گزارش پیاده سازی و نتایج مقاله اصلی

عنوان مقاله:

Spectral CT imaging: Technical principles of dual-energy CT and multi-energy photon-counting CT

نگارنده:

فاطمه باقری

بهار 1403

فصل1

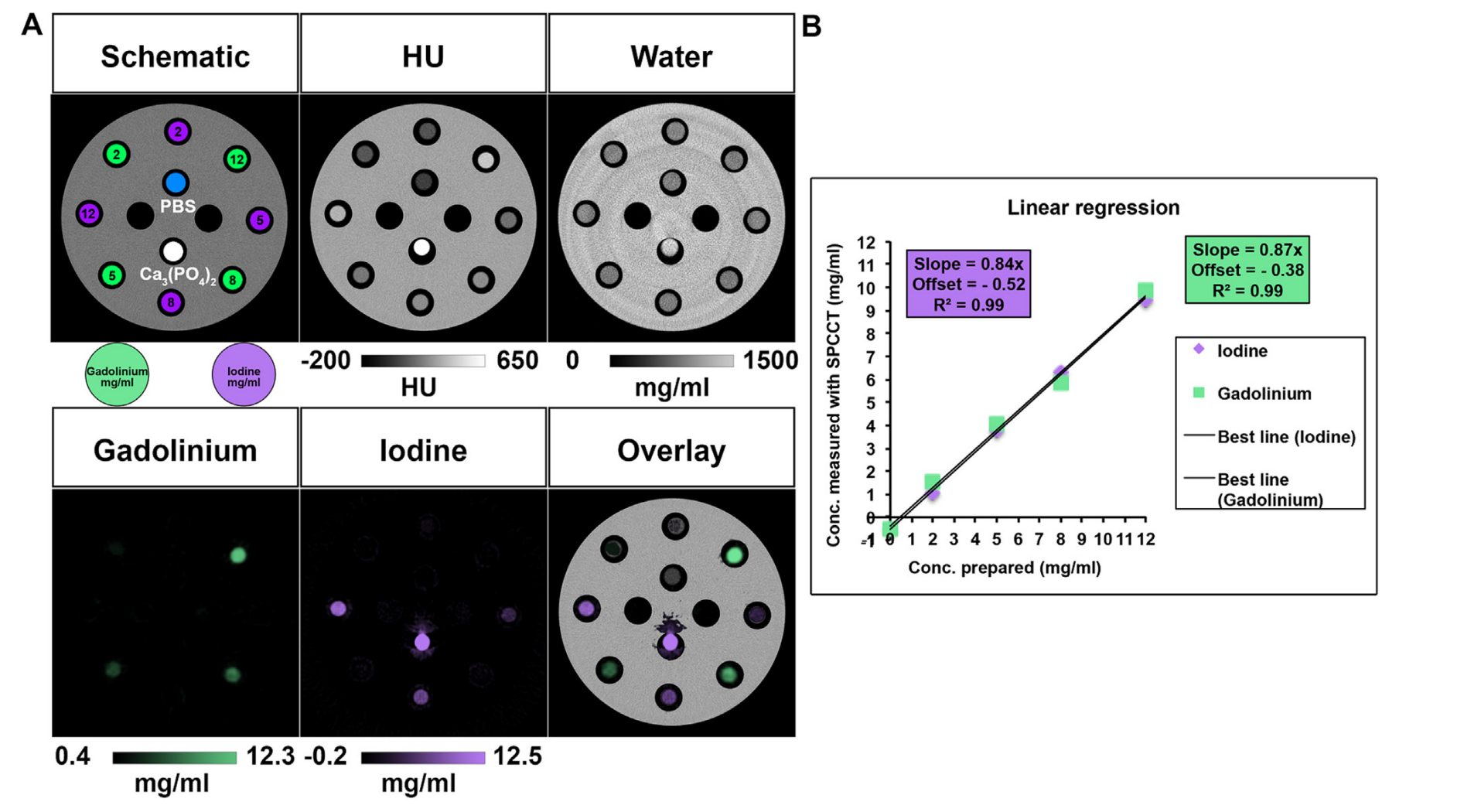
نتایج مقاله اصلی:

