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Advancing Translational Medicine Through Preclinical Imaging: Reflections on TPIC 2024

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Editorial

As we embrace 2024, the field of translational medicine stands at an exciting crossroads where innovation, collaboration, and cutting-edge technology converge. Among the most powerful tools driving this transformation is preclinical imaging, a discipline that continues to redefine our ability to understand disease mechanisms and accelerate the development of effective therapies.

Preclinical imaging offers an unparalleled window into the living body—enabling researchers to monitor biological processes at anatomical, cellular, and molecular levels in real time. From high-resolution micro-ultrasound and MRI to PET, SPECT, and CT, these imaging modalities are integral to visualizing disease progression, evaluating therapeutic responses, and ultimately bridging the bench-to-bedside gap in translational research.

Building on the success of previous years, the TPCF (Tehran University of Medical Sciences Preclinical Core Facility) has taken a bold step forward in 2024 by expanding its flagship event into The 1st International Tehran Preclinical Imaging Conference (TPIC 2024). This evolution from symposium to conference reflects the growing impact of preclinical imaging and our community's commitment to advancing translational science.

TPIC 2024 serves as a dynamic platform for researchers, clinicians, engineers, and industry partners to exchange knowledge, present novel findings, and explore emerging imaging technologies that are shaping the future of biomedical research. With a robust scientific program, including keynote lectures, oral and poster presentations, and hands-on workshops, the conference highlights both foundational innovations and practical applications in drug discovery, disease modelling, and therapy development.

We are proud that Frontiers in Biomedical Technology (FBT) continues its tradition of supporting scientific dissemination by publishing the abstracts from TPIC 2024. This compilation represents the dedication, creativity, and rigor of a global community united by a shared vision: to harness the power of imaging for better health outcomes.

We invite all attendees, contributors, and readers to explore these abstracts and join us in celebrating the progress and promise of preclinical imaging. For more information about TPIC 2024, including the full program and future initiatives, please visit our website at www.TPCF.ir.

Together, let us continue to illuminate the path of translational medicine—one image at a time.



High-Resolution Ultrasound Imaging for Non-Invasive Characterization of androgenetic Alopecia on Male C57BL/6 Mice Skin Tissue: A Non-Invasive Approach to Characterizing Androgenetic Alopecia in Mice

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Abstract

Background: There are different types of hair loss known as alopecia. Androgenetic Alopecia (AGA) is a common type of hair loss that affects up to 50% of white men by age 50 and approximately 50% of women during their lifetime. Various methods of treating AGA are being investigated in the preclinical stage using C57BL/6 mice affected by this disease.

The purpose of the study was to evaluate the effects of Dihydrotestosterone (DHT) on the skin layers of male C57BL/6 mice, simulating a model of AGA using high-resolution ultrasound imaging.

Materials and Methods: Seven-week-old male C57BL/6 mice were selected for the study. To induce AGA, three of the mice received intraperitoneal injections of DHT at a dosage of 1 mg per day for five consecutive days — a known method for provoking hair loss via androgenic pathways. Utilizing high-resolution ultrasound imaging at 40 MHz and 75 MHz frequencies allowed detailed observation of skin layer changes due to DHT administration. Elasticity measurements (shear modulus and Young's modulus) were taken using a pressure gauge with a 40 MHz ultrasonic probe. Both normal and AGA-affected groups were evaluated through structural imaging, with findings compared against Hematoxylin and Eosin (H&E) and Trichrome staining results.

Results: Ultrasound imaging revealed that the epidermis thickness was 0.22 mm in the normal group compared to 0.31 mm in the AGA group at 40 MHz. At 75 MHz, these measurements were 0.062 mm for the normal group and 0.082 mm for the AGA group. The dermis thickness measurements showed 0.3 mm in the normal group and 0.7 mm in the AGA at 40 MHz, while at 75 MHz, the thicknesses were 0.65 mm for the normal and 0.70 mm for the AGA group. H&E staining results aligned with these ultrasound findings, confirming increased epidermal and dermal thicknesses in the AGA group. Elasticity metrics indicated a shear modulus of 1.19 kPa for the AGA group and 6.70 kPa for the normal group, while Young's modulus demonstrated values of 6.47 kPa for normal and 22.69 kPa for the AGA group. Further corroboration of altered tissue elasticity was provided by Trichrome staining, indicating significant changes in skin structure.

Conclusion: The administration of DHT in the C57BL/6 mice model leads to notable structural changes in skin layers, evidenced by increased thickness of both the epidermis and dermis, along with diminished mechanical properties of skin elasticity. These findings provide valuable insights into the pathophysiology of AGA and emphasize the potential of high-resolution imaging techniques for studying hair loss mechanisms. Further research is warranted to explore therapeutic interventions that may mitigate these structural changes.

Keywords: Androgenetic Alopecia; High-Resolution Ultrasound Imaging; Skin.

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Deep Learning-Based Reconstruction Using Low-Dose Preclinical CT Images

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Abstract

Background: In preclinical imaging, micro-Computed Tomography (CT) provides a powerful tool to acquire high-resolution anatomical images of animals and offers the advantage of in vivo non-invasively to assess disease progression and therapy efficacy. As in humans, much higher resolutions are needed to achieve scale-equivalent discriminatory capabilities in animals, but high-resolution imaging comes at the expense of increased scan times and higher doses. Specifically, with preclinical longitudinal imaging, there are concerns that dose accumulation and long sedation may affect the experimental outcomes of animal models. Providing a solution to the mentioned issues has always been important. Therefore, various techniques have been developed to reduce the noise of low-dose CT scans. Deep Learning (DL) is one of the increasingly popular techniques for medical imaging enhancement tasks, such as denoising, super-resolution, and artifact removal. In particular, Convolutional Neural Networks (CNN) show important performance gains in noise reduction in low-dose imaging, and also the deconvolution layer is effectively established for end-to-end mapping between low- and high-resolution images. The principles of DL denoising are equally applicable to both clinical and preclinical settings. However, the majority of research efforts have been focused on clinical low-dose CT, with only a few studies exploring the benefits of dl-based image enhancement for preclinical imaging. So, this study investigates the possibility of Low-Dose CT (ldct) imaging to reduce the radiation dose and proposes a method based on deep learning that improves the image quality.

Materials and Methods: The dataset consists of two different scans of a chicken bone obtained from a cooked chicken. For each scan 721 x-ray projections. The x-ray source was set at 40 kv with a 0.5 mm aluminum filter. For the different scans, the relative doses, tube currents, and exposure times were:

- 10 % relative dose: tube current 0.2 ma, exposure time 1000 ms.
- 100 % relative dose: tube current 1 ma, exposure time 2000 ms,

The scans were made in sequences, proceeding from the lowest dose (ldct) to the highest dose (hdct). All images were transformed into four images using wavelet transform. This approach was chosen to effectively reduce noise, enable multi-scale image decomposition, and enhance model accuracy. Two different deep learning-based approaches have been employed: convolutional neural networks (CNNs) and deconvolution neural networks (DNNs). The results show that cnns achieved significant performance improvements in noise reduction for low-dose imaging. Additionally, dnns were effectively established for end-to-end mapping between low-resolution and high-resolution images.

Results: The three metrics, including the peak signal-to-noise-ratio (psnr), root Mean Square Error (rMSE), and Structural Similarity Index Measure (SSIM), which measured between the denoised ldct and hdct, are 15.3455, 0.1748, and 0.8443, respectively.

Conclusion: The findings demonstrate that deep learning can significantly enhance the quality of micro-CT imaging, even in low-dose acquisition settings. This capability is particularly valuable in preclinical research, as it paves the way for minimizing cumulative radiation exposure in longitudinal studies, thereby offering a safer and more effective approach for managing long-term experiments.

Keywords: Androgenetic Alopecia; High-Resolution Ultrasound Imaging; Skin.



A Case Report of FATE in a Female Persian Cat

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Abstract

Background: Aortic thromboembolism in cats is a serious condition that can occur secondary to other heart diseases such as hypertrophic cardiomyopathy, potentially leading the animal to death. These thromboembolisms, presumed to originate from the left atrium, enter the aorta and typically embolize at the point where the aorta branches; causing symptoms such as pain, ischemia, coldness, and paralysis of the hind limbs. Predisposing factors for this condition include left atrial enlargement and systolic failure, which damage the endothelium and increase von Willebrand factor, tissue factor in the serum, platelet reactivity, and thrombin-antithrombin complexes, all of which raise the likelihood of intravascular thrombosis. Given the significance of gender in the occurrence of this disease with most reports indicating that aortic thromboembolism primarily affects male cats. A Persian female cat presented to the hospital with hind limb paralysis and a history of hypertrophic cardiomyopathy.

Materials and Methods: Para clinical tests, including radiology and ultrasonography, revealed a 12 mm clot at the bifurcation of the abdominal aorta, confirming the diagnosis of aortic thromboembolism, introducing a novel discussion in veterinary science.

Results: In this cat, due to its cardiovascular issues, the risk of recurrent thromboembolism increased, posing a serious threat to its health.

Conclusion: Despite available treatment options, due to the poor prognosis and the owner's request, the animal was euthanized. Subsequent necropsy confirmed the diagnosis of aortic thromboembolism by removing the thrombus from the abdominal aorta.

Keywords: Feline Aortic Thromboembolism; Persian Cat; Hypertrophic Cardiomyopathy.



Radiographic Examination of Pneumonia in Marghoz Goat

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Abstract

Background: Pneumonia is the most common and significant respiratory disease in goats, leading to substantial economic losses in the livestock industry worldwide. Accurate diagnosis of lung infections is based on clinical evaluation, radiographic, and laboratory studies. Clinical and chest radiographic features (interstitial, alveolar, vascular, and mixed patterns) should be aligned to enable differential diagnosis. Although many pathogens may have overlapping features, dominant clinical and radiographic characteristics can assist in the differential diagnosis of respiratory diseases.

This study aimed to investigate the radiographic features of respiratory diseases in goats and analyze their prevalence during the winter of 1393 and spring of 1394 at the Agricultural Research Center of Sanandaj.

Materials and Methods: The study was conducted during the winter of 1393 and spring of 1394. Goats showing more than 30% of the total respiratory symptom index were selected for X-ray analysis. Fifty radiographs of male and female goats, as well as lambs, were taken during each season. Radiographs of the thoracic area (ventrodorsal, lateral, and standing lateral views) were prepared and interpreted based on recorded radiographic patterns.


Results: The results indicated that during winter, the lowest incidence was unstructured interstitial patterns (6.66%), while the highest prevalence was interstitial nodular lesions (38.66%). In spring, vascular pattern lesions had the lowest incidence (9.09%), whereas interstitial nodular lesions were most prevalent (30.31%). Adult males showed the lowest incidence of lesions in the spring (7.27%), while the highest was nodular interstitial patterns (38.18%). Lambs had no knotted interstitial pattern lesions, but unstructured interstitial patterns were most prevalent (45.71%). Poor ventilation and high livestock concentrations in northern areas contribute to lung injuries in this population.

Conclusion: The integration of pattern recognition and clinical knowledge is the best approach to interpreting radiological pneumonia. Radiological imaging allows for differential diagnosis and serves as a tool for establishing therapeutic protocols.

Keywords: Pneumonia; Goats; Radiographic Patterns; Respiratory Diseases; Veterinary Diagnostics.



Comparative Preclinical Study of the Effect of Anesthesia Method on Heart and Brain Image Quality for Xtrim Micro-PET

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Abstract

Background: Preclinical imaging has merit and crucial role in drug development and efficacy, toxicity and basic understanding of mechanisms of disease for clinical applications. Micro-PET imaging modality using the radiopharmaceutical ¹⁸FDG has been widely used in animal studies of the brain and heart function. Anesthetic agents are generally used for animal imaging to prevent motion artifacts caused by animal movement during the scan. Anesthetic agents such as isoflurane and ketamine/xylazine mixture induce hyperglycemia that it profoundly competes with administrated FDG in animal and thus significantly affect the results of FDG-PET studies included in FDG uptake and Image Quality (IQ) parameters. In this work, we aim to investigate the effect of different anesthesia methods on Xtrim micro-PET image quality in terms of Signal-to-Noise Ratio (SNR), Contrast-to-Noise Ratio (CNR) and tissue to background ratio in both Heart and Brain organs. Finally, the Correlation between SUV estimated by PET image vs γ -Counter were evaluated.

Materials and Methods: 28 male Wistar rats at an age of 8 weeks (body weight of ~200 to 220 g) were randomly kept in 5 groups, G₁-G₅ (n=4) in individually cages. The G₁ and G₂ group were anesthetized at all over experiment time, FDG injection, uptake and PET scan by 2% Isoflurane (ISO) and ketamine (100 mg/kg) and xylazine (10 mg/kg) mixture (Ke/Xyl), respectively. Both G₃ and G₄ group were anesthetized only at PET scan time by 2% ISO and Ke/Xyl, respectively. The G₅ group were anesthetized at FDG injection, and PET scan by 2% ISO.

Results: TBR and CNR results of Heart PET image showed similar pattern as expected. The highest and lowest IQ of Heart PET image is for ISO group, G₁ and G₅, and Ke/Xyl group, G₂, respectively. The parameters are in direct relationship to SUV and %ID/g. The highest IQ of Brain PET image is related to G₁ protocol that rat was anesthetized in all over experiment by %2 ISO, although other protocols can be comparable to each other. With regard to Brain, it is noted that both TBR and CNR behaved almost similar to the uptake values (SUV and %ID/g) except G₂. The results of SNR confirm that SNR is independent of anesthesia method for both cardiac and cerebral organs. Our study highlighted that increase in Blood Glucose level due to anesthesia and stress caused by FDG injection in conscious group (G₃ and G₄) considerably impacts on parameters related to IQ, TBR and CNR.

Conclusion: Initial results with the given data of 28 Wistar healthy male rats demonstrated that G₁ protocol using %2 ISO anesthesia in all over experiment (¹⁸FDG administration, uptake and PET scan) could be sufficient to yield good images for both Heart and brain in terms of TBR, CNR and SNR. In the future, more work needs to be done to validate the results with a larger population and data.

Keywords: Micro Positron Emission Tomography; Anesthesia; Heart; Brain; Image Quality.



Optical Fluorescence Imaging for Assessment of Mesenchymal Stem Cell Viability Encapsulated in Alginate Hydrogel

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Abstract

Background: Host immune response to the transplanted biomaterials and fibrotic overgrowth on implanted hydrogels will reduced in vivo application of these therapeutics. Considering the results of previous reports related to the immuno-modulatory properties of mesenchymal stem cells (MSCs), we hypothesized that encapsulated MSCs could reduce the host immune system response against implanted spheres.

Considering the results of previous reports related to the immuno-modulatory properties of mesenchymal stem cells (MSCs), we hypothesized that encapsulated MSCs could reduce the host immune system response against implanted spheres.

Materials and Methods: The MSC-laden alginate solution was cross-linked with a calcium chloride reagent. Cell-free capsules or cell-laden spheres were implanted into the peritoneal cavity of BALB/c mice. Two weeks after sphere transplantation into the peritoneal cavity, hydrogel spheres were recovered for investigation of fibrotic tissue adhered to the sphere surface. Acridine orange and propidium iodide staining were implemented for optical fluorescent imaging of encapsulated cells. Scanning electron microscopy, swelling and degradation analysis were used for morphological and mechanical characterization of hydrogel.

Results: Analysis of cell viability using fluorescent acridine orange/propidium iodide staining demonstrate that host immune response against cell-laden spheres lead to fibrotic tissue formation on the surface of spheres and reduced cellular viability.

Conclusion: MSCs within alginate hydrogel could not mitigate the foreign body response against implanted spheres. There is an essential need for biomaterials that could reduce the host immune response as an important issue in the progression of regenerative medicine.

Keywords: Mesenchymal Stem Cell; Encapsulation; Immune Response; Alginate; Hydrogel.



Morphophysicochemical Characteristics of Exosomes Derived from Tumor Antigen-Loaded Monocytes-Like Macrophages of Canine Breast Cancer: Suitable for Targeted Breast Cancer Therapy

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Abstract

Background: Canine breast cancer is a prevalent neoplastic disease in female dogs. Approximately 50% of canine mammary tumors are malignant with high metastatic potential. Early diagnosis is critical for favorable prognosis, with benign tumors typically showing a high rate of recovery. However, malignant tumors often recur and metastasize, reducing survival rates. Current therapeutic interventions for canine breast cancer include surgery, alongside adjuvant therapies like chemotherapy and, less commonly, radiation therapy. Despite these efforts, malignant tumors frequently exhibit resistance to chemotherapy, and treatment outcomes are further complicated by side effects like immunosuppression, gastrointestinal toxicity and possible secondary infections. These challenges highlight the need for more targeted and less invasive treatment modalities. Notably, the similarities between canine and human breast cancer in terms of hormonal regulation, tumor biology, and metastatic behavior make canine models invaluable for translational research. Exosomes, nanosized extracellular vesicles (30-150 nm) secreted by (non)immune cells, play crucial roles in intercellular communication and can influence the tumor microenvironment and immune response. Exosome-based therapy shows promise for treating breast cancer by delivering targeted, reducing side effects and improving efficacy. As research advances, exosome therapies may offer a less invasive, more precise and biologically compatible treatment for malignant breast cancer. To evaluate the potential of exosomes derived from tumor antigen-loaded monocytes-like macrophages (MLMs) of canine breast cancer for targeted breast cancer therapy. This can be done through analysis of their size, charge, and molecular composition.

Materials and Methods: First, biopsy from canine breast cancer was obtained through surgery, and tumor lysates were extracted from a mixture of tumors. Monocytes were then isolated from canine blood and matured with the tumor lysate in Dulbecco's Modified Eagle Medium cell culture for 24 hours. Next, the exosomes secreted by the MLMs were collected from the culture medium using an Exosome Isolation Kit (Exocib S, Cib Biotech Co). Their characteristics-including size, charge, shape, and concentrations of protein, RNA, and DNA were analyzed. Dynamic Light Scattering (DLS) and Zeta Potential analysis were used to assess size and charge, while protein, RNA, and DNA concentrations were measured using Nanodrop. The shapes of the exosomes were observed with Scanning Electron Microscopy (SEM).

Results: The exosomes had an average size of 144.8 nm with a polydispersity index of 0.669, confirmed by SEM showing spherical particles of 130-144 nm. Zeta potential analysis indicated -58.7 mV, and Nanodrop analysis revealed protein concentration of 1575 µg/mL, DNA concentration of 59.388 µg/mL, and RNA concentration of 67.969 µg/mL. UV-Vis spectroscopy showed significant absorption at 220 nm, indicating the presence of proteins and nucleic acids.

Conclusion: The results demonstrate that the exosomes derived from tumor-educated MLMs possess characteristics consistent with functional exosomes, including appropriate size, charge, shape, and molecular content. The substantial presence of proteins, DNA, and RNA highlights their potential for intercellular communication and therapeutic applications. Zeta potentials $> \pm 30$ mV usually indicate stable colloidal suspensions due to electrostatic repulsion, reducing the likelihood of aggregation. This could have significant implications for its use in drug delivery or as a biomarker carrier, where stability is critical.

Keywords: Breast Cancer; Exosomes; Monocytes; Immunotherapy; Extracellular Vesicles.



Pressure Attenuation and Temperature Increase in Transcranial Ultrasound: A Simulation Study

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Abstract

Background: Considering the significant advantages of ultrasound such as non-invasive and non-ionizing, the use of ultrasound has become increasingly common in the medical field for various diagnostic and therapeutic purposes. Therapeutic applications include thermal ablation, opening the blood-brain barrier, and neuromodulation. Transcranial ultrasound imaging has long been used to image vasculature and blood flow through temporal windows, but its generalization is still problematic. The propagation of ultrasound waves through different environments, including tissues, forms the basis of its application. However, the sound field distribution characteristics are seriously affected by the attenuation of the environment. Attenuation of these waves, especially in intracranial ultrasound, is a significant challenge. The difference in absorption coefficients of tissues such as ultrasound gel, skull, and brain tissue attenuate these waves. On the other hand, with the absorption of ultrasound in the tissue the absorbed energy of the primary acoustic turned into heat and increased the temperature. The thermal effect of ultrasound brings concerns about possible harmful effects.

The objective of the present study was to simulate the head of the rat at first to investigate the attenuation of acoustic pressure with pass different head tissues and evaluate the resulting pressure. The second purpose was to investigate the amount of increase in temperature as the result of the collision of ultrasound with tissues.

Materials and Methods: Based on the real rat head structure and biological tissue properties of the head region, a series of simulation models were designed using finite element software COMSOL Multiphysics v6.1. In the first step pressure acoustics in the frequency domain are simulated, and then the heat calculated from step one is used as a source to model heating in tissues in a time dependent study.

Results: As the initial pressure increases, the pressure at the endpoint in the brain domain (on the center line) increases linearly. For all initial pressures from 0.1 to 0.6 MPa, the pressure at the endpoint decreases by 21%, and the greatest amount of reduction occurs as a result of passing through the bone domain. The maximum temperature rise is about one degree, which happens in the skull domain. The magnitude of the increase the temperature depends on the time that source is on and also the amplitude of initial pressure acoustic.

Conclusion: For different head tissues, the skull was found to be the most attenuator for ultrasound, the pressure of wave after passing the tissues attenuated 21% for 1MHz and 90 days old rats. Consistent with the results of both the simulation and experimental data, the attenuation increased as the skull thickness increased. There was a significant correlation higher than 0.99 between the results. To don't happen hyperthermia with these radiation conditions and to have a temperature increase of less than 4 degrees, the radiation time should not exceed 12 seconds or instead continuous wave, use a pulse wave.

Keywords: Transcranial Ultrasound; Bioheat; Simulation; COMSOL.



Biocompatible Collagen/PVA Nanofibers for BMSCs Cultivation: Innovations in Solvent and Crosslinker Selection for Tissue Engineering Applications

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Abstract

Background: Electrospinning is a method for fabricating fibers with nano and micro scale meshes. It is highly valuable for mimicking the extracellular matrix due to its ability to create scaffolds with high porosity and a high surface to volume ratio. Collagen is one of the most abundant proteins in the extracellular matrix of the human body. To enhance the strength and improve the mechanical properties of tissues made from this material, synthetic polymers are often used, which provide excellent biocompatibility without compromising biological activity.

In this study, we explored the potential of electrospun scaffolds composed of collagen as the main component and Polyvinyl Alcohol (PVA) as a carrier polymer, which contributes to stability and mechanical strength.

Materials and Methods: Lactic acid, a biocompatible solvent and a suitable alternative to other common solvents, served to compare and assess the effect of solvents on the structure and properties of collagen. Citric acid facilitated fiber stabilization due to its ability to create strength and form ester bonds that maintain biocompatibility. Rat tail collagen was chosen as the main component of the study, to control the PH of the solution, a 1 molar lactic acid was used. The resulting solution was electrospun with PVA, and citric acid was used as a natural, non-toxic cross-linking agent for the structural integrity of the scaffolds. To evaluate the suitability of these scaffolds for biomedical applications, structural and biological assessments were conducted. The obtained scaffold underwent Fourier-Transform Infrared spectroscopy (FTIR) analysis, Scanning Electron Microscopy (SEM) imaging, and MTT cell viability assays. Finally, the proliferation of Bone Marrow-derived mesenchymal Stem Cells (BMSCs) on the scaffold was quantitatively and qualitatively examined.

Results: Morphological analysis results showed a uniform scaffold with appropriate fiber diameter for cell attachment. The MTT assay with L929 cells demonstrated biocompatibility, cell viability, and proliferation. FTIR spectroscopy confirmed cross-linking and the preservation of collagen structure integrity. The culture of BMSCs on the scaffolds, followed by cell fixation and staining with crystal violet, showed suitable proliferation and survival compared to the control sample.

Conclusion: The results indicate that the use of lactic acid leads to the formation of a homogeneous solution that preserves collagen structure and facilitates the electrospinning process. Additionally, citric acid acts as a significant cross-linking agent in forming stable ester bonds with biopolymers, significantly improving the mechanical strength and durability of the fibers. The study of BMSC culture demonstrates the promising potential of this scaffold for biomedical and tissue engineering applications.

Keywords: Electrospinning; Collagen; Lactic Acid; Citric Acid.



Dose Reduction and Image Quality Assessment of Non-Lead Nano Composite Shield in Chest CT Scan

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Abstract

Background: Lead is a common shield used for radiation protection, but it has the limitation of being unable to protect the patient organs in the field of CT scan imaging area at the same time. However, composite shields have been developed to address this issue and facilitate radiation protection of organs during CT scans. These shields consist of a polymer material serving as a matrix and a filler material used for reinforcement to mitigate exposure to X-rays.

The present investigation examines the behavior of two metals, Tungsten (W) and Bismuth (Bi), within Epoxy (Ep) matrix to illustrate the contrasting effects of utilizing shielding and operating without shielding on the level of radiation dose and also, it investigates the effect of composite shields on the image quality in the CT scan device.

Materials and Methods: The composite shield, made up of 5% Bi, 5% W and 90% Ep, was created following the Researcher protocol. A chest CT examination was conducted both with and without the shield, and the PTW Diadose dosimeter was used to measure the dose reduction for comparison. To carry out this comparison, the Diadose dosimeter and composite shield was positioned at the 12 o'clock mark in the CTDI phantom, and imaging tests were carried out. To perform image quality assessment, four slices were selected in the same sequence and adjusted with the same window width and window level from the CT-gram images using ImageJ software. The ROIs in similar locations used for image analysis were determined by selecting 8 ROIs from each slice. Consequently, image noise values were obtained and compared.

Results: The comparative analysis of radiation doses in unshielded and shielded conditions revealed a 15% dose reduction in the imaging area when utilizing the shield. Also, when using the shield, the average noise values at the 6 o'clock, 12 o'clock, 3 & 9 o'clock positions, and the center of the phantom were 5.44 ± 0.03 , 6.10 ± 0.07 , 5.78 ± 0.13 , and 8.19 ± 0.28 Hounsfield, respectively, which showed 2%, 6%, 4% and 1% noise increase for mentioned positions compared to the case without shield, respectively. Also, the overall increase in noise was 3% compared to the case without shield.

Conclusion: Based on the test results, the shield manufactured with an Epoxy matrix containing Bismuth and Tungsten metals has been shown to reduce radiation exposure during chest CT scans. Additionally, it does not significantly increase image noise and maintains image quality in the targeted imaging area.

Keywords: Composite Shield; Chest Computed Tomography Image Quality; Dose Reduction; Image Noise.



Revisiting the Blurring Function Induced by Simple or Non-Filtered Back-Projection Reconstruction

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Abstract

Background: One of the most basic techniques of tomographic reconstruction, mostly in Single-Photon Emission Computed Tomography (SPECT), is the analytic method namely Back-Projection (BP). A prominent feature of this process is the artificial elevation of the intensity of pixels outside the regions of hot objects as a result of smearing, i.e., “blurring” effect or artifact. In the most literature, this blurring effect in simple or non-filtered BP is roughly approximated with a simple mathematical function of $1/r$, where r is the distance from the point source or hot pixel. However, no solid evidence is available for the exact model or mathematical function representing this phenomenon and it seems that it is only a postulate or rough estimate.

To model the blurring effect induced by simple or non-filtered Back-Projection (BP) using curve fitting analysis and then, the resulting PSFs are used for restoring or recovering the original image by the process of deconvolution.

Materials and Methods: A point source object (as unit impulse) and “modified Shepp-Logan” phantom are reconstructed by simple or non-filtered BP method. The data extracted are fitted by various models, including exponential, bi-exponential, rational, and power series functions. By method of nonlinear least squares, coefficients or parameters in the mathematical fit models and indices of goodness-of-fit (summed square error, root mean square error, R-square, and adjusted R-square) are calculated. The fitting functions or point-spread functions are used in the process of deconvolution or deblurring. Final results on tomographic image of “modified Shepp-Logan” phantom are compared qualitatively and quantitatively (using similarity index).

