncept för en digital lärplattform har tagits fram med syfte att harmonisera kompetensutvecklingen på avdelningarna i Sverige där ett urval av medicintekniska avdelningar har fått möjligheten att testa och ge återkoppling på lärplattformens innehåll och funktioner. Under medicinteknikdagarna vill vi presentera det slutgiltiga resultatet av undersökningen och konceptet samt bjuda in till diskussion hur en lösning för en digital lärplattform skulle kunna ge värde till medicintekniska avdelningar.

Figur 1.Tidslinje för den pågående studien över behov för och önskemål av en anpassad utbildningslösning för medicintekniska avdelningar.

O14 - Healthcare Transformation Academy: Empowering Healthcare Professionals through continued education across Europe

4. Biomedical engineering education
Fernando Seoane
Farhad Abtahi, Heikki Teriö

Abstract text*: Unfortunately, the European vision for Lifelong Learning for Healthcare professionals has failed short while healthcare providers and healthcare professionals are today more than ever in need for it to ensure the professional development and up-skilling of the workforce to face the challenge for an effective, high-quality and sustainable healthcare.
The Healthcare Transformation Academy aims to offer customized programs to various healthcare professionals, focusing on incorporating the patient's perspective. By partnering with top-tier hospitals and medical education universities, the academy ensures high-quality education.
The European University Hospital Alliance, along with other organizations, created a consortium to identify competence gaps and develop courses using backward design methodology. The Kirkpatrick methodology was chosen for course evaluation. The consortium received financial support from EIT Health to establish the academy within four years.
In 2022, the academy, with 18 partnering organizations, offered 17 courses in areas such as innovation management in healthcare, high-value care, personalized and precision medicine, leadership development, and digital health transformation. An online community of practice is being developed to support the lifelong learning process through networking, and experience sharing. Accreditation and certification processes are being developed. More than 700 healthcare professionals and 39 facilitators from over 25 countries participated in the courses during last year, and 20 patients contributed to the academy. A lifelong learning partnership program has been initiated to expand the academy's reach across Europe.
In conclusion, the Healthcare Transformation Academy is successfully providing a diverse range of programs to healthcare professionals across Europe. While progress has been made, there is still room for development and scalability. The academy aims to become a self-sustainable lifelong learning ecosystem, enabling healthcare providers to stay updated with the skills and knowledge necessary for transformative actions within hospitals. The collaborative approach of the academy allows any hospital to join and benefit from it.

Imaging and Image Processing

2023-10-10
14:15 - 15:45

O15 - Speed-of-sound as a novel ultrasound imaging biomarker for breast cancer and density

9. Medical imaging, image processing

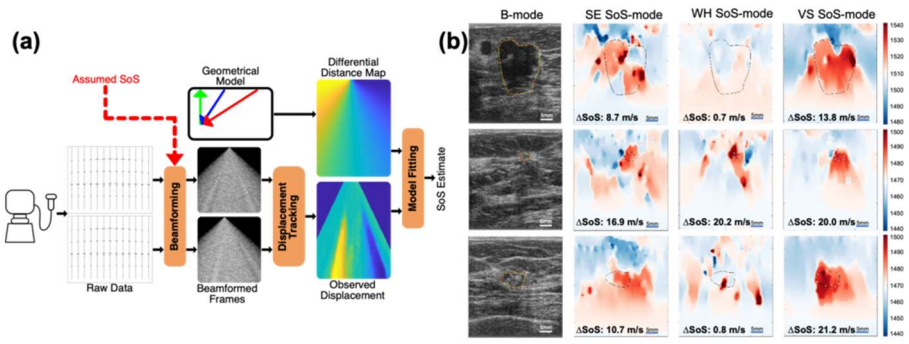
Can Deniz Bezek[1]
Dieter Schweizer[2], Rahel A. Kubik-Huch[3], Orcun Goksel[1, 2]
[1] Department of Information Technology, Uppsala University, Sweden
[2] Computer-assisted Applications in Medicine Group, ETH Zurich, Switzerland
[3] Kantonsspital Baden, Switzerland

Abstract text*: Being low-cost, non-ionizing, and real-time, ultrasound (US) is a widely used medical imaging modality. Typical B-mode US images display the reflectivity of tissue structures, which however is only qualitative information. Biomechanical characteristics, such as shear-modulus that can be estimated via ultrasound elastography, can provide quantitative tissue info. Speed-of-sound (SoS) is an alternative quantitative biomechanical marker that relates to bulk modulus and may therefore provide complementary and/or independent information on tissue composition and any pathology.

Reconstructing local maps of SoS as well as attenuation was proposed using transmission-based US computed tomography. These however require bulky and expensive setups, complicated to operate, and require suspending the anatomy in a water bath. For imaging tissue SoS, we instead develop pulse-echo mode US methods applicable on conventional US machines and transducers.

In this abstract, we first demonstrate a novel technique for global (beamforming) SoS estimation which is important both for the quality/accuracy of B-mode images and local SoS reconstructions. First, we beamform raw data from two different transmit (Tx) sequences using an assumed SoS value, Fig.(a). Any mismatch between actual and assumed SoS values causes a shift between the beamformed frames. Using these shifts/displacements and differential distance map from the transducer geometry, we estimate global SoS.

We also demonstrate our recent advances in pulse-echo SoS imaging of the breast. Local and global SoS estimations are sensitive to motion, which is inevitable when using hand-held transducers in clinical settings. We develop motion-insensitive imaging sequences and show that local SoS contrast can be imaged for differential diagnosis of breast cancer. We demonstrate this on three preliminary cases of breast cancer patients with biopsy-confirmed invasive ductal carcinoma, Fig.(b). We evaluated SoS contrast of manually-delineated inclusion to background. Clinical results shows the motion-resilience of developed virtual source (VS) Tx, compared to single element (SE) and Walsh-Hadamard (WH) Txs.



O16 - Improved frequency estimation using pre-beamformed ultrasound data

9. Medical imaging, image processing

Tobias Erlöv[1]
Magnus Cinthio[1]
[1] Department of Biomedical Engineering, Faculty of Engineering, Lund University

Abstract text*:

Background

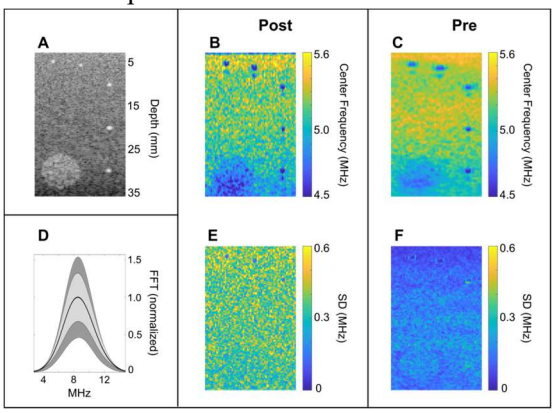
Frequency content in ultrasound data has been extensively used to characterize tissue, both in frequency- and time domain data. Normally the frequency is estimated in post-beamformed RF-data. But in this study we propose to instead estimate the frequency in pre-beamformed data, and then beamform the frequency values instead of the RF-data, leading to a significant increase in stability - potentially having a large impact on several applications.

Methods

Two different ultrasound scanners were used in this study and multiple independent acquisitions were made on a tissue-mimicking phantom. The imaged region contained objects that alters the backscattered frequency content compared to the surrounding homogeneous background. The frequency content in the RF-data, both in time- and frequency domain, was calculated in both pre- and post-beamformed data. Comparing results, the following was evaluated: 1) how frequency estimates varied between images, with depth and in relation to the aperture, 2) differences in spatial resolution.

Results & Discussion

The figure shows a B-mode image (A) and the center frequencies estimated in post- (B) and pre-beamformed data (C). Comparing ten similar but independent images, the frequency content was significantly more stable when using pre- (F) instead of post-beamformed data (E). The figure also shows an example of an FFT (D) and its standard deviation, when calculated in pre- (light gray) and post-beamformed data (dark gray). On average, the standard deviation decreased by 57% (time domain) and 40 % (FFT). The frequency estimates were consistently and significantly more stable when using pre-beamformed data compared to regular post-beamformed RF-data. This was true regardless of scanner, transducer, and pulse characteristics as well as for depth, location in relation to aperture and window sizes. Further, as can be seen in (A-C) when comparing the size of objects there was only a minor difference in spatial resolution.



O17 - Motion magnification improves 2D micrometer motion estimation in skeletal muscle B-mode ultrasound images

9. Medical imaging, image processing

Christer Grönlund[1]
Marko Nygård[2], Robin Rohlén[3]
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[2] Region Västerbotten, Umeå, Sweden
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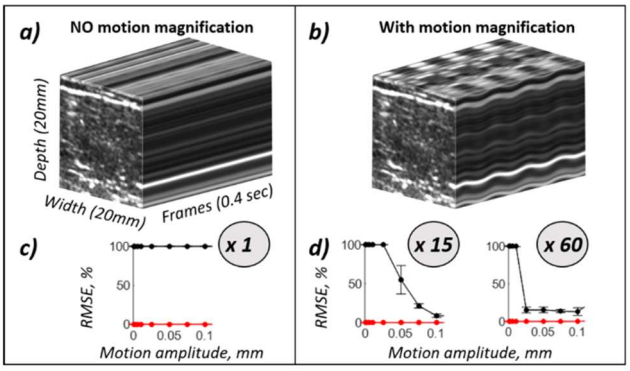
Abstract text*: Background
Ultrafast ultrasound (UUS) can detect the subtle microscopic motion of twitches of the fibers of individual motor units in skeletal muscles, providing new information on the motor unit to state-of-the-art electrophysiological techniques. Currently, the tissue dynamics of the UUS recordings are quantified based on 1D motion estimates in the axial direction. Since the muscle fibers are distributed within a multilevel mesh of connective tissue, causing complex deformations, 2D motions (axial and lateral directions) should better describe the neuromechanics of motor units. The challenge of using a 2D speckle-tracking technique on this application is that these subtle motions are on a sub-pixel level. This study hypothesizes that motion magnification can be used as a pre-processing step to improve sub-pixel motiontracking performances of motion-tracking techniques.

Methods
Motion magnification (Fig. 1a-b) was achieved using phase-based Eulerian Video Magnification by 1) spatially decomposing the images into different spatial scales, 2) applying a 5-25 Hz bandpass filter with a phase magnification step, and 3) finally reconstructing the sequence. Four 2D motion tracking methods were included covering conceptually different motion tracking methods; based on image registration, block-matching, and phase-shift. Finally, we used numerical simulations of skeletal muscle motions recorded using plane wave ultrasound image sequence to evaluate the concept. We evaluated the sub-pixel motion estimation performance with respect to the motion amplitude range, and motion magnification.

Results
We found that motion magnification improved the sub-pixel tracking performance of all tested tracking methods compared to their performance with no magnification – in both axial and lateral directions. Also, motion magnification enabled common motion estimation methods to track subtle muscle tissue motion down to 2.5-5 µm amplitude in the best cases and down to 25 µm in the worst case (Fig. 1c-d). Finally, motion magnification enables correct super-pixel motion visualization where no magnification provides no visual movement.



O18 - Speed-resolved perfusion imaging for assessment of chronic limb-threatening ischemia

9. Medical imaging, image processing

Martin Hultman[1, 2]
Sofie Aronsson[3], Karl Palm[3], Helene Zachrisson[3], Håkan Pärsson[4], Marcus Larsson[1], Ingemar Fredriksson[1, 2], Tomas Strömberg[1]
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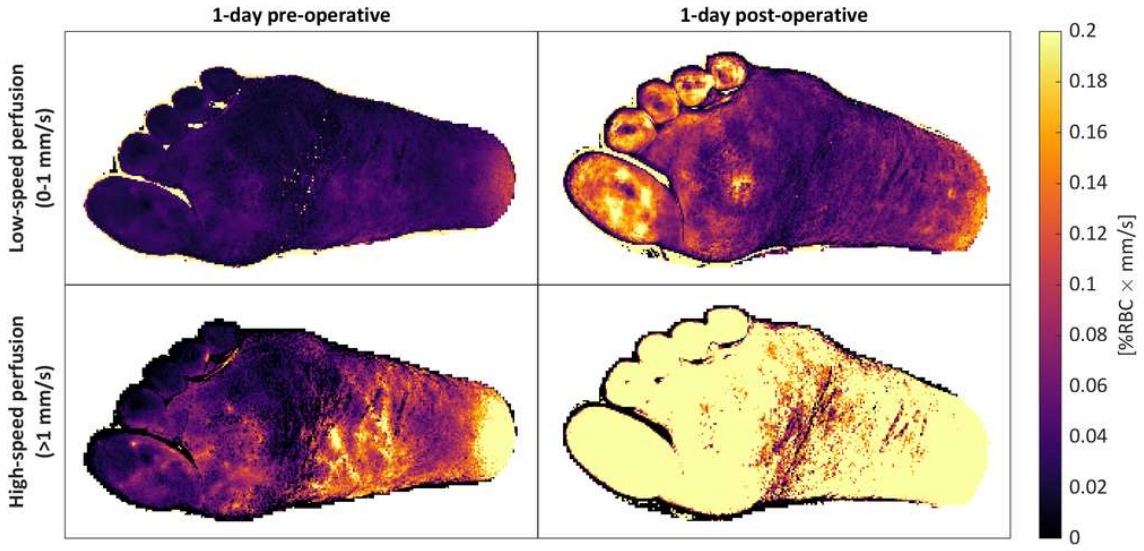
[2] Perimed AB, Järfälla-Stockholm
[3] Region Östergötland, Department of Health, Medicine, and Caring Sciences
[4] Linköping University, Department of Biomedical and Clinical Sciences

Abstract text*: Chronic limb-threatening ischemia (CLTI) is the end stage of peripheral artery disease associated with impaired quality of life, amputation, and mortality. Current clinical tools only assess macrocirculation, i.e. the flow in large vessels, but do not assess the microcirculation, i.e. where the oxygen exchange between the blood and cells take place. The global vascular guidelines for diagnosis, treatment, and monitoring of CLTI has advocated for the development of new technology measuring microcirculation, to better assess the function of this vital part of the circulation system. We present a new perfusion imaging system, based on multi-exposure laser speckle contrast imaging (MELSCI) and machine learning, that for the first time images speed-resolved perfusion of the microcirculation. Where existing perfusion imaging devices measure the overall perfusion in the microcirculation, our speed-resolved system can separate the contribution from low-speed and high-speed blood flow, giving more detailed insight into the physiology.

Here we present data from CLTI-patients admitted for intervention surgery to Linköping University hospital, where we measured 1 day before surgery, 1 day after surgery, and at a 1-month post-surgery follow-up. Several microcirculation parameters showed statistically significant changes from pre- to post- to revisit-measurement. These promising results suggest that, in combination with existing tools for macrocirculatory assessment, this technique can enable a more comprehensive assessment of the peripheral circulation in patients with CLTI.



Sensors and Diagnostic Systems

2023-10-11
08:30 - 10:00

O19 - Continuous monitoring of lung function for patients in intensive care using diode laser spectroscopy

12. Sensors, diagnostic systems

Anna-Lena Sahlberg[1]
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[2] Department of Clinical Sciences, Anesthesiology and Intensive Care Medicine, Skåne University Hospital, Lund University, Lund, Sweden
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Abstract text*: When patients are treated in a ventilator during intensive care, or put in ventilators during surgery, there is always a certain risk for lung complications to occur. There is an especially high risk for smaller children, since the margins for error in ventilation and treatment of complications are much smaller. There is also a large number of patients treated in intensive care for severe respiratory disorders, e.g., pneumonia, lung fibrosis, chronic obstructive pulmonary disease, and recently SARS-Cov-2. In the care of neonatal infants, lung complications constitute a severe risk due to lung immaturity. For all these patients, a non-invasive, harmless, continuous lung surveillance technique for careful monitoring of lung function and detection of complications, such as pneumothorax, can lead to optimal respiratory support and prompt detection and treatment of complications. Currently, there is no such diagnostics method available at hospitals: the most common method, X-rays, can only give a momentary image of the lungs and frequent X-rays carry risks especially for small children.

Lung monitoring with infrared diode lasers, using gas in scattering media absorption spectroscopy (GASMAS) has demonstrated an ability to continuously measure lung function in neonatal children and promptly identify severe lung complications, e.g., pneumothorax (collapsed lung) [1]. Lung monitoring in older children or adults using GASMAS has so far not been possible, due to the larger geometries leading to extremely low light intensities reaching the detector, as compared to the successful measurements on infant lungs. The current research is focused on how to scale up the successful application of GASMAS for lung monitoring from infants to larger children and adults for non-invasive, continuous lung monitoring in patients in intensive care [2].

References

[1] E. K. Svanberg et al., Pediatric Research, 89, 823-829, (2021)

[2] Y. Lin et al., Translational Biophotonics, 3, e202100003 (2021)

O20 - Dissecting the multiomics atlas of extracellular vesicles in Parkinson's disease

13. Other
Vaibhav Sharma[1]
Sanskriti Rai[2], Saroj Kumar[1, 2], Fredrik Nikolajeff[1]
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Abstract text*: Introduction

Parkinson's disease (PD) is a neurodegenerative disorder that currently suffers from diagnosis at late stages. As currently there is no cure for PD, the pressing need of the hour is the discovery of molecular markers that would be potent in diagnosing the disease at its early stages. Therefore, a biomarker with interconnecting links between the proteome and miRNAs may be imperative in PD. With the proven link of exosomes in the progression of neurodegenerative diseases, these nanovesicles have extensive potential in finding novel biomarkers for PD. To date, integrated omics-based profiling, establishing the links amongst proteomic and miRNomic of the exosomes has not been worked upon in PD. Our current work focuses on this area for opening up new avenues in the mechanistic details of this intricate neurodegenerative disease.

Methods

Salivary-derived EVs from PD patients and healthy cohorts were isolated by chemical precipitation followed by antibody-based validation through CD63, flotillin, and CD9 (universal surface marker) and confirmed neuronal origin by CD171. These nanovesicles were also characterized by an Electron microscope and via NTA. Additionally, miRNA and protein were purified from these different cohorts. Finally, miRNA and proteomic analyses were performed via Illumina and Mass Spectrometry-based platforms.

Results

We have correlated the multi-omics data from the exosomal set of PD-diseased and healthy cohorts. We were able to find some significant differences between PD patients and healthy controls. The miRNA data shows some unique miRNAs, solely expressed in PD disease. Additionally, proteomics data also highlights some possible biomarkers for PD. The implications of these results will be discussed.

Summary/Conclusion

This study highlights potential molecular biomarkers via extensive pathways analysis and interconnecting pathways between proteomes, and miRNaome respectively. These markers could later also be identified in the biofluids directly.

O21 - On-chip colorimetric assay for point-of-care lithium blood level determination using finger-prick-blood

12. Sensors, diagnostic systems

Carl Olsson[1]
Federico Ribet[1], Janosch Hauser[1], Olof Beck[2], Fredrik Wikström[2], Martin Schalling[2], Lena Backlund[2], Niclas Roxhed[1]
[1] KTH Royal institute of Technology, Stockholm, Sweden
[2] Karolinska Institutet, Stockholm, Sweden Introduction

Abstract text*: Introduction

Lithium (Li+) is one of the most effective mood stabilizers used to treat bipolar disorder, a prevalent disorder afflicting 1-2% of the population. However, Li+ treatment is problematic due to a small therapeutic window and the risk of severe adverse effects at high Li+ blood levels, necessitating the need for tailored doses to suit each patient. Li+ monitoring is essential for all patients undergoing treatment and is accomplished by frequent blood tests at the start of treatment with regular follow-ups three times a year. The lack of more frequent testing is one of the reasons Li+ is not used as often as it should since infrastructure for continuous testing, and follow-ups are needed. This work presents a prototype device that allows patients to perform these tests at home, like a diabetic patient monitors their glucose levels. We developed a simple-to-use and disposable point-of-care on-chip colorimetric assay for Li+ concentration measurements from finger-prick blood using a colorimetric assay.

Results and Discussion

We successfully demonstrated Li+ measurement using 60 µL spiked whole blood (Hct 45%) with an effective standard deviation of less than 0.08 mM. Results indicate a linear relationship between 0 mM and 0.9 mM with an R^2 of 0.94. Absorbance measurements were carried out at 550 nm and 490 nm using a plate reader.

Conclusion

This paper demonstrates a functional point-of-care prototype device able to precisely meter and mix a sample and reagent for on-chip concentration determination of Li+ in blood using a colorimetric assay. This platform is potentially compatible with any single-reagent assay. The presented device could help make Li+ treatments safer and available to more patients by increasing the frequency of measurements and decreasing the reliance on laboratories offering Li+ tests.

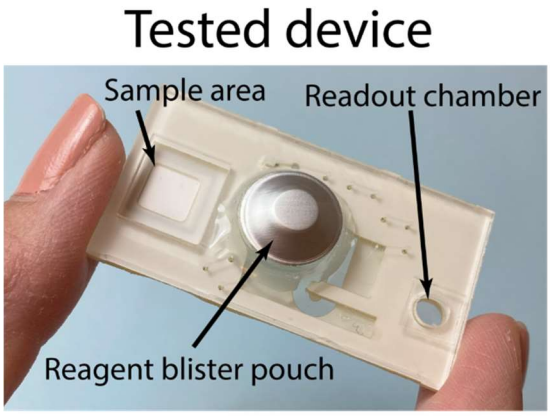

Figure 1: A fabricated device with dimensions 50 x 27 x 3.5 mm³.

O22 - In-line detection of TNF-α using an acoustic trap connected to an Infection-on-Chip model

12. Sensors, diagnostic systems

Gabriel Werr[1]
Lisette van Os[2], Joanna Nowacka[3], Dominik Eckardt[3], Olivier Guenat[2], Maria Tenje[1]
[1] Department of Materials Science and Engineering, Science for Life Laboratory, Uppsala University, Uppsala, Sweden
[2] ARTORG Center for biomedical engineering, University of Bern, Bern, Switzerland
[3] Miltenyi Biotec B.V. & Co. KG

Abstract text*: Introduction
Cytokine detection is a common procedure to follow cell-responses in organ-on-chip (OoC) systems. To reduce the required sample volume withdrawn from the OoC, we present a chip for in-line TNF-α detection from an Infection-on-Chip (IoC) model using a bead-based assay together with an acoustic trap and a confocal microscope for read-out. We demonstrate a volume reduction by more than 95% for the TNF-α detection assay.

Methods
The chip uses an acoustic trap to hold a cluster TNF-α-antibody coated capture beads (130-109-694, Miltenyi Biotec, Germany) in place against a flow of sequential sample, label, and washing fluid. The capture beads and the label are fluorescent at 530nm and 770nm respectively, using this the area for detection can be determined in the before and after pictures of the cluster. After the assay the cluster can be released and is ready to capture a new cluster for the next measurement. The total assay time is 40min.

Results and Discussion
It is possible to connect an acoustic trap to an IoC-model for repeated, in-line measurements of TNF-α concentration in the cell media. Preliminary results indicate an increase of TNF-α secreted by the immune cells over time, caused by exposure to LPS. To translate the measured intensities to TNF-α concentration, a calibration step will be done. This assay required 2.5µl of sample, the chip can also operate with aliquots of 5µl.

Conclusion
We have shown that the needed sample volume can be significantly reduced for bead-based cytokine assays by directly connecting an acoustic trap to an IoC.

Acknowledgments
This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No [812954]. We acknowledge Myfab Uppsala for providing facilities and experimental support. Myfab is funded by the Swedish Research Council as a national research infrastructure.

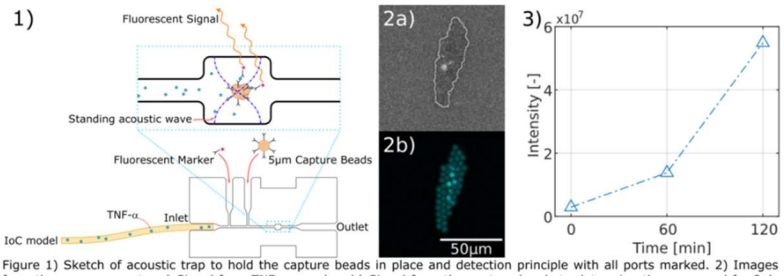

Figure 1) Sketch of acoustic trap to hold the capture beads in place and detection principle with all ports marked. 2) Images from the measurements, a) Signal from TNF-α marker, b) Signal from the capture beads to determine the area used for 2a). 3) Measured signal intensity from TNF-α, produced by immune cells stimulated with 1 µg/ml LPS over a time period of 2h.

O23 - A mobile app-based hearing test to detect 'the hidden hearing loss'

7. In-house medical devices
Amin Saremi[1]
Ghazaleh Ghaffari[1], Fredrik Öhberg[2], Per Hallberg[1, 3]
[1] Department of Applied Physics and Electronics, Umeå University, 901 87 Umeå, Sweden
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[3] Region Västerbotten, CIMT, Medicinsk teknik, FoU, 901 87 Umeå, Sweden.

Abstract text*: Hearing impairment is traditionally identified based on hearing threshold elevations (over 20 dB at any frequency) during the standard audiometry test. However, many listeners who are categorized as 'normal hearing' based on this definition, might still have substantial difficulty hearing in the presence of background noise. This phenomenon has been associated with damage to the auditory nerve terminals, a condition known as synaptopathy or 'the hidden hearing loss'. The auditory synaptopathy does not affect the hearing thresholds in silence but rather impairs the coding of the temporal information. We hypothesize that the hidden hearing loss can be detected by a psychoacoustic test known as 'temporal masking'. In this test, the participant is subjected to a stimulus containing a long noise, followed by a gap of silence, and a short tone. The purpose is to estimate the participant's hearing threshold of the tone as a function of the gap duration. A mobile application has been created in Java-Android to perform both tone audiometry and temporal masking. The tone audiometry is performed at 0.25, 0.5, 1, 2, 3, 4, 6, and 8 kHz. The temporal masking test is performed at 0.5, 2, and 4 kHz and at gap duration of 5, 10, 20, 40, and 80 ms. We have tested the mobile application in a group of 20 young individuals as compared with a standard clinical protocol, no significant differences were found. We are currently designing a clinical test to include hearing-impaired subjects in our study with two goals: 1) verify that these app-based tests yield similar results compared to their clinical-based counterparts in this group, and 2) validate our hypothesis about the 'hidden hearing loss' subgroup. To validate our hypothesis, we also include the standard hearing-in-noise test (HINT) that assesses the individual's speech perception in noisy background.