فناوری CT شمارش فوتون طیفی

## اصول

CT شمارش فوتون طیفی (SPCCT) یک فناوری جدید و در حال ظهور در زمینه تصویربرداری طیفی است.از آشکارسازهای حل انرژی، به نام آشکارسازهای شمارش فوتون (PCDs) استفاده می‌کند که اخیراً در پلتفرم‌های CT بالینی ادغام شده‌اند. PCD ها از مواد نیمه رسانا ساخته شده اند که امکان تبدیل فوتون های ورودی به طور مستقیم به بارهای الکتریکی را فراهم می کند که به یک شمارش مهاجرت می کنند (مدار مجتمع ویژه برنامه، ASIC. ASIC یک پالس ولتاژ متناسب با انرژی فوتون ورودی را شکل می دهد و هر فوتون را می توان در دامنه با توجه به انرژی خود متمایز کرد. بنابراین، طیف ارسالی را می توان در چند سطل انرژی که با سطوح مختلف انرژی آنها تعریف می شود، مشخص کرد. در مقایسه با توانایی‌های CT با انرژی دوگانه، SPCCT این پتانسیل را دارد که نمونه‌برداری کامل‌تر و دقیق‌تری از وابستگی انرژی موجود در تصاویر CT ارائه دهد. هنوز می توان مزایای بسیاری را در توسعه فعلی انتظار داشت. با این حال، شایان ذکر است که SPCCT با بهبود جداسازی انرژی بین فوتون‌های پر انرژی و کم انرژی، رویکرد گسترده‌ای را به تصویربرداری طیفی باز می‌کند. این وضوح بیشتر ضرایب سهم/جذب فوتوالکتریک و کامپتون را ارائه می‌دهد که قابلیت‌های طیفی شناخته شده فعلی مانند تصاویر تک رنگ مجازی (VMI) را افزایش می‌دهد. مزیت دوم این است که می توان مواد اضافی را بر اساس انرژی های لبه K (یعنی انرژی اتصال بین پوسته K و هسته) به تجزیه طیفی تصاویر اضافه کرد. این را می توان به عنوان سومین عامل ناشناخته اضافه شده به معادله توسط آلوارز و ماکوفسکی (معادل ۵) درک کرد.

که در آن fmaterial تابعی ریاضی است که اثر فوتوالکتریک ماده لبه K را مشخص می کند و ماده ضریب جذب فوتوالکتریک ماده است. این رویکرد که به آن تصویربرداری لبه K می‌گویند، یک پیشرفت واقعی در پس پردازش CT است و با نوید در دسترس بودن در نسل بعدی سیستم‌های SPCCT بالینی همراه است. عمدتاً نوید غلبه بر محدودیت‌های فناوری CT با انرژی دوگانه را می‌دهد که نمی‌تواند به طور خاص یا کمی مواد مختلف را در یک وکسل (یا به صورت مشترک ثبت شده)، مانند ید و کلسیم جدا کند (شکل ۳). این تصاویر به زودی همراه با تصویر HU معمولی به رادیولوژیست ها ارائه می شود که با سی تی متعارف یا سی تی انرژی دوگانه غیرممکن است. تصویربرداری با لبه K شبیه روش تصویربرداری هسته ای دوگانه توموگرافی گسیل پوزیترون-CT است که در آن اطلاعات عملکردی با وضوح پایین در مورد جذب ۱۸F-fluorodeoxyglucose بر روی اطلاعات تشریحی با وضوح بالا قرار می گیرد و یک رویکرد کاملاً جدید CT را برای عملکرد، مولکولی یا تصویربرداری التهاب و بسیاری از مناطق دیگر که نیاز به کاوش دارند.



شکل1\_3. تصویری از قابلیت های تصویربرداری رنگی لبه K که توسط فناوری CT شمارش فوتون طیفی در یک فانتوم با مواد متعدد فعال شده است.

الف. طراحی شماتیک، تصاویر CT شمارش فوتون طیفی (SPCCT) و تصاویر تجزیه مواد به آب، ید و گادولینیوم K-لبه یک فانتوم حاوی لوله هایی با غلظت فزاینده مواد حاجب (۲، ۵، ۸، و ۱۲ میلی گرم در میلی لیتر)، با فسفات کلسیم و لوله های نمکی بافر فسفات. در حالی که تصویر معمولی شکست خورد تصویربرداری خاصی از هر ماده حاجب ارائه می دهد و تصاویر ید قادر به تمایز بین ید و کلسیم نیستند، تصویر گادولینیم K-edge تمایز خاصی را نشان می دهد.

لوله های گادولینیوم بدون آلودگی متقابل با مزیت کمی بودن. ب، مقایسه غلظت عامل کنتراست اندازه‌گیری شده با SPCCT، که یک همبستگی خطی را نشان می‌دهد .