Results: Considerable edge blurring and background enhancement are visualized during BP reconstruction. Values of SSE and RMSE are negligible (all below 0.02) and values of R-adjusted are roughly 0.99 or higher which means that fitting model can explain 99% of total variance of data about mean. Outcome for all PSFs are look similar for “modified Shepp-Logan” phantom both visually and quantitatively, with higher accuracy for power series functions and followed by rational-1 and bi-exponential functions.

Conclusion: Blurring effect is an undesirable consequence of simple or non-filtered BP that is best modeled by power series functions according to curve fitting analysis. However, other models, bi-exponential and rational, fit the data with a high degree of precision.

Keywords: Blurring Effect; Reconstruction; Back-Projection; Curve Fitting.



Comparison of the Four-Energy Window (FEW) with Dual-Energy Window (DEW) and Triple-Energy Window (TEW) Scatter Correction Methods

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Abstract

Background: Single Photon Emission Computed Tomography (SPECT) is a nuclear imaging technique that uses radiopharmaceuticals to visualize internal tissue function. A key challenge in SPECT is photon scattering, where emitted photons deviate from their original paths after interacting with body tissues. This scattering leads to errors in identifying radiation sources, reducing image contrast, accuracy. Scattered photons can cause incorrect representation of radiopharmaceutical distribution, affecting diagnostic precision. Effective photon scatter correction is crucial for improving image quality and diagnosis and there are various methods for this. However, more efficient and accurate methods are still needed to completely solve this problem. In SPECT imaging, scatter correction methods like Dual-Energy Window (DEW) and Triple-Energy Window (TEW) have shown promising results, offering high contrast and superior signal-to-noise ratios with relatively low noise levels. However, increasing the number of energy windows and fine-tuning the settings could further improve contrast and signal-to-noise ratios. This innovative approach focuses on optimizing imaging parameters and using advanced processing techniques to enhance image quality.

Materials and Methods: In order to achieve the mentioned goals, a Whole-Body SPECT scanner was simulated with the help of GATE Monte Carlo simulator software and the scanner performance parameters such as sensitivity, scattering fraction and FWHM were evaluated by NEMA 2018 1NU standard. To check the scattering correction, the images were first corrected using the double energy window and triple energy window methods for ^{99m}Tc radiopharmaceutical. Then, scatter correction was applied to the images using an innovative method (Four Energy Windows (FEW)). Finally, the results of these methods in terms of contrast, Signal to Noise Ratio (SNR), relative noise and Structural Similarity Index (SSIM) were calculated by Python and MATLAB software and analyzed and compared.


Results: Based on the obtained results, the innovative FEW method shows a contrast increase of approximately %36 compared to DEW and % 40 compared to TEW. Also, this method has improved the signal-to-noise ratio (SNR) by %3 compared to DEW and %5 compared to TEW. In addition, according to the more comprehensive estimation of the scattering spectrum in the photopic window, the relative noise in this method is %4 lower than DEW method and %6 lower than TEW. It is worth mentioning that with the precise and optimal setting of the energy windows, the two-energy window method is superior to the three-energy window method. Therefore, increasing the number of energy windows does not necessarily lead to improved dispersion correction performance.

Conclusion: These findings indicate that the FEW method, with its comprehensive scatter spectrum estimation, provides a more effective solution for scatter correction in SPECT imaging. However, the study shows that simply increasing the number of energy windows does not necessarily improve performance, as the dual-energy window method surpassed the triple-energy window method. Thus, while further improvements to multi-window techniques could enhance image quality, it is essential to carefully optimize the parameters to maximize the potential benefits.

Keywords: Single Photon Emission Computed Tomography; Scatter Correction; Energy Window Method; Image Quality Optimization.



Reducing the Risk of Breast Cancer Using Tin Nanoparticle Composite Shield

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Abstract

Background: Nowadays, more attention has been paid to this point that using ionizing radiation is in company with late effects and cancer risk. Using composite shield that are lead-free and non-toxic for problem solving of ionizing radiations is recommended.

In this study, the risk of Breast cancer during CT-scan using nanocomposite shield was investigated. The risk of death due to breast cancer was calculated using the software.

Materials and Methods: Epoxy matrix and Tin metal filler used according to the researcher's protocol for the design of shield against X-rays. Exposure condition of the chest CT was 120 kV, 100 mA and 1-second rotation time for each test. The absorbed dose of the breast in chest CT-scan was recorded by TLD which was placed on the PMMA phantom. According to the relevant formula, it was converted into an equivalent dose. Using PCXMC software, the risk of death due to breast cancer was obtained.

Results: The equivalent doses in chest CT scan were calculated and compared in the area of the breast with and without Epoxy- Tin shield. In the first test, the difference between equivalent dose in unshielded and shielded conditions was obtained 9.25 percent. The risk of death due to breast cancer in the second test in 30-year-old females in unshielded and shielded conditions was calculated and difference was 4.63 percent per million.

Conclusion: Epoxy/Tin shield can reduce breast dose in chest CT scan without missing diagnostic medical information. Therefore, composite shield has effective role in reducing the risk of breast cancer.

Keywords: Shielding; Tin Composites; Radiation Risk; Computed Tomography Scan Dose.



Comparative Evaluation of Scatter Correction in Xtrim PET Scanner: Energy Window and Iterative Techniques

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Abstract

Background: One of the most considerable physical parameters which affect on the quality and quantity of Positron Emission Tomography (PET) images is the scatter of photons. Compton scattering is the most common type of PET scatter detection.

Overestimating the activity is the result of compton scatter, which tends to increase the number of detected counts. To enhance the contrast of reconstructed PET images and improve the accuracy of activity quantification, scatter compensation is commonly used. This study is designed to evaluate scatter correction in Xtrim PET scanners through the use of Energy Window and a new method namely iterative technique.

Materials and Methods: The technique is a conventional dual-window technique and an iterative method. Various energy windows (200-650 keV, 350-650 keV, 450-650 keV) were considered in the Image Quality (IQ) phantom's images. The reconstruction method was OSEM (4 iterations, 5 subsets) and a system matrix 200×310 was chosen. The IQ phantom was filled with 3.7 MBq of 18FDG and scanned about 20 min with the Xtrim PET scanner. The iterative method was also considered for the images of the IQ phantom. In this method, the average of non-zero pixel values were calculated. Pixel values that were smaller the mean value became zero and this step was repeated. In each step, some pixels with a small value become zero. The Contrast Recovery Coefficient (CRC) parameter was calculated for two cold chambers of IQ phantom. In addition, the profile line was also generated from a cross-sectional plane of the uniform section of the IQ phantom's image.

Results: Lower values of pixels mostly cause scatter photons which degrade the image quality. The iterative method limited the scattered photons in the background and the image's edge. The CRC value of the energy window of 350-650 keV was 0.74 and 0.78 for the water and air chamber which were increased compared to other energy windows and iterative methods. In the absence of scatter correction, the CRC values for the air and water chambers were 0.69 and 0.73, respectively. These values reached 0.73 and 0.76 by restricting the detection of scatter photons with an energy window of 450-650 keV. Using the iterative method, the profile line of one of the reconstructed images of the uniform part of the IQ phantom revealed any count in the image's background. This image showed a low count of scatter photons in an energy window of 450-650 keV compared to others.

Conclusion: Image contrast can be improved by correcting photon scatter, which is necessary for accurate estimation of activity distribution in PET imaging. According to this study, the appropriate energy window for an Xtrim PET scan was 350–650 keV, and the scatter photon was eliminated through an iterative process.

Keywords: Scatter Correction; Preclinical Positron Emission Tomography Scan.



Influence of Folate-Conjugated Fe₂O₃@Au Core-Shell Nanoparticles on Oxidative Stress Markers, Genotoxicity, and Histopathological Features: Insights from In Vitro and In Vivo Studies

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Abstract

Background: The emergence of nano-based platforms has transformed the early detection and treatment of numerous diseases. Specifically, iron oxide-based Nanoparticles (NPs) have become a focal point in cancer research. The objective of this study was to evaluate the cytotoxicity, genotoxicity, and histopathological effects of folate-conjugated Fe₂O₃@Au core-shell nanoparticles (Fe₂O₃@Au-FA NPs) using both in vitro and in vivo models.

Materials and Methods: The cytotoxic effects of the Fe₂O₃@Au-FA NPs by Human Umbilical Vein Endothelial Cells (HUVECs) were assessed using the 3-(4, 5-Dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide (MTT) assay. A safe dose was established and subsequently employed for various cytotoxicity assays, which evaluated total protein levels, Total Antioxidant Capacity (TAC), Reactive Oxygen Species (ROS), and DNA damage. In the animal model, 32 Wistar rats were randomly divided into four groups and administered intraperitoneal injections of the safe dose. Blood samples were analyzed for biochemical properties and histopathological changes.


Results: MTT assay results indicated that a concentration of 20 µg/ml was safe for the Fe₂O₃@Au-FA NPs. The in vitro tests showed no significant cytotoxicity or genotoxicity at the established safe dose of NPs. Furthermore, there was no notable increase in intracellular γ-H2AX levels, total protein levels, TAC and ROS after treating HUVEC cells with safe dose of Fe₂O₃@Au core-shell NPs (P>0.05). In the in vivo assessment, no significant differences were found in the serum biochemical parameters of rats treated with doses of 50 mg/kg and 100 mg/kg of the Fe₂O₃@Au-FA NPs. Histopathological examinations revealed that liver and kidney tissues were not adversely affected at doses of 50 mg/kg (liver) and 50 mg/kg or 100 mg/kg (kidney) following Fe₂O₃@Au-FA NPs administration (P>0.05).

Conclusion: These results indicate that the nanotoxicity of Fe₂O₃@Au-FA NPs in HUVECs and animal models is largely dose-dependent. Our study suggests that Fe₂O₃@Au-FA NPs, when administered at a safe dose, could be potential candidates for nano-biomedical applications as theranostic agents.

Keywords: Fe₂O₃@Au-FA NPs; In Vitro/In Vivo; Cytotoxicity; Oxidative Stress; Histopathology.



Investigating the Effect of Exosomes Derived from Mammary Gland tumor antigens-exposed monocytes-like macrophages (MLM) on apoptosis, necrosis, and expression of NLRP-3 and MyD88 genes in Canine MLM

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Abstract

Background: Exosomes, small extracellular vesicles secreted by various cell types, have emerged as potential therapeutic tools in cancer immunotherapy due to their ability to modulate immune responses and deliver molecular cargo. In the context of breast cancer, particularly in canine models, exosomes derived from tumor antigen-pulsed macrophages hold promise for influencing cellular mechanisms such as apoptosis, necrosis, and gene regulation. The NLRP-3 inflammasome and MyD88 pathways are critical mediators of inflammation and immune responses. Understanding how these pathways are modulated by exosome treatments may lead to innovative approaches in cancer treatment.

This study aimed to investigate the effects of exosomes derived from tumor antigen-pulsed macrophages on the induction of apoptosis and necrosis, as well as the expression of NLRP-3 and MyD88 genes in macrophage-like monocytes from canine breast cancer models. The overarching goal was to evaluate the therapeutic potential of exosome treatments in modulating inflammatory responses and promoting cell survival in this context.

Materials and Methods: Monocytes were isolated from the blood of a healthy dog, differentiated into macrophage-like cells after being incubated for 24 hours, and then were treated with exosomes derived from tumor antigen-pulsed macrophages. Flow cytometry (FACS) was used to assess apoptosis and necrosis levels, while quantitative PCR (qPCR) was performed to evaluate the expression of the NLRP-3 and MyD88 genes. A control group with untreated cells was also included for comparison.

Results: The flow cytometry analysis revealed that exosome-treated cells exhibited a significant increase in cell survival, with a 67.1% increase in live cells compared to the control group. Necrosis levels were reduced to 14.2% in the treated group, while the control group showed higher necrotic cell percentages. Although there was a slight increase in early apoptotic cells in the treated group (2.13%) compared to the control (1.68%), this difference may indicate a balanced regulatory effect of exosomes on apoptosis pathways. In terms of gene expression, qPCR results demonstrated a marked reduction in NLRP-3 expression in the exosome-treated group, suggesting a dampened inflammatory response. However, MyD88 gene expression could not be reliably detected due to technical challenges with primer design, highlighting the need for further optimization in future experiments.

Conclusion: This study underscores the potential of exosomes derived from tumor antigen-pulsed macrophages as a promising therapeutic tool in modulating key cellular processes in breast cancer. The reduction in necrosis and downregulation of NLRP-3 expression point to a protective role of these exosomes in reducing inflammation and promoting cell survival. Further research is needed to refine the understanding of MyD88 regulation and explore the broader implications of exosome-based therapies in canine breast cancer and beyond. These findings offer a foundation for future studies on exosome applications in cancer immunotherapy and their potential to enhance anti-tumor immune responses.

Keywords: Exosomes; Canine Breast Cancer; Apoptosis; Necrosis; Cancer Immunotherapy.



Design and Development of a Dual Energy Window Scatter Correction on Animal SPECT List Mode Data

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Abstract

Background: Scattered photons present a significant challenge in SPECT imaging, leading to reduced contrast, resolution, and quantitative accuracy. Scatter correction methods play a crucial role in addressing these issues. One common approach involves using energy window-based methods, such as Dual-Energy Window (DEW) or Triple-Energy Window (TEW) techniques. These methods utilize sub-windows to approximate the scatter distribution in the main photopeak window, allowing for the estimation and correction of scatter events. In this study, we focus on implementing and evaluating the DEW scatter correction method using Animal SPECT list mode data.

Materials and Methods: Using the User Datagram Protocol (UDP), raw data is transmitted to the computer. A multi-threaded acquisition pipeline is initialized to process the received data packets and generate calibrated projections, including linearity, uniformity, and energy calibration. Simultaneous acquisition of photopeak and scatter window projections was performed using a 30% energy window centered on the 140 KeV photopeak of Tc99m, along with a 20% scatter window below it. Scatter projections were subtracted from the photopeak using a k-value of approximately 0.57, assuming a similar scatter distribution in both windows. The corrected projections were then reconstructed using the Maximum Likelihood Expectation Maximization (MLEM) algorithm with 20 iterations. To evaluate the effectiveness of the correction method, reconstructed images were compared with non-corrected ones, focusing on data acquired from a NEMA IQ phantom in Animal SPECT studies.

Results: To assess the effectiveness of scatter correction methods, we calculated two key parameters influenced by scatter photons—Contrast-to-Noise Ratio (CNR) and Spill-Over Ratio (SPR)—within the cold spheres of the IQ phantom. The Spill Over Ratio (SPR) was calculated within two cold spheres of a phantom containing air and water. The SPR values were reduced after scatter correction, in the air sphere decreasing from 0.38 to 0.31 and the water sphere decreasing from 0.4 to 0.34. Additionally, CNR was computed for hot rods and cold spheres within the phantom, revealing a notable increase of approximately fivefold in both regions following scatter correction.

Conclusion: Scattered photons can harm the quality of medical images and reduce their diagnostic accuracy. Our research demonstrates that by effectively removing scattered photons from the primary image, we can enhance image quality, as evidenced by improvements in Contrast-to-Noise Ratio (CNR) and reduced Spill- Over Ratio (SPR). This indicates that photons that were erroneously detected in false positions can be identified and eliminated, leading to more accurate results.

Keywords: Dual Energy Window; Single Photon Emission Computed Tomography; Spill Over Ratio.



Investigation of ML-EM and OSEM Image Reconstruction Methods on the Accuracy of Tumor Detection in Beating Cardiac Models Using the XCAT (4D) Monte Carlo Simulator GATE

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Abstract

Background: Today, Positron Emission Tomography (PET) images play a vital role in the early detection of cancer and the design of appropriate treatments for cancer patients. With continuous advancements in data collection and image reconstruction techniques in medicine, the quantitative and qualitative assessment of these images has become a necessary requirement. PET images allow physicians to observe the metabolic activity of tissues, which is especially effective in cases where cancerous tumors have not yet grown large.

Materials and Methods: This study focuses on examining two image reconstruction algorithms, namely ML-EM and OSEM, along with two different subsets to evaluate the accuracy of tumor detection. To accurately simulate the imaging system, Gate 7.2 software was utilized. The simulation process involved using XCAT software to create a cardiac phantom containing a tumor. Subsequently, the binary files were converted to DICOM format and combined with MATLAB. After isolating the trans axial slices containing tumor tissue from the heart, the file formats were changed to MHD to ensure compatibility with Gate software.

Results: The results showed that as the number of iterations in the ML-EM algorithm increased, noise intensified up to iteration 53, while image contrast improved up to iteration 33. Beyond these points, both noise and contrast decreased accordingly. In the OSEM algorithm with two subsets, noise increased until iteration 27 and then decreased, while image contrast improved until iteration 16 before declining. The findings derived from PSNR, SSIM, and RMSE values indicate that the OSEM algorithm with two subsets accelerates the ML-EM algorithm in the reconstruction process and achieves similar results with fewer iterations. It should be noted that in the OSEM algorithm with two subsets, some data and images are disregarded in each iteration.

Conclusion: The optimal visually appealing image was obtained from the MLEM algorithm with 33 iterations and OSEM with two subsets and 16 iterations.

Keywords: 4D Digital Extended Cardio Torso Phantom; Image Reconstruction; Ordered Subset Expectation Maximization Machine Learning Expectation-Maximization Algorithms; GATE Software.



X-Ray Radiography for Identifying and Diagnosing Lung Cancer in Mice

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Abstract

Background: Accounting for about 1.5 million deaths annually, lung cancer is the prevailing cause of cancer deaths worldwide, mostly associated with long-term smoking effects. Numerous small-animal studies are performed currently in order to better understand the pathogenesis of the disease and to develop treatment strategies.

We propose to exploit X-ray dark-field imaging as a novel diagnostic tool for the detection of lung cancer on projection radiographs.

Materials and Methods: Imaging using a small-animal scanner optimized for murine lung imaging involved validation with ex vivo lung, in vivo mouse, and mouse models. The scanner included a three grating Talbot-Lau interferometer, X-ray gantry, and additional monitoring systems. Attenuation and dark-field images were obtained, while differential phase contrast images were available for reference.

Results: We demonstrate in living mice bearing lung tumors, that X-ray dark-field radiography provides significantly improved lung tumor detection rates without increasing the number of false-positives, especially in the case of small and superimposed nodules, when compared to conventional absorption-based imaging.

Conclusion: While this method still needs to be adapted to larger mammals and finally humans, the technique presented here can already serve as a valuable tool in evaluating novel lung cancer therapies, tested in mice and other small animal models.

Keywords: Mice; X-Ray; Lung; Cancer; Mammals.



Assessment of Normal Renal Scintigraphy Indices in Domestic Short-Haired (DSH) Cats of Kerman: A Comprehensive Study on Renal Function Parameters

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Abstract

Background: The urinary system in cats is one of the most common organ systems to experience disorders and diseases. Specific systemic conditions affecting feline kidneys include lymphoma and feline infectious peritonitis. Scintigraphy is an advanced diagnostic technique used for precise diagnosis of renal diseases. The first scintigraphic images of organs such as brain tumors, liver, spleen, and gastrointestinal tract were obtained by scientists in the 1970s.

There are various reasons for employing scintigraphy, including its ability to rapidly diagnose diseases, determine the degree of dysfunction, monitor diseases in real-time, and provide detailed reports on surgical outcomes in some cases.

Materials and Methods: This study was conducted on three adult male DSH (domestic shorthair) cats in Kerman to obtain Glomerular Filtration Rate (GFR) parameters, including overall GFR, individual kidney GFR, time to peak activity, and half-life of drug clearance. The indices were acquired using scintigraphy with a gamma camera and technetium-based radiopharmaceutical, administered via the saphenous vein. The scan duration was 30 minutes. The purpose of this research was to gather this data in DSH cats residing in Kerman and compare it with data from cats in other regions and breeds.

Results: The overall GFR was 125.66 ± 5.03 . The GFR for the left and right kidneys were 51.27 ± 2.29 and 48.78 ± 2.75 , respectively. Time to peak activity for the left and right kidneys was 4.4 ± 0.43 and 4.6 ± 0.12 , respectively. The half-life of drug clearance for the left and right kidneys was 11.3 ± 0.62 and 11.5 ± 1.08 , respectively.

Conclusion: The values obtained from this study fall within the normal range, aligning with our expectations. This research demonstrates the reliability of scintigraphy for evaluating renal indices in cats. Additionally, the data collected from DSH cats in Kerman provides a valuable reference for comparing renal function in cats from different regions and breeds. Further studies with larger sample sizes may help to establish more comprehensive renal scintigraphy norms for diverse feline populations.

Keywords: Scintigraphy; Kidney; Cat; Diagnostic Imaging.



Quantitative and Qualitative Examination of Kidney Scintigraphy of Normal White New Zealand Rabbit After Administration of Saffron

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Abstract

Background: Scintigraphy is one of the diagnostic and therapeutic methods in nuclear medicine. For the first time, in the 1970s, scientists took pictures of organs such as brain tumors, liver, spleen, and digestive tracts. Also, in the 1980s, radiopharmaceuticals were used to diagnose heart diseases. Today, nuclear medicine is used with a very high accuracy rate in the process of diagnosis, prevention and treatment of various diseases. Among the reasons for the importance of nuclear medicine, we can mention speeding up the diagnosis of the disease, determining the amount of disorder in the patient, the ability to check the disease in real time, accurate reporting of the results of surgery in some patients, etc. The superiority of scintigraphy over the aforementioned methods is the ability to examine the physiological image of the kidney. Since the effect of increasing the blood flow by saffron has been proven in the past.

To evaluate the efficacy of scintigraphy in assessing renal physiology and the impact of saffron on enhancing kidney blood flow within the framework of nuclear medicine.

Materials and Methods: In this research, it has been tried to quantitatively and qualitatively examine the kidneys of four healthy male laboratory rabbits of the New Zealand white breed using the radiopharmaceutical 99mTc-DTPA, and in this way, the percentage of GFR General and exclusive and time peak before and after the administration of saffron extract were investigated and compared.

Results: The result of the current research was an increase in GFR and a decrease in time peak after the use of saffron extract.

Based on the results of this research, Total GFR before and after injection of saffron extract was 108.9±1.4 and 134.2±1.6 respectively, and Individual GFR was 53.7 in the left kidney and 55.2 in the right kidney before usage of the substance, this numbers after usage of substance were 68.3 in the left kidney and 65.9 in the right kidney.

Conclusion: The present study shows that saffron extract has a very positive effect on the healthy kidney of rabbits.

Keywords: Saffron; Rabbit; Scintigraphy; Kidney.



Comprehensive Review of the Effect of Pomegranate Peel Extract on Rabbits Kidney Efficiency and Functionality Assessed through Scintigraphy: Insights and Implications for Renal Health

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Abstract

Background: Kidney failure is characterized by a decrease in the Glomerular Filtration Rate (GFR), reduced urine output, and elevated creatinine levels in the blood. Previous studies have indicated that pomegranate peel extract positively affects kidney biochemical indicators by increasing the excretion of urea and decreasing blood creatinine levels, while also causing a modest increase in renal blood flow. Thus, pomegranate peel extract emerges as a promising candidate for enhancing kidney function and improving GFR.

Numerous diagnostic imaging techniques are available for kidney assessment, with scintigraphy being capable of evaluating GFR levels. This study investigates the effect of pomegranate peel extract on kidney efficiency—specifically GFR, estimated GFR (eGFR), and maximum renal efficiency—in albino rabbits using scintigraphy.

Materials and Methods: 6 rabbits were used in study.

A gamma camera and the radiopharmaceutical ^{99m}Tc-DTPA were employed for the imaging.

Results: The results indicated the following values: in the control group, the maximum activity of the left kidney was 254±13.2, and 287±24.3 for the right kidney. In contrast, the extract group exhibited values of 628±37.1 for the left kidney and 513±39.9 for the right kidney. The total eGFR index was 606.4±11.7 in the control group, while it rose to 652±20.1 in the extract group. Additionally, the overall GFR index was 77±3.7 for the control group and 83±5.0 for the extract group.

Conclusion: These findings demonstrate an increase in both total and specific GFR, as well as maximum kidney efficiency. This study confirms the potential of pomegranate peel extract to enhance renal function, as evidenced by the mentioned indicators evaluated through scintigraphy.

Keywords: Pomegranate Peel; Scintigraphy; Kidney; Rabbit.



Volumetric Study of the Skull of the Slow Loris Using Computed Tomography

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Abstract

Background: Slow lorises (*Nycticebus* spp.) are among the nocturnal mammals found in 14 Asian countries. However, their taxonomy, ecology, and geographical distribution are poorly understood. Eight known species have been identified, five of which are listed as vulnerable or critically endangered in the IUCN Red List, and three species have not been assessed yet. These mammals face threats such as habitat loss and illegal wildlife trade. Therefore, understanding these animals' natural and healthy anatomy is essential for veterinarians.

Materials and Methods: A CT scan of an adult male slow loris was performed using a Somatom spirit helical 2-slice CT scanner at the Veterinary Hospital of the University of Tehran. The volumes of various skull parts such as total volume, nasal and oral cavities, eye sockets, and auditory bullae were automatically measured by introducing the required regions into the CT scanner.

Results: The results of these measurements are as follows: the volume of the right eye socket was 1.83 cm³, and the left eye socket was 1.75 cm³. The volume of the brain cavity measured in this CT scan was 6.50 cm³, and the volumes of the nasal and oral cavities were 1.00 and 2.10 cm³, respectively. The estimated total volume of the skull was 28.02 cm³. Another important feature in these measurements is the ratio of structures to the total skull volume. The ratios of the left eye socket to the skull, the right eye socket to the skull, the brain cavity to the skull, the nasal cavity to the skull, and the oral cavity to the skull were 0.065, 0.062, 0.2, 0.036, and 0.075, respectively.

Conclusion: The study conducted by Vaji and colleagues on *Rhesus* monkeys shows that the ratios of the nasal and brain cavities to the total skull volume in this species were higher compared to slow lorises. Additionally, these ratios were lower compared to other animals such as cats, donkeys, goats, and sheep in the same study.

Keywords: Computed Tomography Scan; Slow Loris; Volumetry; Skull.



Radiographic and Echocardiographic Findings and Determinants in Pets with Cardiomegaly: A One-Year Retrospective Study from South of Iran

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Abstract

Background: Cardiomegaly and Dilated Cardiomyopathy (DCM) are common heart diseases in pets such as cats and dogs, which are life-threatening and if not diagnosed and treated on time, have a poor prognosis. Considering the scarcity of representative studies in Iran, we aimed to conduct this study to detect the prevalence and correlates of DCM in the pets.

Materials and Methods: All records of referred pets to the reference veterinary imaging clinic in Fars province of Iran in 2023, were reviewed. Cardiomegaly had been detected by Chest X-ray (CXR) and DCM had been diagnosed by echocardiography. Studied variables included: DCM, Fraction Shortening (FS), Ejection Fraction (EF), species of pet (dog/cat), sex, age, size, and the involved ventricle. Data were analyzed in SPSS 25, by univariate tests (t-test, chi-square) and multivariate linear regression (Backward method), considering $P < 0.05$ as the significance level.