O24 - In-ear pulse wave amplitude recordings during synchronized walking

12. Sensors, diagnostic systems

Aurora Rosato[1]
Fran Iriso Wicijowski[1], Seraina A. Dual[1]
[1] Department of Biomedical Engineering and Health Systems, KTH Royal Institute of Technology, Stockholm, Sweden

Abstract text*: One way to improve hemodynamic efficiency is the synchronization of the stepping with the diastolic phase of the cardiac cycle (diastolic stepping), minimizing peak pressures on the heart level. At head level, we expect maximized pressure waves and maximized blood flow. On the contrary, stepping during systole has the opposite effect. The aim of this study is to analyze the pulse wave (PW) amplitudes in the ear during diastolic vs systolic stepping.

Four subjects (2/2 w/m, 27± 3 years) walked at a comfortable speed on a treadmill and guided by an auditory signal to achieve diastolic (5 min), constant (5 min) and systolic stepping (5 min). We acquired continuous PW on the subjects' tragus by an optosensor (TCRT1000, Vishay, USA), including analog filtering at 100 Hz (GD32VF103, GigaDevice, China). To validate the in-ear measurement, we compared the PW heart rate (HR) to the HR based on the electrocardiogram (ECG) at 125 Hz from a chest strap.

The HRs from the optosensor are on average 0.73 ± 1.4 beats/min lower than the ECG ones. During diastolic stepping, the PW amplitude is greater than during systolic stepping (16.2 ± 12.3% increase) and placebo (16.7±14.7% increase), Figure 1.

Synchronized walking modulates the PW amplitude in the ear in healthy subjects to a variable extent, resulting in maximized amplitude during diastolic stepping. The magnitude of the diastolic amplitude increase varies across subjects.
We observed high beat-to-beat variability in the measured PW amplitude, limiting beat-wise detection of synchronization. The results of the HR analysis suggest that some beats are missing or not recognizable in the PW signal. A more stable sensor configuration should be considered to decrease the variability and increase the accuracy. Further studies will investigate the higher frequency content of the wave and compare different sensor modalities to quantify pressure changes.

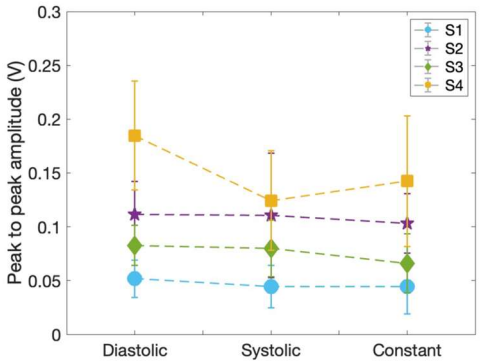

Figure 1: Normalized pulse wave peak to peak amplitudes during each stage

Cardiovascular Engineering

2023-10-11
08:30 – 10:00

O25 - The physiological basis for the longitudinal motion of the arterial wall

5. Cardiovascular engineering
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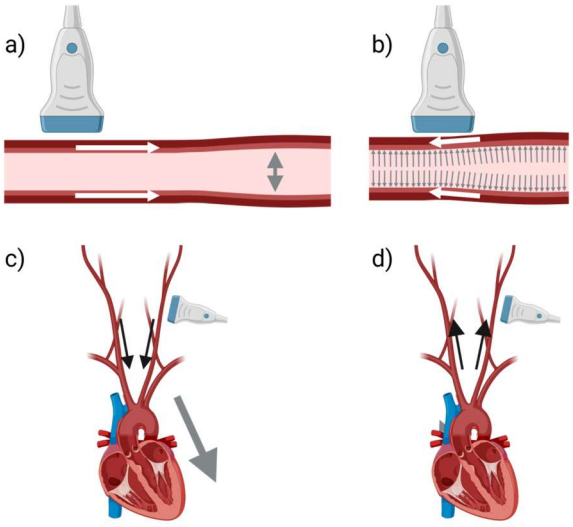
Abstract text*: The longitudinal motion of the arterial wall gain increasing interest thanks to its potential to be an image-derived marker for future cardiovascular disease and its potential importance for the vascular wall health. However, to understand the mechanisms between longitudinal motion and cardiovascular health an understanding of the physiological basis for longitudinal motion of the arterial wall is needed. The potential factors underlying longitudinal motion of the arterial wall *in vivo* are several and intertwined. Our potential hemodynamical scenario described below is based on numerical simulation models, phantom measurements, and i*n vivo* measurements. In the figure below the measurements site is marked by the transducer. a) A retrograde movement at late diastole occurs potentially due to the need of recruiting tissue distally (white arrows) via a longitudinal-circumferential mechanical coupling when the lumen diameter increases (grey arrow) proximal to the measurement site. b) An antegrade movement (white arrows) at early systole occurs potentially due to a longitudinal pressure resultant at the small taper angle formed by the propagating pulse wave (grey arrows). c) A retrograde movement at peak and late systole, probably originating from ventricular contraction that cause the fibrous aortic annulus to descend (grey arrow) and pull down the proximal vasculature creating an elastic wave that propagates through the vascular wall (black arrows) to the measurement site and creates a retrograde movement. d) During the retrograde movement an antegrade force is passing by the measurement site creating phase X at late systole. The antegrade force can potentially originates from the closure of the aortic valve. Other hemodynamical phenomena influencing the longitudinal motion include arterial stiffness, intramural friction, and pre-stretch of the arterial wall. Once again suggesting that the longitudinal motion of the arterial wall has a potential to be used as an image-derived biomarker for future cardiovascular disease.



O26 - Heart rate variability analysis in heart rate regions – a tool to study autonomic function in children with Long QT Syndrome?

5. Cardiovascular engineering

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Abstract text*: Heart rate variability (HRV) normally varies with heart rate (HR). Therefore, different adjustments have recently been suggested, such as dividing all HRV indices with mean heart rate. In this study, we instead focus on the analysis of HRV in different HR regions. The proposed method is evaluated in HRV assessed in 24-hour Holter-ECG recordings in children with the Long QT syndrome (LQTS), performed before and after the initiation of betablocker treatment.

Materials: Included were Holter-ECGs before and after initiation of betablocker treatment from 38 children with LQTS and 78 age- and sex-matched healthy children. The recordings were divided in 5-min segments and HRV was assessed based on auto regressive modelling in each segment. Log10-transformed HRV data were sorted in 10 different HR regions from 40-140 beats/min, and the mean HRV was calculated in each region. The relation between HRV and HR in each group was determined based on linear effects mixed model analysis, including a random intercept (corresponding to HRV at HR=60 beats/min) and slope (decrease in HRV at higher HR) for each subject.

Results: LQTS patients off betablocker treatment presented with a significantly steeper slope of the estimated regression line for total HRV compared to controls, but no significant difference in the intercept. No significant changes were noted in the slope or intercept for total HRV after betablocker treatment, but small changes were observed in the other spectral components.

Conclusions: By analyzing the relation between HRV and HR, we found that children with LQTS both before and after the initiation of betablocker treatment have reduced HRV compared to healthy children, but only at high heart rates. This has not been revealed in our previous analyses based on the traditional HRV analysis, i.e., by calculating the average HRV over different time periods (24-hour, day, night).

O27 - Numerical and experimental investigation of an ECMO drainage cannula

5. Cardiovascular engineering

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Abstract text*: Extracorporeal membrane oxygenation (ECMO) is a life-saving therapy used in case of heart and/or lung failure. Oxygenation of the blood is performed by a membrane lung placed in an extracorporeal circuit comprising cannulae for drainage and return of the blood from/to the native circulation, a pump to drive the flow and tubing with connectors. Exposure of blood to non-physiological conditions is related to thromboembolic complications, hemolysis and bleeding. Detailed knowledge of the flow structures occurring in the components under different scenarios is important to assess and mitigate these complications. An investigation of the flow structures occurring in a lighthouse tip drainage cannula was performed with computational fluid dynamics and particle image velocimetry. The objective was to quantify the variation in drainage performance and stress characteristics induced by different viscosity models, hematocrits, and flow rate ratios. The results showed that recirculation zones developed behind the 90° bends of the flow entering the side holes. The most proximal holes drained the largest fraction of fluid regardless of hematocrit and cannula-to-vessel flow rate ratio. The flow field was dominated by a jet-in-crossflow type of structure (Figure 1) and the effect of the non-Newtonian nature of blood was less relevant in the drainage area [1]. Two-dimensional data underestimated the shear stress levels of 50%. Due to blood behaving in a Newtonian fashion in the drainage area, drainage performance could be estimated by water experiments with appropriate scaling of boundary conditions.

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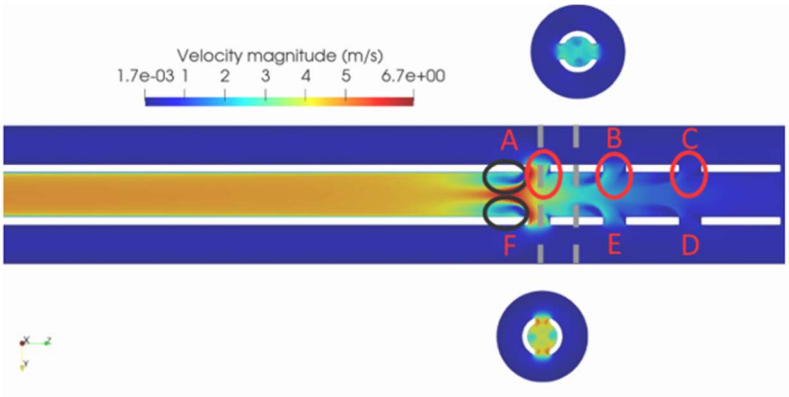

Figure 1: Time-averaged flow field highlighting jets in crossflow (red) and recirculation zones (black). The grey lines indicate the location of the cross-planes. Adapted from [1].

O28 - Vascular robotics: A bioinspired robot for versatile application in vascular channels

5. Cardiovascular engineering

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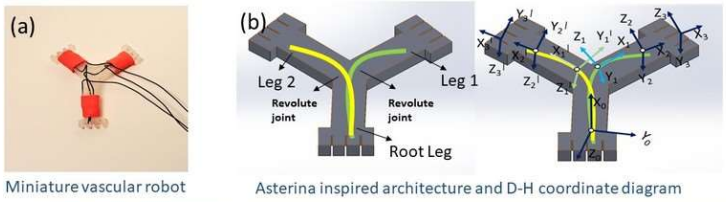
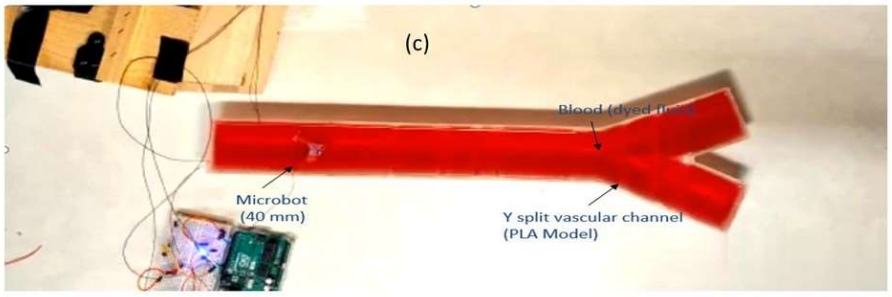
Abstract text*: Medical robotics has globally revolutionized healthcare technology in providing effective non-invasive treatments. However, most of these systems are expensive, bulky, and used as a tele-manipulator for surgery as it lacks the autonomous elements of a robot. In this work, we focus on creating a soft miniature robotic system that is scalable, conformable, inexpensive, and able to navigate human vascular channels for possible drug delivery and diagnostic applications.
The major diseases that cause early mortality in humans include cancer and cardiovascular disease. In the case of cancer treatment, an autonomous miniature robot could navigate to the exact location and deliver the drug to the affected area while protecting the healthy cells surrounding it. Also, in the case of cardiovascular disease like atherosclerosis, the miniature robot could navigate itself to the target and clear the block through suitable drug delivery or removal. Given its medical applications, the miniature robot in this work was manufactured to be fully biocompatible, and it was achieved by choosing a biocompatible shape memory alloy such as nitinol as the actuator and polydimethylsiloxane (PDMS) as its soft exoskeleton. The robot consists of three legs and is bioinspired by Asterina architecture, including the traversing gait. The fabrication of the robot was facilitated by hybrid additive manufacturing, and after process optimization, it could be made fully 3D printable, reducing overall production costs. We present the proof of concept using a flexible and conformal 40 mm miniature robot, which will be scaled down with further optimization. An emulatory Y-split vascular channel was 3D printed and filled with a simulated biological fluid. The proof of concept is demonstrated as a bioinspired robot traversing through this Y-split narrow channel.



Miniature vascular robot

Asterina inspired architecture and D-H coordinate diagram



Vascular robot traversing through Y-split channel

O29 - A computational platform for virtual trials of fluid responsiveness in critically-ill patients

5. Cardiovascular engineering

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Abstract text*: Intravenous fluids are commonly given to critically-ill patients to manage hemodynamics. Despite negative effects of fluid overload have been widely reported, assessing fluid responsiveness of a specific patient remains challenging. Mechanical ventilation affects hemodynamics through so-called heart-lung interactions. Such interactions have been used to develop methods for bedside prediction of fluid responsiveness such as pulse pressure variation and standardized ventilator maneuvers [1]. The applicability of such methods in different patient groups and mechanical ventilator settings are not fully understood and difficult to assess comprehensively in traditional clinical trials. We hypothesize that a computational simulation platform can be used to assess the performance of different fluid responsiveness methods in simulated critically-ill patients.

A previously validated computational cardiorespiratory model [2] has been extended with pulmonary capillaries and a module for mechanical ventilation to realistically simulate heart-lung interactions. The model was validated, both qualitatively by comparing general simulations output with heart-lung interactions described in the literature, and quantitatively by comparing the magnitude of simulation output such as arterial pulse pressure variations against clinically relevant values. The simulator can be tuned to a specific virtual patient by altering, for example, heart rate, systemic vascular resistance, left ventricular function and total blood volume. Different fluid responsiveness methods can be applied to the virtual patient.

The extended computational simulator has shown to capture realistic heart-lung interactions and can be used to assess different fluid responsiveness methods. This is a promising methodology to investigate fluid responsiveness methods and hemodynamic strategies in several different critically-ill patients groups in an efficient and systematic way.

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[2] L. Fresiello *et al.* 2015. doi: 10.1016/J.JBI.2015.07.004.

O30 - Assessment of Femoro-femoro Extracorporeal Membrane Oxygenation in a Computation Fluid Dynamics Model

5. Cardiovascular engineering

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Abstract text*: Venovenous (VV) extracorporeal membrane oxygenation (ECMO) is a last resort treatment for severe acute respiratory distress syndrome. The treatment requires blood to be drained, oxygenated and returned to the patient's venous system. Due to limitations in employing *in vivo* studies of cannulation, Computational Fluid Dynamics (CFD) simulations can provide valuable data on the performance of different strategies.

Femoro-femoro (FF) cannulation is an alternative to atrio-femoral (AF) and the more conventional femoro-atrial (FA). Under FF, both return and drainage cannulas are inserted in each femoral vein, eliminating the need for cannulation into the upper body. This project aims to aid in the definition of optimal cannulation strategies by quantifying the fluid mechanical characteristics and oxygenation performance of FF cannulation.

Using a previously published patient model, computer aided design models with ECMO cannulas were created [1]. The Maquet HLS Multistage 25Fr/55cm cannula was used for drainage and the Medtronic Bio-Medicus FLEX 21Fr/55cm cannula for return. To study the flow field, Large Eddy Simulations (LES) simulations were carried out, applying a non-Newtonian Quemada viscosity model. Different cannula flow rates (2 – 6 L/min) were considered. The results indicated that similar flow structures occurred in the right atrium, with and without FF cannulation. At high flow rates, FF cannulation displayed recirculation fractions (oxygenated ECMO return flow directly drained back into the ECMO circuit) similar to AF, and higher than FA. Moreover, similar to other cannulation strategies, the flow exhibited elevated shear stress levels that may impact coagulation in the patient.

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Biomaterials

2023-10-11
10:30 - 12:00

O31 - Nanotechnology-enabled medical devices against infections

2. Biomaterials, tissue engineering
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Abstract text*: Because of the continuous use and abuse of antibiotics to fight infections, antimicrobial resistance in some bacterial strains (the so- called "superbugs") has emerged. That constitutes the most serious public health threat today termed as "slow-motion catastrophe". Nanoscale materials offer advantages and solutions to this public health threat because they may exert antimicrobial action by multiple mechanisms rendering the emergence of antimicrobial resistance rather unlikely. In this talk, I will highlight a few examples utilizing responsive nanomaterials in medical devices against infections. We employ flame direct nanoparticle deposition on substrates and combine nanoparticle production and functional layer deposition in a single-step with close attention to product nanoparticle properties and assembly of devices [1-2]. For example, utilizing this technology, it is possible to develop nanomaterials as biosensors for physiological parameters (e.g. pH, H_2O_2) [2-4] relevant to bacterial infections or for food safety, as nano-enabled coatings on medical devices to eradicate bacterial biofilms [5,6].

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O32 - Electrical field accelerated wound repair – what we learnt from cell culture and the next steps towards clinical application

2. Biomaterials, tissue engineering

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Abstract text*: The concept of electrical field guided wound repair is based on electrotaxis, a mechanism common to many cells. When the skin cell migrate, they can align their migration trajectories under the influence of an applied electrical field. It is hypothesized that the endogenous fields of around 200 mV/mm that naturally occur around skin wounds promote cell migration into the open wound this way. Analogous to this, artificially generated electrical fields in the skin could draw advantage of the same mechanisms to encourage faster re-epithelialization by ensuring keratinocytes and fibroblasts invade the wound area more effectively. This would be particularly important for patient groups with impaired wound healing, which are at risk for developing a chronic wound.

Most of the experimental work on electrotaxis studies how the field act on single cells, and a field in the range of 200-400 mV/mm is sufficient to direct fibroblast and keratinocyte migration. Keratinocytes migrate cathodally while fibroblasts move towards the anode. In tissue, cells do not act as solitaires but are influenced by a multitude of factors including other cells. When keratinocytes form confluent layers their electromigration persists but traction forces and crowding of neighboring cells restrict their possible movements. We have been able to analyze this in a tailor-made microfluidic scratch test assay and shown that the most effective stimulation pattern is to stimulate across the wound. With such stimulation the model wound closes up to three times faster than controls. These findings has implications for how an electrical wound dressing should be designed to allow the most effective wound closure based on electrical stimulation.

My presentation will summarize our findings from 5 years of research on this topic and the next steps towards clinical translation. Finally, I will outline how such concepts may be translatable to other regenerative applications including implanted bioelectronics.

O33 - Antimicrobial Nanocellulose-based Wound Dressings for Treatment of Wound Infections

2. Biomaterials, tissue engineering

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Abstract text*: Wound infections significantly affect the physical and mental well-being of patients and impose a considerable financial burden on healthcare systems. Therefore, timely and effective treatment of infections is crucial for wound healing and prevention of severe outcomes.
In this study, we present novel wound dressing materials based on bacterial nanocellulose (BC) that combine excellent wound dressing properties with potent antimicrobial activity. BC is a nanofibrillar biomaterial which exhibits good gas permeability, transparency, conformability, and mechanical strength, which make it excellent for wound dressings. However, bacteria already present in the wound can thrive in the protected microenvironment under the wound dressing.
To confer antimicrobial activity to the BC dressings, we functionalized the BC with antimicrobial peptides (AMPs) which present high antimicrobial activity against multiple wound pathogens while demonstrating low cytotoxicity against human primary fibroblasts and keratinocytes. Two AMP release mechanisms were investigated: i) passive AMP release, and ii) release triggered by relevant wound proteases.
Passive release was achieved by AMP physisorption into pristine BC and mesoporous silica nanoparticle (MSN)-functionalized BC. Physisorption of AMP to BC did not result in release concentrations sufficient for eradication of infections. Instead, the use of MSNs resulted in more than 5-fold increase in specific surface area, while minimally impacting on the dressing properties. AMP loading capacity increased by 20% and AMP release increased by 8-fold. Furthermore, these dressings were able to retain the antimicrobial properties for longer times.
Triggered release mechanism was attained by loading AMPs into a protease-degradable hyaluronic acid hydrogel grafted to BC. The presence of collagenase-1 in the wound environment augmented AMP release by more than 6 times with respect to non-infected wound release.
The AMP functionalization of advanced BC wound dressings paves the way to improving the applicability and performance of these materials in facilitating the healing of infected wounds.

O34 - Nanocellulose meets host defense peptides: Investigating the functionalization of cellulose nanofibrils with KR-12 to obtain bioactive wound dressings

2. Biomaterials, tissue engineering

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Abstract text*: Chronic wounds are a major public health concern, associated with an economic burden estimated to be 2-4 % of the health budgets, and significantly affecting the quality life of the patients.[1] Chronic wounds are characterized by an unbalanced healing process with excess of reactive oxygen species (ROS), high level of proteases and in many cases bacterial infection. Bioactive dressings capable of stimulating local cells to migrate and proliferate, modulate the levels of ROS and/or fight bacterial infections are promising strategies to fulfill the unmet needs in chronic wound care.[1]

Wood derived cellulose nanofibrils (CNFs) present highly tunable properties in terms of surface chemistry and rheological properties, which makes it a valuable material for wound care applications.[2] Here we propose the functionalization of CNFs with the host defense peptide KR-12 to endow CNFs with antibacterial and anti-inflammatory properties. We investigated the effect of different functionalization chemistries (amine coupling through carbodiimide chemistry, thiol-ene click chemistry, and Cu(I)-catalyzed azide-alkyne cycloaddition) on the bioactivity of the KR12-CNF conjugates. The covalent incorporation of KR-12 onto the nanofibrils provided antibacterial activity against *Escherichia coli* and resulted in conjugates able to modulate the inflammatory response of lipopolysaccharide (LPS)-stimulated macrophages. The KR12-CNF conjugate prepared by thiol-ene chemistry was the most bioactive, a finding that was related with a favorable peptide conformation and accessibility as indicated by molecular dynamics simulations. This work represents a step forward in the development of CNF-based wound dressings for chronic wound care and provides valuable insights into the effect of functionalization chemistry on the bioactivity of immobilized host defense peptides.

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O35 - Additively manufactured Mg alloys may provide improved bioactivity

2. Biomaterials, tissue engineering

Niccoló De Berardinis[1]
Hanna Nilsson Åhman[1], Cecilia Persson[1], Gry Hulsart Billström[2]
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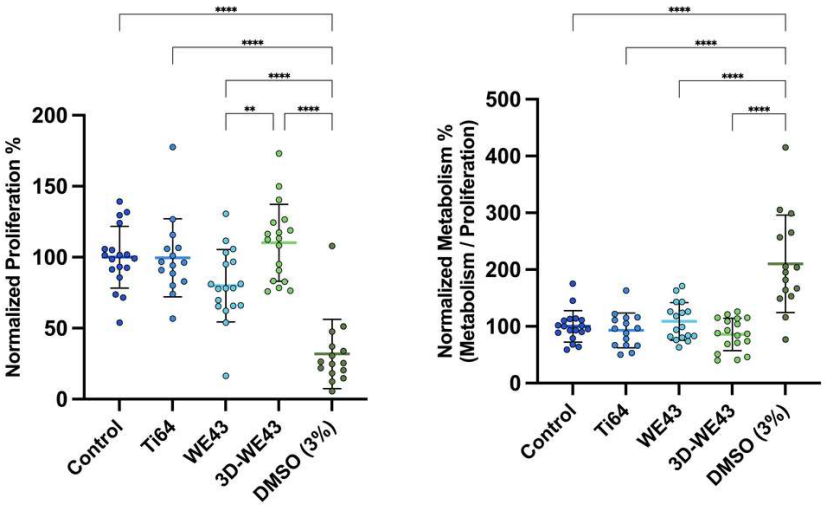
Abstract text*: Nowadays, magnesium alloys are considered to be one of the most promising materials for the production of biodegradable orthopaedic implants in the future. A reason for this is the numerous studies in the literature that have shown highly beneficial effects of Mg on various types of bone-related cells. Additive manufacturing techniques for metal alloys, such as PBF-LB (Powder Bed Fusion - Laser Beam), have allowed for possibilities to greatly improve design optimization compared to the standard extrusion production technique, where it is difficult to achieve complex structures as the material is forced through a series of dies to create the desired shape. In this study, we present a first step in the biological *in vitro* characterization of a WE43 Mg-alloy produced with PBF-LB (3D-WE43), evaluated against its extruded counterpart (WE43, Mg-4Y-3Nd) and one of the most commonly used titanium alloys for bone implants (Ti-6Al-4V, also extruded). The WE43 alloy was chosen as it is currently available in small (non-printed) screw implants commercially. The biocompatibility of the 3D printed WE43 was assessed by measuring both cell proliferation and metabolism of the well-established pre-osteoblastic mouse cell line MC3T3-E1, cultured with conditioned media produced by the extraction of the different materials considered in the study. All analyzed materials performed extremely well in terms of maintaining cellular metabolism and, remarkably, in terms of proliferation, 3D-WE43 showed the highest value among all of them, significantly higher than the extruded WE43. These findings will be pursued in more advanced studies to increase the understanding of the effect of the combination of this advanced manufacturing technique and the bioactive effect of Mg-alloys.



O36 - An examination of microbiological and structural interactions between implants and tissues in a cohort of extracted bone-anchored hearing implants

2. Biomaterials, tissue engineering

Marsel Ganeyev[1, 2]
Margarita Trobos[1], Tim Calon[3], Malou Hultcrantz[4], Howard Savage Jones[5], Peter Monksfield[6], Robert Stokroos[3], Peter Thomsen[1], Anders Palmquist[1], Martin Lars Johansson[1, 2]
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Abstract text*: Most of the current knowledge about bone conduction devices (BCDs) is based on subjective clinical measurements, while information about the biological events at the interface between tissues and the devices is limited. Very few cases have analysed the implant and surrounding tissues, as controlled elective retrieval is rare. To gain a better understanding of the mechanisms for successful and unsuccessful outcomes, the present study has implemented multiple analytical and correlative strategies, allowing for an investigation of the interface between tissue and BCDs in humans. Thus, the main objective of this study is to identify correlations between implant-tissue interactions and clinical patient data to further transfer it into translational research.

We have previously concluded that systematic retrieval protocols can be implemented to efficiently preserve tissue for state-of-the-art analytical techniques, and by using a logistic scheme, we can correlate the clinical history of patients who have had their implants removed with the microbiological, cell biological, and morphological fingerprints obtained in the laboratory. Thus, in the established network, different sampling procedures and analytical tools were employed, including X-ray micro-computed tomography (micro-CT), histology/histomorphometry, fluorescence in situ hybridization (FISH), and microbiology. To date, 13 electively retrieved BCDs have been investigated. Reasons for removal were chronic pain, recurrent infection and inflammation, or mechanical complications. Prior to retrieval, tissue samples were obtained for molecular and microbial analyses in some cases. After retrieval, tissue samples were subjected to micro-CT analysis and embedded for histological and ultrastructural analyses. In the present work, we combined the collected data for the biggest cohort of explanted BCDs.

By implementing a systematic retrieval network and a subsequent multi-scale analytical strategy, it is possible to improve the correlation between the clinical history of patients and the microbiology, cell biology, and morphology of the tissues that interface with electively removed or failed bone conduction implants.

Digitalization and Informatics in Healthcare

2023-10-11
10:30 - 12:00

O37 - A Scoping Review of Views, Use, and Experiences of Online Access to Pediatric Electronic Health Records for Children, Adolescents, and Parents

6. Digitalization and informatics in healthcare

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Abstract text*: Ongoing efforts worldwide to provide patients with patient-accessible electronic health records (PAEHRs) have led to variability in adolescent and parental access across providers, regions, and countries. There is no compilation of evidence to guide policy decisions in matters such as access age and the extent of parent proxy access. With the aim of summarizing existing knowledge about different stakeholders' (eg, children and adolescents, parents, health care professionals (HCPs), policy makers, and designers of patient portals or PAEHRs) views, use, and experiences of electronic health records (EHRs) access for children, adolescents, and parents, we conducted a scoping review. The literature search of papers published between 2007 and 2021 resulted in 4817 identified articles and 74 (1.54%) included articles. The papers were predominantly viewpoints based in the United States, and the number of studies on parents was larger than that on adolescents and healthcare professionals combined. First, adolescents and parents without access anticipated low literacy and confidentiality issues; however, adolescents and parents who had accessed their records did not report such concerns. Second, the main issue for HCPs was maintaining adolescent confidentiality. This remained an issue after using PAEHRs for parents, HCPs, and other stakeholders but was not an experienced issue for adolescents. Third, the viewpoints of other stakeholders provided a number of suggestions to mitigate issues. Finally, education is needed for adolescents, parents, and HCPs. Our findings could inform the design and implementation of future regulations regarding access to PAEHRs. Further examination is warranted on the experiences of adolescents, parents, and HCPs to improve usability and utility, inform universal principles reducing the current arbitrariness in the child's age for own and parental access to EHRs among providers worldwide, and ensure that portals are equipped to safely and appropriately manage a wide variety of patient circumstances.

O38 - Towards providing type-2 diabetes patients with homogenous information on physical activity

6. Digitalization and informatics in healthcare

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Abstract text*: Aiming at developing a digital support system which provides specific promotion of physical activity (PA), an online questionnaire was administered to Swedish nurses specialized on diabetes in 2021. We investigated what PA information is provided to non-insulin dependent patients with type-2 diabetes mellitus (T2DM), and how this corresponds to existing recommendations on PA. The questionnaire contained both yes/no and open-ended follow-up questions.

eFYSS states that patients with T2DM should perform 150 min/week of PA at moderate intensity (distributed over 3-7 days/week), or 75 min/week of PA at vigorous intensity (distributed over 3-5 days/week), and resistance training (8-10 exercises, 8-12 repetitions, 1 set, 2-3 times/week). The PA's effect on blood glucose level regulation lasts only for 48 hours. Therefore, the time between resistance training sessions shall be < 2 days.

A total of 44 nurses, representing a majority of the Swedish regions, responded. Information on PA is provided in written, orally, and/or practically to patients recently diagnosed with T2DM. The majority of the nurses provide recommendations on duration per week, frequency, intensity and type of PA.

Their recommended duration per week varies: > 150 min (20 nurses), > 210 min (14 nurses), > 420 min (one nurse), and individualized recommendations (7 nurses). Five nurses recommend a certain duration per week but adjust it to the individual if required, and 18 nurses recommend their patients to perform resistance training. Some of them include it in the total recommended duration per week, others do not. The recommended intensity varies.

The study, conducted within the scope of the KKS-funded ESS-H+ research profile, shows that several nurses provide PA information that does not corroborate with current PA recommendations.

Since patients with T2DM feel as good as possible if performing self-care according to treatment guidelines, we recommend the provision of homogeneous and correct PA information through a digital support system.

O39 - En förstudie av utmaningar och behov i det dagliga arbetet på intensivvården

6. Digitalization and informatics in healthcare

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Abstract text*: Bakgrund
Intensivvårdsavdelningen hanterar och genererar stor mängd patientdata. Personalen utsätts dagligen för hög kognitiv belastning och måste lära sig att navigera bland all data för att hitta rätt information vid rätt tillfälle och därmed kunna ge patienten den bästa tänkbara vården.

Syfte
Syftet med denna studie var att tillsammans med sjukvårdspersonalen på intensivvården kartlägga deras arbetsflöde samt hitta utmaningar och behov i det dagliga arbetet, specifikt med fokus på interaktioner med datasystem och annan personal.

Studiedesign
I studien deltog totalt 26 läkare, sjuksköterskor och undersköterskor från två svenska intensivvårdsavdelningar. Intervjuer hölls för att förstå det dagliga arbetsflödet för de tre personalkategorierna. Observationer på plats gjordes för att identifiera skillnader mellan *beskrivet arbete* och *utfört arbete*. Två workshops genomfördes för att bekräfta och komplettera fynden samt elaborera kring de utmaningar och behov som observerats under processen.

Resultat
Fem olika datasystem användes frekvent: journalsystem, PDMS (Patient Data Management System), SIR (Svenska Intensivvårdsregistret), läkemedelsprogram samt PACS (Picture Archiving and Communication System). Utöver dessa tillkom dessutom interaktioner med medicinteknisk utrustning, intranät och lokala PM samt telefonkontakter. Även om digitala system användes i olika utsträckning på de två intensivvårdsavdelningarna fann vi att utmaningarna var påfallande överensstämmande. Tre huvudområden identifierades: kommunikation, dokumentation och patientöversikt. *Kommunikation* och informationsöverföring sker oftast muntligt trots olika system, vilket kan bli ett problem då information lätt faller bort mellan olika skift. *Dokumentation* tenderar att nedprioriteras på grund av att det är tidsödande och ofta inte den mest kritiska uppgiften. *Patientöversikten* är ibland svår att få då information lätt försvinner i mängden av data. Även om informationen finns i dagens system är den ofta dåligt visualiserad.

Slutsats
Många olika system som är tänkta att underlätta arbetet för intensivvårdspersonalen upplevs begränsande och irriterande då det tar lång tid att logga in, systemen är inte integrerade med varandra och data är dåligt presenterade.

Föreläsning och diskussion: Information och IT-säkerhet för MT lösningar

Carl-Johan Ekelund/ Atea (45 minuter)

Informationssäkerhet – möjliggöraren!

”Informationssäkerhet är något många uppfattar som en bromskloss i digitalisering, ”the no in innovation” lite skämtsamt. I själva verket är det i samband med informationssäkerhetsarbetet man kan lägga alla kort på bordet och se till att de som kan och ska ta beslutet gör det på bra grunder.

Atea går igenom vanliga missförstånd och situationer, hur man kan arbeta för att undvika dessa och vem som egentligen ska ansvara för vad.”

Innovation and Translation in Biomedical Engineering

2023-10-11
13:15 - 14:45
Innovation and translation in biomedical engineering

O40 - Single-use microwell chips for immune cell screening

8. Innovation, translational biomedical engineering

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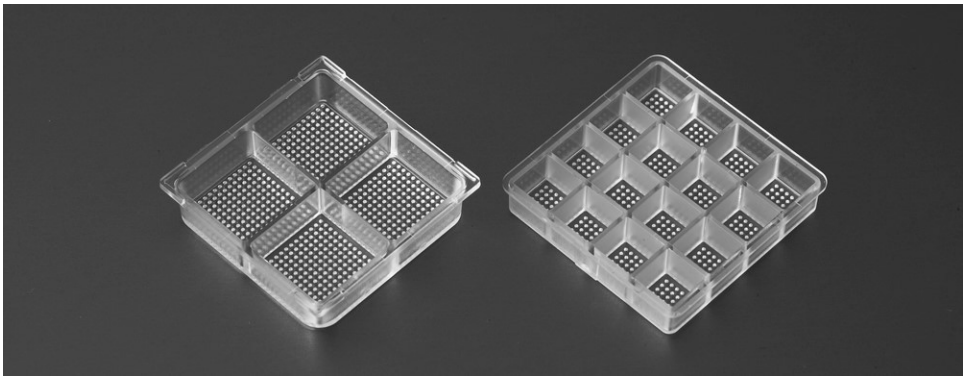
Abstract text*: Immune cell screening assays plays a critical role for the development and evaluation of immunotherapies for cancer patients. Longitudinal assays based on microscopy screening can reveal heterogeneity in immune cell dynamics and function, such as cytotoxic potential against tumor cells. Single-use plastic multiwell plates are often used in these types of assays, both in research and clinical settings. Their strength relies on the use of an array of wells in which many different conditions can be tested. On the other hand, they are limited by low optical quality, screening performance and large volumes. Alternative miniaturized methods have been developed to address these issues, for example microwell chips, but they are often based on expensive materials or fabrication technologies that restrict their use to academic research. Together with a Swedish industrial partner, we have recently developed injection molded plastic microwell chips that joins the merits of single-use plastic multiwell plates and high-performance microwell chips. Our chips have excellent optical properties and enable rapid screening as well as high-resolution imaging of immune cells. We demonstrate the applicability of the single-use chips in both conventional 2D cell assays and 3D tumor spheroid assays. The chips can be used for both routine imaging tasks as well as complex assays, offering the possibility to relate dynamic functional readouts and phenotypic snapshots in the same cell or spheroid. Our aim is that these newly developed plastic microwell chips will enable the use of advanced immune cell imaging assays for immunotherapy development and precision medicine in the clinic.



O41 - UTI-lizer: Digital Point-of-Care Culture for Urinary Tract Infections

8. Innovation, translational biomedical engineering

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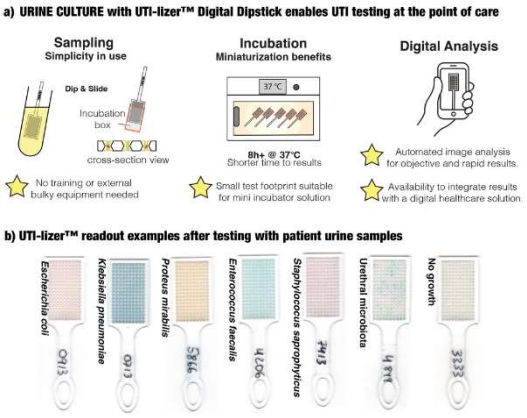
Abstract text*: Digital dipstick (UTI-lizer) is a new tool for detecting and quantifying bacteria for PoC diagnosis of urinary tract infections [1,2]. This study aimed to assess the accuracy of UTI-lizer compared to current standard diagnostic practices in clinical laboratories, using patient urine samples.

The study had two parts. Firstly, urine samples were collected retrospectively from patients with UTIs caused by five common pathogens, as well as negative control samples. Each patient's urine sample was tested using UTI-lizer, standard urine culture (considered the gold standard), and a urine test strip. All isolates were identified with MALDI-TOF-MS. Secondly, urine samples were collected prospectively from healthcare clinics and compared the results of UTI-lizer with the findings from the clinical laboratory.

The retrospective study showed that UTI-lizer had a sensitivity and specificity of 100% for detecting bacteriuria and a sensitivity of 98.6% and a specificity of 96.8% for identifying the five microorganisms compared to clinical standards (n=104). The urine test strip predicted the presence of bacteriuria in 36% of cases. The prospective study demonstrated a sensitivity of 100% and specificity of 89.6% for detecting significant bacteriuria within the test's intended use (n=121), covering 88.3% of all samples (n=137).

The results of the study indicated that UTI-lizer tests were comparable to the gold standard in detecting and identifying primary UTI pathogens in patient urine samples. UTI-lizer has the potential to decentralize UTI diagnosis and screening at primary care or point-of-need settings due to their low cost, quick handling time, lack of requirement for complex external equipment and automated digital image analysis.



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Conflict of Interests: E.I. and W.v.d.W, are co-founders and A.v.B. is the scientific advisor of UTIlizer AB.

O42 - Adding the third dimension to histology

9. Medical imaging, image processing

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Abstract text*: Standard histopathological analysis of biopsies and resected tissues is performed by light microscopy, which gives high-resolution images but requires slicing of the sample and only allows access to information in two dimensions. Complementary methods, enabling volumetric imaging of the sample, would reduce the risk of missing important features lying outside the acquired slices, but such methods are non-existent in the clinical workflow today.

We have previously shown that with high-resolution x-ray computed tomography (micro-CT), entire formalin-fixed and/or paraffin-embedded soft tissue samples can be scanned to acquire cellular-resolution volume reconstructions [1,2]. Ongoing work on tumours from liver and pancreas shows great potential in evaluating the success of a cancer surgery by analysing the tumour in 3D, by either scanning it fixed or paraffin embedded. The micro-CT is completely non-destructive and classical histology can always be performed afterwards on chosen slices.

Our Exciscope Polaris research instrument is built with a high-performance x-ray source, detector and motorised stages, bringing 3D imaging of soft tissue from large-scale synchrotron facilities to the lab. With a liquid-metal-jet x-ray source [3], the x-ray flux is superior to conventional micro-CT systems and exposure times can be kept short, enabling 3D histology results of an entire sample within a couple of hours. Future improvements can reduce the total imaging time to less than 30 minutes, which opens up for micro-CT of tissue samples as intra-operative feedback, for example during tumour surgery.

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O43 - Electroosmosis-based Technique for Cerebral Edema Treatment

8. Innovation, translational biomedical engineering

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Abstract text*: Abstract
Brain edema is a significant medical concern affecting many patient groups, including those with traumatic brain injury (TBI), stroke, tumors, and brain infections. The current clinical management of edema is limited and has various limitations. Therefore, alternative treatments are needed to improve the current practice. In this study, we propose an electroosmosis-based technique for edema treatment. This technique involves the application of a minor external current to the head, which induces electroosmotic flow. The flow directs edematous fluid to other brain regions, facilitating absorption into the cerebral spinal fluid absorption system. To verify the feasibility of this approach, we developed detailed finite element head models. These models demonstrate the feasibility and safety of the technique, including patient-specific investigation using patient data. The numerical simulations show that the approach allows for the induction of fluid flow within the critical time window for edema resolution. Furthermore, the induced current density and temperature increase remains within the safety range [1,2]. Additionally, the electrodes can be designed for optimal treatment as a complement to hyperosmotic therapy [3]. Moreover, we conducted pilot animal experiments on rats, which demonstrated that the technique could induce interstitial fluid flow. The direction of flow can be controlled by adjusting the electrode configuration, and the technique facilitates faster resolution of brain edema.

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O44 - 3D Spike micro-particles enhance transdermal drug delivery

8. Innovation, translational biomedical engineering

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Abstract text*: Novelty Claims
In this work, we present the design, fabrication and testing of 3D micro-particles for the painless puncture of the stratum corneum to enhance topical drug delivery. Our devices utilize geometric design to cause shallow skin penetrations despite being fabricated from a relatively soft material. Topical application of these micro-particles can achieve micropenetrations over any desired target area which are totally imperceptible, but do provide an avenue for drug diffusion and uptake through the epidermis.

State of the art
Topical drug delivery would be a great alternative to the common systemic administration for a significant number of patients - if not for the barrier layer of the skin, the stratum corneum. Microneedle mediated delivery via puncture of the SC is a good compromise of a non chemically specific and safe/comfortable method.

Description of new method
Utilizing 2-photon-polymerization we can fabricate devices overall smaller than the available printing field (Ø400um) of the Nanoscribe© PPGT2 (25x objective) from the non-cytotoxic, epoxy-based IP-S© resin. The devices have a main body in the shape of a regular dodecahedron, with penetrators of ~1um tip radius based on each of its vertices (Figure 1). The printing time is ≤1min/particle. Applying an ointment containing such particles requires nothing additional from the patient, produces no discomfort, and can enhance the drug uptake drastically.

Experimental results
Penetration of SC was confirmed via gentian blue staining of micro-particle treated areas on porcine ear skin. Additionally, we performed preliminary volunteer experiments. The application of such particles was shown to aid the effect of a histamine aqueous solution (10mg/mL) over the ventral area of the forearm (Figure 2). A histamine induced reaction was observed only in the "treated" area.

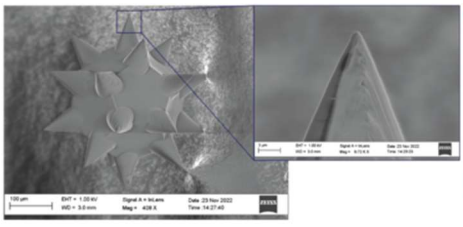

Fig.1: SEM Micrograph of printed Spike Microparticle

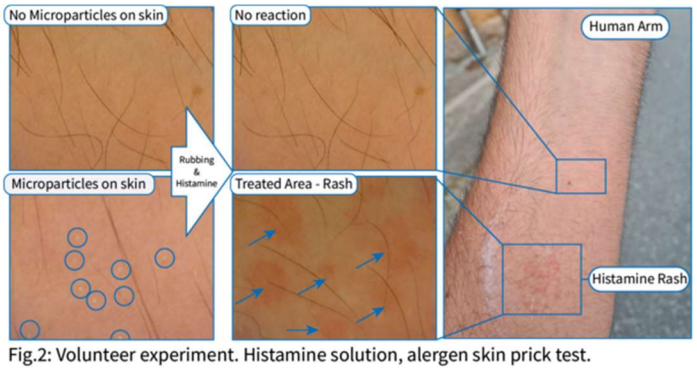

Fig.2: Volunteer experiment. Histamine solution, alergen skin prick test.

O45 - Targeting the vagus nerve non-invasively by using multiple temporal interference technology

8. Innovation, translational biomedical engineering

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Abstract text*: Neural reflexes regulate organ function. Progress over recent decades has identified a multitude of neural conduits that regulate key physiological functions. These insights enable use of implanted nerve stimulators for treatment of a range of diseases. For example, vagus nerve stimulators are used for treatment of intractable epilepsy and deep brain stimulators in Parkinson's disease. To date, these treatments require neurosurgical implantation of the stimulation device. The methods not only have medical risks, but are also associated with high costs and patient inconvenience. A non-invasive approach would in many cases be preferable. Recent work on experimental animals show that multiple temporal interfering electrical fields can create a focal point that non-invasively activates peripheral nerves selectively.

Accordingly, we set out to perform a first-in-human experiment using multiple temporal interference (mTI) technology to activate the cervical vagus nerve in healthy volunteers. After informed consent, five subjects without known ongoing diseases were included and subjected to mTI. The carotid artery was identified by palpation and an electrode array applied and centred at the identified location. Stimulation was delivered at 50Hz for 15-20s. Heart rate was measured throughout the experiment after application of the electrode array since it is regulated by the vagus nerve and decreases with vagus nerve activation. We observed a significant decrease in heart rate during active mTI and heart rate returned to baseline when mTI was stopped.

Thus, we found that mTI applied to target the right cervical vagus nerve reduced heart rate in healthy volunteers. Our findings indicate that mTI technology can be used to activate the vagus nerve in humans and we anticipate that this approach will be useful for a range of peripheral nerves that regulate organ function, potentially enabling rapid clinical translation of advances in our understanding of how nerve signals control disease development.

Neural Engineering and Bioelectronics

2023-10-11
13:15 - 14:45

O46 - B-CRATOS Wireless Brain-Connect interface TO MachineS

10. Neural engineering

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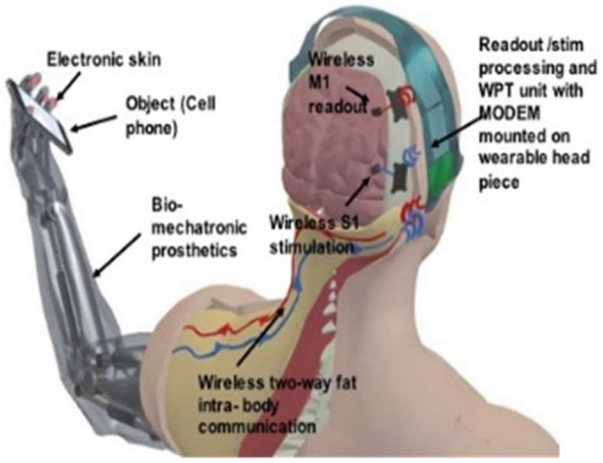
Abstract text*: A true non constrained brain-machine interface has limitless potential. One can foresee its application to the extend and beyond where the lost human bodily functions can be restored in their entirety assuring the quality of their natural state. Furthermore such a system established in its full capacity could cater to mechatronic, sensorics applications and in gaming, enhanced perception and augmented reality. The global brain computer interface market size was valued at $1,488.00 million in 2020, and is growing at a CAGR of **13.9%**from 2021 to 2030. Modern day Brain computer Brain Machine interfaces are subject to various impediments. B-CRATOS' makes earnest effort in overcoming the technological barriers in the advancement of BMIs. B-CRATOS is farsighted since it aspires to realise visionary technologies such as a Brain Machine interface with the capability of direct brain read and write. Exploiting the brain plasticity we can avoid the situation of machine learning outrunning human capacity by directly connecting the brain to machine. Creating a data fluous bridge between brain and machine will enable full cognitive immersion essential for augmented realism. Restoration of bodily functions by means of neuroprosthetics specifically neural bypass systems will help in treatment of neurological diseases, cognitive disorders and even to re-instate motor functions of the body, treatment of paralysis. Will be key solution for maintaining homeostasis through closed loop control of bodily functions.



B-CRATOS System

O47 - Calibration-Free Myoelectric Decoding

10. Neural engineering

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Abstract text*: Machine learning (ML) has for a long time been the central tool for motor-intent decoding of surface electromyography (sEMG) signals, with envisioned uses of ML-based muscle-computer interfaces ranging from prosthetics to consumer electronics. Existing ML-based myoelectric pattern recognition algorithms, albeit functional, require the collection of substantial amounts of gesture- and user-specific training data to achieve acceptable performance, making them impractical for many purposes. This paper presents a framework for myoelectric interfacing intended to work for new users without collecting any new training data. At the core of our approach lies a Transformer-based model architecture that (i) can operate on input sEMG windows collected from arbitrary electrode configurations and (i) outputs a generalized intent representation. These properties make it possible to train a single model instantiation on virtually all currently available sEMG databases. We initially pretrain our model on a selection of 29 such databases, together comprising more than 500 subjects and over 100 unique gestures. The resulting configuration-agnostic model was thereafter both evaluated directly and finetuned on a held-out database and evaluated w.r.t. inter-subject performance. We demonstrate that user-agnostic models are competitive with user-specific Linear Discriminant Analysis (LDA) models, indicating the feasibility of calibration-free intent decoding models that work 'out of the box'. However, as trained models are much larger than what would fit on embedded hardware, modifications are needed to make the method practically viable for applications in prosthetics and wearables.

O48 - MAPPING IMPROVEMENT AND SIDE EFFECTS IN DEEP BRAIN STIMULATION

10. Neural engineering

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Abstract text*:

BACKGROUND

Deep brain stimulation (DBS) is an established therapy for symptom alleviation in Essential tremor (ET) through electrical stimulation of deep brain tissue. While the method has been shown to be effective and tremor reduction often can be established, the occurrence of side effects (SE) still poses a challenge in DBS programming optimization. This work aims to apply statistical methods for mapping the effectiveness of treatment together with locations correlated with side effects.

METHODS

Data from 74 ET patients operated in caudal Zona incerta was included in this study (Ethics, Dnr. 2017/122-31). Each contact of the quadripolar DBS lead was evaluated for improvement and occurrence of SEs by increasing the amplitude, 0.5-5 V. To estimate the extent of stimulation, electric field simulations were computed for all settings where SEs occurred and for the lowest amplitude with the highest improvement for each contact. These simulation results were used to compute probabilistic stimulation maps, i.e., a voxel-wise statistic was applied to determine the degree of improvement (t-test) or probability of SEs occurrence (Wilcoxon signed rank test) [1]. The statistical maps, corrected with a permutation test for Type-1 error, were thresholded at a p-value of 0.05 and the remaining voxels were combined into clusters related to improvement or SEs.

RESULTS AND CONCLUSION

Clusters related to improvement or SEs were found to overlap with several thalamic and subthalamic structures. Several SE clusters differentiated from the improvement cluster with a clear overlap with the subthalamic nucleus and the ventral posterior medial nucleus of thalamus. The cluster based on speech affection also reached the margin to the ventral posterior lateral nucleus of thalamus. With this method, it is possible to map regions related to improvement or SEs which can further aid the optimization of DBS therapy.

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O49 - Brain microcirculation in neurointensive care

10. Neural engineering

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Abstract text*: The pathophysiology following a subarachnoid haemorrhage (SAH) is not fully understood but is believed to be multifactorial[1]. Despite a multimodal monitoring approach in the neurointensive care unit (NICU), detecting secondary insults in time for treatment remains difficult. Continuous monitoring of the brain microcirculation through laser Doppler flowmetry (LDF) could add useful information in addition to the mainly intermittent methods not directly related to blood flow. In this project, we aim to investigate if LDF brain microcirculation signals contain earlier signs of secondary insults and to correlate LDF with other NICU signals to learn more about the pathophysiology.