Results: Out of 4668 studied pets (3276 dogs and 1392 cats), 118 (102 dogs and 16 cats) had cardiomegaly, which showed a prevalence of 2.5%, 3.1% and 1.1% of cardiomegaly in all pets, dogs and cats, respectively. Out of 118 pets with cardiomegaly, 65 (55%) were female and 53 (45%) were male. Furthermore, 51 was small (50%), 32 were medium (31.5 %) and seven cases (7%) were large size. The mean of the age of all 118 cases was 96 ± 57 months. Out of 118 cardiomegaly cases, 27 cases (23%) had DCM, including 25 dogs and 2 cats, which showing the overall prevalence of DCM (27 out of 4668) was 0.6% and 23 % (27 out of 118) in cardiomegaly cases. The prevalence of DCM in the dogs was 0.8%, while it was 0.1.5% in the cats. In DCM cases, 5 (19%) had dilatation of the left ventricle and 22 (81%) had dilatation in the both ventricles. The mean of age of pets with DCM that involved both ventricles (108.1 ± 46.9 months) was significantly more than animals that only had involvement of only left ventricle (79.2 ± 18.1 months), ($P = 0.03$). Moreover, the mean of FS among DCM cases (34.8 ± 3.3 %) was lower than normal pets (49.5 ± 4.2 %), ($P < 0.001$). The mean of EF was also lower in DCM cases ($46.8 \pm 4.2\%$) compared to the normal pets ($65.8 \pm 8\%$) ($P < 0.001$). Multivariate analysis showed that EF was related directly with FS (Beta=1.16, CI95%=0.96-1.36, $P < 0.001$); meaning that for each 1% decrease in FS, 1.16% decrease in EF is expected. Moreover, a significant indirect association between EF and animal size was found ($P = 0.04$), meaning that with an increase of the pet size, the EF will be decreased by 1.62% on average.

Conclusion: In this study, it was shown that cardiomegaly is nearly prevalent among pets (25 in 1000) and in dogs, it is three times more common than cats. The prevalence of DCM was 8 cases per 1000 dogs and 1 case per 1000 cats. Moreover, aged and large pets were more suffered from DCM and decreased EF. Therefore, early screening of pets regarding cardiomegaly and DCM is recommended.

Keywords: Prevalence; Dilated Cardiomyopathy; Cardiomegaly; Pets; Shiraz.



A Case Report of Acute Osteosarcoma in a 3-Year-Old Qadarijani Dog

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Abstract

Background: The Qadarijani dog is a breed native to Iran, specifically the Isfahan province. These dogs are known for their large and robust body structure, with a muscular build and a prominent black muzzle. They are typically used as herding or guard dogs and have a lifespan of 10-15 years. However, despite their strong appearance, they are not immune to health issues, such as osteosarcoma, which is a common bone tumor in dogs. This type of cancer is most.

Materials and Methods: A 3-year-old dog was referred to Adorina Clinic with a history of lameness in the right limb and recurrent wound infections. Over the past six months, the dog has developed mild skin lesions which gradually worsened, leading to swelling in the limb and increased lameness. The dog was no longer able to move due to the severity of the lameness. During the examination, there was significant swelling in the right forearm and arm. Additionally, there was extensive redness and soft tissue damage caused by improper placement of the motor organ on the skin. The right motor organ was twice the size of the left organ in diameter. X-ray examination revealed extensive periosteal bone lesions with a Sunburst periosteal reaction pattern. This was diagnosed as extensive metastatic osteosarcoma, as there were also metastatic nodular areas in the lung. The dog was euthanized due to severe limb pain and at the request of the owner frequently seen in larger breeds and typically affects dogs around 8 years of age.

Results and Conclusion: The utilization of diagnostic aid techniques and the prevalence of a referral culture among veterinarian colleagues are crucial factors in ensuring proper management, timely diagnosis, and treatment of patients in small animal medicine. Had this patient been referred at the onset of symptoms, treatment options such as amputation and chemotherapy would have been available. However, due to the delay in seeking treatment and the severity of the disease, the only humane option was to provide a painless death for the animal.

Keywords: Osteosarcoma; Qadarijani; X-Ray Examination; Metastasis; Euthanasia.



Caligonum Comosume Extract Improves Pregnancy Rate, Live Birth and Ovarian Function in Female Mice Model of Endometriosis

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Abstract

Background: Endometriosis is a chronic disease in which endometrial tissue grows outside the uterus and causes it. It causes severe pelvic pain and infertility problems. Calligonum comosum is a medicinal plant that grows in the desert and is used in traditional medicine for menstrual pain. This plant has been effective in treating endometriosis in mouse models of endometriosis and has also affected fertility and live birth. This study was conducted with the aim of investigating the effect of Calligonum Comosum Total Extract (CCTE) on pregnancy and live birth in a rat model with endometriosis.

Materials and Methods: In this study, 24 NMRI female mice with an age of 8 weeks and an approximate weight of 25-30 grams were studied.

It was created by creating endometriosis-like lesions in NMRI strain mice by surgical method and by creating autologous transplant in the form of removing uterine tissues and transplanting it to the abdominal wall of the mouse itself. Mice were randomly divided into two groups under treatment and control. The treated group received a dose of 50 mg/kg of Tom Scanbil extract, and the control group received normal saline. The growth of the lesion with the formation of cysts was examined by ultrasound imaging in the second week. In the 4th week after transplantation and after Removal of lesions with scanbil extract, pregnancy and live birth, ovarian histology, endometriosis lesions, and growth indicators of newborns were investigated.

Results: The results of this study showed that the pregnancy rate was more than twice in the treated group compared to the control group, and also the live birth rate in the treated group was twice more than the control group ($P < 0.05$). Ovarian function was better in the treatment group and pre-antral follicles were more in the treatment group than in the control group and cysts It was also lower in the treatment group than the control group. Also, the endometrial wall in the treatment group was less than the control group ($P < 0.05$). The number and size of endometriosis lesions were also significantly lower in the treatment group compared to the control group ($P < 0.05$). Growth indices in Babies in the treated group were significantly better than the control group ($P < 0.05$).

Conclusion: The total extract of Caligonum comosum had a significant effect on pregnancy and live birth and positive effect on ovarian factors and pseudo-endometriotic lesions and growth indicators of newborns in the mouse model of endometriosis, and it can be a promising treatment. It is suggested that these studies enter the clinical phase and in Study the clinical phase of this extract.

Keywords: Scanbil; Mouse Model; Endometriosis; Pregnancy Rate; Live Birth Rate; Infant Growth Index.



A Case Report of Hydatid Cyst in the Mesentery and Iliopsoas Muscles of a 4-Year-Old Male Rhesus Monkey

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Abstract

Background: The hydatid cyst is a larval stage of *Echinococcus granulosus*, a parasitic tapeworm. *Echinococcus granulosus* has a complex life cycle. Its definitive hosts, carnivorous animals like dogs and foxes, play a crucial role in its transmission. Humans and domestic animals serve as intermediate hosts, where hydatid cysts develop. Interestingly, there are reports of infection in non-human primates such as rhesus monkeys and other wild animals, like camels and giraffes. Although often asymptomatic, these cysts can manifest clinical signs depending on their location, leading to respiratory symptoms, abdominal pain, or neurological issues. Treatment typically involves surgical removal of the cyst or anti-parasitic medications. This case report presents diagnostic imaging and laboratory findings in an asymptomatic 4-year-old male rhesus monkey from the Royan Institute diagnosed with hydatid cysts in the abdominal cavity.

Materials and Methods: A 4-year-old male rhesus monkey from the Royan Institute was referred to the Pet Planet Polyclinic for a routine check-up ultrasonography, the monkey was asymptomatic at the time. Based on ultrasound findings, a plane and post-contrast CT scan of the abdominal cavity were performed.

Results: The initial abdominal ultrasound examination revealed multiple round cystic lesions in the dorsal and cranial aspect of the bladder, not adherent to any surrounding organs or tissues. The largest measured approximately 3.53 × 2.55 cm, with a thick wall and irregular internal layer. The cyst content appeared hypoechoic to anechoic, providing crucial information for the diagnosis. Importantly, no abnormalities were detected in the liver or other tissues, further narrowing down the diagnostic possibilities. For more evaluations, a CT scan was performed at the Small Animal Hospital of Tehran University that showed multiple cystic structures of varying sizes in the caudal abdominal region, with a mean Hounsfield unit of -100 and partial mineralization around the cysts. The most extensive cysts had the same appearance explained in ultrasound findings and compressed the urinary bladder. Both iliopsoas muscles exhibited signs of myositis, with increased muscle volume and a mottled hypoattenuated appearance in the area behind the largest cysts to the cranial aspect of the prostate. Enlarged mesenteric lymph nodes were observed in the affected area, with no other significant abnormalities in other organs. Then, a fine needle aspiration was performed under ultrasound guidance, and fluid from the cysts was analyzed. Hooklets, characteristic of hydatid cysts, were identified in the cyst fluid.

Conclusion: Hydatid cysts, potentially occurring in various tissues, present a diagnostic challenge. However, with advanced imaging techniques such as ultrasound, CT scan, and MRI, diagnosis has become more precise and reliable. In this report, we presented abdominal hydatidosis with the origin of the iliopsoas muscles causing compression on the urinary bladder with no significant clinical sign, diagnosed with ultrasound and CT scan and confirmed with cytology. More evaluations are possible with surgical removal of the cysts and histology evaluations.

Keywords: Hydatid Cyst; *Echinococcus Granulosus*; Rhesus Monkey; Ultrasonography; Computed Tomography.



Ultrasonographic and MRI Imaging of the Urinary System in Iranian Squirrels: A Study on Anatomical and Physiological Insights for Conservation and Medical Care

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Abstract

Background: The Iranian squirrel, a rare and unique species found in only a few countries, is facing a critical survival threat in Iran. Indiscriminate trapping, primarily driven by the demand for these squirrels as pets, is a significant factor. The lack of genetic diversity resulting from limited opportunities for interbreeding among captured squirrels further endangers the species, leading to potential extinction risks that we must urgently address. This study aims to evaluate the urinary system's ultrasonographic and MRI imaging characteristics in Iranian squirrels, providing insights into the anatomical and physiological aspects critical for their conservation and medical care.

Materials and Methods: Healthy squirrels were selected and housed in specially prepared cages. During their maintenance, a proper diet was provided. For ultrasonography, the squirrels were restrained using a combination of ketamine and diazepam administered intramuscularly. The abdominal hair was shaved to improve imaging quality, and ultrasound gel was applied. Standard methods, such as the use of a high-frequency transducer and the application of gentle pressure to visualize the urinary tract, were employed for the ultrasonographic evaluation, supplemented by specific tests in some instances. MRI imaging was also performed, focusing on T1 and T2 sequences to assess the bladder, urethra, ureter, kidney, medulla, and cortex.

Results: Ultrasonographic imaging revealed a hypoechoic longitudinal view of the bladder with three distinct layers. In the longitudinal view, the kidney exhibited three distinguishable regions, with the most central hyperechoic area corresponding to the renal sinus fat surrounding the pelvis. The hyperechoic region encasing the pelvis included the medulla, while the outer, moderately echogenic area represented the kidney cortex. MRI imaging in the T1 sequence showed the bladder as a hypointense signal, with indistinguishable layers and no visible urethra or ureters. The kidney presented a uniform hypointense signal extending to the bladder, rendering the medulla and cortex indistinguishable. In the T2 sequence, the bladder layers were somewhat discernible, and the urethra was occasionally visible in sagittal images. The medulla and cortex were separable in this sequence.

Conclusion: This study provides crucial insights into the urinary system's ultrasonographic and MRI imaging characteristics in Iranian squirrels. These findings are not just interesting, but they also play a significant role in understanding the species' anatomy, which is essential for their conservation and clinical management.

Keywords: Ultrasonography; Magnetic Resonance Imaging; Persian Squirrel; Urinary System.



Using X-Ray Dark-Field Radiography to Identify Radiation-Induced Lung Damage Early in Mice

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Abstract

Background: Radiation therapy is a popular treatment for thoracic malignancies, but it can have serious adverse effects on the lungs, including malignancy, fibrosis, and inflammation. The earliest possible detection of lung injury is ideal for the best follow-up care. In clinical practice, Computed Tomography (CT) or chest x-rays are used to identify alterations in the lungs. While CT offers three-dimensional information about the lung at a greater dosage, projectional data from chest x-rays gives limited spatial information and needs less treatment.

Comparing the effectiveness of x-ray dark-field contrast with x-ray transmission contrast in radiography to see which is better for the early detection of radiation-induced lung damage in mice.

Materials and Methods: For 28 weeks following irradiation, two groups of female C57BL/6 mice—one group treated with radiation and the other as a control—were scanned monthly using both contrasts. Six mice were exposed to 20 Gy of radiation, preserving the left lung. The six mice in the control group received no radiation. For both groups, a total of 88 radiographs with both contrasts were assessed using average values for two areas of interest: the healthy left lung and the (irradiated) right lung. For both comparisons, the difference between healthy and injured lungs was identified by the ratio, or R, of these average values. The moment at which R's deviations from a healthy lung surpassed 3σ was identified and contrasted. Using the Wilcoxon-Mann-Whitney test, the null hypothesis that there is no difference was tested.

To test against the null hypothesis—that there is no difference between the two groups—the Wilcoxon-Mann-Whitney test was employed. Radiologists evaluated 32 radiographs that they had chosen. Sensitivity and specificity were calculated to evaluate the diagnostic capabilities of the two contrasts. Cohen's kappa was used to assess the accuracy between and within readers.

Results: Radiation can cause morphological changes in lung tissue, deviations from the control group were assessed using x-ray dark-field contrast on average 10 weeks earlier than x-ray transmission contrast. The use of dark-field radiography resulted in increased sensitivity, specificity, and accuracy.

Conclusion: Radiation-induced changes in the morphology of lung tissue are detected by X-ray dark-field radiography earlier than transmission radiography in a preclinical mouse model.

Keywords: X-Ray; Lung Damage; Radiography; Morphology.



RASDA Microbubbles Preparation: Contrast Agent for Ultrasound Imaging and Therapy

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Abstract

Background: Microbubbles (MB) are used as contrast agents in ultrasound imaging and recently as therapeutic agents with ultrasound. The size of these microbubbles is between 1 and 4 micrometers (smaller than red blood cells) that move in the blood circulation system. Each microbubble contains a gas trapped in a shell of albumin, lipid, or polymer. The material of the shell is effective on the acoustic response and mechanical elasticity, while the gas core determines the acoustic response. Protein microbubbles usually consist of a thin and hard shell of human or bovine serum albumin.

In this research, Room-Air Sonication Dextrose Albumin (RASDA) microbubbles are made. Their size is measured and their safety is shown in rats with B-mode ultrasound images. Also, the effectiveness of these microbubbles as a contrast agent is shown in the ultrasound image.

Materials and Methods: First, 5% human serum albumin and 5% dextrose were mixed in a ratio of 1:3 and dissolved in 15 ml of distilled water (16 ml in total) and then the solution was completely uniform with a magnetic stirrer (for 1 hour). After the solution became uniform, the solution and room air were completely mixed by pumping in a ratio of 2:1 with the help of two Lovelock syringes and a three-way valve. The dimensions of Microbubbles (MB) were measured by Dynamic Light Scattering (DLS) (Particle Size Analysis, Brookhaven, 90plus, Sweden). To show the presence of microbubbles in the rat's body, the following experiment was performed: A solution containing microbubbles was prepared and a rat was anesthetized with the combination of ketamine and xylazine. The hair around the animal's heart was shaved. An ultrasound probe (Sonix Touch ultrasound system, Ultrasonix Medical Corporation, Richmond, Canada) was placed on the heart and imaging was performed. Then, simultaneously with microbubble injection into the heart (0.01 ml), imaging was done.

Results: RASDA microbubbles can be seen under a microscope. The result of DLS of the microbubbles showed an average size of 1170 nm. The concentration of microbubbles was obtained by counting with a Neubauer slide, 2.6×10^6 MB/ml. To show the presence of microbubbles in the rat's body, B-Mode ultrasound imaging was performed at the same time as microbubbles were injected into the rat's heart. In addition to the fact that the rat survived with the microbubble injection, which indicates the appropriate dimensions of the microbubble and the absence of blockage of the rat's blood vessels. Using Image J software (National Institutes of Health, Public Domain, BSD-2, New York, USA) the brightness of each image was calculated in the equal-sized areas shown in the figure with circles, and their difference shows a 40% increase in contrast in the presence of microbubbles ($(121.089 - 80.925) \times 100 = 40\%$).

Conclusion: With the sonication of ultrasound waves, due to the presence of microbubbles containing gas, the homogeneity of the environment changes and imaging is performed with a higher contrast. In addition to diagnostic use, microbubbles can also act as drug carriers, which are opened under the influence of ultrasound waves and the drug is transferred to the target tissue. In this study, we fabricated a sample of microbubbles containing room air with a coating of protein.

Keywords: Microbubbles; Ultrasound Imaging; Ultrasound Therapy.



Deep Learning-Based Quantitative Assessment of Pulmonary Vascular Changes Using Histological Microscopy Images

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Abstract

Background: Pulmonary Hypertension (PH) is associated with structural remodeling of pulmonary circulation vessels, leading to increased arterial pressure. The hypertrophy index, representing the ratio of vascular wall area to total vessel area, is a key metric for evaluating these structural changes. Manual analysis of histological images for this purpose is time-consuming and requires expertise. This study introduces a deep learning-based method designed to automate quantitative assessments of vascular changes from histological microscopy images, improving the efficiency and scalability of analysis.

The objective of this research is to develop and validate a deep learning model for predicting the hypertrophy index from histological microscopy images of pulmonary circulation vessels, focusing on optimizing model architecture and hyperparameters to achieve high accuracy while reducing overfitting.

Materials and Methods: The dataset comprises 609 histological images of pulmonary vessels from preclinical studies using a rat model of Chronic Thromboembolic Pulmonary Hypertension (CTEPH), prepared through Hematoxylin and Eosin (H&E) staining (resolution: 0.34 $\mu\text{m}/\text{px}$). Each image includes detailed annotations of vascular parameters such as vessel diameter and hypertrophy index. A Convolutional Neural Network (CNN) based on ResNet18 was employed, with modifications to the fully connected layers to improve regression performance. Images were preprocessed using a pipeline that included resizing, normalization, and advanced augmentation techniques like elastic transformation to address overfitting. Multiple rounds of hyperparameter tuning were conducted along with architectural changes, to improve model generalization and performance.

Results: The refined model demonstrated robust predictive performance, with strong correlation observed between predicted and true hypertrophy index values across the test set (MAE of 4.2475 and an R^2 score of 0.9320). Through iterative adjustments to the architecture and hyperparameters, the model effectively mitigated overfitting and achieved stable predictions. Compared to traditional manual analysis, which typically requires 15-20 minutes per image and is subject to inter-observer variability, our model processes images in seconds with consistent results. This represents a significant improvement in both speed and reliability over existing methods. These results indicate that the proposed deep learning model can serve as a reliable tool for automating the analysis of pulmonary vascular changes.

Conclusion: This deep learning-based framework offers an efficient alternative to manual quantification of vascular remodeling in pulmonary hypertension. By automating hypertrophy index prediction, this approach has significant potential for both research and clinical applications in the analysis of pulmonary circulation vessels.

Keywords: Deep Learning; Pulmonary Hypertension; Histological Microscopy; Convolutional Neural Network.



Studying the Possibility of Direct CT Lymphangiography in Mice

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Abstract

Background: Lymphatic leakage can be a fatal condition and requires early and appropriate treatment, and lymphangiography plays an important role in the success of interventional procedures for the lymphatic system. In the past, lymphangiography has been performed by puncturing the lymphatic vessels in the dorsum of the foot; however, direct puncture of the inguinal lymph nodes with subsequent embolization of the leakage site has become a widely accepted treatment in this. Although lymphatic embolization has been mainly performed for chylothorax, there have been attempts to apply it to the treatment of chylous ascites as. In any case, the use of appropriate contrast media and obtaining a clear lymphangiography are of vital importance for the success of this procedure.

To establish a CT lymphangiography method in mice via direct lymph node puncture.

Materials and Methods: We injected healthy mice (n=8) with 50 µl of water-soluble iodinated contrast agent (iomeprol; available, 350 mg/ml) subcutaneously in the left hindpaw (internasal Tezer) and 20 µl of the same contrast agent. they did 2 days later directly to the popliteal lymph nodes (direct puncture). In addition, we performed interstitial MR lymphangiography on eight mice as a control group. We calculated the contrast ratio for each lymph node and evaluated the image of the lymph nodes and the lymph string as a result of three points.


Results: The contrast ratios of 2-min post-injection images of sacral and lumbar–aortic lymph nodes were 20.7 ± 16.6 (average \pm standard deviation) and 17.1 ± 12.0 in the direct puncture group, which were significantly higher than those detected in the CT or MR interstitial lymphangiography groups (average, 1.8–3.6; $p = 0.008$ – 0.019). The visual assessment scores for sacral lymph nodes, lumbar–aortic lymph nodes, and cisterna chyli were significantly better in the direct puncture group than in the CT interstitial injection group ($p = 0.036$, 0.009 and 0.001 , respectively). The lymphatic vessels between these structures were significantly better scored in direct puncture group than in the CT or MR interstitial lymphangiography groups at 2 min after injection (all $p \leq 0.05$).

Conclusion: In CT lymphangiography in mice, the direct lymph node puncture provides a better delineation of the lymphatic pathways than the CT/MR interstitial injection method.

Keywords: Mice; X-Ray Microtomography; Lymphography; Contrast Media.



A Novel VEGFR-Targeting Radiotracer for Breast Cancer Imaging

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Abstract

Background: Angiogenesis is essential for tumor growth and metastasis, contributing to cancer progression and mortality. The vascular endothelial growth factor receptors (VEGFR-1 and VEGFR-2) are highly expressed on breast cancer cells and are integral to the angiogenic process, promoting neovascularization and tumorigenesis. Thus, targeting these receptors can be considered as a promising approach for early detection and treatment of breast cancer.

This study aimed to develop and evaluate a novel radiolabeled peptide, [⁶⁸Ga]Ga-DOTA-Ahx-VGB3, targeting VEGFR-1/2 for noninvasive imaging of angiogenesis in breast cancer. The objectives were to assess its tumor-targeting ability, receptor binding affinity, and in vivo biodistribution of this radiotracer in a 4T1 tumor-bearing mouse model.

Materials and Methods: The VEGFR-1/2-specific peptide VGB3 was chemically conjugated to 1,4,7,10-tetraazacyclododecane-1,4,7,10-tetraacetic acid (DOTA), utilizing 6-aminohexanoic acid (Ahx) as a linker to prevent steric hindrance in binding. The DOTA-Ahx-VGB3 was radiolabeled with Gallium-68 (⁶⁸Ga) and characterized for radiochemical purity and stability. In vitro cell binding assays were performed using the 4T1 breast cancer cell line. Finally, the tumor-targeting potential of [⁶⁸Ga]Ga-DOTA-Ahx-VGB3 was assessed through in vivo biodistribution and PET/CT imaging studies in 4T1 tumor-bearing mice.

Results: DOTA-Ahx-VGB3 was successfully radiolabeled with Gallium-68 with high radiochemical purity (98%) and demonstrated excellent stability in different buffer systems. In vitro studies on 4T1 cells showed approximately 17% internalization of the radiopeptide after 2 hours of incubation. The calculated IC₅₀ value of 867 nM indicated a favorable binding affinity to VEGFR-1/2. In vivo biodistribution and PET/CT studies revealed that [⁶⁸Ga]Ga-DOTA-Ahx-VGB3 could effectively localized to the tumor site. Furthermore, the radiopeptide was excreted rapidly through the renal system, helping to reduce unnecessary radiation exposure.

Conclusion: The results of this study demonstrate that [⁶⁸Ga]Ga-DOTA-Ahx-VGB3 is a promising radiotracer for the noninvasive imaging of VEGFR-1/2 expression in tumors. Its high radiochemical purity, efficient tumor targeting, and rapid clearance suggest that this radiolabeled peptide could serve as a suitable diagnostic tool in breast cancer, particularly for early detection and monitoring of tumor angiogenesis.

Keywords: Gallium-68; Vascular Endothelial Growth Factor Receptor; Peptide; Positron Emission Tomography Imaging; Breast Cancer.



The Role of PSMA-11 in Targeting Iron Oxide Nanoparticles Enhancing the Contrast of Prostate Magnetic Resonance Images: A Pre-Clinical Study

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Abstract

Background: Prostate Cancer (PCa) is the most common cancer among men, necessitating precise diagnostic techniques to enhance early detection and patient outcomes. Ultrasound-guided biopsy is considered the gold standard, but it often experiences lower sensitivity due to random sampling. Conversely, multiparametric MRI is recognized for having the highest sensitivity among diagnostic methods for PCa. However, its specificity is inferior to that of biopsy and PET/CT imaging, which leverages the PSMA-11 ligand specifically designed for PCa. Along with advancements in medical imaging techniques, various imaging probes have been developed to enhance contrast in identifying specific molecular structures. One of the most well-known imaging probes is Iron Oxide Magnetic Nanoparticles (IONPs).

This study aimed to increase MRI specificity for PCa diagnosis by conjugating PSMA-11 peptide to IONPs, which are well recognized as a contrast agent in MRI.

Materials and Methods: The synthesized IONPs were modified with Bovine Serum Albumin (BNPs) to enhance their stability and biocompatibility, facilitating PSMA-11 binding. After determining the physical and chemical properties, cytotoxicity was assessed on PSMA+ LNCaP cell line, and relaxometry along with quantitative measurement of cellular uptake of the nanostructures in the cellular environment was evaluated. The coronal T2*-W images were obtained before and 6 h post injection 2.8 mg Fe/kg of the nanoprobes through the C57BL6 nude mice tail vein.

Results: In vitro studies indicated a 5.02-fold higher uptake of PSMA+ LNCaP cancer cells from the targeted group compared to the non-targeted group, affirming the effectiveness of the targeting strategy. The Contrast-to-Noise Ratio (CNR) between targeted and non-targeted IONPs at a concentration of 750 μ M was calculated as 4.65. Relaxometry performed with a 1.5T MRI scanner yielded an r_2 (mM-1s-1) value of 68.25 for BNPs. Additionally, the targeted nano-probes exhibited higher r_2 values in in-vitro conditions compared to the non-targeted ones. In-vivo results indicated a marked reduction in signal intensity, with TBNPs exhibiting superior contrast enhancement over non-targeted BNPs.

Conclusion: Successful targeting of superparamagnetic iron oxide nanoparticles was confirmed through cellular uptake and relaxometry experiments. The efficacy of the new TBNPs as a negative contrast agent for molecular imaging of PCa was validated.

Keywords: Iron Oxide Nanoparticles; Prostate-Specific-Membrane-Antigen; Molecular Imaging; Prostate Cancer; Magnetic Resonance Imaging.



Comprehensive Morphometric and Volumetric Analysis of the Skull in Romane Sheep Using Computed Tomography

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Abstract

Background: The exploration of anatomical shapes and their variations is a significant focus in medical and veterinary research, as understanding these variations can provide insights into evolutionary adaptations, developmental stages, and the effects of selective breeding. Among numerous techniques utilized for anatomical investigation, Computed Tomography (CT) stands out as a powerful method for producing high-resolution images of internal structures. This non-invasive technique has become indispensable in morphometric studies, especially in livestock research, where anatomical knowledge can influence breeding strategies and improve production efficiency. Romane sheep, recognized globally for their exceptional meat quality and genetic adaptability, are a prime candidate for such anatomical studies due to their pivotal role in meat production systems. The primary aim of this combined study is to present a morphometric and volumetric analysis of the skull in Romane sheep, encompassing both mature individuals and lambs. By using advanced CT imaging techniques, this study seeks to elucidate the distinct anatomical features of the skull that may correlate with the breed's high productivity and adaptability.