A workflow for LDF monitoring during neurointensive care is set up[2]. An optical probe is surgically inserted and fixated after informed consent. The probe remains inserted as long as invasive monitoring is clinically relevant and data is acquired both bedside and during other aspects of neurointensive care, such as MRI and endovascular treatment for vasospasm. Software for single and multiparametric analysis is under development, focusing on time series patterns and frequency content. Additional parameters at hand include for example intracranial pressure (ICP), systemic blood pressure, microdialysis and access to the medical record. Known secondary insults in SAH patients are for example impaired autoregulation, cortical spreading depolarizations and vasospasm.

Six SAH patients have been monitored for up to 10 days. One pattern seen in the LDF data is flowmotion, also reflected in the ICP (figure 1). Flowmotion results from vasomotion, which in turn is believed to be part of the blood flow regulation. Additional patterns of interest may be trends, level changes and waveform morphology. All in all, by combining LDF and other NICU signals, we can learn more about SAH pathophysiology.

References

1. Dodd, W. S., et al., *J Am Heart Assoc.*, 2021
2. Mauritzon, S., et al., *Front. Neurosci.*, 2022

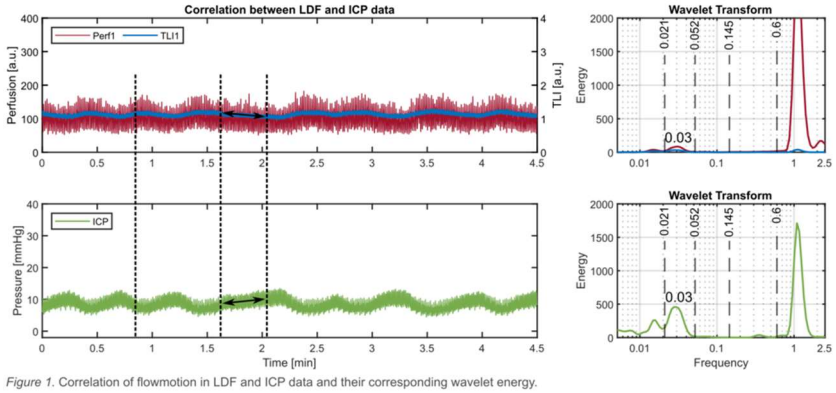

Figure 1. Correlation of flowmotion in LDF and ICP data and their corresponding wavelet energy.

O50 - Unlocking the Potential of Ion Channels as Novel Biomarkers and Therapeutic Targets in Endometriosis and Ovarian Cancer

8. Innovation, translational biomedical engineering

Oliya S. Abdullaeva[1]
Vaibhav Sharma[1], Fredrik Nikolajeff[1]
[1] Department of Health, Education and Technology, Luleå University of Technology, Luleå, Sweden

Abstract text*: Endometriosis is a chronic gynecological disorder characterized by the presence of ectopic endometrial-like tissue outside the confines of the uterine cavity. Despite its benign nature, this condition afflicts women with chronic pain, infertility and other debilitating symptoms attributed to the abnormal growth of endometrial-like tissue in regions other than the uterus. The lack of timely, non-invasive diagnostic tools and long-lasting therapeutic interventions underscores the significant socio-economic burden and healthcare challenge posed by endometriosis, affecting an estimated 190 million women worldwide. Furthermore, the striking resemblance between endometriosis and cancer, coupled with evidence suggesting endometriosis as a risk factor for specific types of epithelial ovarian cancer, namely endometrioid ovarian cancer and clear cell carcinoma, further demonstrates the urgent need for a comprehensive understanding of the biological mechanisms that govern the hallmarks of endometriosis. Such knowledge is imperative for the development of novel, minimally invasive diagnostic and therapeutic approaches that not only offer timely effective management of endometriosis but also hold promise in mitigating the malignant transformation of endometriotic lesions into ovarian cancer. Focusing on ion channels as potential novel biomarkers and therapeutic targets is a promising approach towards novel therapeutic interventions and diagnostic tools. Here, we characterize the expression levels of calcium-permeable mechanosensitive and voltage-gated ion channels in an ovarian cancer cell line which we utilize in this pilot study as a model system. In addition, we determine migratory and invasive properties of these ovarian cancer cells and determine their dependence on the function of ion channels.

O51 - Portable Semi-Shielded Chamber for Evaluation of Fat-Intrabody Communication

6. Digitalization and informatics in healthcare

Pramod K. B. Rangaiah[1]
Roger L. Karlsson[1], Arvind S. Chezhian[1], Laya Joseph[1], Bappaditya Mandal[1], Bobins Augustine[2], Maria Mani[3], Mauricio D. Perez[1], Thiemo Voigt[2], Robin Augustine[1]
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[2] Div. of Networked Embedded Systems, Dep. of Electrical Engineering, Uppsala University, Box 65, 751 03 Uppsala, Sweden
[3] Div. of Plastic Surgery, Dep. of Surgical Sciences, Akademiska sjukhuset, Ingång 70, 1 tr., 751 85 Uppsala, Sweden

Abstract text*: Fat-intrabody communication (Fat-IBC) uses human fat tissue for microwave communication with intrabody medical devices. Torso phantoms are used for evaluation and it is important that the signals only propagate through the phantom. It is essential to prevent surface waves along the exterior of the phantom and to avoid signal leakage that may reach the receiving sensor through reflections.

To solve this issue, a modified design of a semi-shielded chamber is presented. The chamber, built from a wooden crate of length 100 cm and cross section 60 cm × 60cm, is covered with microwave absorbers on the inside and with a thin shielding aluminium layer on the outside. The substantially smaller torso phantom should be placed centered at the bottom of the chamber. A separation wall, covered on both sides with absorbers and shaped to exactly follow the contour of the phantom, is then placed to divide the chamber into two equal parts with the phantom in between. The separation wall prevents reflections from propagating between the two parts of the chamber and the absorbers of the wall, being in contact with the surface of the phantom, attenuates surface waves, allowing only signal propagation through the phantom.

The outer walls of the semi-shielded chamber and a solid separation wall have been evaluated according to standards for anechoic chambers, such as shield attenuation, field uniformity, and site voltage standing wave ratio (VSWR). Broadband horn antennas and monopole antennas were used. The separation wall had a shield attenuation of 30–60 dB for frequencies of 0.7–18 GHz, respectively, while the corresponding values for the external walls were 45–70 dB, values which are sufficient for the semi-shielded chamber. Field uniformity and site VSWR were also within the prescribed limits.

Applications of the semi-shielded chamber include *e.g.* Fat-IBC, brain-computer interface, brain-machine interface, and body area networks.

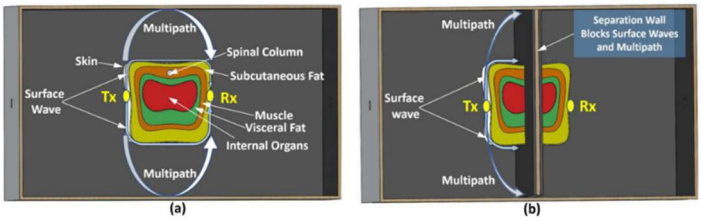


Figure 1: The proposed Fat–IBC technique, (a) problem posed by external signal paths such as surface waves and multipath (reflections), and (b) solution by introducing a separation wall across the torso phantom.

Safety, Regulatory Affairs, Standards

2023-10-11
13:15 - 14:45

O52 - Standarder och dess nytta inom vård och innovation

11. Safety, procurement, standards, regulatory affairs

Jenny Acaralp[1, 2]
[1] Jenny Acaralp
[2] Lena Morgan

Abstract text*: Exempel ges från befintliga standardiseringsprojekt inom hälsa, vård-och omsorg. Hur man kan lösa gemensamma problem samt hur standarder kan vara en möjliggörare i innovationsprocessen inom medicinteknik. Svensk sjukvård har tillsammans med medicintekniska företag en lång tradition av att påverka internationella standarder, vilket leder till ökad säkerhet och bättre resursutnyttjande för alla inblandade. Projektledare från SIS presenterar standardiseringsprocessen och former för deltagande i standardisering. Vi resonerar hur standarder kan bidra till framtidens vård, möjliggöra innovationer och hur Sverige kan uppnå en mer sammanhållen informationsstruktur och hur man kan underlätta implementering av nya tekniker. Behovet av standarder ökar när de digitala kontaktytorna mellan sjukvård, omsorg och befolkningen blir fler, t ex genom hälsoappar och andra tekniska välfärdslösningar.

Vi berättar om det senaste gällande revideringen av standarden för International Patient Summary, IPS som säkerställer att vårdpersonal världen över har tillgång till grundlagda kliniska data i händelse av en oväntad eller oplanerad medicinsk situation

Ett annat område som vi har arbetat de senaste åren och fortsätter arbeta med är harmoniserade standarders förhållande till Europas nya regelverk för medicintekniska produkter, Medical Device Regulation (MDR) och In vitro-diagnostik (IVDR). Ny europeisk lagstiftning ökar också behov av harmoniserade standarder, hur kan standarder hjälpa till med att uppfylla krav som ställs på medicintekniska produkter i MDR och IVDR? Vi redogör för det senaste inom den processen, vilka standarder har blivit antagna som harmoniserade standarder och vilka är under framtagning.

Vi berättar även om pågående nya arbeten samt nypublicerade dokument som kan vara till stor nytta för olika processer inom vården.

O53 - MILITÄRA KRAV PÅ MEDICINTEKNISKA PRODUKTER

13. Other

Bo HÖJDEFORS[1]

[1] Chefsingenjör sjukvård, Medicinteknisk ingenjör; VerkO Log G Hälso- & Sjukvårdssystem; FMV, Försvarets materielverk

Abstract text*: Presentationen avser att ge en Introduktion till FMV:s kravställning och hantering av medicintekniska produkter (MTP) som Försvarsmakten använder. Fokus ligger på medicinteknisk utrustning (MTU). Flera likheter finns mellan det civila och militära området, liksom många olikheter. Olika uppdrag, olika scope/omfattning etc. Vi arbetar med Pre-hospital akutvård. Från skadeplats/olycksplats bakåt till akut omhändertagande, vidare bakåt till akut vård och behandling inkl livräddande alt stabiliserande kirurgi. För mer avancerad vård och behandling sker överföring till civilt sjukhus.

Likheter i kravställning: samma grundläggande parametrar som ska mätas, tillgängliga produkter på marknaden. Materielen är COTS (*commercial off the shelf*; hyllvaror) till 95% och CE-märkt. Max 5% är egenutvecklat eller framtaget för direkt militär användning.

Skillnader i krav: exempel: andra användningsmiljöer, hellre robust teknik än senaste teknik, användare med olika kompetens, hårdare miljökrav inkl hantering, EMC, vikt, storlek, längre tid i omlopp, långa förrådstider, förrådshållning, strömförsörjning, batterier, underhåll, reservdelar samt avveckling. Krav på flexibilitet, mobilitet varför mycket handlar om säkra och patient-säkra transporter. Dokumentation, utbildning och registrering är viktiga delar.

FMV tar fram kravspecifikation utifrån Försvarsmaktens systemmålsättning, prestanda för systemet/gruppen, varefter upphandling sker via ramavtal, anbud, utvärdering och avrop. MTU ska som minimikrav uppfylla europeiska/globala standarder. Flertal moment, verifieringar, DoC, gås igenom innan överlämning sker till Försvarsmakten för deras utplacering, användning och vidmakthållande (dvs hantering inkl underhåll). FMV bistår sen med teknisk support, materieländringar samt vid avveckling av produkterna. I framtiden kommer NATO:s system för inköp att användas i större omfattning.

I nästa pass presenterar Försvarsmakten Sjukvårdssystemet.

Ambpatgb 203. Foto: Jorchr

Röntgen digital. Foto:Ulrika Roos/Försvarsmakten

O54 - Försvarsmaktens Sjukvårdssystem. En viktig del av Funktionskedja sjukvård.

13. Other

Jens Lönnblad[1]
Anders Ericsson[1], Krister Jakobsson[1]
[1] Försvarsmakten. Försvarsmedicincentrum i Göteborg

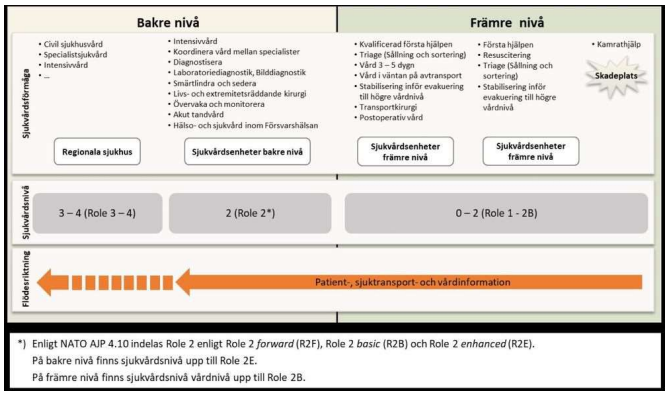
Abstract text*:

Detta abstract belyser en övergripande beskrivning av Försvarsmaktens Sjukvårdssystem.
Försvarsmakten har under en mängd år, efter Warszawapaktens sönderfall, varit inriktad mot Internationella insatser, vilket även påverkat Försvarsmaktens sjukvårdssystem. Nu är nationellt försvar åter Försvarsmaktens fokus och därmed bygger Försvarsmakten om sitt kommande sjukvårdssystem i enlighet med denna riktning. Generalläkaren i Försvarsmaktens Högkvarter har nyligen, i samarbete med Försvarsmedicincentrum, fastställt inriktningen för Försvarsmaktens Sjukvårdssystem.

Försvarsmaktens sjukvårdssystem består av sjukvårdsenheter inom samtliga försvarsgrenar och stridskrafter som tillsammans med den civila sjukvården omfattar en heltäckande sjukvårdskedja, - Funktionskedja sjukvård, vilken sträcker sig från skadeplats till civil sjukhusvård. Funktionskedjan omfattar alla förmågor för omhändertagande samt transporter av skadade och sjuka från skadeplats till rätt vårdnivå för respektive skada eller sjukdom.
Den civila sjukvården verkar inom den bakre nivån, medan Försvarsmaktens sjukvårdsystem verkar på både bakre och främre nivån. Systemet omfattar den organisation, personal, materiel och metoder som krävs för att säkerställa omhändertagandet av soldater/sjömän samt tredje part.

Vårdförmågan hos de enheter som ingår i Totalförsvarets sjukvårdssystem ska kunna hantera sjukvårdsnivåerna 0 – 4 vilka till stor del motsvaras av NATO:s förmågenivåer Role 1 – 4. Den civila sjukvården utgör normalt sjukvårdshänvisning samt ska kunna stödja FM med sjukvårdsnivåerna 3 – 4, medan FM sjukvårdssystem ska kunna hantera sjukvårdsnivåerna 0 – 2.

Författarna verkar vid Utvecklingsavdelningen vid Försvarsmedicincentrum i Göteborg.
Krister Jakobsson (krister.jakobsson@mil.se), Avdelningschef och Utvecklingschef; Anders Ericsson (anders.ericsson@mil.se) samt Jens Lönnblad (jens.lonnblad@mil.se) Medicintekniska Ingenjörer.



O55 - Säkerhet i medicinska gassystem: Fjärde utgåvan av SIS HB 370 publiceras med översättning av SS EN ISO 7396-1

11. Safety, procurement, standards, regulatory affairs
Janie Marie Thunman[1]
[1] Svenska Institutet för Standards

Abstract text*: Sverige har en lång historik av regelverk inom medicinska gasanläggningar för att säkerställa hög kvalitet, renhet och säkerhet som började med en branschstandard.

Syftet med SIS HB 370 är att ge vägledning för implementering av SS-EN ISO 7396-1:2016 och SS-EN ISO 7396-2:2007 samt tillverkning och drift av egentillverkade medicinska gasanläggningar.

Handboken är helt omarbetat jämfört med tredje utgåvan. Handboken är skriven för att dels omfatta tekniska produktkrav för medicinsk gasanläggning och baseras på SS-EN ISO 7396-1:2016, Medicinska gassystem och dels för att beskiva ansvar, roller, hantering för egentillverkning och drift samt annat som krävs för en säker och ändamålsenlig hantering av medicinska gasanläggningen.

Till skillnad från den tidigare utgåvan av SIS HB 370 är den nya versionen mer anpassad till MDR.

Det har varit ett omfattande och intensivt arbete med handboken HB 370. Handboken kommer at publiceras i år. I handboken är inkluderat en översättning av SS EN ISO 7396-1 som är standarden som ligger till grund för HB 370.

SIS ser fram emot att publicera den mest omfattande och genomtänkt versionen av HB 370. Efter handboken är publicerade kommer vi att rikta fokus på revideringen av SS EN ISO 7396-1 på ISO-nivå samt harmoniseringen av standarden mot MDR på CEN-nivå.

Dessa regelverk och deras föregångare har bidragit till att Sverige anses vara en föregångare gällande medicinska gasanläggningar.

O56 - Tillsammans för patientsäkerhet

13. Other

Patrick Borén[1]
[1] Läkemedelsverket

Abstract text*: Läkemedelsverkets avdelning för Medicinteknik föreläser om vikten av vårdens anmälningar av olyckor och tillbud, som inträffat med medicintekniska produkter, samt tillverkarens ansvar att följa upp dessa.

Det medicintekniska regelverket kräver av tillverkaren att de följer upp och utreder olyckor och tillbud som sker med deras produkter i användning och använder denna information för att kontinuerligt förbättra produkterna.

Läkemedelsverket granskar tillverkarnas utredningar och slutsatser, samt de åtgärder som vidtas.

Vårdens anmälningar till Läkemedelsverket regleras genom Socialstyrelsens föreskrifter HSLF-FS 2021:52 och sker via en e-tjänst på Läkemedelsverkets hemsida.

Under föreläsningen kommer utdrag ur avslutade produktutredningar att förevisas, samt en beskrivning ges av ett ärendes gång från vårdens anmälan till de åtgärder denna anmälan ledde till.

O57 - Medicinteknisk apparatur i hemmet (MAH) SLSO

13. Other

Jimmy Daoud[1]
Med medarbetare[1]
[1] Medicinteknisk apparatur i hemmet (MAH) SLSO

Abstract text*: Stockholms läns sjukvårdsområde (SLSO) har visionen *”Rätt vård när och där du behöver”*. För att uppnå detta arbetar Medicintekniska apparatur i hemmet (MAH), som är en del av resultatenheten Hjälpmedelsverksamheterna inom SLSO, med att tillhandahålla medicinsk teknik som används i hemmamiljö, där ett axplock av produkter kan vara allt från mindre apnélarm till respiratorer och större luftrenare.
Med uppdrag från Hälso- och sjukvårdsförvaltningen (HSF) har MAH ett regionsövergripande ansvar att distribuera och lagerhålla MTP samt ge teknisk support dygnet runt till patienter, brukare och även till förskrivare.
Genom den ständiga utveckling som sker inom området tillsammans med nya regelverk att efterleva, behöver även MAH anpassa sig till dessa förändringar och gör detta genom ständig uppföljning och kvalitetsutveckling inom olika delar utav verksamheten, där nära dialog med vården är en viktig del för att hålla en hög patientsäkerhet.

Hur hanterar MAH frågor som:

- Förskrivning av olika typer av medicintekniska hjälpmedel till olika behov?
- Upphandling för att införskaffa produkter som kan leva upp till dessa behov?
- Service och support till patienter och förskrivare?
- Telemonitorering på MTP blir vanligare?
- Anpassning till aktuella och nya regelverk?
- Spårbarhet på MTP?
- Säkerhetsmeddelande?
- Förebyggandeunderhåll på MTP som är utspridda i hela regionen, planering och utförande?

Dessa och många andra frågor är något MAH arbetar med dagligen!

Poster Exhibition

2023-10-10
16:45 - 18:00

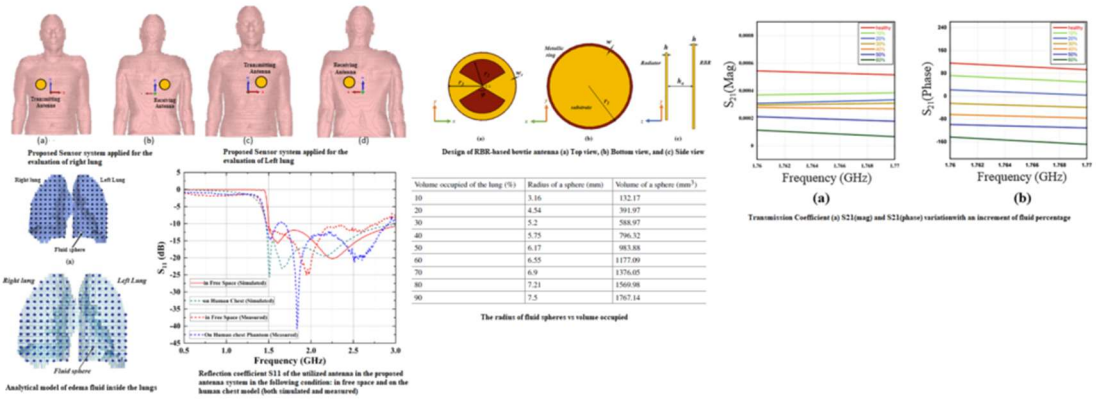
Poster Pitches

OP1 - AI-integrated Microwave Antenna System for Detection of Acute Respiratory Distress Syndrome (ARDS)

1. AI, machine learning, big data in medicine

BAPPADITYA MANDAL[1]
Adarsh Singh[2], Debasis Mitra[2], Robin Augustine[1]
[1] Microwaves in Medical Engineering Group, Electrical Engineering, Division of Solid-State Electronics, Uppsala University
[2] Department of Electronics and Telecommunication Engineering, IIEST, Shibpur, India

Abstract text*: Acute Respiratory Distress Syndrome (ARDS) is a significant cause of respiratory failure. The COVID-19 pandemic in 2019 introduced COVID-19 ARDS, a severe viral pneumonia caused by SARS-CoV-2. Approximately 33% of hospitalized and 75% of ICU-admitted COVID-19 patients develop ARDS. ARDS diagnosis traditionally involves chest X-rays and CT scans. Their frequent use, however, is limited due to ionizing radiation, high costs, and lack of portability. Given the rapid escalation of ARDS, particularly in the post-COVID-19 era, consistent monitoring is critical. As a result, safe and affordable electromagnetic (EM) techniques are emerging as healthcare alternatives for tasks such as blood glucose monitoring, breast cancer detection, and brain hemorrhage detection. ARDS causes fluid accumulation in the lungs, which affects their oxygenation ability. This fluid affects the dielectric properties of the lungs, suggesting potential for ARDS diagnosis using microwave methods. This research presents a two-antenna microwave system, integrated with AI, for early ARDS severity detection. The proposed microwave antenna system operates based on the transmission coefficient S_{21}, which is a measure of the ratio of the transmitted signal to the incident signal. Transmission parameters (S_{21}) collected over a frequency range of 0.5GHz to 3.5GHz, at a frequency interval of 0.01GHz, are used to predict fluid concentration levels in a patient's lung. Concentration levels are classified into four categories: Class 0: No Risk (healthy-25%), Class 1: Mild (26% - 50%), Class 2: Medium (51%-75%), and Class 3: Severe (76% - 100%). An Artificial Neural Network (ANN) is used to classify these S_{21} parameters into the corresponding severity classes. The dataset is generated based on simulation data, where fluid accumulation percentages are altered by 1%, and S_{21} parameters (amplitude and phase) are collected across the entire frequency range. This innovative method has the potential to fundamentally change our understanding and management of ARDS in the future.



OP2 - CT Data Harmonization And Image Quality Enhancement For Lung Nodule Segmentation And Detection

1. AI, machine learning, big data in medicine

Francesco Di Feola[1]
Susanna Jakobson Mo[1], Mikael Johansson[1], Paolo Soda[1, 2]
[1] Department of Radiation Sciences, Umeå University, Sweden
[2] Research Unit of Computer Systems and Bioinformatics, Campus Bio-Medico University of Rome, Rome, Italy.

Abstract text*: Computed Tomography (CT) is a 3D imaging method that provides clear, non-overlapping visual information about internal body structures and distinguishes between various soft tissues. Nowadays, CT is used in many clinical applications for diagnostic and prognostic purposes, playing an important role in lung cancer diagnosis, therapy assessment and precision medicine delivery. The widespread adoption of this imaging modality has increased the number of CT scanners, produced by different manufacturers, but also the number of acquisition protocols (e.g., adjusting the kernel function, the amount of radiation, the slice thickness, etc.) used to tailor the treatment for the single patient. The sensitivity to different acquisition parameters creates data discrepancy among the acquired images, reflecting in radiomic features differences, segmentation, and detection variability which hinders the reliability of the quantitative information extracted. With the increase of multicentric studies, and hence with the increasing number of heterogenous datasets, this issue is still an open challenge. In this respect, we aim to investigate AI-based strategies to standardize and enhance the quality of CT data. The goal of the project is two-sided: first, we aim to reduce the cross-domain variability while preserving the within domain variability of the datasets, addressing the issue as an Image-to-Image translation (I2I) task (e.g., using Generative Adversarial Networks), second, we aim to integrate the harmonization task with State-Of-The- Art lung nodule segmentation and detection algorithms by defining ad hoc loss functions and customizing the architectures of the models. On the one side, the integration between I2I and segmentation/detection enables an optimized harmonization of CT scans, on the other side, given the well-known difficulty of assessing the quality of the generated images, it provides further quantitative instrument (e.g., Area under the Curve, Intersection Over the Union) to assess the image quality from a different perspective.

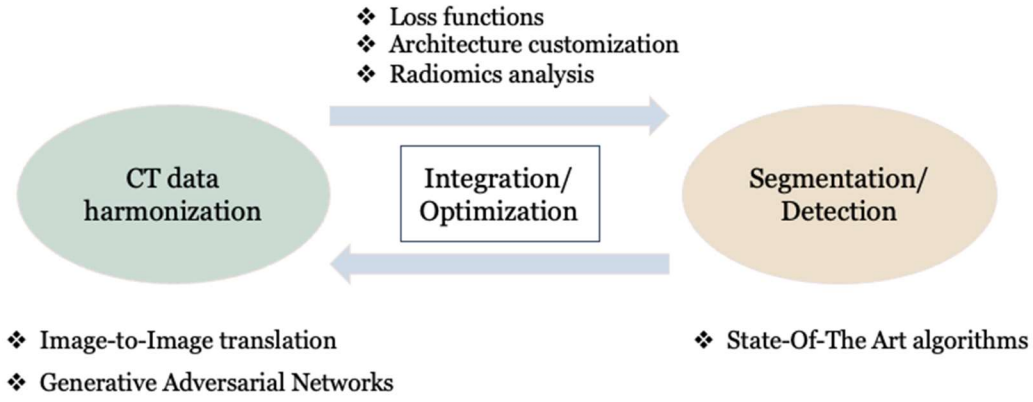


Figure 1. Pipeline of the project.

OP3 - Förstå Tal

1. AI, machine learning, big data in medicine

Birger Moell[1]
Birger Moell[1], Fredrik Sand Aronsson[2], Per Östberg[2], Jonas Beskow[1]
[1] KTH
[2] KI

Abstract text*: Neurocognitive disorders, such as Alzheimer's Disease (AD), manifest themselves in different aspects of human behaviour, and speech and language often contain early signs. The ability to make an earlier diagnosis of AD would not only spare much individual suffering, but also potentially generate massive economical savings for society. There is also much to gain by implementing mechanisms to follow up and track progress of these diseases over time in a non-intrusive way.

This collaborative project between speech technology group at KTH and speech therapy clinic at Karolinska University Hospital, propose to develop methods for automatic analysis of speech and language based on AI and machine learning, facilitated through a mobile application, both in-clinic and in the home.

The goal is to increase efficiency and reliability in diagnosis of patients with cognitive decline, including Mild Cognitive Impairment (MCI) that might lead to the development of Alzheimer's Disease (AD). The project contains three main components to accomplish this goal.

1) Development of a powerful AI-based toolchain for speech- and language based cognitive assessment.
These tools build on state-of-the-art foundation models for speech and language processing and provide digital biomarkers, as well as direct predictions of diagnosis probabilities.
2) Implementation of a new digitalized testing platform in the speech pathology clinic.
By conducting tests on a tablet with voice and pen recording capability, instead of pen- and paper, patient speech- language and pen data can be directly analyzed and digital biomarkers can directly support the clinician in their assessments.
3) A randomized controlled study of domestic longitudinal cognitive monitoring based on speech and language.
A cohort of 200 patients from the clinic will be enrolled in a study where they will interact with a mobile application on a weekly basis to perform a number of speech and language based excercises.

OP4 - Identification of Renal Function Progression Trajectories on Patients with Proton Pump Inhibitor and Histamine-2 Receptor Blocker Therapies

1. AI, machine learning, big data in medicine

Kaile Chen[1, 2]
Farhad Abtahi[1, 2, 3], Hong Xu[4], Juan-Jesus Carrero[5], Carlos Fernandez-Llatas[6], Fernandez-Llatas Seoane[1, 3, 7, 8]
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[3] Department of Clinical Physiology, Karolinska University Hospital, 17176 Stockholm, Sweden
[4] Division of Clinical Geriatrics, Department of Neurobiology, Care Sciences and Society (NVS), Karolinska Institute, 17177 Stockholm, Sweden
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[6] SABIEN, ITACA, Universitat Politécnica de Valencia, Valencia, Spain
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Abstract text*: Chronic kidney disease (CKD) is a persistent illness that can lead to severe outcomes if not managed effectively. Glomerular filtration rate (GFR), as measured by estimated GFR (eGFR), is a crucial clinical metric for the diagnosis of CKD. An established approach for evaluating and predicting the prognosis of CKD is to assess the trajectory of eGFR over time. In this retrospective study, we utilised data from the Stockholm Creatinine Measurements cohort to investigate the eGFR trajectory patterns among CKD stage-3 patients who had been treated with either proton pump inhibitors (PPI) or histamine-2 receptor blockers (H2B). To explore the eGFR trajectory patterns, we employed process mining methodology in conjunction with the Cox proportional hazard model. Four distinct eGFR trajectory patterns were identified: *Fluctuation*, *Decrease*, *Increase*, and *Unchanged*. After adjusting for age and gender, our analysis found that patients who took PPI medication had a 2.3 times higher risk (95% Confidence Interval 1.44 ~ 3.79) of exhibiting the *Decrease* pattern compared to those who took H2B medication. This study provides evidence for the use of process mining methods to analyse eGFR trajectories in individuals with CKD. In addition, our findings suggest that process mining may be beneficial in supplementing conventional statistical models for longitudinal analysis of chronic diseases.

OP5 - Precision Kidney Medicine based on Advanced Optical Imaging and Deep Learning Segmentation

1. AI, machine learning, big data in medicine

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Abstract text*: Current pathological evaluation of kidney biopsies is carried out using methods dating back at least 50 years. Here, a combination of two-dimensional microscopy methods (histopathology, immunofluorescence, electron microscopy (EM)) are applied in order to visualize all pathologically relevant features followed by qualitative assessment by a trained pathologist. This workflow has been shown to render diagnostic variabilities originating from limited data throughput, sample selection and spatial resolution as well as subjectivity in the qualitative assessment. To resolve these issues, AI-assisted pathology has recently gained large momentum and has proven beneficial in minimizing variability while also saving expensive working hours. However, these studies are still based on the old two-dimensional microscopy methods currently used in clinical pathology. In this study, we combine deep learning-based image segmentation and data analysis with advanced, super-resolved, three-dimensional fluorescence imaging. Using this approach, we demonstrate that several pathologically relevant features in kidney tissue samples can be visualized, segmented and quantitatively analyzed. The quantitative data extracted from the three-dimensional imaging datasets is then correlated to clinical data and patient history in order to reveal new biomarkers for kidney disease and efficacy of treatment. We demonstrate that our new innovative approach is both simpler, cheaper, and faster than the current methods while also providing more data with consequently higher sensitivity. Currently, precision medicine is largely based on genetic information. We believe that our methods can provide important complementing data regarding tissue morphology and protein expression on all length scales which can help stratification of patients for different treatments and types of kidney disease.

OP6 - Bone structure, composition, and osseointegration in a leptin receptor-deficient rat as a model of human metabolic syndrome

2. Biomaterials, tissue engineering

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Abstract text*: Metabolic syndrome represents a cluster of health conditions including hyperglycaemia, dyslipidaemia, central obesity, and hypertension that can lead to type 2 diabetes mellitus and cardiovascular disease[1]. Obesity and hyperglycaemia can impact both bone quantity and quality and are generally considered contraindications for successful implant treatment. In a novel rat model, the Lund MetS (metabolic syndrome) rat, harbouring a congenic leptin receptor deficiency ($LepR^{-/-}$) we performed microscale characterisation of femur and calvarium representative of endochondral and intramembranous ossification. Moreover, an extensive evaluation of osseointegration was made using titanium implants installed in tibiae of male rats following 28 days of healing. We find that $LepR^{-/-}$ animals at 20 weeks of age have altered femur microarchitecture with shorter femurs and reduced bone volume (Fig. 1A) and a changed calvarial morphology with thinner parietal bones and shorter sagittal sutures (Fig. 1B). Bone extracellular matrix composition was similar to control animals ($LepR^{+/+}$) with hypermineralised cartilage islands and hypermineralised bone found in both animal groups. Overall, osseointegration at 28 days was comparable between $LepR^{-/-}$ and $LepR^{+/+}$ animals. However, low bone volume within the implant threads, higher bone-to-implant contact but comparable biomechanical stability of the implants (Fig. 1C), and a significant difference in carbonate-to-phosphate ratio (Fig. 1D) point to delayed bone formation and/or remodelling in the peri-implant bone of $LepR^{-/-}$ rats. Gene expression of markers for bone formation and remodelling were comparable between the two animal groups, suggesting a state of equilibrium in bone formation and/or remodelling at 28 days of healing. Altered metabolic state in $LepR^{-/-}$ animals affects bone formation with changed morphology and microarchitecture in femurs and calvaria of these animals. However, delayed skeletal development of $LepR^{-/-}$ animals does not appear to have a significant influence on osseointegration of titanium implants in $LepR^{-/-}$ rats.

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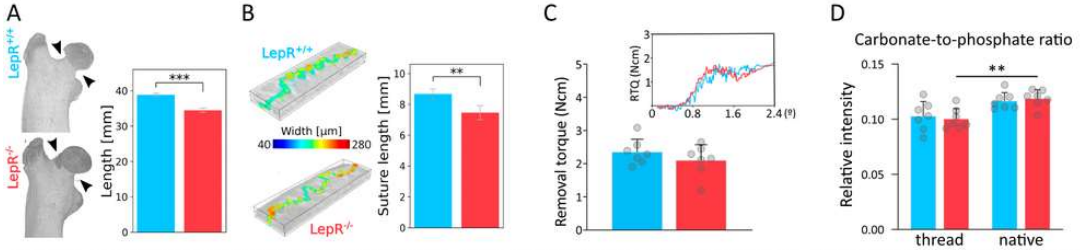

Figure 1. A) Femur length and altered microarchitecture. B) Sagittal suture length. C) Implant stability. D) Extracellular matrix composition.

OP7 - Electrical characterization of barrier integrity in a gut-on-chip

2. Biomaterials, tissue engineering
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Abstract text*: The study of biological barriers is a highly relevant topic in life sciences and the inclusion of these barriers in organs-on-chip systems enable new ways to control and study them. The formation of tight barriers is commonly measured through transepithelial electrical resistance (TEER) – a non-invasive and label-free method [1]. We present a gut-on-chip system with multiple integrated TEER electrodes distributed along the cell culture area in a microfluidic chip for spatiotemporal monitoring of barrier integrity.

The chip (figure 1a) comprises an upper, middle, and a lower channel separated by porous membranes. Intestinal epithelial cells (Caco-2) were cultured for 14 days on top of the middle membrane with constant perfusion of cell media above and below[2]. Using integrated electrodes, TEER was measured across the epithelial barrier every 15 min at four positions along the channel. After stabilization of the TEER values, the cell media was replaced by Ca^{2+} free media for a period of 1 day to intentionally disrupt the barrier integrity by breaking the tight junctions[3]. As an end-point assay, the chip was opened and the tight junctions of the intestinal cells were stained.

At day four after seeding the TEER values were higher closer to the outlet of the chip (figure 1b). Variations that might suggest an uneven distribution of the cells during seeding. Switching to Ca^{2+} free media led to a reduction in the TEER values by ~20% after a 1.5 h delay and a full recovery of the TEER values when switching back, also with a 1.5 h delay. Our experiments show ability to investigate the dynamics of biological barriers and brings attention to that the barrier integrity may be non-uniform in microfluidic systems.

In conclusion, a gut-on-chip system that enables spatiotemporal monitoring of barrier formation and dynamics was developed.

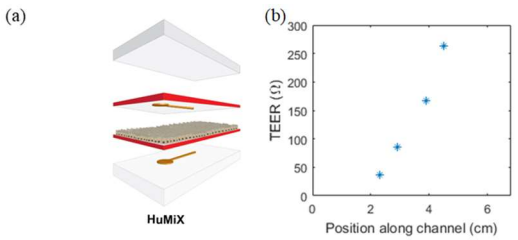

Fig. 1. (a) Picture of the HuMiX chip with integrated electrodes, (b) TEER values for a Caco-2 barrier at different positions along the cell culture channel at day 4 after seeding. The inlet is positioned at 0 cm and the outlet at 6.8 cm. The data is normalized by subtracting the background.

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OP8 - Modulating Dynamic Crosslinking for Enhanced 3D Bioprinting of Hyaluronic Acid Hydrogels

2. Biomaterials, tissue engineering

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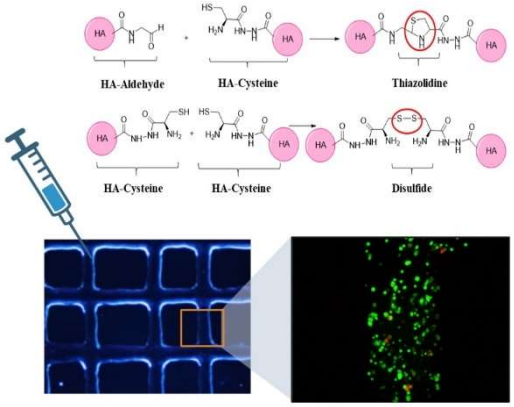
Abstract text*: Background: 3D bioprinting is a groundbreaking technology that enables the fabrication of intricate, cell-laden structures for tissue repair and disease modeling. Despite notable advancements in hydrogel-based bioinks, there remains a demand for materials that closely mimic the cellular microenvironment, possess appropriate viscosity and stability for printing, and ensure biocompatibility of the printed cells. To tackle this challenge, we have developed a novel bioink for 3D printing of stem cell-laden scaffolds by leveraging a combination of disulfide and thiazolidine chemistry.

In our approach, we synthesized hyaluronic acid (HA) derivatives containing 1,2 aminothiols and aldehyde functional groups, employing the optimized EDC chemistry previously established in our research group. The conjugation of 1,2 aminothiols, such as cysteine, with HA significantly lowered the thiol pKa and facilitates disulfide formation at physiological pH. Capitalizing on this enhanced thiol reactivity, we combined disulfide chemistry with thiazolidine chemistry (1,2 aminothiol reaction with aldehyde) to finely tune the hydrogel properties, enabling shear thinning behavior and promoting improved cell viability post-injection.

Results and discussion: In this study, we focused on the development of bioinks utilizing hyaluronic acid (HA) derivatives with 1,2 aminothiols and aldehyde functional groups, achieving approximately 10% degree of chemical modifications. By incorporating varying ratios of HA-cysteine and HA-aldehyde concentrations, we investigated the optimal combination for 3D printing of hydrogels containing human mesenchymal stem cells (hMSCs).

The rapid reaction kinetics of the thiazolidine chemistry improved the initial viscosity of the matrix, while the formation of disulfide bonds enhanced structural stability and stiffness. Our optimum design of dually crosslinked hydrogel demonstrated that the hybrid hydrogel effectively shielded stem cells from anoikis during the extrusion process, surpassing the cell protection afforded by extrusion in culture media alone.

Overall, our approach presents a valuable strategy for designing hydrogel inks with tunable properties for 3D bioprinting applications.



OP9 - Monetite-based bioceramics for bone repair and regeneration – Where do we go now?

2. Biomaterials, tissue engineering

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Abstract text*: Calcium phosphates (CaP) are the most commonly used bone graft substitute materials today[1]. Here, we have demonstrated bone formation, repair, and regeneration using multi-component CaP materials containing monetite ($CaHPO_4$) with small additions of beta-tricalcium phosphate (β-TCP), and calcium pyrophosphate (Ca-PP). In large cranial defects reconstructed with monetite-based bioceramics, both in preclinical and clinical scenarios, histological, ultrastructural, and compositional investigations revealed the presence of remodelled and well-vascularised *de novo* bone after 12 and 21 months, respectively[2]. Moreover, same material displayed the capacity to guide bone formation outside the confines of the skeletal envelope[3]. We found that the micro- and ultrastructure of such supraperiosteally formed bone within the hollow-dome constructs was comparable to that of the lamellar bone, with well-developed osteocyte lacuno-canalicular network. Finally, to explore the osteoinductive potential of these multi-component CaP, we have tested a range of compositions in subcutaneous sites in sheep (*Ovis aries*), where ectopic bone was detected regardless of Ca-PP content (up to 12.5%), indicating that Ca-PP does not hinder bone induction. High-angle annular dark field scanning transmission electron microscopy (HAADF-STEM) revealed direct bone bonding and a native-like nanoscale arrangement of mineralised collagen fibrils in bone formed adjacent to CaP[2,3]. Furthermore, micro-Raman spectroscopy characterisation of the *de novo* bone confirmed that the extracellular matrix composition was comparable to that of native bone. The CaP itself significantly degraded *in vivo* and underwent a chemical transformation to carbonated apatite. In all cases (in bone, bone-associated, and soft tissue sites), the presence of *de novo* bone showcases the osteoconductive and osteoinductive potential of this biomaterial. Specifically, monetite-containing multi-component CaP materials offer promising treatment alternatives to autologous bone grafts.

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OP10 - Resorbable antibacterial wound dressing using Ag/SiO2 nanoparticles

2. Biomaterials, tissue engineering
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Georgios Sotiriou[1]
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Abstract text*: Wound healing is a complex biological process that occurs in the body to repair damaged tissue and restore its structure and function. It involves a series of sequential and overlapping phases, each with specific cellular and biochemical events. Infected wounds occur when bacteria or other microorganisms enter a wound and multiply, leading to an infection. The presence of infection in a wound can significantly impede the healing process and pose potential risks to overall health including delayed healing, cellulitis, abscess formation, blood poisoning, or deep tissue and bone infections. Antibacterial dressings are specialized wound dressings that contain agents or substances with antibacterial properties. These dressings are designed to help control and reduce bacterial colonization in infected wounds, thereby promoting healing. Silver has long been recognized as an antimicrobial agent; however, concerns have emerged regarding the resistance of bacteria towards silver ions and side effects caused by the spontaneous release of these ions. There is also a rising demand for eliminating dressing removal to prevent complications, particularly in sensitive or fragile wounds. Here, we present a solution by developing a resorbable antibacterial wound dressing using silver-silica (Ag/SiO_2) nanoparticles. These particles are produced by flame spray pyrolysis-a scalable fabrication process and are then incorporated into PVA/PLGA-based electrospun fibers. These fibers are bioresorbable in 24 hours and provide sustained release of silver ions. We further demonstrate the antibacterial action of these dressings with Methicillin-resistant Staphylococcus aureus (MRSA). The present approach shed new light on resorbable wound dressings with promising applications for nanoparticles.

OP11 - Soft hydroxyapatite composites based on triazine-trione systems as potential biomedical engineering frameworks

2. Biomaterials, tissue engineering

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Abstract text*: Composites of triazine–trione (TATO) thiol–ene networks and hydroxyapatite (HA) have shown great potential as topological fixation materials for complex bone fractures due to their high flexural modulus, biocompatibility, and insusceptibility to forming soft-tissue adhesions. However, the rigid mechanical properties of these composites make them unsuitable for applications requiring softness. The scope of these materials could therefore be widened by the design of new TATO monomers that would lead to composites with a range of mechanical properties. In this work, four novel TATO-based monomers, decorated with either ester or amide linkages as well as alkene or alkyne end groups, have been proposed and synthesized via fluoride-promoted esterification (FPE) chemistry. The ester-modified monomers were then successfully formulated along with the thiol TATO monomer tris [2-(3-mercaptopropionyloxy)ethyl] isocyanurate (TEMPIC) and HA to give soft composites, following the established photo-initiated thiol–ene coupling (TEC) or thiol–yne coupling (TYC) chemistry methodologies. The most promising composite shows excellent softness, with a flexural modulus of 57 (2) MPa and ε_f at maximum σ_f of 11.8 (0.3)%, which are 117 and 10 times softer than the previously developed system containing the commercially available tri-allyl TATO monomer (TATATO). Meanwhile, the surgically convenient viscosity of the composite resins and their excellent cytotoxicity profile allows them to be used in the construction of soft objects in a variety of shapes through drop-casting suitable for biomedical applications.

Additionally, the most recent results from the collaboration with the University of Bergen, Norway, suggest that these novel materials are able to support the proliferation and thereafter osteogenic and neurogenic differentiation of bone marrow mesenchymal stem cells (BMSCs).

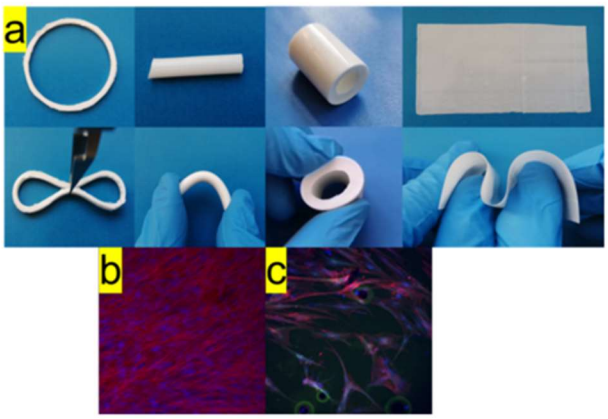

Figure: (a) the novel TATO materials in different shapes, (b)&(c) osteogenic and neuronic differentiations on the surface of discs made by the TATO materials

OP12 - Hemodynamic assessment of the Realheart® Total Artificial Heart using a Hybrid Mock Loop

5. Cardiovascular engineering

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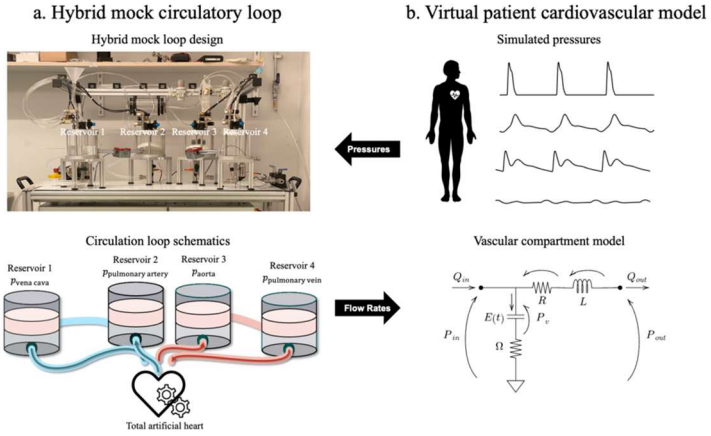
Abstract text*: Heart failure constitutes a growing health challenge, necessitating innovative and safe therapies such as total artificial hearts (TAHs). In this study, we aim to conduct a hemodynamic assessment of the Scandinavian Realheart® TAH using a real-time hybrid mock loop of the cardiovascular system.

Hybrid mock loops are a unique way to model the interface between a physical medical device prototype and a virtual model of the cardiovascular system physiology. We will test the Realheart® TAH in a cardiovascular hybrid mock loop. This setup will include inflow connections at the left and right atrium, as well as outflow connections at the ascending aorta and pulmonary artery. By controlling the physiological parameters of the virtual patient, we evaluate the Realheart® TAH's ability to regulate and deliver blood flow.

In the virtual patient, we statically and dynamically vary systemic vascular resistances (SVR), pulmonary vascular resistances (PVR), pulmonary/systemic arterial compliances to simulate physiological variability in pre- and afterload. This will allow us to explore and assess how the Realheart® TAH adapts to different hemodynamic conditions in terms of stroke volume and pumping rate.

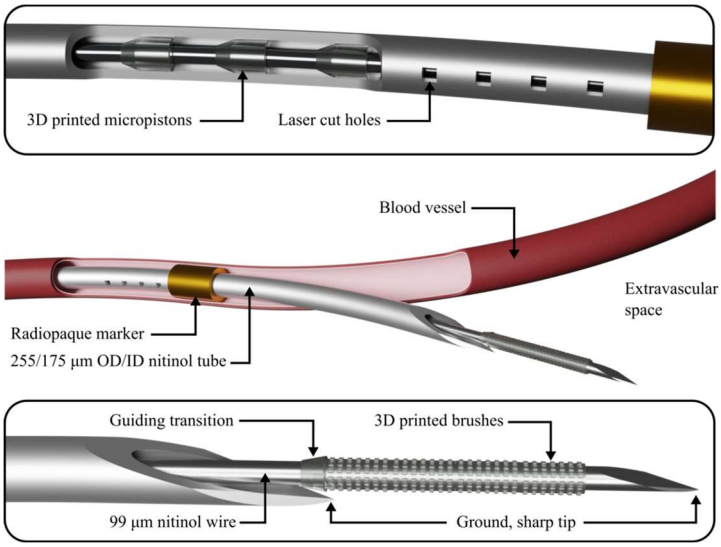
By dynamically manipulating the physiological variables according to hemodynamically meaningful scenarios, we provide understanding of the Realheart® TAH's flow and pressure regulation capabilities. The insights gained from this research will contribute to advancing the knowledge of the Realheart® TAH as a viable therapeutic option for patients suffering from heart failure.



OP13 - Sampling through a transvascular working channel

5. Cardiovascular engineering
Mikael Sandell[1, 2, 3]
Arvin Chireh[2], Argyris Spyrou[1, 3], Stefan Jonsson[1], Wouter van der Wijngaart[1], Göran Stemme[1], Niclas Roxhed[1, 3], Staffan Holmin[2]
[1] KTH Royal Institute of Technology
[2] Karolinska Institutet
[3] MedTechLabs

Abstract text*: Endovascular biopsies are widely utilized for many organs, either as standard practice or when there are contraindications to the percutaneous route. Depending on the target site, currently used devices for sampling through the endovascular route is either not possible to use, such as in the brain, or present certain risks due to their size, such as in the heart or liver. A recent development in catheter technology has opened up new possibilities for parenchymal access through a microscopic working channel. Through this method essentially all organs can be accessed safely without causing hemorrhagic complications. Here, an endovascular sampling device designed to be used through this channel is presented. The device contains 3D-printed brush structures and is tested in the liver, kidney, brain and pancreas. Cytological data reveals the presence the tissue in question.