Materials and Methods: A total of six Romane sheep, comprising three skeletally mature individuals and three lambs, underwent detailed CT scanning using a Somatom Life Net Sprite 2-slice CT machine. The scanning parameters included kVp set at 120 and mAs at 80, with a slice thickness of 1.0 mm. Utilizing Viasis software, morphometric measurements of the skull were recorded, such as length, width, and height. Additionally, volumetric analyses of the overall head, nasal cavity, and oral cavity were conducted, providing a comprehensive understanding of the anatomical characteristics of both mature and juvenile Romane sheep.

Results: The morphometric study revealed that the average skull dimensions for mature Romane sheep were 23.16 ± 0.20 cm in length, 11.77 ± 0.32 cm in width, and 13.82 ± 0.39 cm in height. In comparison, the skull dimensions of Romane lambs showed a proportionality ratio of approximately 0.6 relative to the mature individuals. Volumetric analysis indicated that the average estimated head volume in mature Romane sheep was 615.64 ± 1.59 cm³, whereas lambs exhibited a significantly smaller average head volume of 340 ± 23.26 cm³. The specific volumes for the nasal and oral cavities were 38.77 ± 1.50 cm³ and 44.32 ± 0.99 cm³ for mature sheep, contrasted with 21.84 ± 3.17 cm³ and 22.22 ± 2.67 cm³ in lambs, respectively. Interestingly, the ratios of nasal cavity volume to head volume were recorded at 0.06 for both age groups, while mature Romane sheep had an oral cavity volume ratio of 0.07, compared to 0.06 in lambs. This suggests an increase in oral cavity volume relative to size as sheep mature.

Conclusion: This dual study offers critical insights into the skull morphology and volumetric characteristics of Romane sheep, serving as a foundational reference for future studies and breed assessments. The comparative analysis underscores distinct anatomical features that differentiate Romane sheep from other breeds, such as Alborz wild sheep and Ile de France sheep, highlighting the importance of breed-specific anatomical knowledge. Moreover, this research represents one of the pioneering efforts in evaluating the skull morphology of immature ruminants, paving the way for future inquiries into their growth and development.

Keywords: Computed Tomography; Romane Sheep; Skull; Volumetry; Morphometry.



Applying Artificial Intelligence in Computed Tomography for Early Diagnosis in Rabbit Models during Preclinical Studies

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Abstract

Background: Artificial Intelligence (AI) pertains to systems that enable computers or machines to replicate human thought processes. Machine learning is an advanced form of AI that enables computers to continuously enhance their abilities based on their experiences, without the need for direct human instructions. While deep learning has been extensively studied for assisting in medical imaging diagnoses in human healthcare, there has been minimal research in veterinary medicine. Computed tomography has been extensively utilized in preclinical studies involving animals like rabbits. Several articles have focused on the application of artificial intelligence in this field. In this section, we closely examine this topic.

Materials and Methods: In this review article, data was gathered from various international scientific databases such as Google Scholar, Scopus, PubMed, and Elsevier. The search focused on the keywords "Machine Learning," "computed tomography," and "preclinical research."

Results: It has been established machine learning algorithms to detect photothrombotic lesions in histological images of rabbit brains subjected to photothrombosis. It has been employed six machine learning algorithms for binary classification and assessed their accuracies in differentiating between normal tissues and photothrombotic lesions. The classification model comprised a 3-layer neural network utilizing a Rectified Linear Unit (ReLU) activation function, Xavier initialization, and Adam optimization, and it was trained on datasets sized at 128×128 pixels, achieving the highest accuracy of 0.975. It was confirmed that the model could effectively identify regions of the brain that were damaged by photochemical ischemic stroke. Xiaolei Luo *et al*, introduce the integration of an improved Artificial Rabbits Optimization (ARO) algorithm as an agent in the reinforcement learning framework. The approach, termed RL-mARO, is utilized for medical image registration. By using Normalized Mutual Information (NMI) as reward and penalty feedback for the similarity metric, the agent continuously modifies and adapts the learning strategies within the population, gradually moving towards the appropriate registration direction. The results demonstrate that the RL-mARO model exhibits elevated robustness and registration accuracy.

Conclusion: By developing machine learning-based models for classifying photothrombotic lesions and comparing their performance, It has been established that machine learning algorithms can be effectively applied in histopathology and various medical diagnostic methods. As technology advances, AI-assisted diagnosis is set to become a crucial component of laboratory research. More training in data analytics will be necessary to effectively utilize AI-generated insights. Furthermore, the effectiveness of AI predictions relies heavily on the quality of the data used for training the algorithms. Inaccurate or biased data can lead to incorrect assessments and miscalculations.

Keywords: Computed Tomography; Laboratory Animals; Artificial Intelligence; Preclinical Research.



Evaluation of Subjects with TBI and PTSD, Using Brain Olfactory Functional Connectivity Networks with Resting-State fMRI Data

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Abstract

Background: Olfactory dysfunction is highly prevalent in military populations and is often attributed to the long-term effects of mild Traumatic Brain Injury (mTBI) and chronic psychiatric disorders. Both mTBI and Post-Traumatic Stress Disorder (PTSD) are common outcomes for members of the military. The emerging evidence suggests that the olfactory system is particularly susceptible to damage, and therefore, olfactory dysfunction may be considered one of the silent indicators of these two conditions. The studies indicate that resting-state functional Magnetic Resonance Imaging (rs-fMRI) has played a prominent role in enhancing the understanding of the mechanisms of the olfactory brain network.

Given that the olfactory system's function has not been extensively studied in military populations, our aim was to investigate the functional connectivity network of the olfactory regions of the brain in individuals with PTSD and TBI using resting-state functional Magnetic Resonance Imaging (rs-fMRI).

Materials and Methods: In this study, we used the data from the DOD ADNI website of the US Ministry of Defence. 276 non-demented veterans' data rs-fMRI of patients in four groups (CONTROL= 69, PTSD=69, TBI=69 PTSD+TBI = 69), in the age range of 80-90 years were evaluated. The MATLAB Conn Toolbox was used for data processing and pre-processing. Functional Connectivity (FC) network of primary olfactory regions in 4 primary olfactory regions; orbitofrontal cortex (OFC), amygdala, piriform, and uncus was analyzed as seed in seed to voxel (SBC) analyze.

Results: In to regions OFC and piriform showed the highest correlation with Frontal Pole Right (FPR) in All subjects in each 4 groups. PTSD+TBI and CN showed a lot of correlation in amygdala with Temporal Pole Left but in PTSD group the highest correlation is with Temporal Pole Right. The superior parietal lobule has the most connectivity of all clusters in PTSD + TBI in uncus seed. In all groups, Middle Frontal Gyrus Right has the lowest correlation with amygdala. Compared to the Control Group, decreased activity was observed in all four regions.

Conclusion: The results show that the Functional Connectivity (FC) between the four seeds of the Olfactory Network (ON) and in four groups may be a sensitive marker for Presence and progression of the disease.rs-fMRI parameters may serve as potential biomarkers for traumatic and psychiatric anosmia by revealing more extensive functional damage than previously thought.

Keywords: Traumatic Brain Injury; Post-Traumatic Stress Disorder; Olfactory Network; functional Magnetic Resonance Imaging; Functional Connectivity; Resting State.



Machine Learning-Based Classification of Post-traumatic stress disorder and Normal Subjects Using Olfactory Brain Network Features from Resting-State fMRI

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Abstract

Background: Post-Traumatic Stress Disorder (PTSD) is a stress-related disorder that can develop after a person is exposed to a traumatic event. Studies have indicated that approximately 2.2 to 15% of veterans who served in the Vietnam War were diagnosed with PTSD. As a marker of brain dysfunction, PTSD, which is prevalent among combat veterans, can lead to alterations in the central nervous system, consequently affecting olfactory function.

The aim of this study is to classify individuals with PTSD and normal Subjects using resting-state functional imaging and various machine learning algorithms.

Materials and Methods: In this study, 69 male participants with PTSD and 69 age- and gender-matched healthy male controls were included. Resting-state functional magnetic resonance imaging (rs-fMRI) data was extracted from the DOD ADNI database (a subset of ADNI). The DOD ADNI database is affiliated with the United States Department of Defence and contains data related to Vietnam War veterans. Input features for machine learning algorithms to classify PTSD and control groups included the results of the seed-based connectivity analysis (SBCA) matrix among four olfactory regions (OFC, piriform, amygdala, and uncus), psychological test results, and participants' age. The rs-fMRI data have been distributed in training, validation, and testing group for maturity, implementation of machine learning techniques.

Results: Our findings demonstrate that machine learning models can effectively differentiate between PTSD and control groups based on connectivity, functional, and psychological test results derived from fMRI data. Among the various models, SVM with a linear kernel achieved an accuracy of 77.25% and with a sigmoid kernel, 75.71%. Additionally, the Random Forest model exhibited superior performance with an accuracy of 83.35%, while Logistic Regression and KNN yielded accuracies of 76.54% and 61.04%, respectively.

Conclusion: Overall, this study demonstrates that features extracted from functional and effective brain connectivity, along with psychological test results, can be powerful tools for distinguishing between PTSD and control groups. Specifically, these findings indicate that the Random Forest model emerged as a top choice for classifying between these two groups, exhibiting a superior performance compared to other methods. These results not only contribute to a better understanding of PTSD but can also lead to the development of treatment and prevention strategies based on brain and psychological data.

Keywords: Post-Traumatic Stress Disorder; Olfactory Network; functional Magnetic Resonance Imaging; Functional Connectivity.



Comparison of DTI and PET Imaging for ALS Detection: A Deep Learning Approach - A Narrative Review

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Abstract

Background: Amyotrophic Lateral Sclerosis (ALS) is a progressive neurodegenerative disorder characterized by motor neuron degeneration, leading to muscle weakness and atrophy. Early and accurate diagnosis remains a significant challenge in ALS management. This narrative review explores the potential of two advanced neuroimaging techniques—Diffusion Tensor Imaging (DTI) and Positron Emission Tomography (PET)—in ALS detection, with a focus on the application of deep learning algorithms to these imaging modalities. This review aims to critically evaluate and compare the efficacy of DTI and PET imaging techniques, analyzed through deep learning approaches, in the detection and diagnosis of ALS.

Materials and Methods: This narrative review synthesizes recent literature on DTI and PET imaging in ALS diagnosis, emphasizing studies that employ deep learning methodologies. A comprehensive search was conducted using electronic databases including PubMed Central, Google Scholar, and arXiv. The search strategy incorporated key terms such as "ALS detection," "DTI imaging," "PET scan," and "deep learning in neuroimaging". Relevant literature from the past decade was identified. The review process focused on identifying salient trends, innovative applications, and comparison of DTI and PET in the context of ALS detection and deep learning integration.

Results: The literature review reveals that both DTI and PET imaging, when analyzed using deep learning algorithms, demonstrate significant potential in ALS detection. DTI exhibits particular efficacy in visualizing white matter tract degeneration, notably in the corticospinal tracts. Deep learning models applied to DTI data have shown promising results in differentiating ALS patients from healthy controls. PET imaging, especially utilizing novel radiotracers targeting neuroinflammation, has demonstrated high specificity in identifying ALS-related functional alterations. Deep learning analysis of PET scans has yielded encouraging outcomes in terms of specificity and sensitivity. Notably, several studies suggest that the integration of both imaging modalities through ensemble deep learning models could potentially enhance diagnostic accuracy. However, the field would benefit from standardization of imaging protocols and larger, multi-center studies to validate these preliminary findings.

Conclusion: This narrative review underscores the complementary strengths of DTI and PET imaging in ALS detection when leveraged through deep learning analysis. While DTI excels in capturing structural changes, PET provides valuable insights into functional and metabolic alterations associated with ALS. The integration of these imaging modalities with sophisticated deep learning algorithms presents a promising avenue for enhancing ALS diagnosis. Future research should focus on developing robust, multimodal deep learning frameworks that effectively combine DTI and PET data. This approach has the potential to not only improve diagnostic accuracy but also uncover novel biomarkers for ALS progression, ultimately contributing to more personalized treatment strategies and improved patient outcomes. As the field evolves, continued exploration of these technologies may significantly impact ALS patient care and management, potentially leading to earlier interventions and improved quality of life for those affected by this devastating disease.

Keywords: Amyotrophic Lateral Sclerosis; Diffusion Tensor Imaging; Positron Emission Tomography; Deep Learning.



Magnetic Permeabilization of Cell Membranes to Facilitate Drug Delivery: A Preclinical Review

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Abstract

Background: The selective transport of substances through the cell membrane is crucial for cellular survival. However, some therapeutic strategies require the introduction of substances that typically cannot pass through the membrane. Magnetic permeabilization, also known as magneto-poration, is a physical technique that enhances membrane permeability using pulsed magnetic fields. As a drug delivery method, it offers benefits such as deep magnetic field penetration, non-invasiveness, safety, and cost-effectiveness compared to other permeabilization techniques.

In this review, we aim to highlight key findings from previous preclinical studies and expand the potential applications of the magnetic permeabilization method (magneto-poration) for enhancing cell membrane permeability, with a specific focus on its use in drug delivery and cancer treatment.

Materials and Methods: This comprehensive review involved searching multiple information databases, including Scopus, PubMed, and Web of Science, without any restrictions on the publication time or language of the studies. Additionally, relevant studies were identified through citation tracking tools in PubMed and Google Scholar.

Results: Preclinical studies suggest that pulsed magnetic fields, by inducing electric fields and generating electric currents in biological tissues, significantly increase cell membrane permeability to fluorescence markers and chemotherapy drugs in animal models. High-intensity pulsed magnetic fields enhance the absorption of otherwise impermeable molecules, improve cell membrane conductance, and increase the uptake of chemotherapy drugs, which can lead to the death of cancer cells.

Conclusion: Combining magneto-poration with chemotherapy can lead to the development of magneto-chemotherapy for tumor treatment. If preclinical successes translate to clinical trials, this innovative approach could significantly improve efficacy, lower costs, and reduce side effects compared to traditional methods.

Keywords: Magnetic Permeabilization; Cell Membrane; Drug Delivery; Preclinical.



Gold Nanotheranostics for Cancer, A Novel Approach in Cancer Nanomedicine

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Abstract

Background: Traditional diagnostic and therapeutic approaches have disadvantages, including low sensitivity, specificity, and inefficiency in addressing metastatic cancers. Gold nanotheranostics has emerged as a promising alternative, leveraging the unique optical and electronic properties of gold nanostructures for simultaneous diagnosis and therapy. Gold nanostructures provide better Photothermal Treatment (PTT), Photodynamic Therapy (PDT), and contrast in imaging methods such as MRI and CT scans because of their variable size, shape, and Surface Plasmon Resonance (SPR). The development of gold nanocomposites further addresses limitations such as photoinstability and poor targeting, paving the way for better in vivo applications.

This study aims to investigate and assess the potential of gold nanostructures and their composites as theranostic agents for cancer treatment, with particular emphasis on their capacity to enhance targeted therapy, diagnostic imaging, and overall treatment efficacy.

Materials and Methods: A PubMed database search was performed using the strategy “((gold and nanotheranostics and cancer))” with a time frame from 2017 to the present. Studies that were non-English, duplicates, review articles, preclinical research, or unrelated to the topic were excluded.

Results: This article presents studies that show the better photothermal conversion efficiency of gold nanoparticles, especially in anisotropic forms such as nanorods and nanocages, which makes them useful agents in PTT. By adding components like iron oxide and silica, gold nanocomposites improve photostability and biocompatibility and increase drug loading capacity and imaging capabilities. When radioiodine-labeled gold nanoballs were delivered by macrophages to the tumor site, they uniformly distributed and significantly raised the temperature there after laser irradiation, eliminating cancer cells. Clinical stages have been reached in the in vivo studies of gold-based formulations like Aurimmune and AuroLase, demonstrating promise in the treatment of malignancies such as prostate cancer.

Conclusion: With its ability to provide accurate image-guided therapy and non-invasive treatment alternatives, gold nanotheranostics offers great potential. Problems like toxicity, off-target effects, and photoinstability are resolved by integrating gold nanocomposites. Gold-based theranostic compounds have the potential to be a key component of customized cancer treatment as research progresses, enabling early diagnosis and efficient therapy with few side effects. But further research is required to fully maximize their therapeutic uses and get over their disadvantages.

Keywords: Nanotheranostics; Gold; Cancer.



A Review of Neoplastic Diseases Diagnosis and Treatment Methods in Ornamental Birds

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Abstract

The incidence of neoplastic diseases, commonly known as cancers, while less frequent than in mammals, has been increasingly documented in companion birds particularly in parrots and cockatiels. This trend is particularly notable among psittacines, especially parrots. In avian species, including pet birds, Cancers are frequently linked to viral infections. Viruses such as avian leukosis virus, Marek's disease virus, reticuloendotheliosis virus, and lymphoproliferative disease viruses are known to contribute to the development of tumors in birds. While these viruses commonly cause cancer in species like chickens, they can also affect other birds, including pet species like parrots. The most common tumors in these birds are lipomas (benign fatty growths), fibrosarcomas, and squamous cell carcinomas, especially affecting the skin. While lipomas occur most frequently and can impact birds' movement and breeding ability. Another tumor that is prevalent in companion birds is lymphoma. Diagnosing avian cancer is challenging due to birds' small size, intricate anatomy, and subtle early symptoms. Initial diagnosis typically involves a thorough clinical exam, looking for signs like weight loss, lethargy, or unusual masses. Advanced imaging techniques such as radiography, ultrasonography and CT scans are crucial for detecting internal tumors, while endoscopy can help visualize growths in body cavities. Fine needle aspiration and biopsy remain the most reliable methods for obtaining tissue samples for histopathological analysis, helping identify tumor type and grade. Treatment options vary based on the tumor type and location. Surgical intervention, when anatomically feasible and the bird can safely undergo anesthesia, often proves to be the most efficacious treatment strategy, particularly for localized cutaneous neoplasms for example lipomas. However, it is important to note that anatomical constraints may limit surgical options in some instances. Also, Advanced surgical techniques like Ultrasonic Aspiration (CUSA) help reduce bleeding and tissue damage. Alternative treatments exist when surgery isn't possible, including electrochemotherapy using cisplatin, which shows promise for cockatiel (*Nymphicus hollandicus*) skin tumors, as well as chemotherapy, photodynamic therapy, cryosurgery and radiation for aggressive cancers. For ovarian tumors, treatments like fluid drainage and hormone therapy can help manage symptoms. Squamous Cell Carcinoma (SCC), a frequently encountered skin cancer in avian species especially in cockatiels and Amazon parrots, exhibits low metastatic potential but demonstrates local invasiveness. In contrast, malignant neoplasms such as soft tissue sarcomas, hemangiosarcomas, and osseous tumors necessitate more aggressive therapeutic interventions, including wide surgical excision and chemotherapy. However, due to the relative rarity of these cases in avian species, the long-term outcomes of these treatments remain inadequately studied. Radiation therapy and chemotherapy, particularly for systemic cancers like lymphoma, require precise dosing because of birds' unique metabolism and small size. While catching and treating cancer early improves survival chances, outcomes largely depend on factors like the bird's species, age, and how far the cancer has progressed when discovered. Diagnosing and treating cancer in pet birds remains complex. This article is a review of the latest advancements in cancer diagnosis and treatment for ornamental birds.

Keywords: Ornamental Birds; Cancer; Diagnosis; Treatment.



Analysis of Haralick Features for Discrimination of Malignancy from Benignity in Breast Ultrasound Images by Machine Learning

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Abstract

Background: Effective detection of breast cancer is crucial as it is a major cause of female mortality. While mammography is the primary screening method, ultrasound is also valuable, especially for young women and those with dense breast tissue. However, ultrasound imaging has resolution constraints and is susceptible to noise, which makes distinguishing between benign and malignant breast cancer challenging. Artificial intelligence, specifically machine and deep learning, offers a promising solution through automated image analysis and diagnostic support. This study aims to evaluate the effectiveness of Haralick's texture features, extracted from 2D breast ultrasound images, in classifying tumors as benign or malignant. The ultimate goal is to determine the suitability of these features for machine learning applications and comprehensive characterization of breast lesions.

Materials and Methods: In this study, breast ultrasound images containing both benign and malignant masses were used as the dataset. The images have been divided into two categories: benign and malignant. Some of the images containing two masses have been removed from the dataset. The remaining images were then examined for size consistency, and those that were not of the same size were excluded from the dataset. The skimage.feature library was used for extracting Haralick features by Python. In this library, a GLCM (Gray-Level Co-occurrence Matrix) matrix was first obtained from the ROI (Region of Interest). Six Haralick features, namely Contrast, Dissimilarity, Homogeneity, ASM (Angular Second Moment), Energy, and Correlation, were extracted at four different angles: 0, 45, 90, and 135 degrees. Subsequently, the extracted features were averaged for each angle, and these averaged values were used as the final dataset for analysis.

Results: The number of benign and malignant data points in this study is 437 and 211 respectively. Shapiro-Wilk test was conducted on the Data by Python from breast ultrasound images in two groups, benign and malignant, which showed that the data distribution does not follow a normal distribution. Therefore, a Mann-Whitney test was used to compare the means of the features. The Mann-Whitney test was performed for both groups of images, and it was concluded that all six Haralick features were suitable for classification.

Conclusion: One of the crucial steps in machine learning is selecting appropriate features for data modeling and classification. One effective approach to finding suitable features is using statistical tests. To employ statistical tests, it's necessary to determine the data distribution type. In this study, the type of data distribution was identified as non-normal using the Shapiro-Wilk test. Consequently, the Mann-Whitney test was applied for data analysis, in this test, the p-value for each of the six features was much less than 0.05 revealing that six Haralick features extracted from ultrasound images are suitable for classification.

Keywords: Haralick Features; Breast Cancer; Gray-Level Co-Occurrence Matrix; Python.



A Review of Recent Advancements in the Diagnosis and Treatment of Oral Cancer in Pets

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Abstract

Oral cancer in small animals, especially dogs and cats, represents a major health issue that impacts their overall well-being and lifespan. These cancers can develop in various parts of the mouth, including the gums, tongue, and palate, posing both diagnostic and treatment challenges. Factors like age, breed, and gender play a role in tumor formation, with breeds such as German Shepherds, Pointers, and Boxers being more susceptible. Male dogs are generally more affected than females, with common tumors in dogs including melanoma, Squamous Cell Carcinoma (SCC), and fibrosarcoma, while in cats, SCC and fibrosarcoma are more prevalent. Early detection plays a critical role in preventing oral cancers and improving treatment outcomes. Most of the oral cancers initially show only subtle symptoms. The most frequent signs include swelling, ulcers, drooling, and dysphagia. Diagnostic methods like Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are essential for assessing tumor size, location, and spread. The pathology biopsy represents the gold standard for diagnosis, while Fine-Needle Aspiration (FNA) and cytology provide additional information. The treatment of oral cancer in small animals usually employs a multimodal strategy. Surgical removal is the mainstay method, particularly effective for early-stage tumors, and ensuring complete excision with clear margins is vital to prevent recurrence. In more advanced cases, aggressive procedures such as mandibulectomy or maxillectomy may be required. Radiotherapy is often used alongside surgery or as a primary treatment for tumors that cannot be surgically removed, especially for radiation-sensitive cancers like SCC. Chemotherapy is utilized for advanced or metastatic cancers, with drugs such as cisplatin, doxorubicin, and carboplatin, though management of systemic side effects is important. New treatment options, like immunotherapy, show new approaches, particularly for oral melanomas in dogs. For instance, canine melanoma vaccines may help prolong survival by activating the immune system to attack cancer cells. Additionally, drug delivery systems based on nanotechnology are being researched to enhance the effectiveness of chemotherapy while reducing side effects. In addition to traditional treatments, studies on herbal compounds suggest potential complementary therapies. For example, *Vernonia cinerea* has shown anti-proliferative properties against oral squamous cell carcinoma by inhibiting cancer cell growth. Likewise, *Wedelia chinensis*, which contains compounds like wedelolactone and luteolin, has exhibited lasting anti-tumor effects in animal studies. *Plantago ovata* has been investigated for its potential to manage oral mucositis, a chemotherapy side effect, which could enhance the quality of life for cancer patients. Ultimately, the outlook for small animals with oral cancer varies based on the type and stage of the tumor at diagnosis. Early detection and treatment greatly improve survival rates, particularly for SCC and fibrosarcoma. Ongoing research into innovative therapies, including gene therapy, immunotherapy, and herbal remedies, holds promise for enhancing outcomes in veterinary oncology. This article reviews the latest advancements in oral cancer diagnosis in small animals and its treatment using herbal and synthetic compounds.

Keywords: Oral Cancer; Pets; Treatment; Diagnosis.



Comparative Review of Micro-Computed Tomography and Histopathology Data in Evaluating Angiogenesis in Bone Regeneration

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Abstract

Background: Bone regeneration is a complex biological process that repairs and remodels pathologically damaged bones. Angiogenesis, the formation of new blood vessels, is a critical process in bone repair and regeneration. Traditional histopathological methods have been the gold standard for evaluating angiogenesis, but they are often destructive and limited to small tissue samples. Micro-Computed Tomography (micro-CT) offers a nondestructive alternative, providing high-resolution, three-dimensional images of bone structures. This study aims to review the existing literature on the correlation between micro-CT scan data and histopathological findings in evaluating angiogenesis during bone repair, providing a comprehensive understanding of the vascular changes during the healing process.

Materials and Methods: This review uses a query in PubMed's public database, focusing on three different MeSH term patterns. After applying the inclusion criteria, 15 research were chosen for our review. Additionally, 34 other articles were selected without a systematic search, and besides them related investigations by authors of the current literature. A comprehensive literature review was conducted, analyzing studies and articles that utilized both micro-CT scans and histopathological examinations to assess angiogenesis in bone repair. Key studies were selected based on their relevance and contribution to the understanding of the correlation between these two diagnostic methods.

Results: The literature review revealed a strong correlation between micro-CT scan data and histopathological findings in the evaluation of angiogenesis. Micro-CT scans were consistently shown to accurately identify the formation of new blood vessels and the progression of bone repair, which were confirmed by histopathological examination. Histological assessment involves the preparation of tissue samples followed by staining techniques such as Hematoxylin and Eosin (H&E), Masson's trichrome, and immunohistochemistry. These methods, especially specific markers like CD31, can effectively show newly formed blood vessels. CD31, also known as PECAM-1, is specifically expressed in endothelial cells and can accurately indicate newly formed vessels. For instance, Gregor in 2012, demonstrated that micro-CT imaging could be effectively correlated with quantitative histology to assess bone quality and vascular networks. It should be mentioned that Micro-CT and histopathological examinations, provides quantitative data on newly formed blood vessels. Hence, the combination of these methods can provide a detailed and comprehensive evaluation of angiogenesis in bone repair.

Conclusion: This correlation of micro-CT scan data with histopathology offers a powerful approach for evaluating angiogenesis in bone repair. This nondestructive method enhances the understanding of vascular changes during the healing process and can be used to improve bone repair strategies. Future research should focus on further refining these techniques and exploring their applications in clinical settings. If future research establishes and defines a correlation coefficient between the number of newly formed blood vessels counted by micro-CT scan and histopathological examinations, this coefficient could be easily used to estimate the degree of angiogenesis and bone repair. This approach would eliminate the risk of tissue damage for the patient.

Keywords: Micro-Computed Tomography; Angiogenesis; Bone Regeneration; Histopathology.