OP14 - A Robust Method for Automatic Calculation of Hypotension During Surgery using Physiological Sensor Data

6. Digitalization and informatics in healthcare

Martin Jacobsson[1]
Max Bell[2], Arman Valadkhani[2], Thorir Sigmundsson[2]
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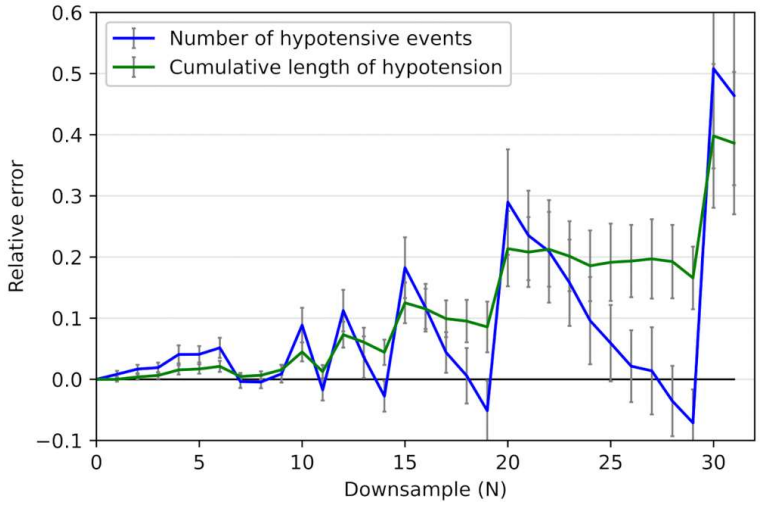
Abstract text*: During surgery and intensive care, it is common to measure the arterial blood pressure (ABP) curve of a patient using a catheter in the radial artery. One important reason for this is to monitor and manage the blood pressure of the patient. It is known that hypotension, a too low blood pressure, is harmful to the patient and hence we need to track the exposure of hypotension. A common definition of a hypotensive event is a mean arterial blood pressure (MAP) under 65 mmHg for at least 1 minute. Since, we know that complications correlates with hypotension, we track the number of hypotensive events, their cumulative length, and their cumulative area under threshold (length multiplied with the average depth under the threshold).

We used data collected from 138 surgical patients at the open abdomen surgery unit at Karolinska, Solna. We removed patients with zero hypotensive events and problems with collected data. This left us with 76 patients, with a total of 1,318 hypotensive periods.

Collecting the full resolution wave forms of the ABP signals of all patients requires significant amount of data storage and management. Therefore, it is common to just store the parameter data, such as the calculated MAP. To reduce further, it is common to only store these parameter values once every 10 seconds or less frequent. However, downsampling leads to measurement errors.

In this work, we calculate the relative errors introduced by different amount of downsampling. Unfortunately, the relative error can be as large as 51% for the number of hypotensive events and up to 40% for cumulative hypotensive length. The figure shows the amount of relative error caused by different amount of downsampling. Due to the definition of a hypotensive event, maximum errors are found when the sample time is an integer fraction of 1 minute.



OP15 - Measurements of balance using a smartphone - A pilot study

6. Digitalization and informatics in healthcare
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Fredrik Öhberg[1, 2]
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Abstract text*: Background: Measurement's of a person's balance and gait performance can give important information in the follow-up procedure of vestibular disorders. Today's clinical assessments are often based on clinical scales and questionnaires, and could be improved by adding more sensitive outcome scores. The purpose of this study is to evaluate whether a smartphone can give reliable outcome measures of a person's balance performance.

Method and results: A pilot group of persons without known disorders or injuries affecting the balance were recruite. Each person performed a series of 4 balance tests with different levels of difficulty: (1) eyes open, (2) eyes open and head turning, (3) eyes closed and (4) eyes closed with head turnings. In each test, the person stood on a foam pad with feet together and arms crossed over the chest, as long as possible without losing balance, at a maximum of 30 seconds. Each balance test was performed once. The test was interrupted if the test person lost balance (moving legs and/or arms). A smartphone attached to the lower lumbar region with an elastic band registered the persons pelvic angular velocity and linear acceleration at 40 Hz.

The sway path length (absolute and time-normalized); SPL and NSPL; was calculated based on the gyroscopic and accelerometric data [1]. Preliminary results show that the parameters could differentiate between the the four tests, with greater values for the test with higher degree of difficulty.

Preliminary results indicate that these parameters are suitable for follow-ups of persons with vestibular disorders. Next step will be to evaluate balance parameters in larger groups of healthy persons and patient groups with vestibular disorders.

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OP16 - Empowering Elderly Cancer Survivor Care through Digital Health Innovations: An Overview of the LifeChamps Project

8. Innovation, translational biomedical engineering

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Abstract text*: Cancer's global prevalence, especially among individuals over 65, significantly challenges healthcare systems. Age-related complications could significantly impact these survivors' health-related quality of life (HRQoL) [1], thus stressing the need for tailored geriatric care. However, there needs to be more methodical care and assessment strategies. Approaches centered on geriatric assessment can help classify patient risk and mitigate unwarranted healthcare utilization within this vulnerable population [2]. Integrated digital oncology care interventions encompassing geriatric, QoL, symptom metrics, information technology, and data analytics can improve risk profiling.

The LifeChamps project (https://lifechamps.eu/), is endeavoring to establish a sophisticated, multifaceted digital oncology platform, which incorporates a cloud platform, edge component, and various end-user applications [3]. Employing a participatory design approach, this project aims to enhance elderly cancer patients' aftercare through consistent refinement based on stakeholder inputs.

The project includes small-scale pilots in Greece, Sweden, and Spain to collect real-world data, test predictive analytics, and develop a frailty reference model involving patients over 65 years with breast, prostate, and skin cancer post-initial treatment. LifeChamps strives to improve monitoring, risk categorization, and self-management for elderly cancer survivors to boost their HRQoL.The results from ongoing data collection efforts and the development of predictive models will inform the project's outcomes, which will be further evaluated through a feasibility study.

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OP17 - En "mockup" för att underlätta utvecklingsarbetet av ett medicintekniskt instrument som detekterar cancer på ytan av prostatakörteln.

8. Innovation, translational biomedical engineering
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Abstract text*: Prostatacancer (PCa) är den näst vanligaste cancerformen för män. Bara i Sverige diagnosticerades 10101 män med PCa 2021. Cirka 60% av prostatacancerpatienterna i Europa väljer kirurgiskt avlägsnande av prostata, sk radikal prostatektomi (RP), snarare än strålning, som botande behandling. Vid RP behöver 10–20% av patienterna efterbehandling pga. att kirurgen inte lyckats avlägsna all cancervävnad och patienten riskerar att få återfall samt att cancern sprids i kroppen. Standardmetoden för kontroll är att den uttagna prostatan snittas och studeras i mikroskop (histologi) varvid cancercellerna räknas. Detta görs vid patologlaboratoriet och det tar veckor innan svar. Avsikten med vår metod är att korta tiden till svar genom att kombinera styvhetsmätning med resonansteknik och vävnadskaraktärisering med Ramanspektroskopi för upptäckt av cancerceller. Dessa två metoder kan snabbt skanna prostatakörteln i operationsrummet. Kirurgen ges beslutsunderlag huruvida all cancervävnad tagits bort och att nerver och blodkärl som styr urinering och den sexuella funktionen sparas. Vi utvecklar en prostataskanner (ProScan) som säkrar proceduren vid RP och kommer att spara lidande, tid och pengar för patienter och hälso- och sjukvård. I utvecklingsarbetet som skall leda fram till en produkt på hälso- och sjukvårdsmarknaden har vi arbetat i ett team med interaktionsdesigner, mjukvaruutvecklare, sjukhusingenjörer och medicinsk personal.

Metod: För att enklare kunna visualisera och demonstrera den tänkta produkten har vi som ett första steg i produktutvecklingen tagit fram en mockup – ett slags förstadie till en prototyp, men utan några integrerade funktioner. Mockupen skapades genom en agil designprocess som inkluderade slutanvändare och expertis inom området.

Resultat: Arbetet utmynnade i en interaktiv mockup som kan användas för att demonstrera instrumentet för intressenter och användas som utgångspunkt i det fortsatta utvecklingsarbetet.

Konklusion: Metoden bjuder in användarna till att kontinuerligt kunna påverka designen och gör det enklare för utvecklarna att förstå användarnas behov och hur instrumentet kan användas praktiskt.

OP18 - Filter-in-Centrifuge Separation of Low-concentration Bacteria from Blood

8. Innovation, translational biomedical engineering
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Kaiyang Zeng[1], Wouter van der Wijngaart[1]
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Abstract text*: Sepsis is one of the biggest challenges to global healthcare, it claims one of every fifth deaths globally and costs $20 billion only to the USA economy. Mostly caused by bacterial infection, the mortality of untreated septic patients decreases by 8% per hour. Long identification and antimicrobial susceptibility testing (AST) of pathogens (3-4 days) exacerbate the situation. There are advanced phenotypic and genotypic methods, which can perform the identification and AST in few hours, but the key challenge is to separate bacteria from whole blood. The lower concentration of bacteria in the blood (10 CFU/ml) and higher concentration of blood cells (4-6 billion/ml) and comparable size bacteria (few microns) and blood cells (RBC around 5 microns) make the task challenging. The state of the art for separating bacteria from whole blood usually have low throughput or works only with high concentration of bacteria. In this study, we developed a filter-based centrifugal device to separate bacteria from whole blood at high throughput. The device can recover 30-40% of the bacteria and remove >99% of the blood cells, from whole blood and can recover the bacteria even at low-concentration of 10 CFU/ml.

OP19 - Targeting brain tumours with radiolabelled chlorotoxin, a scorpion venom peptide

9. Medical imaging, image processing

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Kaj Y. Li[1], Karl H. Pettersson Pettersson Palm[1], Jacqueline Zammit[2], Maria Davydova[2], Mukesh Varshney[3], Li Lu[1], Stefan Milton[1], Thuy A. Tran[1], Tobias Bergstrom[4], Fredrik J. Swartling[4], Jason S. Lewis[2], Staffan Holmin[1], Jeroen A.C.M. Goos[1]
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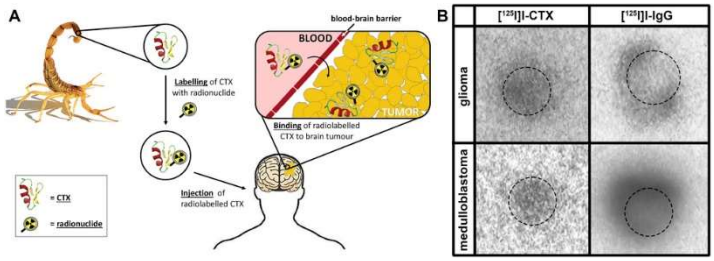
Abstract text*: INTRODUCTION: Chlorotoxin (CTX) is a peptide derived from venom of the Deathstalker scorpion *(Leiurus Quinquestriatus*). It is naturally designed to traffic through the blood-brain barrier (BBB) and to target binding sites, specific for brain tumor cells, in the central nervous system. In *peptide receptor radionuclide therapy* (PRRT), a tumour-targeting peptide is combined with therapeutic radionuclides to deliver a lethal dose of radiation to a tumour. Here, we use CTX as a vector to deliver radionuclides to brain tumours across the BBB (Figure A), with the aim to develop a minimally invasive treatment with minimal side effects.

METHODS: CTX was functionalized with *N*-succinimidyl-3-(trimethylstannyl)benzoate (*m*-MeATE) and radiolabelled with iodine-125 (^{125}I) for its *in vitro* evaluation. First, its binding kinetics were determined in traditional (two-dimensional) glioma and medulloblastoma cell models. Next, its affinity to brain cancer cell lines was measured in (three-dimensional) brain organoids that contain an artificial BBB. Its BBB permeability and penetration into the core was visualised by digital autoradiography and compared to a control vector (radiolabelled IgG). Biodistribution of radiolabelled CTX is currently being assessed *in vivo* in murine models.

RESULTS: *m*-MeATE-functionalised CTX was radiolabelled with ^{125}I (specific activity= 8 GBq/mg) with high radiochemical purity (>99%) and good radiochemical conversion (>99%). Radiolabelled CTX demonstrated specific binding to the glioma and medulloblastoma cell lines (dissociation constants K_D: 0.7 – 2280 nM). Penetration into the core of both glioma (P=0.03) and medulloblastoma (P<0.01) organoids was significantly higher for radiolabelled CTX than for radiolabelled IgG (Figure B).

CONCLUSIONS: Preliminary results indicate a high specificity of radiolabelled CTX for glioma and medulloblastoma cells. As such, a PRRT strategy based on CTX may improve minimally-invasive treatment options for brain cancer and lead to improved survival and quality of life.

ACKNOWLEDGMENTS: Funding from the Swedish Research Council, KI StratNeuro, Karolinska Institute and MedTechLabs is gratefully acknowledged.



OP20 - Carotid ultrasound image denoising using low-to-high image quality domain adaptation

9. Medical imaging, image processing
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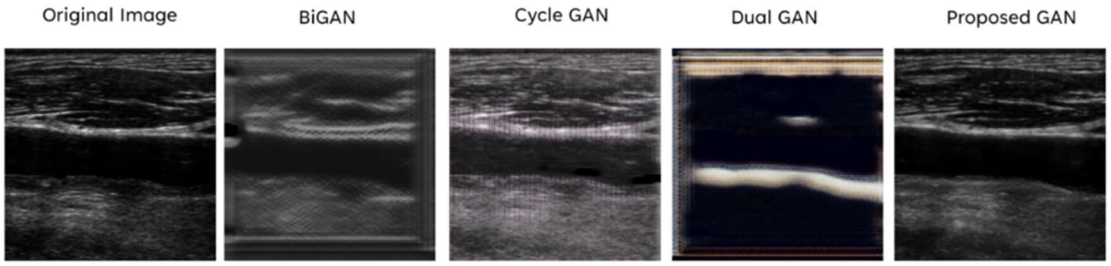
Abstract text*: Ultrasound images play a crucial role in the diagnosis and treatment of various diseases, providing clinicians with valuable insights into a patient's condition. However, ultrasound images are often subjected to various challenges, such as noise, artifacts, and limited resolution, which can hinder accurate analysis and interpretation. In recent years, generative adversarial networks (GANs) have emerged as a promising approach for enhancing the quality of medical images. Despite the advancements made, challenges remain in the application of GANs for ultrasound image quality enhancement.

In this paper, we formulate ultrasound image denoising task as a domain-to-domain translation task between images of low and high quality. In this way we can translate a noisy image into high quality image while the anatomical content of the image is unchanged. We propose a finetuned Cycle-GAN objective function by adding a noise loss, which reduces the noise from images by minimizing the difference among features from early three layers of generator. The generator aims to generate high quality images from noisy images by transferring the noise to another domain, and the discriminator enforces the generated images to have the same content as original images. Several models (CycleGAN, BiGAN, DualGAN and our proposed cycleGAN) were trained on 500 carotid images of each domain, and translation performance was quantified using histogram correlation distances.

Results show that the method is able to translate the noisy low-quality images into a high quality images. The histogram correlation distances between the low-quality test images and the corresponding translated images were 0.96, 0.71, 0.60 and 0.85 for the proposedGAN, biGAN, cycleGAN and dualGAN, respectively.
The experimental results show that the proposed method creates robust transferable features between two domains, and improves the denoising performance compared to the state-of-art methods. The method may be useful for restoration/standardization of retrospective low-quality ultrasound image sequences.



OP21 - Lung cancer diagnosis and prognosis with advanced machine learning methods

9. Medical imaging, image processing

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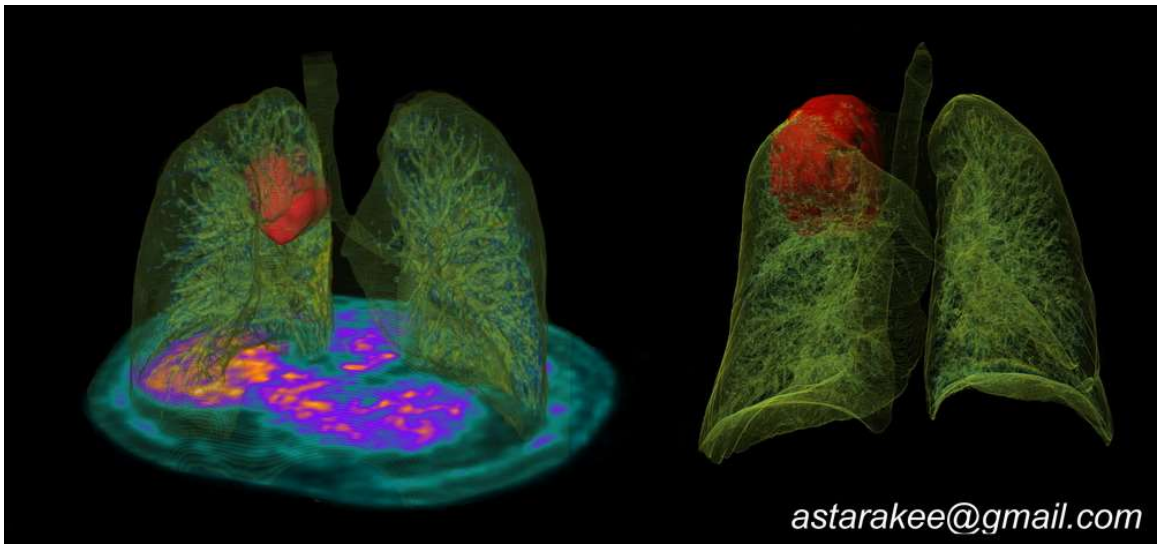
Abstract text*: Segmentation of lung pathology in Computed Tomography (CT) images is of great importance for lung disease screening. However, the presence of different types of lung pathologies with a wide range of heterogeneities in size, shape, location, and texture, on one side, and their visual similarity with respect to surrounding tissues, on the other side, make it challenging to perform reliable automatic lesion segmentation. To leverage segmentation performance, we propose a deep learning framework comprising a Normal Appearance Autoencoder (NAA) model to learn the distribution of healthy lung regions and reconstruct pathology-free images from the corresponding pathological inputs by replacing the pathological regions with the characteristics of healthy tissues. Detected regions that represent prior information regarding the shape and location of pathologies are then integrated into a segmentation network to guide the attention of the model into more meaningful delineations. The proposed pipeline was tested on two types of lung pathologies, including pulmonary nodules, and non-small cell lung cancer. The results show the superiority of the proposed prior model, which outperformed the baseline segmentation models in all the cases with significant margins. Upon the detection of lung pathology borders, in the next step, we developed a dual-pathway deep learning pipeline to distinguish benign pathologies from malignant ones. Extensive quantifications verified the robustness of the proposed method. Finally, a set of imaging biomarkers were developed to accurately predict the early responses of malignant tumors to the applied therapies based on the intratumor heterogeneities.



OP22 - A sensor based rotational system for detection of prostate cancer during surgery

12. Sensors, diagnostic systems

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Abstract text*: Prostate cancer (PCa) is the fourth most common cancer in both sexes combined and the second most common cancer in men after lung cancer, worldwide. Treatment of PCa often causes sexual dysfunction, problems with urination and incontinence. The incidence of PCa in Sweden was 10101 diagnosed cases in 2021. Although PCa death rates have declined during recent years due to better diagnosis methods and treatment, it still causes most of the cancer deaths among men. The most prevalent curative treatment for PCa is radical prostatectomy (RP). About 1900 surgical treatments for PCa are conducted every year in Sweden, and 10-20% of these need subsequent therapies due to incomplete removal of cancer tissue. There is a demand for an instrument that rapidly scans the prostate surface during surgery and gives the surgeon information about correct removal of all cancer tissue to cure the patient. The aim is to develop an instrument that can rotate the excised prostate gland and scan for cancer on the surface, thus guiding the surgery.
We use a sensor setting combining a tactile resonance sensor (in-house developed) and a new fiber-optic Raman spectroscopy system (Emvision LLC, Florida, USA), Fig1. It is already shown that the resonance sensor is a statistically significant predictor of cancer on 10 prostates (AUC=0.74)[1] but Raman has the ability to complete with chemical composition that can be valuable for determining cancer aggressiveness. Furthermore, we have developed a computerised rotational equipment (patent pending) to be able to scan the whole prostate while measuring the surface for cancer with the sensors. Experiments with the instrument on gelatine models, prostate biopsies and rotating whole prostate are promising for detecting prostate cancer.

1. Lindahl, O.A., et al., A tactile resonance sensor for prostate cancer detection - evaluation on human prostate tissue. Biomed Phys Eng Express, 2021. 7(2). https://iopscience-iop-org.proxy.ub.umu.se/article/10.1088/2057-1976/abe681

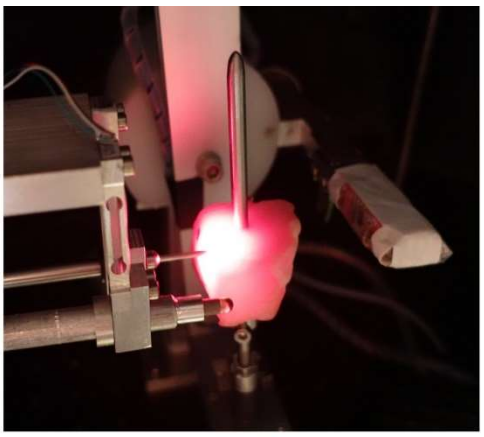

Fig 1. Pork tissue sized like a prostate gland measured with Raman spectroscopy using the experimental setup.

OP23 - Innovative Approaches to Burn Degree Analysis: Non-invasive Microwave Sensor Design and Dielectric Profiling of Ex-Vivo Burnt Human Skin Samples

12. Sensors, diagnostic systems

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Bappaditya Mandal[1], Mauricio David Perez[1], Fredrik Huss[2], Robin Augustine[1]
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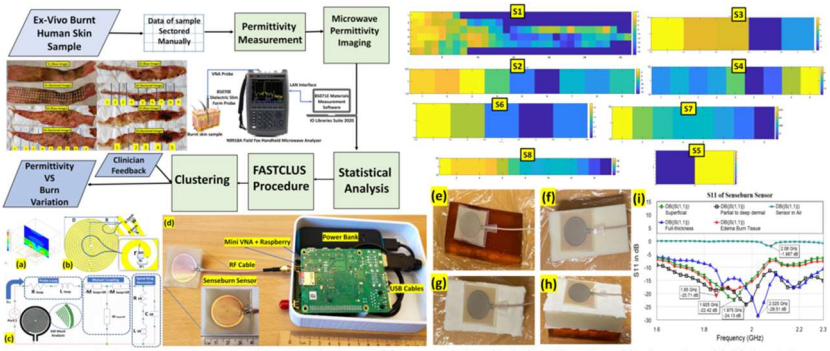
Abstract text*: The main goal of the study is to establish a comprehensive and detailed dielectric database that encompasses various degrees of burn. Additionally, the research aims to develop a novel non-invasive microwave sensor specifically tailored for accurate burn analysis. The proposed sensor design utilizes a magnetically coupled loop probe integrated with a spiral resonator. This configuration allows for precise and sensitive detection of permittivity variations in the burnt skin samples. By monitoring the changes in resonance frequency, the sensor provides a reliable and non-invasive means to assess the severity and depth of burns. To support the development of the sensor and enhance its effectiveness, the research focuses on creating a robust dielectric database. This database includes detailed information on the dielectric properties of skin tissues corresponding to different degrees of burn. By systematically analyzing and categorizing the collected data, the researchers aim to establish a comprehensive understanding of the relationship between dielectric characteristics and burn degrees.

The ultimate objective of this work is to contribute to the advancement of diagnostic tools for burn assessment. By leveraging the developed dielectric database and the innovative microwave sensor, the research team aims to create a portable and efficient diagnostic tool. This tool will enable medical professionals to accurately evaluate the severity and depth of burns, facilitating timely and appropriate treatment for burn victims. By combining state-of-the-art permittivity measurement techniques, advanced image processing algorithms, and the unique microwave sensor design, this research strives to significantly improve the field of burn analysis and treatment. The developed sensor has the potential to revolutionize the way burns are assessed, offering a non-invasive and reliable solution for clinicians. Ultimately, the integration of these advancements into a portable diagnostic tool holds the promise of saving lives and improving the outcomes for burn patients.



Dielectric characterization experimental setup, Senseburn sensor development (a) isometric 3D view of Ez-field in different layers (skin, fat, and muscle), (b) The spiral resonator (SR) with an (c) equivalent circuit and (d) system integration using Sensor, MiniVNA, Power Unit, and Raspberry Pi interface. Senseburn Sensor on the (e) burn tissue with edema, (f) full-thickness burn, (g) Superficial burn, (h) Partial to deep dermal, and (i) S11 measurements using senseburn sensor.

OP24 - Intrabody Communication Through Fat Tissue for Brain-Machine Interface Applications

12. Sensors, diagnostic systems

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Pramod Rangaiah[1], Ted Johansson[1], Mauricio D. Perez[1], Robin Augustine[1]
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Abstract text*: Fat-intrabody communication (fat-IBC) is a novel human body-centric wireless communication technique that uses subcutaneous fat tissue as a channel for microwave signals. In the human body, fat tissue of low permittivity is sandwiched between skin and muscle with higher permittivites, which forms a three-layer dielectric waveguide-like structure through which data can be transmitted. We have shown that fat-IBC can function across a large range of frequencies, including the license-free 2.4 GHz and 5.8 GHz bands used by existing wireless communications protocols such as IEEE 802.11 (Wi-Fi), IEEE 802.15 and Zigbee. Fat-IBC can be used for onbody/inbody communication between e.g. sensors and is an integral part of the EU Horizon 2020 project "B-CRATOS", which aims to wirelessly control a prosthetic arm using neural signals collected from an implanted brain interface. The minimum data rate specified by the project is 32 Mb/s — preferably 64 Mb/s — for the neural signals that will go through the fat tissue. Such high data rates in fat-IBC have not previously been studied. In order to find out whether fat-IBC can support the rates required by B-CRATOS, we performed various tests on artificial tissue-emulating three-layer planar phantoms. Specially designed antennas were placed in direct contact with the fat layer and/or on the skin layer of the phantoms, which were 10, 20 and 30 cm long. The signal loss at 2.45 GHz in the phantoms was roughly 1 dB/cm, which is consistent with previous findings. Using IEEE 802.11n (Wi-Fi 4), a data rate of 92 Mb/s for all tested antenna combinations and phantom lengths was achieved, which was limited by the hardware, not the fat channel itself. Future studies include newer Wi-Fi variants such as IEEE 802.11ax (Wi-Fi 6/6E) at 5.8 GHz and also quantifying how the fat thickness and irregularities in it impact channel performance.

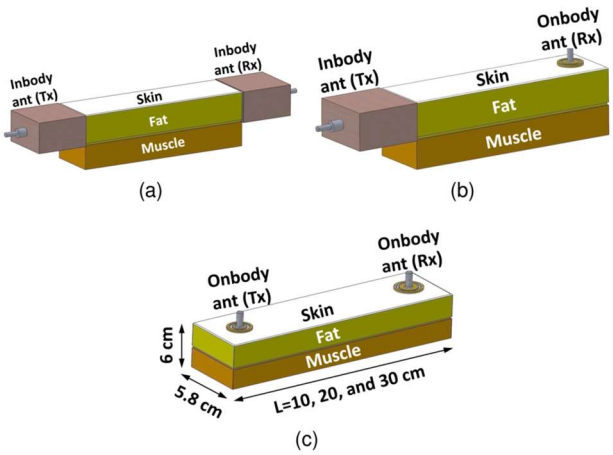

Fig. 1. Antenna connections to the phantoms: (a) Case 1: inbody-to-inbody antennas, (b) Case 2: inbody-to-onbody antennas, (c) Case 3: onbody-to-onbody antennas.

OP25 - MICRONEEDLE-BASED WEARABLE PLATFORMS TOWARD MINIMALLY INVASIVE GLYCINE/LACTATE MONITORING

12. Sensors, diagnostic systems

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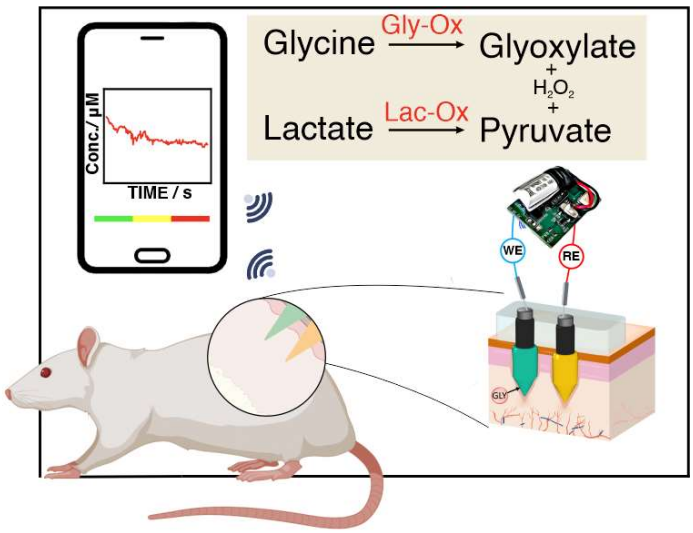
Abstract text*: Microneedle sensors represent a unique platform poised to lead the next generation of decentralized chemical sensors, enabling personalized medicine. This technology presents a distinct combination of miniaturization, minimal invasiveness, easy integration with diverse materials, high biocompatibility, and the ability to provide continuous and real-time information. Our work is based on the hypothesis that the interstitial fluid possesses a similar composition as blood. Thus, at some point, microneedle sensors may be proposed as the replacement for current blood analysis.

Here, we presented MN-based sensors for transdermal amperometric sensing of two small molecules: i) glycine, and ii) lactate. Lactate values were used to assess a range of disorders such as metabolic acidosis, intra-tissue hypoxia, and infectious conditions. On the other hand, glycine monitoring may help manage pathological situations such as stroke recovery, heart disease, and psychiatry.

First, we developed an MN device for GLY monitoring[1]. The versatility of the expanded patch facilities its further implementation for the analysis of lactate. In both cases, we showed in vitro measurements covering the expected clinical levels, resulting in a fast response time, excellent reversibility and repeatability, and adequate selectivity. Sufficient stability and resiliency to skin penetration guarantee the sensor's success in transdermal measurements. The suitability of performing in vivo monitoring is demonstrated, first through ex vivo, by target analyte monitoring on rat skins and euthanized rats, and later in vivo by direct on-body measurements in anesthetized rats. Accuracy is evaluated by comparison with gold standard techniques to characterize collected intradermal fluid. For lactate, the correlation between ISF, and blood values is also assessed.



OP26 - Microwave-Based Planar Methods for Non-Invasive Intracranial Pressure Monitoring: Review and Directions

12. Sensors, diagnostic systems

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Abstract text*: Intracranial pressure (ICP) is essential to improve current clinical decision schemes in different scenarios, to understand cerebrospinal fluid (CSF) mechanics, and to model better physiological conditions. Nowadays, several studies focus on developing non-invasive ICP (nICP) monitoring methods based on different sensing modalities, each with advantages and disadvantages. Among them, microwave-based sensing, particularly planar methods, are in focus for easy integration into wearable electronics and compliance with the body. Here we present a review of major works and propose improvement directions. The review focuses on the employed testbeds and microwave planar sensing approaches and includes our preliminary works from a collaboration between researchers from the Department of Electrical Engineering (Microwaves in Medical Engineering) and the Department of Medical Science at Uppsala University. Our works include experiments on physical phantoms with various probe prototypes and on a live pig model. Our most recent works reproduce findings similar to a work employing the NASA SansEC spectroscopy technology (Griffith trial), but in two new testbeds: a simple physical phantom model (lab trial) and an alive pig model (pig trial) as shown in the Figure. Our findings emphasise the potential of that technology for nICP monitoring. Furthermore, we propose new methods and research directions based on arrays of sensing elements and metamaterials, empowered by a collaboration with the Department of Information Engineering, Pisa University. Microwave-based methods for nICP monitoring have the potential to become instrumental as tools that can be easily embedded and worn and give indications of brain health to trigger proper care in the future.

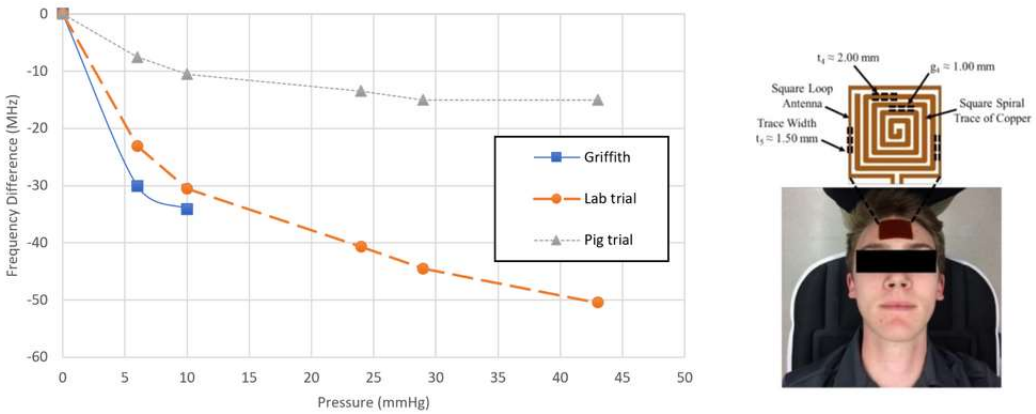

Figure: (left) Frequency-Pressure curves of a NASA SansEC spectroscopy sensor in different testbeds: Griffith trial, a lab trial and a pig trial. (right) NASA SansEC spectroscopy sensor in Griffith trial. Griffith, J. et al. (2018). Non-Invasive Electromagnetic Skin Patch Sensor to Measure Intracranial Fluid-Volume Shifts. MDPI Sensors, 18(4), 1022. doi:10.3390/s18041022

OP27 - Mikrovågsbaserad diagnostik av bristning i hamstringsmuskeln orsakad av idrott

12. Sensors, diagnostic systems
Laura Guerrero Orozco[1]
Andreas Fhager[1]
[1] Chalmers university of technology

Abstract text*: Muskelskador är en av de vanligaste typerna av skador som idrottare drabbas av. Sträckningar och bristningar utgör upp till 30 % av skadorna i fotboll och är särskilt vanliga inom friidrott. Hamstringsmusklerna (baksidan av låret) är de mest drabbade. Tillsammans med en klinisk undersökning spelar bilddiagnostik, mha MRI, en viktig roll vid diagnostisering av dessa typer av skador. Tyvärr är dessa skador sällan prioriterade och det är ovanligt att patienter blir undersökta med MRI. Många patienter får därför inte korrekt diagnos och därmed inte heller adekvat behandling. Följaktligen löper patienter med muskelbristningar, särskilt de med mindre skador, risken att bli odiagnostiserade. Detta kan leda till en för tidig återgång till träning och tävling och därmed en ökad risk för nya och värre skador. För att förbättra diagnos av muskelbristningar behövs ett system som är mer tillgängligt och är förknippat med en lägre kostnad.

Vi utvecklar ett mikrovågsbaserat system för att mäta och detektera den blödning som uppstår när muskeln brister. Systemet består av ett antal antenner i kontakt med låret. Dessa antenner används för att sända mikrovågor genom musklerna i olika riktningar. Dessa signaler kommer att påverkas av de olika vävnaderna på sin väg genom muskulatur, och sedan fångas upp av mottagarantennerna. Mätningar från ett stort antal antennpar samlas in och analyseras för att detektera eventuella blödningar.

Vi har tillverkat och testat en prototyp genom att mäta på kroppslika fantomer samt gjort bilder med en rekonstruktionsalgoritm som är inspirerad av radarteknikens time-of-flight mätningar. Resultaten har varit framgångsrika och vi tror att det finns goda möjligheter att nu kunna gå vidare med kliniska tester.

OP28 - Next generation MEMS-based metal oxide gas sensors on a thin silicon layer of SOI substrate enabling exhaled breath analysis

12. Sensors, diagnostic systems

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Abstract text*: Recent advancements in non-invasive medical diagnosis, especially in exhaled breath analysis, enable users and healthcare providers to detect diseases without relying on invasive techniques like blood tests. To measure and characterize exhaled breath, advanced algorithms together with multiple sensors must work in tandem. One of the most important components in the breath is the exhaled gas such as nitric oxide, isoprene, hydrogen sulfide, carbon monoxide, hydrogen, etc. The sources of exhaled gas such as hydrogen may be an indication of gastrointestinal disease and can be from bacterial fermentation in the bowel. Gas chromatography can be used to quantify several gases that are present in the breath and by measuring the concentration of different volatile organic compounds (VOC) a conclusion can be made about the severity of diseases such as gastrointestinal diseases, asthma, COPD, cystic fibrosis, and even lung cancer. However, these measuring instruments are bulky and expensive. Therefore, there is a need for a portable measurement device that can be carried along by the users for regular measurements. The measurement instrument needs to be smaller and more cost-effective. One such measurement instrument that is being popular is a spirometer. A spirometer measures and quantifies the flow to determine the lung function. When a micro gas sensor is combined, more functionalities can be accomplished with these kinds of instruments. To achieve this goal, we designed and developed a metal oxide gas sensor (MOx) on a silicon-on-insulator (SOI) wafer with a 10 µm device layer sensitive to hydrogen. The sensor measures a few mm^2 in dimension and less than a millimeter in thickness. The sensor manufacturing can be scaled up due to the batch fabrication process. This allows us to integrate into a measurement instrument such as a spirometer, to capture and measure a gas component in the breath.

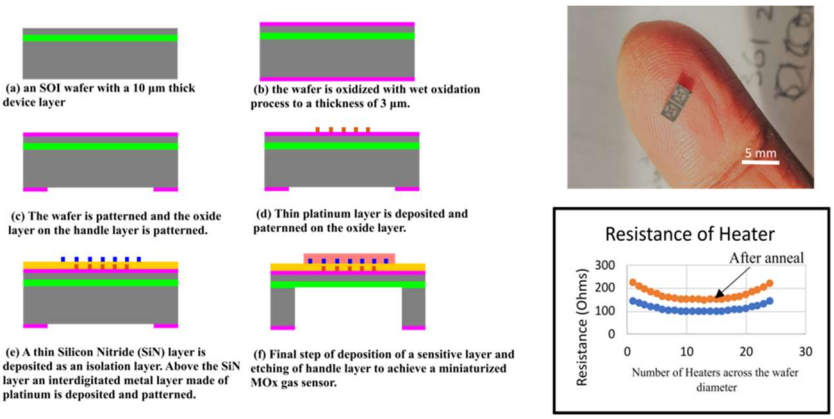

Fig. 1. Next generation highly sensitive hydrogen sensors (a) A SOI wafer is used for manufacturing the MEMS-MOx sensor. The SOI wafer has a device layer of 10 µm thick. (b) Photograph of two manufactured sensors resting on the fingertip showing the dimensions of the sensors. (c) measurement of heater resistance across the SOI wafer showing before and after the annealing of heaters. The variation in resistance is an indication of variation in the sputter deposition thickness. The variation in heater resistance values after annealing is attributed to the diffusion of chromium adhesion layer into the platinum.

OP29 - Mikrovågsbaserat system för detektion av trauma i skalle, bröst och buk

12. Sensors, diagnostic systems
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Mikael Persson[1], Andreas Phager[1]
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Abstract text*: Mikrovågsteknik har visat sig lovande för diagnostik av en bredd av skador och tillstånd. Ett användningsområde är att detektera inre blödningar som kan uppkomma vid fysiskt trauma. Dessa skador kan vara livshotande utan att ge tydliga symptom och behandling behöver ofta ske snabbt. Därmed blir teknik som kan detektera detta mycket viktigt. Mikrovågsdiagnostikens potentiella fördelar inkluderar portabilitet, vilket gör denna teknik intressant för användning inom försvaret. Ett sådant system skulle kunna tas med ut i fält och därmed möjliggöra diagnostik och behandling i ett betydligt tidigare skede än vad som är möjligt idag. Att göra en mätning på en skadad och få ett resultat kan gå mycket snabbt, potentiellt ned mot enstaka minuter. Denna snabbhet är en fördel då många skadade kommer in samtidigt och beslut behöver fattas om prioritering av vård och evakuering med begränsade resurser.

I detta projekt undersöker vi möjligheten att använda mikrovågsteknik för att detektera blödningar i skalle, bröstkorg och buk för tillämpning inom försvaret. Detta tillämpningsområde ställer krav på att systemet är portabelt, snabbt och enkelt att använda, och inte minst robust. Vi presenterar här vårt arbete med att vidareutveckla tidigare arbete inom mikrovågsdiagnostik för att möta de krav som ställs när denna teknik ska användas i ett militärt sammanhang och för denna typ av traumarelateade skador.

OP30 - Standalone microwave device to screen for poor muscle quality

12. Sensors, diagnostic systems
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Bappaditya Mandal[1], Mauricio D. Perez[1], Robin Augustine[1]
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Abstract text*: A need for new tools to assess the muscle quality has been identified [1]. In the Muscle Analyzer System (MAS) project we are developing a standalone microwave device with the purpose of assessing muscle quality. A device like this could be used to screen for patients with poor muscle quality to identify for example sarcopenia. The idea of the device relies on that at microwave frequencies there is a large difference in the dielectric properties of the fat and muscle tissue. Sarcopenia is characterized by fat infiltration into the muscle, something that could be detected with a microwave sensor. Poor muscle quality is also characterized by lower muscle mass, something the sensor could potentially detect as well.
The MAS device consist of a microwave sensor, a vector network analyzer and a computer. The device that have been used to collect data in clinical and volunteer trials relies on using a laptop to run and store the measurements. Figure 1 shows the current iteration of the handheld MAS device, where the laptop has been replaced by a Rapsberry Pi, a small microcomputer, to run the device. The device has a touch screen for ease of navigation in the user interface and a few buttons that can be programmed to e.g. run a measurement or save the current measurement results. Figure 1b shows where the microwave sensor will be connected, it is located so it can easily be placed on the spot of the measurement. The MAS device would be connected to a server onto which it will upload the measurements for post-processing.

(a) (b)

Figure 1: (a) The MAS device, (b) The top persepctive of the MAS device showing where the sensor will be connected.

OP31 - Fat-intrabody Communication Empowering Wearable Devices: The H2020 SINTEC Milestone

13. Other

Mauricio Perez[1]
Laya Joseph[1], Pramod Rangaiah[1], Bappaditya Mandal[1], Robin Augustine[1]
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Abstract text*: The EU Horizon 2020 project "SINTEC" (www.sintec-project.eu) aims to advance a rigid-stretch PCB technology with stretchable substrate and liquid alloy and to demonstrate its usability in complex applications involving fat-intrabody communication (Fat-IBC) [1]. To that end, one of the main objectives is to demonstrate and compare the advantages of antennas for Fat-IBC and low-energy Bluetooth (BLE) communication. Here, we present the results of the concluded project in that direction. We developed and tested two main antenna prototypes for compliant and multi-use applications. The tests were done on physical phantoms and human volunteers. We developed two advanced physical phantoms of the human torso made of semi-solid materials mimicking skin, subcutaneous fat, muscle, spinal column, visceral fat and internal organ (heart). The phantoms represent two fat distribution extremes: an obese and an athlete model. Moreover, we developed tools to cancel undesired radiation/propagation, specifically designed to study the energy ratio in propagating through the fat to other media. The ethically-approved tests on consenting volunteers were done on their torsos, as with the phantoms, in an antenna-antenna range of up to 50 cm and incorporating body movements. The results of the experiments showed that the performance of the BLE and Fat-IBC antennas and the Fat-IBC channel varied depending on the body composition and that both Fat-IBC antennas are comparable and, in many cases, perform better than BLE. The sequence of tests allowed us to validate Fat-IBC technology in the lab for the particular scenario of subdermal Fat-IBC technology.

[1] Asan, N. B., et al 2017. "Intra-body microwave communication through adipose tissue," Healthcare Technology Letters, 4(4), pp. 115-121.

Poster only

P32 - Application of information mining technologies to the study of chronic diseases: A systematic review

1. AI, machine learning, big data in medicine

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Abstract text*: The widespread use of information technology in healthcare leads to a large amount of data being collected, which can be utilised to enhance patient care and management of chronic illnesses. Our goal is to summarise past studies that have used data mining or process mining on chronic diseases to identify research trends and future opportunities. The review covers articles that pertain to the application of information mining technology on chronic diseases, published between 2000 and 2022, and were sourced from PubMed, Web of Science, EMBASE, and Google Scholar based on predetermined inclusion and exclusion criteria. Out of the searched articles, 60 were included in the review. There has been a growing trend in the application of data mining/machine learning techniques to chronic diseases, with diabetes being a popular area of research. The majority of the reviewed articles were focused on prediction, specifically for early disease diagnosis. The three most commonly used data mining methods were Random Forest, Logistic Regression, and Naive Bayes. The main challenge identified in the field is the interpretation of data mining results. Researchers are working towards breaking through the "black box" property of data mining methods, with process mining emerging as a promising new methodology for understanding the progression of diseases by revealing their trajectories.

P33 - Classification of Brain Tumour Tissue in Histopathology Images Using Deep Learning

1. AI, machine learning, big data in medicine

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Abstract text*: Deep learning models have achieved prominent performance in digital pathology, with the potential to provide healthcare professionals with accurate decision-making assistance in their workflow. In this study, ViT and CNN models were implemented and compared for patch-level classification of four major glioblastoma tissue structures in histology images.

A subset of the IvyGAP dataset (41 subjects, 123 images) was used, stain-normalised and patches of size 256x256 pixels were extracted. A per-subject split approach was applied to obtain training, validation and testing sets. Three models were implemented, a ViT and a CNN trained from scratch, and a ViT pre-trained on a different brain tumour histology dataset. The models' performance was assessed using a range of metrics, including accuracy and Matthew's correlation coefficient (MCC). In addition, calibration experiments were conducted and evaluated to align the models with the ground truth, utilising the temperature scaling technique. The models' uncertainty was estimated using the Monte Carlo dropout method. Lastly, the models were compared using the Wilcoxon signed-rank statistical significance test with Bonferroni correction.

Among the models, the scratch-trained ViT obtained the highest test accuracy of 67% and an MCC of 0.45. The scratch-trained CNN reached a test accuracy of 49% and an MCC of 0.15, and the pre-trained ViT only achieved a test accuracy of 28% and an MCC of 0.034. Comparing the reliability graphs and metrics before and after applying temperature scaling, the subsequent experiments proceeded with the uncalibrated ViTs and the calibrated CNN. The calibrated CNN demonstrated moderate to high uncertainty across classes, and the ViTs had an overall high uncertainty. Statistically, there was no difference among the models at a significance level of 0.017.

In conclusion, the scratch-trained ViT model considerably outperformed the scratch-trained CNN and the pre-trained ViT in classification. However, there was no statistically significant difference among the models.

P34 - Machine Learning Algorithm to Assess Muscle from Microwave Sensor Data

1. AI, machine learning, big data in medicine

Viktor Mattsson[1]
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Abstract text*: In the Muscle Analyzer System (MAS) project we are trying to assess the muscle quality from measurements using a microwave device, called the MAS device. The device could be used to screen patients for poor muscle quality. To accurately assess the muscle quality from microwave sensor measurements good knowledge of the skin and fat layer is crucial.
In order to assess the muscle quality we are currently developing the "three-stage algorithm", illustrated in Fig. 1. The name comes from the fact that the algorithm can be divided into three stages. In the first stage the "MAS parameters", the parameters derived from each measurement, are used to predict the skin thickness. In the second stage the MAS parameters are again used, but also the predicted skin thickness, to predict the fat thickness. Then the third stage uses the MAS parameters and the predicted skin and fat thickness to predict the muscle. The reason for doing it this way is that the signal from the sensor first needs to penetrate the skin layer, then the fat layer and lastly the muscle layer. By linking the models together the influence from the previous layers can be accounted for when predicting the subsequent layers. Each prediction box has two main components. First a feature selection method to pick the best MAS parameters for that prediction. Secondly, there is a machine learning model that is trained to predict either the skin or fat thickness or for muscle the cross-sectional area from the rectus femoris muscle.
By using the three stage algorithm algorithm the MAS device becomes a device can assess the body tissue composition rather than just muscle quality since the algorithm is estimating the skin and fat thickness as well as the muscle properties.

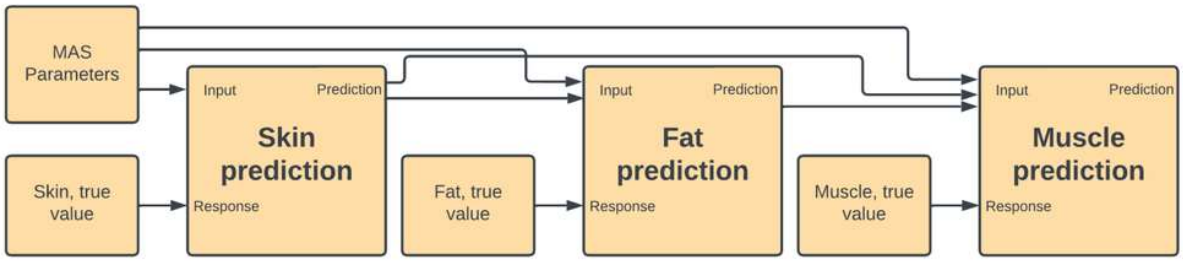

Figure 1: The three-stage algorithm.

P35 - Antimicrobial activity of flame-made Ag/SiO2 nanoparticles

2. Biomaterials, tissue engineering
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Abstract text*: The rise of multidrug-resistant bacteria has created the need for novel therapeutic approaches. Due to their unique physicochemical characteristics, nanoparticles may present a potential strategy against these pathogens. Owing to their size, high specific surface area and the release of Ag^+ ion, silver nanoparticles (Ag NPs) have strong antibacterial properties. Their antibacterial mechanism involves cell membrane disruption and generation of reactive oxygen species[1]. Additionally, the incorporation of silica (SiO_2) in composite Ag/SiO_2 nanoparticles, can enhance their stability and prevent their agglomeration, increasing their antibacterial action[2].

In the current study, we examine the antibacterial efficacy of Ag/SiO_2 nanoparticles against two of the leading pathogens for deaths associated with resistance, a strain of *Staphylococcus aureus* (Methicillin-resistant Staphylococcus aureus, MRSA) and *Pseudomonas aeruginosa* (PA01). The nanoparticles are synthesized with a scalable, and reproducible aerosol-based technique called flame spray pyrolysis, that allows precise control over their specific surface area (SSA)/size, composition, and crystallinity. For the physicochemical characterization of the flame-made nanoparticles with varying silver content (0-40 at. %), N_2 adsorption was employed to determine their SSA, and X-ray diffraction patterns were used to verify their composition and determine their average crystallite size. Their effectiveness against the pathogens was then assessed by the colony forming unit (CFUs) enumeration technique and spot plating assay. Nanoparticle concentrations ranging from 12.5 to 100 μg/ml were examined.

Based on the findings of this study, Ag/SiO_2 nanoparticles' antibacterial effectiveness is stated to be dose-dependent, and antibacterial effectiveness for nanoparticles with higher Ag concentration is found to rise.

(1) Bruna, T.; Maldonado-Bravo, F.; Jara, P.; Caro, N. Silver Nanoparticles and Their Antibacterial Applications. *IJMS* **2021**, *22* (13), 7202.

(2) Mosselhy, D.; Granbohm, H.; Hynönen, U.; Ge, Y.; Palva, A.; Nordström, K.; Hannula, S.-P. Nanosilver–Silica Composite: Prolonged Antibacterial Effects and Bacterial Interaction Mechanisms for Wound Dressings. *Nanomaterials* **2017**, *7* (9), 261.