Enhanced Skeletal Muscle Maintenance on Bioinspired Ponytail Palm-Derived 3D Matrices Treated with Whey Protein

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Abstract

Skeletal muscle is most abundant tissue with critical important for optimal metabolic homeostasis in the human body that support movement, postural behavior, and breathing. Increasing rates of muscle injuries due to accidents, degenerative diseases or sports led to the movement for finding a bioinspired supportive scaffolds for muscle regeneration. Exploiting natural nanoarchitecture has recently suggested as biocompatible, non-toxic and low-cost approach to address such issues. Here, C2C12 cells were cultured on decellularized Ponytail palm treated with whey protein to investigate the capability of natural patterned cellulosic matrices on improving proliferation and differentiation of skeletal muscle cell line confirmed by SEM, AFM, and FTIR as well as MTT assay, and DAPI staining. The cells exhibited increased adhesion, proliferation with better viability rates and maintenance on nanoarchitecture decellularized cellulose scaffolds without any toxicity while treating with whey protein supported the cell attachment, and differentiation of C2C12 cells. Altogether, ponytail palm-derived cellulosic scaffold can simulate the natural cellular niche for skeletal muscle tissue culture majorly when used with whey protein and thus it can be considered as promising sustainable biomaterial for human muscle tissue engineering and developmental studies.

Keywords: Tissue Engineering; Bioinspired Material; Scaffold; Whey Protein.



Unveiling Osteoporosis Screening Using Chest CT-Based Radiomics: A Review

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Abstract

Background: Osteoporosis is a prevalent skeletal disorder characterized by decreased bone mineral density and deteriorated bone microarchitecture, leading to an increased risk of fractures. chest CT imaging, commonly performed for various clinical indications, offers a potential avenue for assessing bone quality using advanced techniques such as radiomics and machine learning approaches. radiomics involves the extraction of quantitative features from medical images, offering insights into trabecular bone microstructure. integrating machine learning algorithms with radiomics features holds promise in enhancing osteoporosis screening and fracture risk assessment using chest CT scans. This narrative review aims to comprehensively assess the current state of knowledge regarding the application of chest CT-based radiomics combined with machine learning approaches in osteoporosis screening. the review seeks to evaluate the feasibility, accuracy, and potential clinical impact of these advanced imaging techniques in identifying individuals at risk of osteoporosis-related fractures.

Materials and Methods: A systematic search of electronic databases, including pubmed, medline, and google scholar, was conducted to identify relevant studies published within the last decade. keywords such as "osteoporosis," "radiomics," "machine learning," "chest CT," and their combinations were used to identify pertinent literature. studies investigating the use of chest CT-based radiomics in osteoporosis screening and incorporating machine learning approaches were included. data related to study design, patient demographics, imaging protocols, radiomic features, machine learning algorithms, and diagnostic performance were extracted and synthesized.

Results: The review identified a growing body of evidence supporting the potential of chest CT-based radiomics in osteoporosis screening using machine learning approaches. several studies demonstrated the ability of machine learning models trained on radiomic features extracted from chest CT images to effectively discriminate individuals with osteoporosis or at risk of fractures from those with normal bone health. furthermore, the integration of machine learning algorithms with radiomics showed improved accuracy in identifying osteoporosis and predicting fracture risk compared to traditional methods.

Conclusion: In conclusion, the integration of chest CT-based radiomics with machine learning approaches holds significant promise for advancing osteoporosis screening and fracture risk assessment. these advanced imaging techniques offer valuable insights into bone microstructure and have the potential to enhance risk stratification and personalized interventions for individuals at risk of osteoporosis-related fractures. however, further research is needed to standardize imaging protocols, validate the clinical utility of machine learning models, and facilitate their integration into routine clinical practice for comprehensive osteoporosis assessment.

Keywords: Radiomics; Computed Tomography; Osteoporosis; Detection.



Assessment of Muscle Elasticity in DMD Patients Using Ultrasound and Young's Modulus

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Abstract

Background: Duchenne Muscular Dystrophy (DMD) is a hereditary disease. In this disease, dystrophin protein, which is an important structural factor in muscle, is not produced, so it leads to the loss of muscle fibers and the replacement of fatty and fibrous tissue in the muscle structure over time. Over time, the elasticity of the muscles changes and the muscles become stiffer. Examining the degree of this stiffness can be a parameter to evaluate the progress of the disease and the effectiveness of new treatments. Ultrasound imaging is a suitable tool for examining muscles. The processing and analysis of images obtained by it can provide a method for examining muscle elasticity parameters.

The purpose of this study is to investigate the elasticity of muscles by calculating Young's modulus parameter. A DMD patient and a healthy person as a control were subjected to ultrasound examination and then the images were analyzed to calculate Young's modulus as a parameter of muscle elasticity.

Materials and Methods: An 11-year-old boy with DMD and an age-matched healthy boy underwent muscle ultrasound using high-resolution ultrasound (Sonix Touch ultrasound system, Ultrasonix Medical Corporation, Richmond, Canada) with probe settings at a 14 MHz frequency, 15 fr/s, and a 4-5 cm depth. The muscles of the lower limbs including biceps femoris, medial gastrocnemius and lateral gastrocnemius of both limbs were examined. For this purpose, a force gauge device was first connected to the ultrasound probe. This set was placed perpendicular to the surface of the muscle. First, a picture of the muscle was taken without applying pressure. Then, the muscle was subjected to a stress of 1 to 10 newtons. Simultaneously, an ultrasound film was recorded in AVI format. By transferring the films to the computer and using the decoding algorithm, consecutive frames in PNG format were obtained from them. Using a combination of maximum gradient and dynamic programming algorithms in MATLAB, the displacement of the specified pixels in the vertical axis was calculated. The maximum and minimum distance between the edges of the muscle was determined. Then Young's modulus was calculated according to the amount of applied stress.

Results: The obtained results showed that the values of the Young's modulus of medial gastrocnemius muscles in patient are almost twice the values of healthy individual. In general, 4 out of 6 examined muscles had higher values of Young's modulus in DMD individual.

Conclusion: Ultrasound imaging of muscles and image processing can be used as a low-cost and low-risk method to investigate the disease process and evaluate the effectiveness of treatments used in DMD patients.

Keywords: Ultrasound; Elasticity; Muscle; Young's Modulus.



Correlation of Micro-CT and Histological Assessment in Animal Models of Bone Regeneration

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Abstract

Background: Bone regeneration is a complex biological process that repairs and remodels pathologically damaged bones. Bone Tissue Engineering (BTE) integrates biomaterial sciences, medicine, surgery, and design principles to enhance bone regeneration. Preclinical studies utilizing micro-computed tomography (micro-CT) and histological assessments are essential in clarifying the impacts of various BTE approaches and their effectiveness in bone regeneration. This review intends to explore the correlation of micro-CT and histological assessment in animal models of bone regeneration, highlighting their respective advantages and disadvantages.

Materials and Methods: This review uses a query in PubMed's public database, focusing on three different MeSH term patterns. After applying the inclusion criteria, 15 research were chosen for our review. Additionally, 34 other articles were selected without a systematic search, and besides them related investigations by authors of the current literature.

Results: With an overview of the evolution history of the micro-CT, its capabilities in improving studies on bone regeneration were elucidated. Micro-CT is a vital imaging technique for assessing bone healing because it offers high spatial resolution and three-dimensional visualization of complex bone structures. It allows researchers to monitor bone healing in real time non-invasively. Micro-CT has been used in various studies to study bone structures, trabecular architecture, osteoporosis, bone resorption, bone remodeling, fracture healing, and bone density and volumetric changes over time. Its non-invasive nature allows for repeated measurements in the same animal, facilitating longitudinal studies.

Histological assessment involves the preparation of tissue samples followed by staining techniques such as Hematoxylin and Eosin (H&E), Masson's trichrome, and immunohistochemistry. These methods allow for the examination of cellular organization, tissue composition, and the presence of specific markers indicative of bone regeneration. Histological assessment provides information on cellular infiltration, mineralization, histomorphometry, and immunostaining.

Micro-CT provides quantitative data on bone morphology, while histology offers qualitative insights into cellular dynamics. Studies have shown a correlation between changes in micro-CT parameters and histological findings. When juxtaposing these two, despite all of their positive features, both techniques have limitations. Micro-CT may have insufficient resolution for fine cellular details and involves radiation exposure. Histology is invasive, requires animal euthanasia, and cannot capture dynamic changes in real-time.

Conclusion: The advantages of both approaches can be combined to provide researchers with a deeper understanding of the mechanisms underlying bone regeneration.

Keywords: Micro-Computed Tomography; Histopathology; Bone Regeneration; Bone Tissue Engineering; New Bone Formation.



Automated Multi-Class Deep Learning Classification of Laryngeal Diseases from Neck CT Images

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Abstract

Background: Laryngeal diseases, particularly tumors (both benign and malignant), are challenging to diagnose due to the complexity of the larynx. Early detection is crucial to prevent tumor spread and increase treatment options. Various imaging techniques, including radiography, laryngoscopy, MRI, and CT, are used to identify abnormalities. CT scans offer a quicker, minimally invasive way to assess tumor extent and are better for evaluating deep structures. Currently, diagnosis relies heavily on radiologists' qualitative evaluations, which can be affected by fatigue and experience, especially for small lesions. There is a significant need for automated algorithms to improve diagnosis accuracy and efficiency in laryngeal disease detection. This research aims to introduce a novel automated algorithm, powered by deep learning techniques, for the detection of laryngeal tumors. The algorithm addresses the intricacies of the larynx area and the challenges associated with diagnosing and distinguishing its abnormalities, resulting in enhanced precision and accuracy of diagnoses. Ultimately, by integrating this algorithm into computer-aided diagnostic software, radiologists will have a powerful tool to assist them in achieving more precise and efficient diagnoses.

Materials and Methods: Neck CT scans of 240 patients were collected, and tumoral and normal slices were manually labeled by an experienced radiologist to provide ground truth data for the deep learning model training.

A novel and advanced image processing algorithm was designed to detect the larynx from other present structures in each slice and extract it as the region of interest to provide the deep learning model with more focused data. Cropped images of the larynx were utilized to train and validate four different pre-trained deep learning models including ResNet50V2, ResNet101V2, InceptionResNetV2, and InceptionV3. To prevent data leakage and enhance model generalizability, we adopted a patient-based splitting approach in the training process of the models. The performance of each model was evaluated using multiple metrics, including accuracy, precision, recall, and F1-score. The model showcasing the highest performance was implemented as the main model for tumor detection.


Results: ROI detection algorithm was able to successfully detect the larynx in %95 of slices. ResNet50V2 outperformed all other models by achieving an accuracy of %88.58, precision of %93.56 for the tumoral and %82.83 for the normal class, recall of %86.27 for the tumoral and %91.77 for the normal class, and %89.76 for the tumoral and %87.07 for the normal class, showing promising results.

Conclusion: In this study, we present a robust classification algorithm suitable for integration into computer-aided diagnostic systems. With room for further optimization of algorithms and models, the findings of this article demonstrate the potential of deep learning algorithms and their image-specialized subgroup of convolutional neural networks for clinical applications and highlight the importance of future investigations to refine and optimize their performance.

Keywords: Artificial Intelligence; Cancer; Head and Neck; Computed Tomography Scan; Classification.



The Role of Gold Nanoparticles in X-Ray Microbeam Radiation Therapy Approach Efficiency: A Macro Scale Simulation Study

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Abstract

Background: Spatially Fractionated Radiation Therapy (SFRT) Such as Microbeam Radiation Therapy (MRT) is a promising technique for cancer treatment due to its ability to deliver highly localized radiation doses to the tumor region while sparing surrounding normal tissues. However, the efficacy of MRT with X-rays can be significantly influenced by factors such as the tumor's size, dose conformity, and biological response to radiation. Gold nanoparticles (GNPs) can increase the absorption of X-rays in tumor cells, leading to enhanced energy deposition and potentially improved treatment outcomes. Thus to enhance the therapeutic potential of MRT, GNPs can be used as radio-sensitizers.

This study aims to evaluate the potential benefits of using GNPs as radio-sensitizers in MRT at a macro scale Monte Carlo simulation. By employing computational simulations, we investigated how the presence of GNPs influence the radiation dose distribution and overall therapeutic efficacy of MRT.

Materials and Methods: A GEANT4 Monte Carlo simulation was developed to simulate the combination of MRT with GNPs. Broad beam and microbeam array were chosen as irradiation settings. The simulation was carried out for energy of 100keV. The range cut value was 1 μ m for all species. In all cases, Microbeams consisted of vertical planar beamlets separated horizontally at various centre-to-centre distances (ctc). The dimensions of the broad beam were 1 \times 1 cm², and in the case of MRT were 50 and 100 μ m with a height of 1cm. The beam sources were placed at the entrance of the water phantom. Two ctc distances were investigated: 200, and 400 μ m. The radiation field of Microbeams covered an area of 1 \times 1 cm². A homogeneous tumor model (1 \times 1 \times 1 cm³) was created in the center of the water phantom (15 \times 15 \times 15 cm³), composed of a mixture of water/GNPs. Nanoparticle concentrations of 1, 2.5, 7.5, 10, and 20%, were investigated within the tumor region. The research studied the contribution of secondary particles, dose enhancement in tumor, peak and valley doses, and Peak-to-Valley Dose ratio (PVDR).

Results: The simulation results showed an enhancement of dose deposition within the tumor region due to the presence of GNPs while maintaining a high PVDR in normal tissues during the MRT approach. However, employing a larger ctc (400 μ m) can lead to greater preservation of healthy tissues due to the increased PVDR, while it causes a reduction in tumor dose conformity and therapeutic efficiency in the absence of GNPs. This non-uniformity can be mitigated when ctc is reduced (200 μ m), while optimal healthy tissue preservation may not be obtained. Nevertheless, by increasing GNPs concentrations, the deposited dose in the tumor is enhanced, leading to better dose homogeneity, Therefore, it could potentially alleviate the challenge of using larger ctc.

Conclusion: The findings of this study contribute to a better understanding of the role of GNPs in the MRT approach and their potential to improve treatment outcomes. The results may inform the biological experiments, the design of future clinical trials, and guide the optimization of nanoparticles-based MRT strategies.

Keywords: Gold Nanoparticles; Microbeam Radiation Therapy; Monte Carlo Simulation; Spatially Fractionated Radiation Therapy; Therapeutic Efficiency; Tissue-Sparing.



Preclinical Cancer Research in Canine Models: The Prospect of Developing New Immunotherapies

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Abstract

Background: Canine models are increasingly esteemed in cancer research due to their genetic, physiological, and immunological similarities to human cancer, which surpass those of established rodent models. Dogs provide a significant opportunity for researchers to investigate cancer development and assess novel therapeutic approaches such as immunotherapy. Tumors such as osteosarcoma, hemangiosarcoma, soft-tissue sarcoma, and non-Hodgkin lymphoma manifest more frequently than their human counterparts.

The rapidly advancing domains of cancer immunology and immunotherapy have transformed the perception and treatment of cancer. The emergence of immunotherapy has advanced the field of cancer beyond conventional treatments such as surgery, radiation, and chemotherapy. Immunotherapy utilizes the body's immune system to identify and eliminate cancer cells. Recent developments in immunology have led to the development of new immunotherapy drugs that specifically target cancer cells while preserving healthy cells. This paper examines the latest cancer immunotherapy instruments assessed in canine models.

Materials and Methods: This review aggregated information and data from several studies sourced from academic journals in PubMed, Google Scholar, and other research platforms.

Results: Canines have been pivotal in facilitating the evaluation of immune-based medicines as we seek innovative and improved methods for cancer treatment, including immune checkpoint inhibitors, cancer vaccinations, and adoptive T-cell therapy. Dogs are crucial in assessing the efficacy and safety of these medicines because to the similarities between their immune systems and ours. Research on canines has resulted in significant advancements in PD-1/PD-L1 inhibitors, demonstrating promising outcomes in the management of canine neoplasms. Researchers are investigating Tumor-Infiltrating Lymphocytes (TILs) in canines to get insights into the mechanisms by which cancers evade detection by the immune system. Furthermore, dogs have aided in the advancement of cancer vaccinations. Research on personalized DNA vaccines aimed at HER2/neu, a breast cancer biomarker, has demonstrated promising outcomes in diminishing tumor size and enhancing survival rates, offering optimism for future breast cancer therapies in humans. Researchers are investigating innovative immunotherapy methods, including oncolytic virotherapy and CAR T-cell therapy, to more efficiently target these cancers. Researchers are developing indicators to identify people who would derive the greatest benefit from immunotherapy.

Conclusion: The findings indicate that there may be similar treatment options available for individuals dealing with breast cancer. These therapies have enhanced outcomes for canines and yielded significant insights for human oncological treatment. Progress in radiation technology and the creation of instruments to assess canine immune responses have enhanced the capacity to translate veterinary clinical trial outcomes to human applications. Progress in canine tumor immunotherapy has facilitated its application in human clinical trials, resulting in the approval of therapies for cancer patients globally. The investigation of immunotherapy in canines has been and will remain a promising pathway for enhancing human cancer therapy.

Keywords: Canine Models; Preclinical Cancer Research; Immunotherapy; Osteosarcoma.



A Novel Approach to Breast Cancer Diagnosis: Merging Advanced Machine Learning with Image Processing Enhancements

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Abstract

Background: Mammography remains the gold standard for breast cancer screening; however, challenges persist in accurately distinguishing between malignant and benign lesions. The effectiveness of Computer-Aided Diagnosis (CAD) systems in enhancing image quality and identifying suspicious areas is crucial, as the quality of preprocessing techniques directly influences subsequent classification and segmentation outcomes.

This study aims to identify the optimal combination of preprocessing algorithms to improve the classification and interpretation of mammographic images, thereby enhancing diagnostic accuracy for breast cancer detection.

Materials and Methods: The research utilized the mini-MIAS database, focusing on various combinations of preprocessing techniques to differentiate between malignant and benign breast lesions. Key preprocessing steps included the removal of label information and the pectoral muscle, followed by the application of Contrast-Limited Adaptive Histogram Equalization (CLAHE), Unsharp Masking (USM), and Median Filtering (MF) to improve image clarity. Subsequently, a k-means clustering method was employed to isolate potentially suspicious regions. Features were extracted from these regions and classified using advanced machine learning algorithms, including artificial neural networks, random forest, and support vector machines.

Results: The study revealed that the integration of CLAHE, USM, and MF preprocessing methods yielded superior classification performance compared to using CLAHE in isolation. This combination significantly enhanced the detection capabilities for distinguishing between malignant and benign lesions.

Conclusion: The findings underscore the importance of advanced preprocessing techniques in conjunction with machine learning methodologies, which collectively improve the accuracy of mammography analysis and facilitate more precise differentiation between malignant and benign breast lesions.

Keywords: Mammography; Classification; Machine Learning; Artificial Neural Network; Breast Cancer.



Investigating the Influence of Optimized CoFe_2O_4 as a Theranostic Magnetic Nanostructures on MRI Contrast Enhancement and Hyperthermia Induction: In Vitro Study

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Abstract

Background: Magnetic Nanoparticles (MNPs), particularly cobalt ferrite (CoFe_2O_4) nanoparticles, have emerged as critical tools in medical imaging and therapy, significantly advancing diagnostic and treatment methodologies. Among these, magnetic nanoparticles stand out due to their ability to enhance contrast in MRI and their effectiveness in inducing magnetic hyperthermia, making them a promising option in the design of theranostic nanostructures. Superparamagnetic properties and high magnetic anisotropy are key features that contribute to the enhanced performance of these nanoparticles, both in improving MRI signal contrast and in generating localized magnetic hyperthermia.

This study is next step (cellular study) to explores the dual functionality of optimized gold shell CoFe_2O_4 nanoparticles, aiming to enhance Magnetic Resonance Imaging (MRI) contrast and improve the efficacy of Magnetic Hyperthermia (MH) therapy within a cellular environment

Materials and Methods: Optimized $\text{CoFe}_2\text{O}_4@\text{Au}$ (cobalt ferrite core, gold shell) nanoparticles were utilized in this study. Characterization techniques, including TEM, SEM, XRD, FTIR, EDS, VSM, SQUID, and AAS, confirmed the nanostructural properties. MR imaging parameters (r_1 , r_2 , and r_2/r_1) were then calculated in cellular environments. Subsequently, magnetic hyperthermia was induced at a frequency of 425 kHz, and the temperature changes and Specific Loss Power (SLP) of the nanostructures were studied by varying the solvent (water and glycerol). Finally, the effects of magnetic hyperthermia induction on cell survival were evaluated at temperatures of 41°C, 44°C, 47°C, and 52.5°C immediately after treatment using the MTT assay.

Results: Among various incubation times, $\text{CoFe}_2\text{O}_4@\text{Au}$ exhibited the highest r_2 value of $165.5 \text{ mM}^{-1}\text{s}^{-1}$ at 4 hours incubation time in a cell medium. A phantom prepared with the MDA-MB 231 cell line incubated with optimized cobalt ferrite ($\text{CoFe}_2\text{O}_4@\text{Au}@ \text{dextran}$) shows a magnetic susceptibility artifact. To calculate parameters for inducing magnetic hyperthermia, $\text{CoFe}_2\text{O}_4@\text{Au}@ \text{dextran}$, with the highest Specific Loss Power (SLP) value of 2449 W/g, was identified as the most suitable nanostructure in an aqueous medium. Inducing cellular hyperthermia at temperatures below 47°C did not significantly affect cell survival, while higher temperatures (47-52.5°C) caused substantial cell damage and death through protein denaturation and thermoablation.

Conclusion: These findings highlight the potential of $\text{CoFe}_2\text{O}_4@\text{Au}@ \text{dextran}$ nanoparticles in theranostic applications, combining diagnostic imaging with targeted cancer therapy. Further research is essential to optimize these nanoparticles for clinical use, with a focus on achieving a balance between efficacy, safety, and biocompatibility.

Keywords: Magnetic Resonance Imaging; Magnetic Hyperthermia; Cobalt Ferrite; Cell Study.



Biomarkers of Autoimmune Disease in CT Images

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Abstract

Background: To investigate the biomarkers of 3 autoimmune diseases) Rheumatoid arthritis, COROHN Disease and Sjögren's syndrome) in Computed Tomography (CT) images. Autoimmune diseases are conditions in which your immune system mistakenly damages healthy cells in your body. Types include rheumatoid arthritis, Crohn's disease, Sjögren's syndrome, Multiple sclerosis, Myasthenia Gravis, etc. This article tries. CT is readily available, less expensive, more rapid, and has a larger gantry. Therefore, CT may be better suited than MR imaging show pathologies in some cases. Rheumatoid arthritis (RA) is the most common inflammatory disorder affecting the cervical spine. Clinical manifestations range from isolated neck pain to compression of the medulla oblongata and spinal cord. Crohn's Disease (CD) is a chronic inflammatory bowel disease characterized by debilitating and chronic relapsing and remitting inflammation of the Gastrointestinal (GI) tract of unknown etiology. Diagnosis of IBD is based on patient symptoms (diarrhea, abdominal pain) and follow-up laboratory testing, radiology, and endoscopy. CT parameters evaluated in this study included bowel-wall thickening, mural hyperenhancement, mural stratification (target sign), submucosal fat deposition, mesenteric hypervascularity (comb sign), increased fat density, mesenteric fibrofatty proliferation, enlarged mesenteric lymph nodes, and stenosis/sacculation. Sjögren's syndrome is characterized by lymphocyte infiltration in exocrine glands such as salivary and lacrimal glands, resulting in dry mouth and dry eyes.

Materials and Methods: To conduct a comprehensive review of the literature to investigate the biomarkers of 3 autoimmune diseases, we performed a systematic search of electronic databases including PubMed, Scopus, and Science direct. The search was conducted from 2015 up to 2024.

Results: The difference between the anterior atlanto-dental interval in flexion and neutral was calculated to quantify the instability of anterior atlantoaxial subluxation. Unstable aAAS was considered to be present when the difference between the anterior atlanto-dental interval in the flexed and neutral position was equal to or more than 2 mm. It was examined the parotid glands of Sjogren syndrome patients by CT, and evaluated tissue-specific X-ray absorption values (CT values). The CT scans showed increasing areas of low CT values in parallel with the advancement in the grade of the parotid gland. The glands classified as grade 4 were almost completely replaced by fat tissue density When each CT value was expressed as a mean within a region of interest placed in each of the parotid glands, the normal parotid glands showed mean CT values of -14 ± 14 .

Conclusion: CT is a useful tool for determining the presence of fat tissue, since the CT value, which is based on tissue-specific X-ray absorption, can help differentiate fat tissue from other soft-tissue body components, such as water, muscle, and even gland parenchyma. Autoimmune diseases such as multiple sclerosis can be diagnosed by considering their symptoms in CT images.

Keywords: Multiple Sclerosis; Rheumatoid Arthritis; Crohn's Disease; Sjögren's Syndrome, Computed Tomography; Biomarkers; Autoimmune Disease.



Therapeutic Efficacy of Stem Cells Labeled with Iron Oxide Particle in a Preclinical Model of Myocardial Infarction: A Meta-Analysis

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Abstract

Background: Stem cell therapy have demonstrated promising potential in cardiac function recovery after Myocardial Infarction (MI). Tracking injected stem cells inside the body is a suitable approach to monitor the biodistribution and fate of them. Labeling stem cells with iron oxide particles has shown potential for enabling Magnetic Resonance Imaging (MRI) to monitor the localization of stem cells injected into infarcted cardiac tissue.

This meta-analysis aims to evaluate the therapeutic efficacy of stem cells labeled with iron oxide particles, as a trackable agent via MRI, for cardiac function recovery following MI.

Materials and Methods: We included published in vivo studies on the use of iron oxide particles for tracking injected stem cells after MI via MRI from databases such as MEDLINE/PubMed, ScienceDirect, Web of Science, Scopus, Google Scholar, and reference lists of retrieved articles (until October 22, 2023). Eligible studies were selected based on predefined inclusion and exclusion criteria. Data were extracted and analyzed using random-effects meta-analysis in Stata version 17.0 and Comprehensive Meta-Analyst version 3.0.


Results: A total of 38 unique records were identified, of which 15 studies met the criteria for quantitative meta-analysis. All studies confirmed that labeling stem cells with iron oxide particles had no adverse effects on their survival, proliferation, or differentiation. In 73.3% of the studies, labeled stem cells were successfully tracked in cardiac tissue after MI using MRI. Furthermore, labeled stem cells significantly improved left ventricular ejection fraction at both the first and fourth weeks post-MI compared to the control group (effect sizes 1.67 and 1.18, respectively; 95% confidence intervals (CI): 0.99 to 2.34 and 0.51 to 1.85). Additionally, administration of labeled stem cells reduced left ventricular end-diastolic diameter at the first and fourth weeks post-MI compared to controls (effect sizes -0.75 and -1.16, respectively; 95% CI: -1.60 to 0.09 and -2.51 to 0.19). These findings indicate that iron oxide-labeled stem cells can be effectively tracked by MRI and significantly improve cardiac function in preclinical MI models.

Conclusion: Iron oxide particles represent a suitable contrast agent for labeling and tracking stem cells via MRI, without negatively impacting the cells' characteristics or therapeutic efficacy in cardiac regeneration post-MI. Future studies are warranted to further assess the long-term safety of iron oxide-labeled stem cells.

Keywords: Cell Tracking; Magnetic Resonance Imaging; Stem Cell; Myocardial Infarction; Iron Oxide Particle.



Designing an Intelligent Algorithm to Implement a Computer-Aided Diagnosis Tool in Femoral Neck Anteversion Using CT Scan Images

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Abstract

Background: Femoral anteversion is the rotation of the bone along its longitudinal axis in the axial plane. Abnormal femoral anteversion could be a risk factor for several conditions such as osteoarthritis, patellofemoral instability, and femoroacetabular impingement. CT scan images are considered the gold standard for measuring anteversion angle. However, with the presence of multiple methods for slice and landmark selection as well as the absence of a standard tool, the task of measuring femoral anteversion has become a time-consuming and subjective process. This study aims to develop a semi-automatic tool to provide radiologists with a fast and reliable tool for the measurement of femoral anteversion from CT scan images using the promising capabilities of artificial intelligence and its subgroup of deep learning models.

Materials and Methods: To develop an AI-based tool for accurate and efficient measurement of femoral anteversion from CT scans, we collected images of 100 patients from four medical imaging centers. To provide ground-truth data, femur was manually segmented in each CT slice under the supervision of an experienced radiologist. A modified U-net deep learning model was trained and validated for automatic segmentation of the bone in proximal and distal regions. To avoid data leakage, data was separated patient-wise rather than slice-wise. To measure the angle automatically, we developed an innovative advanced image processing algorithm to detect required landmarks in the proximal and distal femur from automatically segmented images, based on Murphy and Bicondylar methods, respectively. The measurement of anteversion angle was carried out using the coordinates of each landmark in the 2D space of the image. Segmentation model performance was assessed using Sørensen-Dice index and Intersection over Union (IoU) metrics on test data of 20 patients. To evaluate algorithm performance, 50 cases were randomly chosen from the database. Manual and AI algorithm-based measurement of anteversion angle was carried out on the same slices. Results were compared using Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), R2 score, and Pearson's correlation coefficient.

Results: The AI-based segmentation model developed in this study achieved excellent performance, with a dice similarity coefficient of 0.981 and IoU of 0.963. Comparing manual and algorithm-based measurements of femoral anteversion yielded an MAE of 2.04 degrees, RMSE of 2.56 degrees, R2 score of 0.98, and Pearson's correlation coefficient of 0.99, indicating near optimum performance of the algorithm.

Conclusion: These results highlight the potential of AI-based tools for accurate and efficient measurement of femoral anteversion from CT scans. The high performance of the suggested model shows that it could be a valuable clinical tool for improving diagnostic accuracy and reducing the workload of radiologists. Future research can address other musculoskeletal angle measurements such as tibial torsion to further expand the applicability of artificial intelligence models in the field of medicine.

Keywords: Artificial Intelligence; Segmentation; Musculoskeletal; Computed Tomography Scan.



The Role of ^{18}F -FDG PET/CT-Based Radiomics Features in Prostate Cancer Staging: A Systematic Review

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Abstract

Background: Prostate Cancer (PCa) is a significant global health burden, and accurate staging is crucial for optimal treatment planning and prognosis prediction. Positron Emission Tomography/Computed Tomography (PET/CT) using ^{18}F -Fluorodeoxyglucose (FDG) is increasingly utilized in PCa staging, providing metabolic information that complements anatomical imaging. Radiomics, the extraction of quantitative features from medical images, has emerged as a promising tool for improving diagnostic accuracy and prognostication.

This study aimed to investigate the potential of ^{18}F -FDG PET/CT-based radiomics features in enhancing the staging of PCa.

Materials and Methods: The most relevant databases and web sources such as PubMed, Science Direct, Web of Science, and Google Scholar were interrogated by using the keywords “Prostate Cancer”, “Radiomics”, “ ^{18}F -FDG PET/CT”. English-language original articles published before July 2024 were considered.

Results: The studies reported several predictive markers including first-, second-, and high-order features, such as “kurtosis”, “grey-level uniformity”, and “HLL wavelet mean”, respectively, as well as PET-based metabolic parameters. E.g. one of the radiomics-based models demonstrated superior performance in differentiating between low-risk and high-risk prostate cancer patients, achieving an area under the receiver operating characteristic curve (AUC) of 0.92. This significantly outperformed traditional clinical and imaging methods. The model's accuracy was validated in an independent dataset, confirming its generalizability.

Conclusion: Radiomics-based decision supporting system is a powerful tool in modern medicine to identify new imaging biomarkers for more effective, accurate, and efficient diagnosis and prognostic prediction. Texture features associated with tumor heterogeneity and metabolic activity were identified as key contributors to the model's predictive power. The studies demonstrates that ^{18}F -FDG PET/CT radiomics could be instructive in the predictive prognosis of prostate cancer. The power of combining ^{18}F -FDG PET/CT radiomics and modeling could potentially optimize the individual treatment strategies by avoiding ineffective or excessive management.

Keywords: Prostate Cancer; Radiomics; ^{18}F - Fluorodeoxyglucose Positron Emission Tomography/Computed Tomography.



Evaluating the Effectiveness of AI-Driven Multimodal Image Processing in Enhancing the Diagnostic Accuracy for Early Detection of Cardiac Diseases

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Abstract

Background: The rapid growth of Artificial Intelligence (AI) in the medical field is revolutionizing the way we diagnose diseases and reduce mortality rates. Cardiovascular diseases remain one of the leading causes of death worldwide, highlighting the need for more advanced diagnostic tools. I aim to discuss the role of AI in improving both the accuracy and speed of early detection, ultimately enhancing patient outcomes and preventing fatal complications. The objective of this study is to explore AI as a substitute for scarce medical specialists and to promote the use of non-invasive imaging techniques over invasive methods. AI's potential to improve diagnostic accuracy and accessibility, while reducing patient risks, is a key focus of the research.

Materials and Methods: I conducted a comprehensive search in the Web of Science and PubMed databases, focusing on the advancements and role of AI in predicting cardiovascular diseases and multimodal imaging. Based on my search and specific inclusion criteria, which included publications from 2020 to 2025, exclusion of underage patients, restriction to non-genetic diseases, and exclusion of single-modal imaging studies, I identified 387 relevant data points. After reviewing the full text, abstracts, and conclusions of each study, I analyzed the impact of AI, machine learning, and biomechanical models on the early diagnosis of cardiac-related diseases.

Results: The study highlighted a range of significant cardiovascular diseases, including heart failure, artery stenosis, non-ischemic cardiomyopathy, left ventricular hypertrophy, coronary artery disease, coronary atherosclerotic plaques, myocarditis, and valvular diseases. Notably, AI-based electronic stethoscopes have been identified for assessing heart activity. Various imaging techniques, such as MRI, CT, CCTA, and ECG, were utilized to compare manual diagnoses with AI capabilities in classification, computation, prediction, screening, and disease diagnosis. In most studies, medical data from patient samples were compared to control groups and processed using AI algorithms, resulting in faster and more accurate analyses than traditional manual calculations.

Conclusion: While AI accelerates computations and diagnoses, it faces several challenges:

- 1-Data limitations: Due to diverse data types, privacy concerns, and image quality, creating an ideal algorithm is difficult.
- 2-Control group errors: AI struggles to accurately distinguish between patient and control data, often yielding clinically insignificant results.
- 3-High computational demands: Accurate processing requires extensive computational resources.
- 4-“Black box” problem: AI's complexity makes its outputs difficult to interpret for many specialists.

Despite these challenges, AI remains a promising tool for medical diagnosis, offering fast processing with results that closely match manual methods.

Keywords: Artificial Intelligence; Cardiac Disease; Early Detection; Machine Learning.



Utilizing Artificial Intelligence for Early Detection of Tumor Metastasis by Diagnostic Imaging Modalities Focusing on Bone Metastases in Experimental Rat Models: A Review Article

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Abstract

Background: Artificial intelligence is a field of computer science and engineering which is capable to perform as mimicking human thinking. This feature of AI make it able to analyze medical data as algorithms in which providing disease detection from medical images. In order to optimize patient's respond to clinical treatment and eventually surveillance and quality of life, it is crucial to diagnose metastasis in early stages of spreading. According to daily basis Artificial intelligence progress in medicine, application of AI methods for imaging of suspected areas in each patients may lead proper and rapid detection. In this article we are discussing and evaluating the diagnostic accuracy of AI algorithms in detecting tumor metastasis in laboratory animals using medical imaging modalities, based on researches and experiments have been performed in this field.

Materials and Methods: In this review article, the data was collected from international scientific databases, including Google Scholar, Scopus, PubMed and Elsevier as well as a library search in different sources. The words "Artificial intelligence", "machine learning", "deep machine learning", "tumor metastasis", "rat", medical imaging modalities such as "radiology", "Computed Tomography (CT scan)" and "Magnetic Resonance Imaging (MRI)" were used to search in the sources.

Results: The articles manifested the accuracy percentage of machine learning and deep machine learning up to 86% of tumor metastases, 89.8% of bone metastases, 81.82% of soft tissue such as hepatic metastases; respectively in radiology imaging database, CT imaging database and MRI database. In some researches the percentage of accuracy of AI was higher than radiologists' performances. Six machine learning techniques consist of Logistic Regression (LR), random Forest (RF), Naïve Bayes (NB), Support Vector Machine (SVM), AdaBoost, and Neural Network (NN), have been evaluated by one specific study. The best performance among them was for Naïve Bayes (NB) by correctly identifying the cervical node metastasis in 74.1% of patients through tenfold cross-validation. Thus in the study, performed on experimental rat models by utilizing model-averaged neural network (avNNet), has been indicated that flexibility and adaptation of proposed protocol to train a vast different ML algorithms and most accurate analysis different problems in oncology.

Conclusion: Different algorithm models of Machine learning-based on imaging modalities analysis comprising radiology, CT and MRI offers a feasible tool for prediction of tumor metastasis or micro-metastases in early stage. AI could serve as an assistant tool for early detecting bone metastases in both humans and animals specially for laboratory animals instead of a standalone diagnostic tool. At the same time, there is a critical need for stringent reporting standards, as well as external validation and comparisons with healthcare professionals, concerning the use of AI in the medical field.

Keywords: Early Diagnosis; Artificial Intelligence; Laboratory Animals; Medical Imaging; Tumor Metastasis.



Neuroimaging Classification in ADNI: TabNet for Different Stages of Alzheimer's Disease Using Freesurfer

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Abstract

Background: Alzheimer's Disease (AD) is a progressive neurodegenerative disorder that leads to severe cognitive decline and memory loss. Mild Cognitive Impairment (MCI) is often considered a precursor to AD, with late mild cognitive impairment (LMCI) being a critical stage. Accurate classification of AD, LMCI, Early Mild Cognitive Impairment (EMCI), and Cognitively Normal (CN) individuals is essential for early diagnosis and effective treatment planning. Recent advancements in machine learning have shown promise in analyzing neuroimaging data especially MRI data to distinguish between these stages.

By leveraging advanced machine learning techniques, this study aimed to improve the accuracy and efficiency of AD diagnosis using free surfer features.

Materials and Methods: The data was obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) and was T1-weighted structural MRI (AD:62, LMCI:92, EMCI:45, And CN:51). Free surfer was used to extract brain anatomical features (including volume, thickness, curve, etc). The data preprocessing pipeline, including scaling, label encoding, outlier removal using isolation forest, and feature selection with a linear SVM (L1-based regularization) model, has been applied to the training set. The feature selection reduces dimensionality by selecting the most important features, which improves performance and reduces overfitting. By creating 100 bootstrap samples from the dataset, the model was trained with individual TabNet classifiers on each sample. The ensemble predictions were then aggregated through majority voting to enhance robustness.

Results: The classification model using Free Surfer features achieved an accuracy of 90.00%, with precision of 90.01%, recall of 90.00%, and an F1-score of 89.88%. Bootstrap analysis yielded a mean accuracy of 79.68% (95% CI: 68.42%–92.11%), mean precision of 81.35% (95% CI: 68.50%–92.35%), mean recall of 79.68% (95% CI: 68.42%–92.11%), and a mean F1-score of 79.60% (95% CI: 66.57%–91.87%). These results demonstrate strong and consistent performance with some variability across resampled datasets.

Conclusion: The classification model demonstrated strong performance in identifying Alzheimer's disease, achieving high accuracy, precision, recall, and F1-scores (all around 90%). These results suggest that the model is reliable, but additional refinement could further enhance consistency.

Keywords: Alzheimer's Disease; Deep Learning; Free Surfer; Classification.



Artificial Intelligence-Driven Advancements in Preclinical Cancer Imaging for Improved Diagnostics and Therapeutics

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Abstract

Background: The integration of Artificial Intelligence (AI) into preclinical cancer imaging marks a significant advancement in the field of biomedical research. Traditional imaging modalities, despite their fundamental role, encounter limitations in sensitivity, specificity, and data processing capabilities. AI, with its capacity to analyze extensive datasets and enhance imaging quality, and also the rapid process of analysis offers a promising solution. This review examines the current state of AI-driven innovations in preclinical cancer imaging, highlighting key advancements and persistent challenges. This review aims to critically analyze recent AI-driven advancements in preclinical cancer imaging, emphasizing the potential for improved diagnostic accuracy and therapeutic interventions. The review seeks to synthesize contemporary research findings, providing a comprehensive overview of AI's transformative impact on imaging techniques and cancer treatment protocols.

Materials and Methods: A systematic literature search was conducted using relevant databases, including PubMed, Embase, and Google Scholar, to identify articles published within the last 5 years. The search terms included a combination of keywords related to "cancer", "imaging", "preclinical", "nanotechnology", "surgery", and "artificial intelligence". The selected articles were critically evaluated, and the key findings, methodologies, and future research directions were synthesized.

Results: The review identifies significant enhancements in image acquisition, processing, and interpretation facilitated by AI. For instance, the use of multimodal imaging techniques, such as PET/MRI and PET/CT, has enabled the simultaneous assessment of tumor characteristics, including metabolic activity, vascular perfusion, and the presence of specific molecular targets. Moreover, the integration of nanoparticle-based contrast agents has improved the sensitivity and specificity of imaging techniques, allowing for the detection of smaller tumors and the monitoring of targeted drug delivery. Furthermore, the integration of an Artificial Intelligence (AI) algorithms has shown promise in automating image analysis, improving the accuracy of tumor segmentation and characterization, and assisting in the selection of optimal treatment strategies. Machine learning algorithms have been shown to improve image clarity and detection sensitivity, enabling the early diagnosis of malignant lesions. In addition, AI-driven advancements have notably impacted surgical planning and execution. Enhanced imaging techniques allow for more precise preoperative mapping, aiding surgeons in delineating tumor margins and preserving healthy tissue. Real-time image-guided surgery, augmented by AI algorithms, improves intraoperative decision-making and accuracy, potentially leading to better patient outcomes. However, challenges such as data heterogeneity, algorithm transparency, and clinical translation remain, necessitating further research and development.

Conclusion: AI-driven advancements in preclinical cancer imaging have the potential to significantly enhance diagnostic precision and therapeutic efficacy. However, challenges related to data standardization, algorithm interpretability, and clinical implementation need to be addressed. Continued interdisciplinary collaboration and ongoing innovation are vital to fully realizing the transformative potential of AI in cancer imaging and treatment. The future of preclinical cancer imaging lies in leveraging AI to develop more accurate, efficient, and personalized diagnostic and therapeutic strategies.

Keywords: Artificial Intelligence; Cancer Diagnostics; Preclinical Imaging; Surgery; Therapeutic Interventions.



Artificial Intelligence, Cancer Diagnostics, Preclinical Imaging, Surgery, Therapeutic Interventions

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Abstract

Background: Artificial Intelligence (AI) is transforming cancer diagnosis by enhancing preclinical imaging techniques, including Magnetic Resonance Imaging (MRI), Computed Tomography (CT), and Positron Emission Tomography (PET), enabling earlier and more precise tumor detection. Convolutional Neural Networks (CNNs), in particular, have demonstrated significant success in automating tasks such as tumor segmentation and classification. However, limitations like data scarcity, model interpretability, and algorithm generalization remain major obstacles to the full integration of AI into clinical practice. Addressing these challenges is crucial for maximizing AI's impact on early cancer diagnosis. This review assesses the role of AI in preclinical imaging for cancer diagnosis, focusing on deep learning and machine learning methods. The goal is to identify their strengths and limitations regarding accuracy, computational efficiency, and interpretability. Additionally, the review proposes solutions for key challenges such as data scarcity and model generalization.

Materials and Methods: A systematic review of 38 articles published between 2018 and 2023 was conducted using databases like PubMed, IEEE Xplore, and Google Scholar. Articles were selected based on their application of AI techniques, such as CNNs and Support Vector Machines (SVMs), to preclinical imaging modalities (MRI, CT, PET) for cancer diagnosis. Metrics such as accuracy, sensitivity, specificity, and generalization across different datasets were analyzed. The review also explored how AI models handle various cancer types (e.g., breast, lung, colorectal) and assessed model interpretability in high-stakes clinical decision-making.

Results: Of the 38 studies reviewed, 15 focused on deep learning methods. CNNs consistently outperformed traditional image processing techniques, achieving up to 95% accuracy in tasks like tumor segmentation and classification. For example, CNNs achieved 93.5% accuracy in detecting breast cancer tumors via PET and 95% accuracy in segmenting lung tumors using MRI. Transfer learning, explored in 5 studies, effectively addressed data scarcity by fine-tuning pre-trained models (e.g., ImageNet) for cancer-specific tasks, particularly in rare cancer types. Traditional machine learning models such as SVMs and decision trees were employed in 10 studies, excelling in small datasets and binary classification tasks like distinguishing benign from malignant lesions. However, these models struggled with high-dimensional imaging data, limiting their scalability. The review also identified significant challenges in the application of AI to preclinical imaging. In 8 studies, the "black-box" nature of deep learning models was flagged as a concern, complicating clinical interpretation. Additionally, 7 studies highlighted data imbalance as a critical issue, particularly for rare cancer types. Hybrid models, which combined deep learning with traditional imaging techniques, were explored in 5 studies and demonstrated improvements in both accuracy and interpretability.

Conclusion: AI-enhanced preclinical imaging shows tremendous potential for early cancer diagnosis. However, challenges such as data scarcity, model interpretability, and generalization persist. Future research should prioritize developing explainable AI models and fostering collaboration between researchers and clinicians. The creation of open-access datasets and standardized benchmarks will be critical for advancing AI-driven cancer diagnostics and ensuring its clinical utility.

Keywords: Artificial Intelligence in Preclinical Imaging; Cancer Diagnosis; Deep Learning; Machine Learning; Transfer Learning.



A Statistical Study of Changes in Sales of Gadolinium-Based Contrast Agents in a 15- Year Period in the Pharmaceutical Market of Iran

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Abstract

Background: Magnetic Resonance Imaging (MRI) is a clinical imaging modality effective for anatomical and functional imaging of diseased soft tissues for diagnosis and treatment in medicine and veterinary medicine. Gadolinium is currently the only heavy metal suitable for MRI enhancement. Gadolinium-Based Contrast Agents (GBCAs) are the most commonly used CA in clinical MRI. GBCAs are administered through a small an intravenous catheter that is placed in a hand vein or an arm vein of the patient in up to 35% of all MRI examinations as an important part of lesion detection and characterization. Some conditions for which radiologists may use GBACs include: brain injuries, spinal cord injuries, inflammation of solid organs, inflammation or cancerous cells in bone, muscle and connective tissue, inflammatory bowel disease, inflammatory joint disease, Some types of angiograms (imaging of the blood vessels in the heart) and blood vessel problems. Alone, Gadolinium is toxic to humans. But Gadolinium in GBCAs goes through a process called chelation, which makes it safer for use in the body. In chelation, other chemical ions mixed with Gadolinium will surround the toxic metal and prevent it from harming the body while also preserving its ability to enhance contrast in tissue. GBCAs are divided into linear and macrocyclic categories on the basis of the shape of the organic ligand.

In this study, the sales of GBCAs as an important contrast agent in diagnostic imaging studies (MRI) of soft tissue in the pharmaceutical market of Iran During the 15-year period from 1388 to 1402 were investigated.

Materials and Methods: The pharmacopeia used in the country, published in 1402, were received from the Food and Drug Organization, and the information related to the numerical sales of different packages of GBCAs in the years 1388 to 1402 was extracted from it. The table and chart of the changes in the amount of sales of GBCAs were drawn using Excel software, and the compound annual growth rate (CAGR) which shows how much an initial amount has grown geometrically in each period of time was determined. Statistically significant time period of Gadolinium sales trend was investigated with the help of tests related to linear regression in Minitab software.

Results: In general, the amount of sales of this contrast agent in the 15-year period has been increasing with a low slope, so that its CAGR is +0.31%., a total of about 263 thousand liters of GBCAs material were sold. The highest volume of sales was in 1401 at the rate of approximately 25 thousand liters and the lowest sales volume was recorded in 1395 at the rate of approximately 16 thousand liters.

Conclusion: This study has shown an increasing trend and market demand within the country for GBCAs and, consequently, MRI-based diagnostics. This growing trend in utilization is not unique to Iran but has been observed in many other countries as well.

Keywords: Gadolinium; Contrast Agent; Magnetic Resonance Imaging.



Cracking the Code: A Comparative Review of Imaging Technologies in Bone Fracture Diagnosis

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Abstract

Background: Bone fractures pose a significant health issue, necessitating prompt and precise diagnosis for effective treatment. Traditional imaging methods, such as X-rays and Computed Tomography (CT), are essential in clinical settings. However, these techniques often struggle to identify microdamage or subtle bone lesions, highlighting the need for more advanced imaging options. New technologies, including high-resolution imaging and multimodal imaging systems, are emerging as promising solutions to these challenges.

This review seeks to provide a thorough analysis of both traditional and advanced imaging technologies used in diagnosing bone fractures, emphasizing the diagnostic accuracy, limitations, and potential clinical applications of each method.

Materials and Methods: A systematic review of the existing literature was performed, focusing on imaging technologies such as X-ray, CT, MRI, ultrasound and newer modalities like Atomic Force Microscopy (AFM) and PET/CT. Data were gathered from various peer-reviewed sources, concentrating on advancements in high-resolution imaging, multimodal systems, and their applications in both clinical and non-clinical settings.

Results: Traditional imaging methods like X-rays and CT are still vital, particularly for initial fracture diagnosis, but they often fall short in detecting early-stage bone damage. MRI and high-resolution techniques, such as micro-Computed Tomography (micro-CT) and PET/CT, offer more detailed views of bone microarchitecture, enhancing fracture risk assessment. Innovative imaging methods, including ultrasound and AFM, demonstrate improved detection capabilities at micro and nano levels, paving the way for personalized treatment approaches. In pediatric and high-risk patients, ultrasound has proven to be especially effective, with minimal radiation exposure.

Conclusion: Combining traditional and advanced imaging techniques is crucial for enhancing diagnostic accuracy in managing bone fractures. Emerging technologies, such as AFM and multimodal imaging, hold great potential for improving patient outcomes.

Keywords: Bone Fractures; Imaging Technologies; X-Ray; Magnetic Resonance Imaging; Positron Emission Tomography/Computed Tomography.



Evaluation of Geometric Distortion Brain MRI Images on a 1.5T Scanner

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Abstract

Background: Traditionally, Computed Tomography (CT) images have been the primary modality used for Radiotherapy (RT) treatment planning. However, significant efforts have been recently dedicated to integrating MRI into clinical RT planning and monitoring. In such cases, Magnetic Resonance (MR) imaging often provides precise information on the location and the extent of tumors, access to information on physiologic characteristics, such as diffusion and perfusion, that can provide additional guidance for tumor delineation, because of its high soft tissue contrast resolution compared to x-ray imaging, real-time tumor tracking with CINE imaging, beam gating, and the ability to perform daily Adaptive Radiotherapy (ART). Despite these benefits, accurately addressing geometric distortions inherent in MRI images is crucial to ensure high-accuracy MRI treatment planning.

Therefore, this study aimed to evaluate of geometric distortion present in MRI images. this information is vital for ensuring accurate and reliable treatment planning.

Materials and Methods: CT images, which serve as our standard reference with minimal geometric distortion, were registered with MRI images using the ISOGray Treatment Planning System. Subsequently, contours were generated and extracted from the registered images. Finally, quantitative assessments, including the Dice coefficient and Hausdorff distance, were calculated to compare the volumes of the contours using 3D Slicer modules.

Results: When using CT as the reference, the Dice coefficient and Hausdorff distance values were measured as 0.94 and 19.35, respectively, for the DWI segment. Similarly, comparing to the FLAIR segment yielded a Dice coefficient of 0.95 and a Hausdorff distance of 18.47.

Conclusion: The numerous advantages of MRI over CT have fueled significant interest in utilizing MRI images solely for treatment planning in recent decades. This study has discrepancies between the contoured regions, highlighting the necessity for designing a dedicated phantom to quantify the extent of geometric distortion present in MRI images.

Keywords: Radiotherapy; Treatment Planning; Magnetic Resonance Imaging; Computed Tomography; Geometric Distortion.



The Importance of Preclinical Imaging Protocols in Biomedical Research

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Abstract

Background: Preclinical imaging protocols refer to a set of methods and guidelines used to evaluate and investigate biological processes and therapeutic effects in animal models (such as mice or rabbits) before clinical trials on humans. Preclinical imaging serves as a key tool in medical research, enabling non-invasive assessment of biological processes and therapeutic effects in animal models. These methods assist researchers in obtaining accurate information about health status and disease progression.

The aim of this study is to examine various preclinical imaging protocols and assess their effectiveness in identifying tissue and metabolic changes in animal models.

Materials and Methods: We employed a comprehensive search strategy across multiple electronic databases, including PubMed, MEDLINE, and google scholar. A detailed search was incorporated with keywords and Medical Subject Headings terms related Preclinical, PET imaging, Protocols.

Results: The results obtained from the preclinical imaging protocols demonstrate the high capability of selected methods in providing high-quality and precise images. Evaluation of metabolic activity in animal models using MRI and PET techniques provides valuable insights into disease progression and treatment response. Additionally, data analysis indicates that optimal device settings significantly impact image quality and diagnostic accuracy. These findings emphasize the importance of preclinical imaging protocols in the discovery and development of new drugs.

Components of Preclinical Imaging Protocols:

1. Selection of Imaging Method: * Magnetic Resonance Imaging: For high-quality images of tissues and organs without the use of X-rays. * Positron Emission Tomography: For assessing metabolic activity and cellular function. * Computed Tomography: For rapid and precise images of internal body structures. * Ultrasound: For non-invasive and cost-effective imaging of tissues.
2. Preparation of Animal Models: * Selection of appropriate breed and environmental conditions. * Creation of disease models (e.g., tumors, diabetes) using various methods.
3. Imaging Protocol Guidelines: * Determining imaging timing and frequency. * Adjusting device parameters to optimize image quality.
4. Data Analysis: * Processing and analyzing obtained images to extract key information. * Utilizing specialized software for quantitative and qualitative analysis.

Importance of Preclinical Imaging Protocols:

- * Non-invasiveness: These methods allow for the examination of animal conditions without the need for surgical or invasive tests.
- * High accuracy and sensitivity: The ability to detect small changes in tissues and biological functions.
- * Aid in drug discovery: Enabling assessment of therapeutic effects before human trials.

Conclusion: This study highlights the significance of preclinical imaging protocols. Utilizing advanced techniques such as MRI, PET, and CT allows for accurate evaluation of biological processes and therapeutic effects in animal models. Given the importance of these protocols in drug discovery, it can be concluded that preclinical imaging plays a vital role in advancing medical science and improving treatment outcomes. Optimizing and standardizing these protocols can enhance diagnostic accuracy and expedite research across various medical fields. Ultimately, these results underscore that investment in preclinical imaging technologies is key to the success of future clinical research.

Keywords: Preclinical Imaging Protocols; Magnetic Resonance Imaging; Positron Emission Tomography; Ultrasound.