P36 - Highly biocompatible Mg-Ca alloy with enhanced bioactivity towards bone regeneration

2. Biomaterials, tissue engineering

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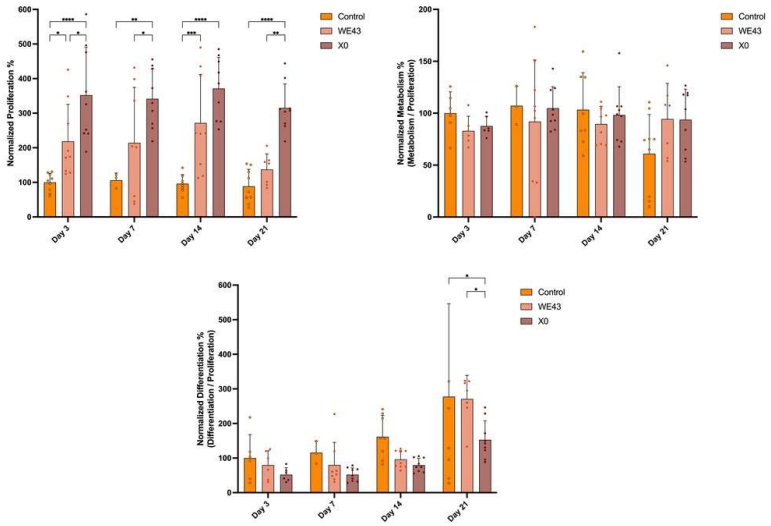
Abstract text*: Mg-containing alloys are widely known in the orthopaedic field and start to be clinically used as bioresorbable implants due to their appropriate mechanical properties and degradation rate. The Mg alloy predominantly used in these (pre-)clinical studies is a WE43 alloy, which contains a fair amount of rare-earth elements (REEs) such as yttrium and neodymium (3.9 wt.% Y, 3.0 wt.% Nd). These provide enhanced corrosion resistance and mechanical properties to the alloy. However, the long-term effects of REEs on human health during their release upon biodegradation and the related excretion pathways are still unknown. For these reasons, REE-free Mg alloys have arisen as an alternative, and a MgCa0.45 alloy (X0, in wt.%) has shown promise as a potential implant material for the treatment of bone fractures. In this study, X0 was compared with the well-established WE43 alloy using different testing methodologies and two consolidated cell lines for evaluating biomaterials: MC3T3-E1 and RAW 264.7. Initially, the materials were tested by culturing both cell lines with conditioned media produced by their extraction. Subsequently, the MC3T3 cells were cultivated using cell culture inserts for a longer period of time. The two materials were found to be highly compatible for both cell lines in terms of proliferation, metabolism and cell maturation. However, X0 exhibited a substantial increase in osteoblast proliferation compared to WE43, although its differentiation was lower than in the other control groups (untreated and WE43). Furthermore, no signs of chronic inflammation were found in the monocytic cell line after cultivating it with conditioned media for three days. Based on these results, the REE-free alloy X0 is expected to generate improved tissue regeneration with no adverse reactions to the immune system.



P37 - Edu-Mphy: A Low-Cost Multi-Physiological Recording System for Education and Research in Healthcare and Engineering

4. Biomedical engineering education

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Abstract text*: Physiological measurements play a vital role in healthcare, providing valuable insights into health characteristics through precise recording and signal processing. This work introduces Edu-Mphy, a novel low-cost multi-physiological recording system developed specifically for educational purposes in research and engineering. The system incorporates biopotential, bioimpedance, and optical measurements, aiming to enhance understanding and promote accessibility in analyzing physiological parameters. Leveraging the Raspberry Pi platform, we have successfully designed an open access custom-made measurement device capable of non-invasively acquiring physiological signals. The obtained waveforms exhibit encouraging outcomes, corroborating the findings of previous studies, and affirming the system's applicability on diverse biomedical applications. The educational system built around this recording platform empowers students, researchers, and educators, providing them with hands-on experience and enabling exploration of the intricate relationships between physiological signals and health outcomes. Notably, the system's low-cost nature ensures affordability and widespread availability, democratizing access to multi-physiological recording capabilities and fostering inclusivity in research and education. By integrating biopotential, bioimpedance, and optical measurements, the system offers a comprehensive educational toolset for studying human health characteristics. It effectively bridges the gap between theoretical knowledge and practical application, facilitating interdisciplinary learning and encouraging collaboration among diverse fields of study. In conclusion, Edu-Mphy represents a low-cost multi-physiological recording system designed specifically for educational purposes, highlighting its feasibility and potential impact on research and engineering education. The system's affordability, versatility, and accessibility significantly contribute to advancing knowledge and promoting innovation in the field of physiological measurements, empower the scientific community, and pave the way for future advancements in healthcare and biomedical engineering.

P38 - Real-Time Portable Raspberry Pi-Based System for Sickle Cell Anemia Detection

4. Biomedical engineering education

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Abstract text*: Sickle cell anemia is a genetic blood disorder that affects millions of people worldwide. Early detection and monitoring of sickle cell anemia can contribute to effective treatment and improved patient outcomes. We present a novel real-time portable system for sickle cell anemia detection based on the Raspberry Pi platform. The system incorporates a 100x zoom USB camera, allowing high-resolution imaging of blood samples, and employs an artificial intelligence (AI) algorithm trained on a publicly available open-access dataset of sickle cell anemia images. The main objective of this research is to develop an educational and training tool for understanding the structural characteristics and detection of sickle cell. The portability of the system enables easy access and utilization in various educational settings, such as classrooms, laboratories, and clinical training environments. The Raspberry Pi-based system provides real-time image acquisition and processing capabilities, facilitating immediate visualization of blood samples on an attached LCD screen. The acquired images are processed using the pre-trained AI algorithm, which identifies and highlights sickle cells in real time. By using the Raspberry Pi's computational power, the system ensures prompt and accurate analysis, enabling efficient identification of sickle cells within the acquired images. The significance of this research lies in its potential to enhance the understanding of sickle cell anemia among students, healthcare professionals, and researchers. The real-time visualization and automatic detection of sickle cells provided by the portable system allow users to observe the characteristic morphology of the disease and gain valuable insights into its diagnosis. Furthermore, the portability and ease of use of the system make it suitable for both educational purposes and clinical settings with limited resources. The affordability and accessibility of Raspberry Pi technology make this system a cost-effective solution for training programs and workshops aimed at improving sickle cell disease awareness and diagnostic skills.

P39 - A haptic-based assistive navigation system for individuals with profound visual impairment

7. In-house medical devices
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Abstract text*: Many assistive technologies have been designed to assist individuals with profound visual impairment in navigation. The most practical and successful tool is the white cane which has existed for a very long time. However, white cane has some known limitations. Here, we provide a haptic-based wireless system that helps the user to map their surroundings and navigate through an unknown landscape. The system consist of two parts: 1) the 'sensor module' which is laser based and can be worn on the belt, and 2) two 'haptic modules' which can be worn on each wrist with its vibrators directly placed on the skin. The direction and the distance to the surrounding objects are calculated by a microcontroller in the sensor module. Based on this information, a signal is sent to the haptic modules wirelessly. The corresponding vibrator(s) are activated with a certain amplitude and frequency to code the surroundings for the user. This navigation system was clinically tested on 7 individuals between 50 and 78 years (Mean = 63.5, SD = 9.3 years) old with profound vision impairment. The participants were asked to walk through an approximately 20 m labyrinth, made of chairs and tables. The participants took the test with only white cane versus with white cane together with the navigation system. According to our preliminary results, the time necessary for the participant to walk through the labyrinth was shorter (Mean = 5.8s, SD = 1.1s versus Mean = 6.7s, SD = 0.9s) and fewer crashes (Mean = 1.8, SD = 0.4 versus Mean = 2.4, SD = 0.5) happened once they had this assistive navigation system. Furthermore, the participants found the system reliable and a good complement to their white cane. These preliminary results motivate for a larger clinical study to statistically investigate the benefits of the proposed system.

P40 - Screening of Tumor in an Anthropomorphic Breast Model

7. In-house medical devices

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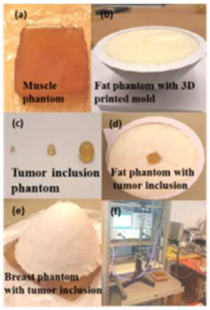
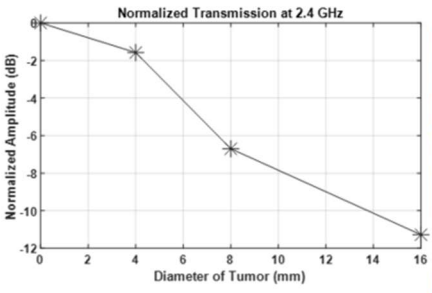
Abstract text*: Microwave imaging-based techniques is a widely researched topic with the aim to develop pain free breast imaging modality. In our work we focus on microwave transmission-based sensing instead of imaging to cater to the need of preliminary screening of breast anomalies before the patient gets recruited for detailed scanning. Such a modality will be highly beneficial to rule out cases that are not of concern and save precious resources, in diagnosing candidates that are in imminent need of detailed check-up without being subject to long waiting time. As part of the proof of concept, in this work we have developed a heterogeneous, human like, in shape and dielectric properties, semi-solid and stable breast phantom with skin, fat, muscle and spherical tumor inclusion models. In conjunction to the phantom development we have designed a transmission-based sensing method for non-invasive tumor detection. The dielectric properties of the breast phantom are measured using open ended coaxial slim probe from Keysight Technologies and is compared with the Nello Carrara Institute of Applied Physics (IFAC) data in the frequency range of 500 MHz - 20GHz. The S21 scattering parameter or the insertion loss is measured and studied for a normal breast phantom with respect to the breast phantom with tumor inclusion models representing various tumor growth stages using Topology Optimized Planar Antenna (TOPA) based probe. The measurements are done by using FieldFox microwave analyzer (N9918A) by Keysight Technologies. The study shows a transmission coefficient variation of 2 – 4 - 8 dB for tumor inclusion models of size ranging from 4mm, 8mm and 16mm diameter respectively with respect to normal breast model. This study indicates that with further development and refinement, transmission-based methods can be used for preliminary screening of breast tumor.





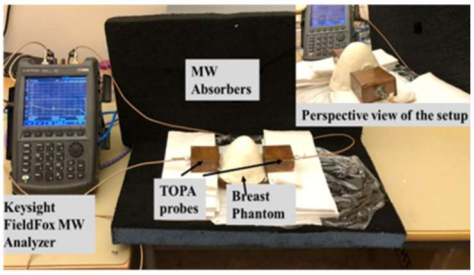


Fig. 1 **Fig. 2** **Fig. 3**

Fig. 1 (a) Muscle tissue (b) Fat tissue with 3D mold (c) Final breast phantom (Muscle, skin and fat) (d) Malignant tissues of sizes 4 mm, 8 mm, 16 mm (e) Phantom with deposited 16 mm malignant tissue (f) Dielectric measurement of muscle tissue phantom.
Fig.2 S21 parameters for normal healthy, malignant tissue sizes of 4mm, 8mm and 16 mm diameter at 2.45 GHz
Fig.3 S21 Measurements for Breast Phantom

P41 - Diagnostic - dielectric microwave sensors: Developing a body composition analyzer for applications in primary and secondary care

8. Innovation, translational biomedical engineering
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Abstract text*: Over the past years, four main techniques have been commonly used to measure lean muscle mass in healthcare: bioelectric impedance (BIA), dual-energy X-ray absorptiometry (DXA), computed tomography (CT), and magnetic resonance imaging (MRI) to replace anthropometry. Currently, the scientific community does not establish a consensus on the best technique to measure lean body mass.

Different diagnostic methods for body composition abnormalities, without any standardization criteria for measurement, may have led to varying prevalences of conditions or disorders in either overestimating or underestimating the measurement results for different patient cohorts. Consequently, many conditions are being missed or underdiagnosed in more than 50% of the cases.

To address this problem, we are developing a non-invasive hand-held device that uses non-ionizing radiation at very low power (< 1 mW). The device uses microwave radiation to quantify tissue properties. Quantification is achieved by analyzing the influence of dielectric tissue properties on the physical behavior of microwaves. Propagation, reflection, and attenuation of microwaves are all influenced by the dielectric properties of the underlying tissue. Analysis of the microwave signal yields accurate information on tissue quantity and quality.

We expect to create a proof of feasibility for the technology once all measurement data sets have been analyzed to optimize the software for the device.

A multimodal approach in diagnostics, monitoring, and follow-up at the point-of-care combined with new approaches in nutrition and pharma using exercise as medicine will contribute to creating a new reference standard at the point-of-care for measuring body composition.

P42 - Engineering of calcium phosphate nanoparticles for antimicrobial drug delivery

8. Innovation, translational biomedical engineering
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Georgios Sotiriou[1]
[1] Department of Microbiology, Tumor and Cell Biology, Karolinska Institutet

Abstract text*: Nanoparticle-based drug delivery systems are rapidly evolving to improve treatment for various diseases. Most of the nanoparticle-mediated treatments approved for clinical use nowadays are using liposomal drug carriers. Although various novel materials have been tested as drug delivery agents, there is still a long way from their demonstration in the laboratory until their large quantity production with reproducible properties that is necessary for clinical use. In this regard, here we propose a novel drug delivery platform based on calcium phosphate nanoparticles (CaP). We fabricate the nanoparticles by flame spray pyrolysis (FSP) that is a nanomanufacturing process famous for its scalability and reproducibility and assess their therapeutic potential against bacterial infections.

We extensively characterize the as-synthesized CaP nanoparticles in terms of their physicochemical properties and establish an experimental protocol for loading biologics. We load antimicrobial peptides (LL-37 and a mannose receptor-derived one) on CaP by physisorption, evaluate the stability of the nanoformulations against proteolytic degradation and assess their antimicrobial performance *in vitro* and *in vivo*.

High peptide loading values are obtained, that guarantee low nanocarrier dose for flame-made nanoparticles. Physisorption of LL-37 on CaP protects the peptide from enzymatic degradation and does not affect its antimicrobial functionality against both Gram-positive (*Streptococcus pneumoniae*) and Gram-negative (*Escherichia coli*) pathogens. Typical fractal-like structure of agglomerated/aggregated flame-made nanoparticles promotes high drug loading efficiency and enables protection of the drug from enzymatic degradation.

Mannose receptor derived (MRC-1) peptide loaded CaP NPs administered intranasally to mice, previously infected by *S. pneumoniae,* are shown to reduce development of pneumococcal disease *in vivo* enhancing mice survival.

In a nutshell, we present nanocarrier synthesis by FSP, an intrinsically scalable and reproducible synthesis method. High loading values achieved along with the *in vitro* and *in vivo* protective effect of the nanoparticles facilitate clinical translation of flame-made CaP nanoparticles as drug carriers.

P43 - Less microbubbles entered into the patients using the venous chamber Emboless® during haemodialysis

8. Innovation, translational biomedical engineering
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Bernd Stegmayr[2], **Per Jonsson**[1]
[1] Institutionen för folkhälsa och klinisk medicin, (1) Umeå (2) Skellefteå, Umeå Universitet
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Abstract text*:
Introduction Air contamination as microbubbles appear in the blood when it passes the extracorporeal circuit (ECC) [].

- Numerous of the microbubbles (MBs) enter back into the lungs, heart and brain of the HD patient - verified at autopsy (Fig 1, Forsberg et al 2023)
- In vitro, the venous chamber Emboless® reduces MBs significantly better than those for AK98, F5008, Artis (Jonsson et al 2023).

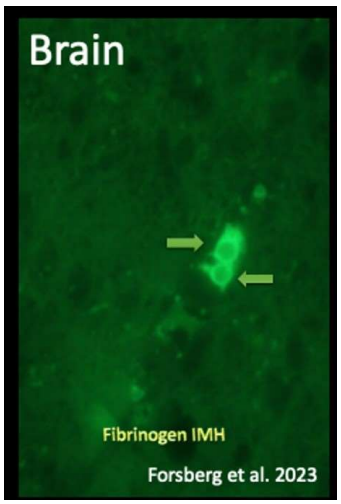
AIM In a clinical study we compared the efficacy of MB elimination of the chamber Emboless® versus the Fresenius 5008 (F5008).

Method 38 dialyses divided in 19 paired dialyses in 11 patients: with Emboless® and F5008, respectively
Ultrasound measured bubbles at the 'Inlet' and 'Outlet' of the venous chamber (sizes 20µm-500µm diameter).
The percentage of change in counts were compared (paired Wilcoxon test).

Results The median overall change of MBs were for :
F5008: **-33%** (mean -20 ±76%) vs Emboless: **-69%** (mean -56 ±54%,) pairs N=8093, **p<0.001**).

Conclusions Less microbubbles entered the patient using the Emboless® bloodline compared to the Fresenius 5008

- Considering autopsy results Emboless® may limit microemboli exposure during each haemodialysis.



P44 - Functional near-infrared spectroscopy, portable imagine techniques:new opportunities to evaluate cognitive processes during walking

9. Medical imaging, image processing

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Abstract text*: Background

The ability to walk without paying attention to the gait, is an important aspect of cognitive processes as it allows us to avoid unexpected events, e.g. a bump or a threat to our balance simultaneously as we are walking. This ability decreases the risk of falling and fall-related accidents(Mirelman et al., 2012).

Walking while attending to a secondary task, is traditionally evaluated using dual-task paradigm (Plummer & Eskes, 2015) but can also be evaluated physically, as cognitive processes consume energy resulting in increased cerebral blood flow. The novel, portable, functional near-infrared spectroscopy (fNIRS) has gained popularity, compared to the more common, fMRI, which is non-portable. fNIRS captures concentration-levels changes in oxyHb and de-oxyHb.

Interaction of cognition and walking in people with a lower-limb amputation (LLA) is rarely explored. Research suggests dual-task interference in standing is greater for people with LLA than non-amputees and also that changing to a more advanced prosthetic componentry can improve dual-task performance which also positively can affect balance and gait performance (Morgan et al., 2018).

Aim

Evaluate differences in cortical brain activity measured with fNIRS in participants with a LLA performing level- and dual-task walking.

Method

Brain activity, measured with fNIRS, and temporospatial parameters was captured in level-walking and dual-task walking.

Twentynine persons with a transfemoral amputation using either a CP(n=15) or a non-CP(n=14) and 16 healthy-controls participated.

Results

Prosthetic users showed significant($p<0.05$) increased brain activity in level-walking compared to healthy-controls.

Non-CP was associated with significant($p<0.05$) increased brain activity in level-walking compared to CP.

No significant changes were observed in brain activity in non-CP users when a secondary task was added.

Discussion/conclusion

Results suggest that walking with a prosthesis increases cognitive demand. Using a CP decreases cognitive load compared to using a non-CP. Moreover, fNIRS seems to be useful in evaluating cognitive load during walking.

P45 - Spatiotemporal PET reconstruction

9. Medical imaging, image processing

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Abstract text*: Positron Emission Tomography (PET) is a medical imaging modality that reconstructs the metabolic activity of body cells, by detecting the two antiparallel 511 keV photons, emitted from an injected positron emmitting radiotracer.
PET diagnostic power for lung lesions at an early stage is however limited, since lesions' dimensions are comparable with the spatial resolution of clinical scanners and their contrast-to-noise-ratio is strongly reduced by respiratory motion.
We hereby propose a modified version of the Maximum Likelihood Activity and Attenuation (MLAA) algorithm, the Morphed-MLAA (M-MLAA), which simultaneously reconstructs the activity and attenuation distribution and performs motion correction from gated emission data. In brief, considering N gates gi, i = 1, ...,N, the algorithm performs the following steps: some initial gated MLAA iterations are used to evaluate diffeomorphisms by Synthmorph, registering gi to gi−1 Then, the evaluated diffeomorphisms are composed with the forward and backward operator in each interleaved update step for activity (M-MLEM) and attenuation (M-MLTR) of the M-MLAA algorithm to reconstruct the whole data set in one chosen gate of reference By exploiting the entire dataset, the contrast-to-noise ratio of the lesions can be improved while preserving full spatial resolution.
Our proposed M-MLAA algorithm has been tested on XCAT phantoms with some added lung lesions and compared (by visual inspection and evaluating Peak Signal to Noise Ratio, Recovery Coefficient and Signal Difference to Noise Ratio) against MLAA reconstruction of reference gate, MLAA reconstruction from the sum of the data in all of the four gates, MLAA single-gates reconstruction and registration with Synthmorph in the reference, MLEM reconstruction of the reference gate with attenuation correction performed through CT-derived attenuation map. Our results show that M-MLAA outperforms clinical standard reconstruction.

P46 - Assessment of Charge Exchange Mechanisms in Bioelectronic Materials during Direct Current Stimulation

10. Neural engineering

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Abstract text*: Electrode materials capable of sustaining direct current electrical stimulation (DCS) are needed to generate consistent direct current electrical fields (dcEFs). Externally applied dcEFs can promote axon regeneration, speed up wound healing, and influence the motility of cancer cells. In this work, we apply amperometric and voltammetric methods (Lindquist, Trasatti, Dunn) to determine the contribution of diffusion-limited (faradaic reactions) and capacitive-like processes (electrical double layer and pseudocapacitance) to charge transfer during DCS of bioengineering-relevant electrode materials (*i.e.* Pt, sputtered iridium oxide films (SIROF), laser induced graphene (LIG) and PEDOT:PSS on LIG and SIROF). Understanding these contributions is essential to ensure the biocompatibility of DCS in applications ranging from cell culture to animal experiments. By performing cyclic voltammetry (CVs) at different scan rates (1 – 300 mV/s) in two electrolytes (PBS to mimic the human body and ferricyanide as a well-described redox reaction), we found that PEDOT:PSS coating increases the electrode's electrochemical surface area and capacitance. The results of the applied methods are comparable. However, they come with method-specific limitations due to the nonlinearity of current vs. scan rate curves at higher scan rates, or the potential shift of current peaks in CVs. To the best of our knowledge, this is the first time that these methods have been applied to materials common in bioelectronics. The results of this work provide bioelectronics researchers with a foundation to make an informed decision on which materials to choose for their DCS experiments. The next step is to measure the concentration of faradaic reaction products during DCS to answer whether a high electrode capacitance correlates to a longer time of capacitive-like current delivery, meaning no release of by-products.

P47 - Design of Metamaterial Integrated Efficient Wireless Power Transfer System for Implantable Biomedical Sensors

12. Sensors, diagnostic systems

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Abstract text*: In this paper, a metamaterial (MTM) based efficient approach is presented to enhance the efficiency of an implantable wireless power transfer (WPT) system for biomedical sensors. The WPT system is designed to operate in the ISM frequency band of 2.40 to 2.48 GHz. The system is designed using a planar loop antenna considered as a receiving (Rx) element. Also, a patch is constructed in an air environment to use as a transmitting (Tx) element. In implantable scenarios, power transfer efficiency (PTE) of the WPT system is low due to compact size of Rx implant and lossy tissue environments. Henceforth, it is highly desired to enhance the efficiency of WPT system. In this regard, a circular spiral split ring resonator (CSSRR) metamaterial structure having high refractive index (HRI) property is used to enhance the efficiency of the proposed system. Due to compact size of the implantable antenna, the effective aperture of the Rx is small as a result antenna performance got degraded which affects the PTE of the system. However, by inserting a CSSRR-MTM slab above the skin surface, the effective aperture of the Rx implant is enhanced as per Snell's law. Consequently, PTE of the proposed system is enhanced significantly.

The schematic of proposed MTM-integrated implantable WPT system has been shown in Fig. 1(a) with the configuration of the Tx, Rx, and MTM slab along with their dimensions and placement positions. The S-parameter characteristics of proposed system with and without (W/O) presence of MTM are presented in Fig. 1(b). The efficiency (η) of WPT system is calculated from transmission coefficient ($|S_{21}|$) as, $\eta = |S_{21}|^2$. The efficiency property of the MTM-integrated system is shown in Fig. 1(c) and it is increased from 0.56% to 1.61%. This study highlights the potential application of MTM for performance enhancement of the implantable WPT system.

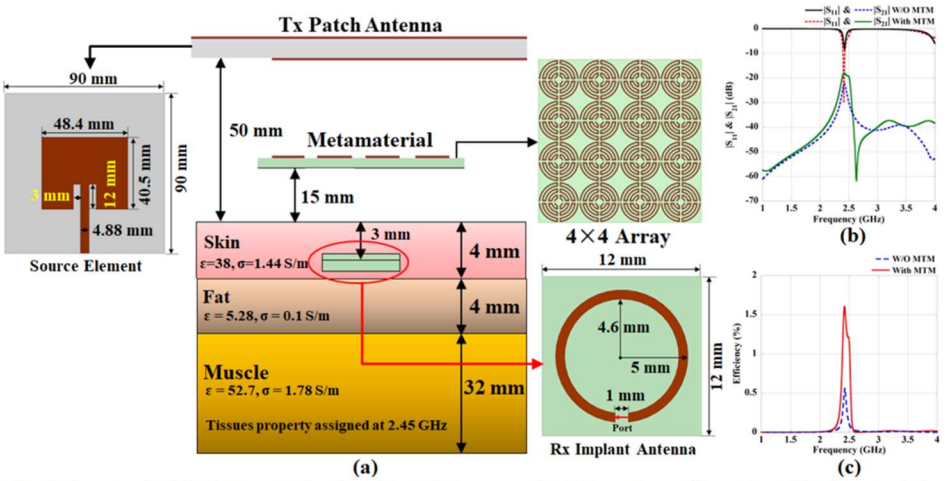

Fig. 1. Proposed MTM integrated implantable WPT system. (a) Schematic configuration, (b) Characteristics of the S-parameters, and (c) Efficiency plot with and without MTM.

P48 - Microwave Diagnostics for Biomedical Applications

12. Sensors, diagnostic systems

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[1] Chalmers University of Technology

Abstract text*: Microwave diagnosis is a potential complement for CT and MRI to diagnose safely, fast, portably and reliably. In this presentation, we present our latest advances in the field of microwave diagnostics for the following two applications.

- Microwave detection of thrombosis:

In this project, the presence of a blockage in the arteries of the brain is diagnosed using microwave antennas operating in below 1 GHz band.

- Microwave monitoring of shunt malfunction in hydrocephalus children:

The aim of this project is to modify the MD100 Strokefinder device to be able to use it on hydrocephalus children with brain tumours to monitor the ventricle size.

P49 - Millimeter-wave radar: the key sensor technology enabling healthcare at home

12. Sensors, diagnostic systems

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Abstract text*: Of Sweden's 10 million inhabitants, 20 % have passed the standard retirement age of 65. This number is going to rise to 23 % by 2040. The normal aging process entails declines in both cognitive and physical functions, which not only largely affects the quality of life for the elderly, but also results in a huge burden to the healthcare system.

To help the elderly live independently and improve the effectiveness of the healthcare system, digitalization in healthcare has become increasingly important. It involves the use of various types of sensors for monitoring the health conditions of the elderly at home and provides medical personnel with vital health data for disease detection and prediction.

Among all the existing sensor technologies, millimeter-wave radar has demonstrated great potential for different health monitoring purposes, including fall detection, vital sign monitoring, blood pressure monitoring, gait measurement, etc. Millimeter-wave radar has many unique characteristics for continuous health monitoring in the home environment. It is contactless, unobtrusive, and most importantly, privacy-preserving. In addition, the radar sensor has a low-cost and small size, making it extremely suitable for widespread home-based use.

In the presentation, I will give an introduction to our work on using millimeter-wave radar for various medical applications with a focus on the early detection of arrhythmia and prediction of fall risk in the elderly.