Ethical Frameworks for Ensuring Transparency and Data Integrity in Preclinical Radiopharmaceutical Research: A Risk-Benefit Analysis

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Abstract

Background: Preclinical research, particularly in the development of radiopharmaceuticals, plays a pivotal role in assessing the safety, toxicity, and efficacy of drugs before clinical trials. However, ethical concerns regarding transparency and data integrity in this field have become increasingly prominent. A key issue lies in the selective publication of positive results while neglecting negative or inconclusive data, which may distort the perceived efficacy of interventions. This practice, coupled with the omission of certain outcomes in multi-assessment studies, undermines the accuracy and reliability of preclinical data used to inform clinical trials. The unique properties of radiopharmaceuticals, including their radioactive nature and complex biological interactions, further complicate the ethical landscape. Given the significant risks associated with these compounds, it is critical to adopt robust ethical frameworks that ensure comprehensive data reporting, statistical transparency, and a thorough evaluation of the risk-benefit ratio.

This article explores the ethical considerations surrounding preclinical radiopharmaceutical research and proposes frameworks aimed at improving transparency and data integrity. By conducting a risk-benefit analysis, we evaluate the effectiveness of these frameworks in addressing the challenges posed by selective reporting and ensuring that all relevant data contribute to the development of safe and effective therapies.

Materials and Methods: A comprehensive search was conducted across PubMed, Scopus, Google Scholar, PLOS Biology, and the Journal of Medical Ethics to perform this review. English-language articles published between 2020 and 2023 were included. Data extracted from each article included the study's objective, methodology, primary findings, and limitations. A qualitative content analysis was employed to analyze the data.

Results: The review identified major issues in preclinical radiopharmaceutical research, including selective reporting, poor statistical transparency, and inadequate risk-benefit assessments. Few studies tackled ethical concerns like publication bias or animal welfare. Ethical frameworks proposing mandatory data sharing, pre-registration, and interdisciplinary collaboration were found effective in improving transparency and data integrity.

Conclusion: The establishment of a robust and transparent system for conducting research on radiopharmaceuticals is imperative. Such a system must ensure that: Comprehensive and accurate information regarding the safety, efficacy, and adverse effects of these drugs is readily available. Research findings are disseminated impartially and without bias. The misuse of research results for commercial or personal gain is prevented. The rights of animals involved in research are fully respected.

Keywords: Ethical Framework; Preclinical; Integrity; Radiopharmaceuticals.



A Review of the Applications of Machine Learning in the Analysis of Ultrasound Images of the Abdomen of Laboratory Animals

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Abstract

Background: Ultrasound imaging is an invaluable non-invasive modality for evaluating the abdominal organs of laboratory animals, yielding critical insights into both physiological and pathological states. In the context of preclinical research, ultrasound plays an essential role in assessing the safety and efficacy of new therapeutic agents before they enter clinical trials. The incorporation of Machine Learning (ML) into ultrasound image analysis has transformed this domain by significantly enhancing diagnostic accuracy and operational efficiency. This review examines the diverse applications of machine learning algorithms in interpreting abdominal ultrasound images of laboratory animals, emphasizing their potential in automated image segmentation, anomaly detection, and feature extraction.

Materials and Methods: In this review article, the data was collected from international scientific databases, including Google Scholar, Scopus, PubMed, and Elsevier. The key words “Machine Learning”, “Ultrasound imaging” and “preclinical Researches” were searched.

Results: By leveraging advanced methodologies such as Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs), researchers have achieved notable improvements in identifying organ morphology, hepatic lesions, and various abdominal abnormalities compared to conventional techniques. Moreover, machine learning enables real-time analysis, allowing veterinarians and researchers to make prompt decisions within clinical and experimental settings. This capability is particularly crucial in preclinical studies, where timely evaluations can guide the development of new treatments and ensure animal welfare. The integration of ML techniques into ultrasound imaging not only streamlines the diagnostic process but also enhances clinical outcomes and refines animal welfare practices. Fourteen Studies have been worked on the abdominal organs and five studies applied DL networks to images of the musculoskeletal system. Thirteen papers, grouped under a miscellaneous category, proposed heterogeneous applications adopting DL systems.

Conclusion: In conclusion, the integration of machine learning into ultrasound imaging has revolutionized the evaluation of abdominal organs in laboratory animals, significantly enhancing diagnostic accuracy and operational efficiency. This review highlights the transformative potential of machine learning algorithms in automated image segmentation, anomaly detection, and feature extraction, leading to improved identification of organ morphology and various abdominal abnormalities. The real-time analysis capabilities of machine learning are particularly beneficial in preclinical studies, facilitating prompt decision-making and ensuring animal welfare. As technological advancements continue, it is imperative to further explore and expand the use of machine learning in preclinical research to develop more sophisticated diagnostic tools and improve clinical outcomes. Embracing these advancements will not only streamline the diagnostic process but also contribute to the overall refinement of animal welfare practices.

Keywords: Machine Learning; Ultrasound Imaging; Laboratory Animals; Preclinical Research.



A Review on the Role of Non-Coding RNAs in Regulating and Predicting Radioresistance/Radiosensitivity of Prostate Cancer

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Abstract

Background: Predicting and managing patient responses to radiotherapy remains a significant challenge in Prostate Cancer (PCa) treatment. Recent studies have elucidated the extensive roles of non-coding RNAs (ncRNAs), including microRNAs (miRNAs), long non-coding RNAs (lncRNAs), and circular RNAs (circRNAs), in pathogenesis, carcinogenesis, tumor progression, and therapeutic response. These ncRNAs serve as both therapeutic targets and predictive biomarkers due to their presence in various body fluids, making them minimally invasive and readily available for clinical application. Personalized medicine, which enhances treatment efficacy and minimizes side effects, can benefit from analyzing ncRNA expression patterns to improve the accuracy and effectiveness of radiotherapy in cancer treatment.

The aim of this study was to investigate and create a comprehensive overview of the effect of ncRNA expression on radioresistance and radiosensitivity and their use as predictive biomarkers in PCa.

Materials and Methods: In this review, we gathered data from peer-reviewed articles and reputable databases such as DIANA Tools and STRING to summarize the current knowledge on the role of ncRNAs in PCa treatment response. The search was performed using keywords such as "non-coding RNAs", "prostate cancer", "radiotherapy", "biomarkers", and "response to treatment". The primary databases used for data collection included: Studies focusing on the role of ncRNAs in PCa, articles discussing the use of ncRNAs as biomarkers for treatment response, and research highlighting the mechanisms of ncRNA action in response to radiotherapy. We categorized ncRNAs based on the increase or decrease of expression and the effect of these expression patterns along with specifying the functional roles including signaling pathways and genes involved in the development of radiation resistance and sensitivity.

Results: Current data indicate, the Overexpression of several lncRNAs such as LINC01600, HOXD-AS1, and CCAT1 are highly correlated with radioresistance in PCa. miR-21, miR-106b Overexpression can caused radiation resistance through promoting cell survival, reducing apoptosis, regulation of DNA damage response, and cell cycle progression. circ-EGFR by promoting tumor proliferation, migration, and invasion and circ-Amotl1 by promoting tumor cell stemness can confer to PCa radioresistance. Furthermore, MALAT1, HOTAIR, miR-107, and circ_0005276 are the most important ncRNAs involved PCa radiosensitivity.

Conclusion: The selected panel of ncRNAs provides a comprehensive overview for future studies and highlights their potential as potential molecular targets to enhance therapeutic response and outcomes in PCa. This review not only emphasizes the improvement of radiotherapy outcomes using the therapeutic potential of ncRNAs, but also provides a roadmap for personalized medicine. Using predictive ncRNA biomarkers, clinicians can stratify patients based on risk to pave the way for more effective treatment strategies.

Keywords: Non-Coding Ribonucleic Acids; Prostate Cancer; Radiotherapy; Biomarkers; Treatment Response.



Effective Treatment of GIST Metastasis by Electrochemotherapy with High Frequency and Low Voltage: Case Report Study

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Abstract

Background: Electrochemotherapy (ECT) is chemotherapy done with the aid of specific electric pulses and a new local treatment method and control for solid and superficial tumors. Short electric pulses make the cell membranes transiently permeable. During this procedure, patients experience discomfort and mild edema. The most unpleasant and painful part is mainly attributed to muscle contractions caused by high amplitude and low repetitions. Electrochemical therapy with high frequency and low voltage has been developed and optimized in laboratory and in vivo conditions and can be used in the clinic. In the present study, a case of uterine and ovarian cancer metastasis in the abdomen is reported. In this case, high frequency and low voltage (LVHF) ECT was used to reduce the size and relieve the pain and symptoms of metastasis to the abdominal region in clinical conditions.

Materials and Methods: A 41-year-old woman with a 9-year history of uterine and ovarian cancer was admitted to the clinical oncology department of Bu Ali Hospital in Tehran with primary surgical treatment. The skin covering the tumor appeared normal. The patient had local and radicular pain in the affected area that interfered with his normal function. The patient's right thigh was numb. Due to the size of the mass and its adhesion to the intestine, surgery was not possible. Because of the risks of the reirradiation procedure, we decided to test the usefulness of LVHF ECT to reduce patient disability. After signing the informed consent form, 4 electrochemotherapy sessions were prescribed for the patient. In each session, the chemotherapy drug containing 30 mg of bleomycin diluted with 200 ml of normal saline was injected intravenously for 20 minutes. Ten minutes after the injection, in the presence of an anesthesiologist, the patient was unconscious and the applicator was placed in the tumor site with six 20 cm electrodes (one negative electrode and 5 positive electrodes) made in Pars Trava company's laboratory, Tehran, Iran, were directly inserted into the tumor tissue. Then, electric pulses (4000 square pulse with an amplitude of 70 V/cm and a frequency of 5 kHz) were applied inside the tumor using an electrochemotherapy device designed and manufactured by Pars Trava Company. The tumor volume was calculated from the main diameter and the longest diameter perpendicular to the main diameter, according to the formula $V = \pi ab^2/6$.

Results: The results show that the relative increase of the tumor volume after the third session compared to before the start of treatment is 51%. According to the WHO guidelines, it is considered a Partial Response (PR).

Conclusion: Our electrochemotherapy method shows good clinical results and according to World Health Organization (WHO) standards, the tumor responded partially to the treatment. However, further studies on this new method are necessary to prove that LVHF ECT can be considered as a standard treatment method.

Keywords: Electrochemotherapy; Tumor; Bleomycin Drug.



Monte Carlo Study of Testicular Absorbed Dose in the Digimouse Phantom: Evaluating the Influence of Organ Position and Surrounding Tissue Composition

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Abstract

Background: Accurate assessment of radiation dose to sensitive organs is crucial in medical imaging and radiation therapy. The testis, in particular, is highly vulnerable to radiation damage, necessitating precise dosimetry to minimize the risk of harm. The complex anatomy and varying positions of organs significantly impact the absorbed dose to the testis. Despite this, there is a lack of comprehensive studies addressing the effects of organ position on testicular absorbed dose. Most existing research has focused on simplified phantom models or has not adequately accounted for the complex interactions between organs and radiation. This study aims to fill this gap by investigating the impact of organ position on testicular absorbed dose using Monte Carlo simulations in the Digimouse phantom. By replacing surrounding tissues with air and simulating the transport of 10^7 photon particles, we aim to accurately quantify the effects of organ position on testicular absorbed dose. This research has significant implications for developing more accurate dosimetry models and optimizing radiation therapy protocols to minimize radiation exposure to sensitive organs.

This article investigates the impact of testicular location and surrounding organs on the absorbed dose in the testicle across different photon energy levels.

Materials and Methods: The Digimouse phantom, utilizing the mesh approach within Geant4, was employed to determine the total deposited energy and absorbed dose in mouse testicular tissue. The organ materials followed the adult mesh-type reference computational phantoms from ICRP Publication 145. Irradiation was conducted from four same mono-radiation sources in four directions (head, tail, right, and left) and the same distance from skin to assess the impact of testis and organ positioning on the absorbed dose. Subsequently, all organs except the testicular tissue were replaced with air, and irradiation was repeated. Both scenarios were examined for photon energies ranging from 2 to 10,000 keV.

Results: It shows by comparing the same radiation sources facing each other (left vs. right, head vs. tail), in the absence of other organs, the difference in the absorbed dose and deposited energy between opposing radiation sources is minimal (less than 5%). Generally, distance from the source is the primary determinant of absorbed dose. However, this difference becomes significant when considering other mouse organs, particularly at low energies (<25 keV). This discrepancy is most pronounced for energy deposited from head and tail sources. At energies between 20 and 30 keV, the difference between the total deposited energy from left and right sources diminishes. This difference decreases at higher energies for head and tail sources as the photoelectric cross-section with limbs decreases. Examining the diagram of total energy deposition in the testis with varying photon energies, it's clear that below 25 KeV, other organs significantly reduce total deposited energy, offering good radiation protection. However, for photons above 25 KeV, they increase the deposited energy in the testis. At 25 KeV, the presence or absence of other organs does not impact the total energy deposition in the mouse testis.

Conclusion: This study demonstrates that the position and presence of surrounding organs play a significant role in influencing the absorbed dose to the testis in medical imaging and radiation therapy. Using Monte Carlo simulations with the Digimouse phantom, we found that the absorbed dose is primarily affected by surrounding organs, these organs can provide considerable protective shielding at energies below 20 keV. However, as photon energy increases, adjacent organs paradoxically enhance energy deposition in the testicular tissue by altering the energy distribution of incident photons. These findings underscore the importance of considering organ positioning and interactions in dosimetry calculations to accurately assess and minimize the risk of radiation exposure to sensitive organs like the testis. This research contributes to the development of more precise dosimetry models and has potential implications for optimizing radiation therapy protocols, ensuring safer and more effective treatment outcomes.

Keywords: Monte Carlo Simulation; Testis Position; Absorbed Dose; Geant4.



Curcumin-Based Optical Imaging for Early Detection of Amyloid- β Plaques in Alzheimer's Disease: A Preclinical Review

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Abstract

Background: Alzheimer's Disease (AD) is a progressive neurodegenerative disorder characterized by memory loss and cognitive deterioration. Key pathological markers include amyloid- β (A β) plaques and hyperphosphorylated tau tangles. While no cure exists, early diagnosis allows symptom management and improved quality of life. Current imaging modalities like Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET), and Magnetic Resonance Imaging (MRI) face limitations such as radiation risks and high costs. In contrast, optical imaging offers advantages like non-invasiveness, high sensitivity, and lower costs. Curcumin-based Near-Infrared (NIR) fluorescence probes, with strong affinity for A β aggregates, show promise for efficient AD detection.

This review aims to provide an overview of the role of curcumin-based NIR fluorescent probes in the non-invasive detection of A β plaques in AD mouse models, highlighting their potential as a tool for advancing Alzheimer's research and diagnostic methods.

Materials and Methods: This comprehensive review involved searching multiple databases, including PubMed, Embase, ProQuest, and Web of Science. Citation tracking tools from PubMed and Google Scholar were also used to identify additional relevant studies on curcumin-based NIR fluorescence probes for detecting A β plaques in AD mouse models.

Results: Curcumin-based fluorescence probes effectively labeled both brain and retinal A β plaques, showing strong fluorescence intensity and excellent photostability. In Tg mouse models of AD, brain fluorescence intensity was higher compared to the Wild-Type (WT) control group. In vivo retinal fluorescence following curcumin injection was significantly greater in older mice (11–19 months) than in younger mice (5–9 months) for both Tg and WT groups. Additionally, retinal fluorescence in Tg mice was notably higher than in WT mice within the older age group. The correlation between retinal fluorescence and A β immunoreactivity in the cortex was stronger in Tg mice compared to WT mice.

Conclusion: Optical imaging of retinal plaques provides a promising, non-invasive method for detecting A β in the retina, potentially reflecting A β accumulation in the brain. Curcumin-based fluorescence probes could serve as a valuable tool for investigating the formation of A β aggregates and identifying effective inhibitors, ultimately deepening our understanding of AD pathology.

Keywords: Alzheimer's Disease; Amyloid- β (A β); Optical Imaging; Curcumin.



Navigating Ethical Frontiers in Preclinical Research: Innovations, Challenges, and Solutions

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Abstract

Background: Preclinical research is a pivotal stage in drug development, aimed at evaluating new treatments' safety and efficacy before they are tested in humans. This phase, predominantly involving animal models, is crucial for advancing medical science and public health. However, the ethical considerations surrounding the use of animals in research pose significant challenges. These concerns highlight the need for rigorous ethical standards to ensure humane treatment of animals while maintaining scientific integrity. The ethical principles guiding preclinical research, particularly the "3R" framework—Reduction, Refinement, and Replacement—are foundational in addressing these issues. Reduction focuses on minimizing the number of animals used, Refinement aims to improve animal welfare and experimental techniques, and Replacement advocates for using non-animal models whenever possible. This paper examines these ethical principles, the challenges faced in their implementation, and the impact of recent advancements in technology. It also explores strategies for enhancing ethical practices in preclinical research, emphasizing the importance of ongoing researcher education and updated ethical guidelines. The ultimate goal is to balance animal welfare with scientific progress, ensuring that research contributes to both humane and high-quality scientific outcomes.

This paper aims to analyze the ethical principles governing preclinical research, assess the major challenges in implementing these principles, and evaluate the benefits and drawbacks of adhering to ethical standards. Additionally, the study seeks to explore recent advancements and innovations in the field and propose strategies for improving ethical practices in preclinical research.

Materials and Methods: A comprehensive literature review was conducted, focusing on existing ethical guidelines, particularly the "3R" principles (Reduction, Refinement, Replacement). The review also examined recent technological advancements such as organ-on-a-chip and advanced simulation models. Data was collected from scientific articles, ethical frameworks, and case studies to provide a thorough analysis.


Results: The review highlights that adherence to the "3R" principles has led to significant improvements in both animal welfare and the quality of research. Innovations such as organ-on-a-chip technologies and sophisticated computational models offer promising alternatives to traditional animal testing. Despite these advancements, challenges remain in balancing scientific validity with ethical considerations. Continuous education and the development of updated ethical guidelines are crucial for overcoming these challenges.

Conclusion: Adhering to ethical standards in preclinical research is vital for ensuring animal welfare and enhancing research reliability. Implementing the "3R" principles and integrating new technologies can reduce animal use while improving research quality. Ongoing training and comprehensive ethical guidelines are essential for maintaining high standards and supporting humane scientific practices. Ethical adherence not only protects animals but also enhances the credibility and effectiveness of research, ultimately benefiting public health.

Keywords: Preclinical Research; Ethical Principles; 3R Principles; Animal Welfare; Technological Advancements.



Couple-Stress Moduli of the Three Dimensional Jaw Bones Micro-Architecture Using the μ CT Image and Finite Element Characterization

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Abstract

Background: Measuring the mechanical, microstructural properties of jaw bones is a challenging task, thus necessitating the development of specialized techniques. Also, micromechanical testing is extremely destructive and difficult, if not impossible, to perform. Moreover, at the micro-scale, because of the size effect, the structure of the bone cannot be modeled as a continuous medium any more. Therefore, higher order continuous theory is applied to account for the size parameter of the jaws. The micro-Computed Tomography (μ CT) approach is regarded as a non-destructive technique to provide the detailed 3D architecture and morphological data. These data are employed as the basic inputs for a finite element analyses and characterization of the mechanics of the jaws. The purpose of the current study was, therefore, to evaluate the effective couple-stress moduli of the three dimensional jaw bones micro-architecture. The couple stress continuum theory addresses the size dependency observed in the microstructural size of mandibular and maxillary bone. Finite element approach coupled with 3D high-resolution micro-Computed Tomography (μ CT) scans was conducted on mandibular and maxillary specimens to compute the elastic mechanical constants of the effective couple-stress continuum.

Materials and Methods: The specimens of mandibular and maxillary bone were obtained from the fresh cadaver of male donors (21 and 37-year-old) at autopsy. Procurement delay was 12 and 20 hours. High-resolution 3D μ CT scan data of the jaws samples were then obtained. The pixel size was 5.0 μ m. Mesh geometries were created from μ CT images using the Solidworks software; after that, the data were converted in to FE models. To evaluate the first stiffness tensor, by using the strain energy based method, boundary conditions comprising both traction and displacement boundary conditions were applied on the boundaries of the jaws' structure. The jaw bones tissue was assumed to be homogeneous linear elastic, and orthotropic media. The elastic properties assigned in finite element analyses were then measured in three anatomically characteristic directions of jaws, which included inferosuperior, buccolingual and mesiodistal ones, using the Atomic Force Microscopy (AFM) nanoindentation technique.


Results: According to the microstructural features of jaws, the elastic constants of the cortical bone in the infero-superior direction was higher than that of the bucco-lingual, as well as mesio-distal directions. Also, the value of this parameters in bucco-lingual direction was higher than that of the mesio-distal direction. The computed elastic mechanical constants of the effective couple-stress continuum showed important variations, according to the three anatomically characteristic directions, thus confirming that the microstructural level of jaws had a strong anisotropic behaviour.

Conclusion: At the microstructure level of jaws, assuming transverse isotropy model can be inaccurate, and orthotropic model has been suggested for the cortical bone. The microstructure-related scale effects are most pronounced on near bone-implant interfaces. And the couple-stress continuum theory is a possible choice to account for the microstructure-related scale effects on the mechanical properties of bone.

Keywords: Couple-Stress Continuum Theory; Mandibular and Maxillary Bone; Size Effect.



External Validation of Deep Learning Algorithm for Diagnosis Active Lesions in Multiple Sclerosis from Non-Contrast MRI

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Abstract

Background: The deep learning algorithm can be used as an alternative method to imaging with the injection of gadolinium-based contrast agents and removing possible complications in the diagnosis of active lesions of Multiple Sclerosis (MS). To evaluate the clinical diagnosis of an algorithm, it is necessary to know its performance for external data sets, which are a different source of development data and were not used in the algorithm's training.

The purpose of this study is to evaluate the generalizability of deep learning for detecting active and inactive lesions based on non-contrast MRI images.

Materials and Methods: Our dataset was obtained from 130 patients with relapsing-remitting MS in four different imaging centers in Isfahan City. Our imaging systems included three MRI systems made by Siemens Medical Systems (in Kashani, Askaria, and Shafa centers) and one MRI system made by Philips (in Al-Zahra center). The data of two imaging centers, Askarieh and Shafa, included 9 and 10 patients, respectively, and were considered as external evaluation data. MS lesions were identified by radiologists and labeled into active and inactive categories. Then, each lesion was separated as a slice from FLAIR sequences of MRI scans to be used as the input of the deep learning network. Next, a Convolutional Neural Network (CNN) was designed as a deep learning network to distinguish active from inactive lesions. First, statistical metrics were calculated as an internal evaluation. Then, for the purpose of external evaluation, CNN training was done based on other data (Kashani and Al-Zhara centers), and the data of two imaging centers of Askaria and Shafa were applied to the network separately as test data and the statistical results obtained from each of them was calculated.

Results: In the general mode (internal evaluation) values of accuracy, recall, and F1-score for active and inactive classes were 78%, 99%, 88%, and 98%, 71%, and 82% respectively. In the case of external evaluation, these values were obtained for Askaria Center, respectively, 76%, 94%, 84%, and 92%, 70%, 78%, and for the data of Shefa Imaging Center, respectively, 77%, 96%, 86%, and 95%, 71%, 81%. Also, the values of accuracy and AUC were evaluated, which were obtained in the internal evaluation as 85% and 0.94, respectively. And in the external evaluation, these values were 82% and 0.84 for Askaria Center, and 83% and 0.88 for Shafa Imaging Center, respectively.

Conclusion: Our designed CNN could distinguish between active and inactive MS lesions without gadolinium injection-based imaging with good performance. Appropriate and reliable results were obtained in both external evaluations of this network, and this shows that the use of our designed deep learning network in detecting active and inactive lesions for different MRI systems has generalizability.

Keywords: Non-Contrast Magnetic Resonance Imaging; Deep Learning; Multiple Sclerosis; External Validation; Fluid-Attenuated Inversion Recovery.



Role of Hyperpolarization in Clinical Applications: A Novel Technology in Magnetic Resonance Imaging

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Abstract

Hyperpolarized Magnetic Resonance Imaging (HP-MRI) is an emerging technology that enhances the ability to visualize real-time metabolic processes, offering a novel approach to disease diagnosis and management. By increasing the signal-to-Noise Ratio (SNR) of MRI by several orders of magnitude, HP-MRI overcomes the inherent limitations of traditional MRI, which often lacks sensitivity to detect certain metabolic pathways. Hyperpolarized tracers, in particular, have demonstrated remarkable potential in various clinical applications, including oncology, cardiology, and neurology. In oncology, hyperpolarized imaging allows for non-invasive assessment of the Warburg effect, enabling precise tumor characterization and monitoring of treatment response. Cardiologists have utilized HP-MRI to evaluate metabolic alterations in ischemic heart disease, offering valuable insights into myocardial recuperation following an infarction. Meanwhile, in neurology, the ability to map energy metabolism in the brain opens new avenues for early diagnosis and monitoring of neurodegenerative diseases such as Alzheimer's and Parkinson's. This technique provides unprecedented real-time insight into metabolic changes, leading to more personalized and precise treatment strategies. Also, diagnostic imaging of the lungs has always been a challenge. Traditional methods like CT scans and scintigraphy have their limitations, including radiation exposure and reduced sensitivity in certain patient populations. Magnetic Resonance Imaging (MRI) is safer but faces a significant hurdle: air and other gases in the lungs dramatically reduce the MRI signal generated by proton density in lung tissue. Hyperpolarized gas MRI is an innovative technique that uses hyperpolarization to significantly increase the sensitivity and contrast of lung MRI. By using hyperpolarized gases, such as helium-3 (^3He) and xenon-129 (^{129}Xe), researchers have made substantial progress in visualizing lung function and detecting pulmonary diseases. While there are technical challenges, such as the hyperpolarized state's longevity and the technology's weakness, advancements are constantly improving the clinical picture. HP-MRI promises to become an integral tool in medical image diagnostic accuracy, potentially changing diagnostic and therapeutic paradigms for the better. This review describes the principles of hyperpolarization and acceptance of current clinical applications. In these studies, we demonstrated the clinical role and potential of HP-MRI in diagnosing some complex diseases.

Keywords: Hyperpolarization; Magnetic Resonance Imaging, Precision Medicine Imaging.



Early Diagnosis of Parkinsons Based on Brain MRI Images Processing Using Deep Learning

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Abstract

Background: Parkinson's Disease (PD) is a prevalent neurodegenerative disorder that affects millions of people globally, causing progressive deterioration of motor functions and significantly impacting patients' quality of life. Early diagnosis of PD is crucial for managing symptoms and slowing the progression of the disease. However, conventional diagnostic methods often fail to detect PD in its early stages, leading to delays in treatment. Recent advances in medical imaging, particularly Magnetic Resonance Imaging (MRI), combined with deep learning methods, offer promising solutions for early diagnosis. The primary objective of this study is to develop a robust deep learning model based on three-dimensional Convolutional Neural Networks (3D-CNN) to accurately diagnose early-stage Parkinson's disease using MRI images. The study also aims to evaluate the effectiveness of various image preprocessing techniques, including Fourier transformation and median filtering, in enhancing the accuracy of the model.

Materials and Methods: This study utilized MRI images from the Parkinson's Progression Markers Initiative (PPMI) database, consisting of 344 images equally divided between 172 PD patients (all in their first year of diagnosis) and 172 healthy individuals. Two 3D-CNN models, one with six layers and the other with four layers, were trained and tested using five datasets: (1) raw MRI images, (2) Fourier-transformed images, (3) combined MRI and Fourier-transformed images, (4) median-filtered images, and (5) combined MRI and median-filtered images. The performance of each model was assessed by measuring classification accuracy.

Results: The results demonstrated that the 3D-CNN model achieved different levels of accuracy depending on the preprocessing applied. For raw MRI images, the accuracy was 91.43%, while Fourier-transformed images resulted in an accuracy of 51.43%. The combination of MRI and Fourier-transformed images yielded 66.67% accuracy. The use of median-filtered images significantly improved the model's performance to 80% accuracy, and the combination of median-filtered and raw MRI images resulted in a perfect classification accuracy of 100%. These findings highlight the importance of appropriate preprocessing methods for enhancing the accuracy of deep learning models in medical image analysis.

Conclusion: This study demonstrates the potential of using deep learning methods, specifically 3D-CNNs, in conjunction with MRI images for the early diagnosis of Parkinson's disease. Median filtering proved to be an effective preprocessing technique, substantially improving diagnostic accuracy. The proposed model, when integrated into clinical practices, could serve as a non-invasive, highly accurate tool for early detection, facilitating timely intervention and improving patient outcomes.

Keywords: Parkinson's Disease; Early Diagnosis; Deep Learning; Magnetic Resonance Imaging; Convolutional Neural Networks.



The Impact of Radiomics on the Diagnostic Accuracy of LDCT for Early Detection of Lung Cancer

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Abstract

Background: Low-Dose Computed Tomography (LDCT) has become an essential tool for early lung cancer detection, helping reduce mortality rates. However, LDCT images often face challenges due to low contrast, making it harder to distinguish between benign and malignant lesions. Radiomic analysis, which extracts detailed features from medical images, has shown potential in improving the diagnostic accuracy of LDCT by offering more insights into tumor characteristics. However, radiomics still faces challenges related to reproducibility and reliability. Factors like radiation dose, slice thickness, and image reconstruction methods affect the stability of radiomic features. Research shows that only a small percentage of radiomic features remain stable across different imaging conditions, especially in low-dose CT, where reduced radiation levels further compromise accuracy. These challenges underscore the importance of refining radiomic techniques to enhance their performance and reliability, making them a more reliable tool for early lung cancer diagnosis. This study seeks to explore how dose variation impacts radiomic analysis in low-dose CT. By evaluating advanced methods, the study aims to improve the classification of pulmonary nodules and predict malignancy risk, resulting in more accurate diagnoses and reducing unnecessary follow-ups.

Materials and Methods: The study extensively evaluated the existing literature using databases such as PubMed and Google Scholar. Searches were used to gather research articles, reviews, and studies up to the predetermined cut-off date. The collected data was then examined to find significant patterns, methodologies, and outcomes related to radiomic analysis in lung cancer detection through LDCT. Studies were selected if they involved radiomic analysis of LDCT, explored methods for improving the reliability of radiomic features, or assessed the impact of dose variation on radiomic results. The studies were further analyzed based on their methodologies, feature extraction techniques, and how dose variation impacted their results. Special attention was given to machine learning techniques and the role of texture analysis in predicting malignancy.

Results: In this study, radiomic analysis was found to significantly improve the diagnostic accuracy of LDCT for detecting lung cancer at an early stage. Radiomic models proved effective in distinguishing between benign and malignant nodules and in predicting cancer progression. For example, HEPP et al. demonstrated that radiomic features of non-small cell lung cancer (NSCLC) can show significant deviations with decreasing dose levels. Some first-order features like the mean and median remained relatively robust under low-dose conditions, while higher-order features were more sensitive to dose variations. This highlights the importance of controlling dose levels when utilizing radiomics in clinical settings.

Conclusion: This review indicates that integrating radiomic models into LDCT workflows could enhance lung cancer detection by improving reliability, reducing unnecessary biopsies, and advancing early diagnosis outcomes. While radiomic analysis is still evolving, it shows great potential to significantly improve lung cancer detection and increase patient survival rates.

Keywords: Low-Dose Computed Tomography; Lung Cancer; Radiomics; Diagnostic Accuracy; Early Detection.



Evaluating the Efficacy of an Advanced AI Algorithm for Pulmonary Nodule Detection in Chest Radiographs to Enhance Lung Cancer Diagnosis

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Abstract

Background: Lung cancer remains one of the leading causes of cancer-related mortality globally, emphasizing the critical need for early and accurate detection methods. Chest radiographs are widely used for initial screening; however, the manual identification of pulmonary nodules can be challenging and subjective. The integration of Artificial Intelligence (AI) in radiological practices holds promise for enhancing diagnostic accuracy and consistency.

This study aims to evaluate the effectiveness of an advanced AI algorithm specifically designed for the detection of pulmonary nodules in chest radiographs, with the goal of improving lung cancer diagnosis.

Materials and Methods: The research analyzed a robust dataset comprised of chest X-ray images sourced from two distinct collections, referred to as Group1 and Group2. The dataset was categorized into Type A, which included images from both groups, and Type B, which consisted solely of images from Group2. The AI algorithm visualized detected pulmonary nodules using heatmap overlays and generated a positive probability score for each radiograph. Performance metrics were assessed using the Receiver Operating Characteristic (ROC) curve to calculate the Area Under the Curve (AUC), specificity, and sensitivity.

Results: The AI algorithm demonstrated a commendable AUC of 0.73 for the Type A dataset, with a specificity of 0.592 and sensitivity of 0.736. Notably, the Type B dataset yielded an improved AUC of 0.782, alongside a specificity of 0.734 and sensitivity of 0.716. These results indicate that the algorithm outperformed radiologists and aligned well with findings from previous studies.

Conclusion: The proprietary AI algorithm demonstrated diagnostic accuracy that not only matches but also exceeds that of radiologists and prior studies, highlighting its significant potential as an effective tool for interpreting chest radiographs in lung cancer detection. Despite being trained on a limited dataset (Type B), the algorithm's robust performance suggests a strong foundation for further development.

Keywords: Artificial Intelligence; Lung Cancer Diagnosis; Pulmonary Nodule Detection; Chest Radiograph Interpretation; Deep Learning Algorithm.



Brain Tumors Segmentation Using Hybrid Method with Level-Set Algorithm and Morphological Feature

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Abstract

Background: Segmentation of brain tumors using magnetic resonance imaging has an important role in early diagnosis, treatment planning and outcome evaluation. Scan analysis of magnetic resonance images is a powerful tool in the latest technology that diagnoses abnormal brain tissues. In brain magnetic resonance images, tumor size can be different for different people. The process of tumor segmentation from brain MRI images is one of the most focused areas of study in the medical science community because MRI is a non-invasive imaging method and avoids biopsy, which is sampling and an invasive method for brain tumor diagnosis. One of the difficulties mentioned is the difficulty in distinguishing between a core tumor and accompanying edema. Segmentation can be performed for tumor detection or tumor and edema detection, which involves separating different tumor tissues from normal brain tissues. In order to improve the results and reduce the complications caused by the process of analyzing medical images, this paper proposes an automatic computer approach for brain tumor segmentation from MRI images using a hybrid model.

Materials and Methods: The aim of this article is to present a combination algorithm of four brain tumor segmentation and classification model techniques. In this approach, at first the pre-processing used to remove noise and optimize images, and then to find the specific regions with tumor, combining the adaptive thresholding method with level set function and active contour with morphological operations using a segmented clustering method have been used to remove some false positives, or in other words, areas with high similarity to the desired area at the edge of the image, and provide a segmented image with a higher quality and some texture and statistical features are extracted from the segmented image. The brain tumor MRI images used in this study were taken from the brain MRI images for brain tumor detection dataset from the Kaggle website, which consists of 2 folders: 1) 98 images without tumors 2) 155 images with tumors. To mention the innovative process that is used in this article, tumor details extraction with morphological operation after the combination of level set algorithm with ACM can be considered.

Results: The experimental results obtained in terms of accuracy, sensitivity, and specificity index are equal to 98.02, 97.02, and 96.04, respectively, and have presented a good performance, which shows that the proposed method can be a suitable solution for brain tumor segmentation from MRI images with a high success rate and it proves that the effectiveness of the proposed method compared to other advanced hybrid methods.

Conclusion: There are no definite and totally efficient strategy for brain tumor classification and regional integration using MRI data has been studied. As a result, an attempt was made in this article to present a framework by providing a combination of existing methodologies to be able to segment images with the maximum accuracy. Following completion of all phases including FCM clustering, the efficiency and performance of the proposed algorithm are calculated using the performance indicators of accuracy, sensitivity, and specificity.

Keywords: Brain Tumor; Segmentation; Magnetic Resonance Imaging; Morphological Operation.



A Comparative Review of Routine Histologic Techniques and Micro-CT Imaging in Preclinical Developmental and Reproductive Toxicology (DART) Studies

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Abstract

Background: Histologic techniques involve the microscopical investigation to detect morphological changes. These methods have been the gold standard due to offering detailed cellular. The term reproductive toxicology and developmental toxicology is respectively defined as the adverse effect either on fertility or on the development of the progeny and the developing organism from the conception stage till sexual maturation. Micro versions of clinical imaging modalities (micro-CT, micro-MRI, micro-PET, micro-SPECT, etc.) have been developed for small laboratory animals (e.g., rodents and rabbits) and have significantly improved nowadays. Developmental and Reproductive Toxicology (DART) studies are crucial in the pharmaceutical and vaccine development process, serving as a critical checkpoint to ensure the safety of new compounds before they reach human trials. In this article we are discussing the ability to evaluate the potential adverse effects of substances on reproduction and development, encompassing a wide range of endpoints such as fertility, embryonic development, and postnatal growth. Traditionally, DART studies have mostly relied on routine histologic techniques. However, with the evolution of imaging technologies, micro-Computed Tomography (micro-CT) is emerging as a powerful alternative. This review aims to integrate conventional histologic methods with micro-CT imaging, focusing on their roles, benefits, and challenges within the scope of preclinical DART studies.

Materials and Methods: In this review article, the data was collected using databases such as PubMed, Scopus, and Google Scholar as well as a library search in different sources. The words utilized in the search included "routine histologic techniques," "micro-computed tomography," "developmental toxicology," "reproductive toxicology," and "preclinical studies." Articles published from 2000 to 2023 were included.

Results: Routine histologic techniques have long been the cornerstone of DART studies, offering high-resolution analysis of tissue samples. These methods allow to identification of subtle morphological changes that may indicate toxicity. However, the process is inherently labor-intensive, time-consuming, and limited to two-dimensional analysis. This limitation can hinder the ability to fully understand complex three-dimensional structures and their interactions. Micro-CT imaging addresses some of these limitations by providing a non-destructive means of visualizing entire specimens in three dimensions without the need for extensive sample preparation. Micro-CT is particularly advantageous for assessing skeletal development and detecting structural anomalies that may not be apparent in two-dimensional histologic sections. Despite its advantages, the resolution of micro-CT images is generally lower than that of histologic sections, particularly at the cellular level. Additionally, soft tissue contrast can be limited without the use of specialized contrast agents.

Conclusion: Combining the strengths of both, histologic techniques and micro-CT imaging methods, researchers can achieve a more complete understanding of the potential risks associated with new pharmaceuticals and vaccines. As increasing tendency, the value of advanced imaging technologies, micro-CT is likely to become an essential component of DART studies. However, routine histologic procedures remain a fundamental aspect of preclinical DART studies. Recognizing the individual merits and limitations of each technique, their integrated use often provides the most comprehensive insights for preclinical safety evaluations.

Keywords: Histology; Micro-Computed Tomography Imaging; Preclinical Study; Toxicology; Developmental and Reproductive Toxicology Studies; Pharmaceutical Development.



The Role of Molecular Imaging in the Evaluation of New Cancer Treatments

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Abstract

Background: Cancer is the leading cause of mortality globally. It was estimated that approximately 2,370,000 and 4,820,000 new cancer cases and 640,000 and 3,210,000 cancer deaths would occur in the United States and China in 2022, respectively. Molecular imaging refers to a non-invasive medical imaging technique that enables the description, visualization, and assessment of biological activities in malignancies at both molecular and cellular scales. This imaging has gained increasing importance as an advanced tool in the diagnosis and monitoring of cancer, especially in novel therapies. These techniques utilize radioactive materials and nanoparticles to allow observation and measurement of biological activities at the molecular level. The primary objective of this study is to evaluate the ability of molecular imaging to assess the effectiveness of novel cancer treatments, including targeted therapies and immunotherapy. This research aims to identify how this technique assists physicians in clinical decision-making and improves treatment outcomes for cancer patients.

Materials and Methods: We employed a comprehensive search strategy across multiple electronic databases, including PubMed, MEDLINE, and google scholar. A detailed search string was incorporated with keywords and Medical Subject Headings terms related Molecular imaging, Targeted treatments, PET-CT Imaging.

Results: Numerous studies have shown that molecular imaging, as an advanced tool, can accurately assess tumor activity before and after novel therapies. These techniques help physicians monitor tumor status at various stages of treatment and effectively identify patient responses.

PET-CT Imaging: One key technique in molecular imaging is PET-CT (Positron Emission Tomography-Computed Tomography). This method has been utilized in patients with lung cancer. PET-CT reveals the metabolic activity of tumor cells using radioactive materials.

Metabolic Changes: By examining changes in the uptake of radioactive substances, physicians can identify abnormal activities in tumors. An increase or decrease in glucose uptake may indicate a positive or negative response to treatment. This information helps physicians make better treatment decisions and adjust protocols if necessary.

Specific Nanoparticles: In addition to PET-CT, the use of specific nanoparticles in molecular imaging is rapidly expanding. These nanoparticles can selectively bind to tumor cells and provide precise information about drug distribution and tumor status.

Identification of Smaller Tumors: Nanoparticles can detect very small tumors that may not be identifiable through traditional imaging methods. This feature aids in early cancer diagnosis and helps predict treatment-related side effects.

Drug Distribution Assessment: Additionally, nanoparticles can evaluate the distribution of targeted drugs in various body tissues. This information allows physicians to assess drug efficacy and avoid unnecessary side effects.

Conclusion: Molecular imaging serves as a powerful tool in evaluating novel cancer treatments, holding great potential for enhancing diagnostic accuracy and treatment management. With further advancements in this field, its impact on clinical outcomes for cancer patients is expected to increase. This technique not only aids in early detection but also provides valuable insights into patient responses to novel therapies, potentially leading to improved treatment decisions.

Keywords: Molecular Imaging; Cancer Treatments; Positron Emission Tomography-Computed Tomography.



Artificial Intelligence in Processing Multimodal Data: Recent Advances in Early Detection and Subtyping of Breast Cancer

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Abstract

Background: Breast cancer is a significant global health issue, originating in the cells of breast tissue. Improving survival rates and patient outcomes requires early detection and a multidisciplinary treatment approach. Artificial Intelligence (AI) has rapidly advanced in breast cancer research, playing a crucial role in analyzing imaging data, genetic information, and medical texts. Artificial Intelligence (AI), which extracts the features from image data and evaluates medical text data or genetic data based on comprehensive analysis, has been making rapid progress in this regard. This review will demonstrate some of applications and potential of AI, such as machine learning and deep learning, in breast cancer early diagnosis and subtyping.

Materials and Methods: This review collected information and data from different studies gathered from academic journals in Pubmed, Google scholar and other academic research tools.

Results: Mammography remains a fundamental diagnostic tool for breast cancer, providing detailed X-ray images to detect abnormalities in breast tissue. Regular mammograms are particularly recommended for women over a certain age or those with a family history of breast cancer, as early detection significantly improves survival rates. Complementary imaging techniques such as ultrasound and MRI can further investigate areas of concern identified during mammography, enhancing the accuracy of diagnosis. In recent years, Computer-Aided Diagnosis (CAD) systems have utilized deep learning models to improve breast lesion identification. Notably, Al-antari and his team developed a deep learning system based on the YOLO framework to detect breast lesions, while Yeman's parallel deep Convolutional Neural Network (CNN) achieved an accuracy of 93.3% using bilateral X-ray views. Riyadh and his team combined deep learning with transformers, achieving 100% accuracy in binary breast cancer classification. These innovations underscore the transformative potential of AI in medical imaging. In breast MRI, a multi-model deep learning approach developed by Abunasser et al. achieved an accuracy of 98.2%, demonstrating AI's efficacy in enhancing diagnostic capabilities. Beyond imaging, Natural Language Processing (NLP) has revolutionized how researchers analyze vast amounts of medical data. AI models like BERT, used by Kumar et al., have demonstrated impressive accuracy in classifying breast cancer-related information from social media, clinical notes, and other text sources. This capability accelerates the research process and provides deeper insights into breast cancer through the automation of data extraction from diverse sources. Recent AI research has also integrated genetic information with deep learning, refining the classification of breast cancer subtypes. Combining genomic data with AI improves the accuracy of breast cancer diagnostics, particularly in detecting genetic mutations such as BRCA1 and BRCA2, which are linked to an increased risk of the disease. This integration fosters personalized diagnostics and therapies, making treatment more tailored to individual patients' needs.

Conclusion: The development of AI-driven image analysis, alongside innovations in deep learning, attention mechanisms, and transfer learning, has greatly enhanced the diagnostic process. Automated models can now identify complex patterns in breast cancer data, leading to earlier and more accurate diagnoses. Ultimately, these advancements are contributing to more precise and personalized approaches to breast cancer treatment, marking a significant leap forward in healthcare technology.

Keywords: Artificial Intelligence; Breast Cancer; Early Diagnosis; Deep Learning, X-Ray Imaging.



Artificial Intelligence in Targeted Drug Delivery for Wound Healing: Advancing Precision Medicine

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Abstract

Background: Wound healing is a complex biological process involving multiple stages: hemostasis, inflammation, proliferation, and maturation. Despite significant medical advancements, challenges persist in treating various wound types due to their heterogeneity and limitations of conventional dressings. Traditional wound care methods often fail to provide optimal outcomes, necessitating innovative approaches to address the diverse needs of patients with different wound types and healing capacities. This review aims to explore the transformative role of Artificial Intelligence (AI) in revolutionizing targeted drug delivery systems for wound healing. We seek to elucidate how AI integration enhances personalized wound care, improves treatment efficacy, and addresses the limitations of traditional approaches.

Materials and Methods: A comprehensive literature search was conducted using Google Scholar, PubMed, and ScienceDirect databases. Keywords including "Artificial Intelligence," "Drug Delivery System," "Chronic Wound," "Nanomedicine," and "Precision Medicine" were used to identify relevant studies published between 2017 and 2024. The selected articles were critically evaluated, and key findings were synthesized to present the current landscape and future directions in AI-driven targeted drug delivery for wound healing.

Results: The review highlights several innovative approaches in AI-driven targeted drug delivery for wound healing. Firstly, AI-enhanced drug discovery which means that machine learning algorithms have accelerated the identification of novel wound-healing agents, including biological agents, antimicrobials, and natural compounds. Secondly, personalized treatment planning: AI systems analyze patient-specific factors (e.g., wound type, comorbidities, genetic profile) to design tailored drug delivery strategies, optimizing healing outcomes. Thirdly, smart nanomedicine: AI-guided design of nanoparticles has improved drug encapsulation, controlled release, and tissue penetration, enhancing the efficacy of wound-healing agents. Also, intelligent nanofibrous scaffolds by AI algorithms optimization of the design and fabrication of electro spun nanofibers, creating scaffolds that mimic the extracellular matrix and promote tissue regeneration. Furthermore, AI-driven 3D bioprinting by machine learning models guide the creation of custom scaffolds with tissue-like structures, incorporating patient-specific factors for personalized wound dressings. However, precision medicine approaches by AI analysis of multi-omics data helps identify patient-specific biomarkers and drug responses, enabling highly targeted therapeutic interventions. Ultimately, challenges remain, including ensuring drug stability, managing formulation complexity, and navigating regulatory obstacles. Future research should focus on interdisciplinary approaches, robust clinical trials, and exploring the potential of AI-driven 3D bioprinting for creating highly customized wound dressings.

Conclusion: The integration of artificial intelligence with targeted drug delivery systems represents a paradigm shift in wound healing therapies. By leveraging AI's capabilities in data analysis, predictive modeling, and personalized treatment design, significant advancements have been made in developing precision medicine approaches for wound care. These AI-driven innovations hold great promise in improving wound healing outcomes, reducing healing times, and enhancing the quality of life for patients with diverse wound types. As research in this field continues to evolve, the synergy between AI and targeted drug delivery is expected to play a crucial role in addressing the complex challenges of wound healing and advancing the field of precision medicine in wound care.

Keywords: Artificial Intelligence; Drug Delivery; Precision Medicine; Targeted Therapy; Wound-Healing.



Recent Developments in Magnetic Iron Oxide Nanoparticles for Brain Tumors Diagnosis and Therapy: From Research to Clinical Trials

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Abstract

Background: The advancement of multifunctional nanoplatforms is increasingly significant in the realm of cancer theranostics.

Materials and Methods: In this context, Nanoparticles (NPs) offer numerous advantages over conventional diagnostic techniques and treatments. Iron Oxide Nanoparticles (IONPs), in particular, possess favorable properties such as ease of modification, high payload capacity, intrinsic magnetic characteristics, excellent biocompatibility, and a strong response to targeting strategies. These attributes make them promising candidates for use as diagnostic contrast agents and as vehicles for drug and gene delivery, as well as for integration into hyperthermia-based therapies. Notably, these agents can be detected using standard imaging techniques like magnetic resonance imaging.

Results & Conclusion: Consequently, the integration of traditional diagnostic methods and therapies with nanotechnology could significantly enhance the survival rates of cancer patients. This review highlights the use of magnetic IONPs in both in vitro and in vivo studies of brain tumors.

Keywords: Iron Oxide Nanoparticles; Brain Tumor; Diagnosis; Therapy.



Tracing of Platelet-Derived Extracellular Vesicles Entrapped in An Injectable Hydrogel Using In Vivo Molecular Imaging

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Abstract

Background: Platelet-derived extracellular vesicles transplantation is one of the most promising strategies for the minimally invasive delivery of bioactive molecules to injured tissue. However, an important challenge to its efficacy is poor uptake by target tissue due to a lack of mechanical protection during injection and an unfavorable microenvironment of living body. Platelet-derived extracellular vesicles uptake by the mononuclear phagocyte system and rapid clearance from body known as some important obstacles for successful treatment of various tissue by these bioactive entities.

Entrapment of platelet-derived extracellular vesicles in biocompatible hydrogel materials facilitate their sustained release and maintenance of their function.

Materials and Methods: Injectable biomaterials demonstrate many advantages including reduced risk of mutation and carcinogenicity, an appropriate degradation rate and low immunogenicity.

Molecular imaging and tracking of transplanted platelet-derived extracellular vesicles labeled with various contrast media could reveal better understanding of their engraftment.

Results: Molecular imaging results reveal that entrapment of platelet-derived extracellular vesicles in hydrogel biomaterials facilitate their controlled release.

Conclusion: Molecular imaging modalities holds great promise for the non-invasive and real-time assessment of entrapped exosomes engraftment and fate in a living body with unique spatial and temporal resolution.

Keywords: Platelet-Derived Extracellular Vesicles; In Vivo Molecular Imaging; Biomaterials; Entrapment; Hydrogel.



A Review and Update on Clinical Uses and Technological Advancements of SPECT/CT

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Abstract

Background: Since the turn of the century, single-photon emission CT (SPECT) in conjunction with anatomical CT has been commercially accessible for use in functional nuclear medicine imaging. The use of both modalities has enhanced the sensitivity and specificity of numerous clinical applications. Additionally, the combination of CT and SPECT enables the spatial overlay of SPECT data on high-quality anatomical pictures. It's also possible that the addition of diagnostic CT units to the SPECT/CT system has made it possible to operate the technology more economically. Most of the SPECT systems available are based on the well-known Anger camera idea using NaI(Tl) as a scintillation material, parallel-hole collimators and numerous photomultiplier tubes, which, from the centroid of the scintillation light, calculate the position of an event. Lately, cadmium-zinc-telluride solid-state detectors have been made accessible, and numerous pinhole collimator clinical SPECT cameras have been produced and released into the market. Nevertheless, photon attenuation, scatter, and collimator response will still have an impact on the SPECT reconstruction even in the case of new systems with improved hardware becoming available. Even in qualitative studies, compensation for these effects is necessary to prevent artifacts that result in false positives. The current developments in new SPECT camera systems and in different data-processing and correction techniques are reviewed in this paper. The single-photon emission CT (SPECT)/CT combination of dual-imaging modality techniques is a clinical application that when introduced was particularly relevant in oncological applications, as it leads to improved sensitivity and specificity by the combination of co-registered anatomical and functional images.¹ When evaluating treatment outcome, the combination of the two modalities may also lead to improved staging and treatment monitoring. Prior to SPECT/CT, most manufacturers offered transmission imaging using scanning line sources, scanning point sources, a single static line source or multiple static line sources. These systems were used to form maps of linear attenuation coefficients for attenuation compensation² and lack the resolution and overall quality for anatomic registration and other applications. The need for more rapidly acquired and more accurate attenuation maps as well as localization capabilities led to the development of SPECT/CT. The diagnostic imaging of tumors was one such application when it was discovered that anatomical information was required. When compared to normal organs, the tumor's uptake of the radiopharmaceutical can sometimes be high, which makes it challenging to pinpoint the tumor for possible future surgery. In most cases, anatomic markers in SPECT pictures are insufficient to pinpoint the exact locations of the cancers. Naturally, this was acknowledged, and studies on rigid and non-rigid image registration between SPECT and CT were carried out. However, precisely achieving this requires a complex mathematical algorithm, and even in cases where a diagnostic CT scan was available, the images did not always match successfully due to organ displacement between the studies. Then, a combined SPECT/CT system was used as the answer, which was made to prevent patient movements when the patient was being translated between the two modalities. The merging of SPECT and CT images was then made possible for clinically common procedures by these so-called hybrid systems.

Materials and Methods: The current review offers an update on the body of proven data by examining the most pertinent of the more than 400 papers that have been published to date on the subject of clinical SPECT/CT. It illustrates the clear benefits of SPECT/CT in a range of disorders over planar and/or stand-alone SPECT. SPECT/CT is already completely integrated into the standard clinical decision-making process for the majority of the applications mentioned above. The data acquired during this analysis also highlights areas in which the use of integrated SPECT/CT imaging has not yet demonstrated clear benefits. The authors are unable to now transfer the use of SPECT/CT into a meaningful clinical impact for management due to a lack of large-scale trials and conclusive evidence. With the introduction of diagnostic ceCT, the potential of SPECT/CT imaging for lesion characterisation will grow.

Results: Since PET/CT was incorporated into clinical practice, hybrid imaging has become increasingly common in the field of radionuclide-based diagnostic methods. Better AC contributes to increased metabolic or functional information from PET or SPECT scans, but the most significant improvement comes from the correlative assessment of changing tracer distribution with anatomical structures. Better performance indices for the diagnostic imaging process are the outcome of this. By customizing clinical interventions to meet the needs of each patient, the nuclear medicine specialist makes a significant contribution to improved healthcare through hybrid imaging in general and SPECT/CT in particular. The fact that "competitive" PET/CT techniques are available for many of the indications included in this review is known to the writers. These techniques are described when accessible (see also online Tables). However, the purpose of this paper was not to provide a thorough analysis of these other modalities. New developments in technology will also strengthen the role that quantitative SPECT/CT will play for dosimetry estimates in thermonostics, an area that merits a dedicated, independent evaluation of existing understanding and contributions.

Conclusion: It is evident that the advent of combined SPECT/CT has enhanced sensitivity and raised the degree of confidence with which many nuclear medicine studies are interpreted. The availability of SPECT/CT may cause referring physicians to gravitate back to oncological applications historically performed by SPECT and planar scintigraphy that currently are performed by CT, PET/CT or MRI. When used in conjunction with iterative reconstruction techniques that accurately model photon attenuation, scatter, and collimator resolution degradation, SPECT/CT systems can be highly advantageous for patient-specific dosimetry or dose planning studies as well as longitudinal investigations. This is particularly true when longer half-live radionuclides that are unavailable for PET imaging are required.

Keywords: Mice; Radiology; X-Ray; Lung Cancer; Human Lung.

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