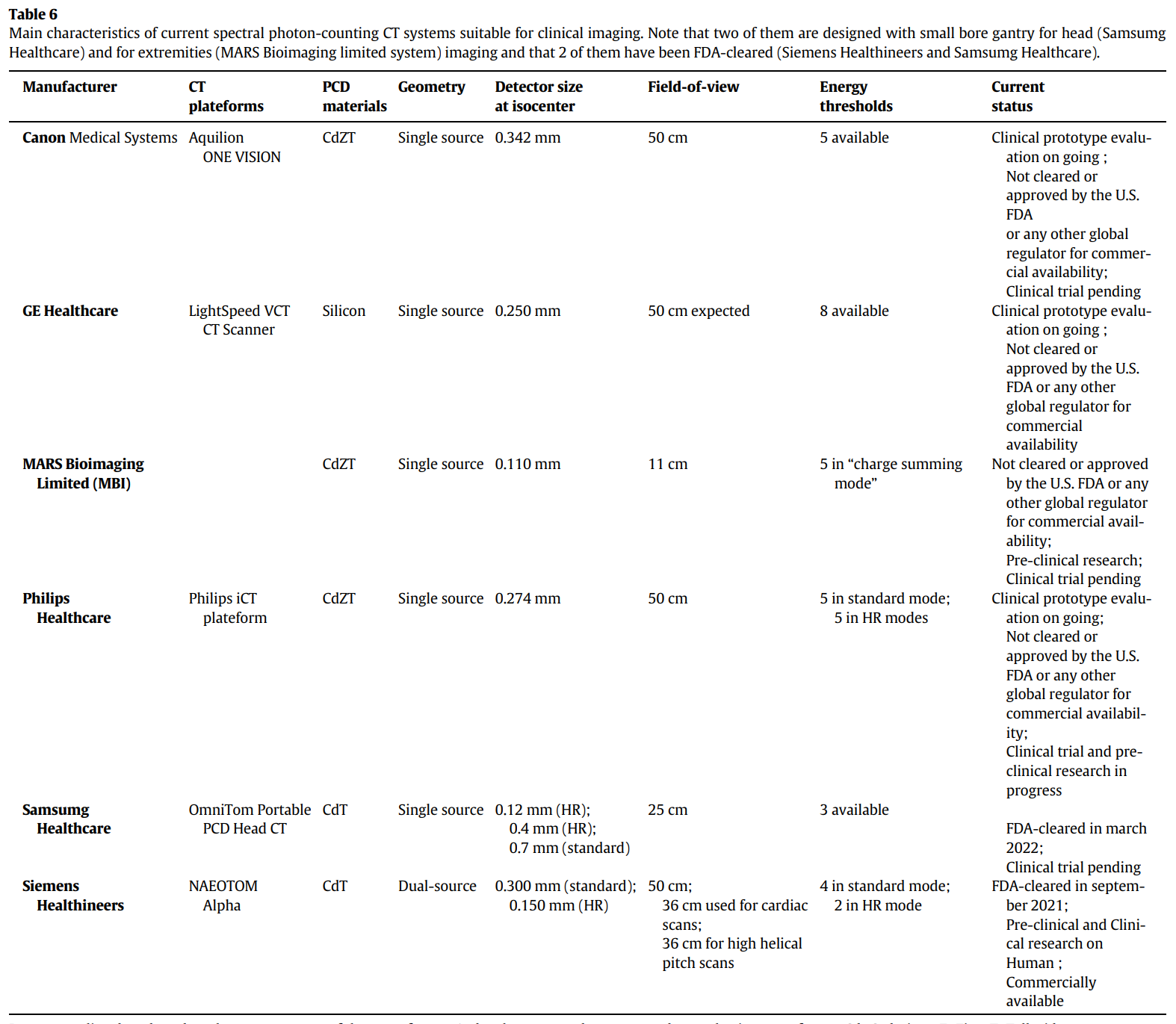
جنبه های تکنیکی

قابلیت‌های حل انرژی PCD نسبت به آشکارسازهای CT معمولی یکپارچه‌کننده انرژی مزایای زیادی دارد که عبارتند از: (i)، شمارش فوتون‌های فردی. (ب)، تبعیض انرژی فوتون فردی. (iii)، بدون نویز الکترونیکی (آستانه برای تمایز بین نویز الکترونیکی و پالس اشعه ایکس). (iiii) وضوح فضایی بهبود یافته: اندازه خوشه بار کوچک و عدم وجود نویز الکترونیکی استفاده از اندازه پیکسل کوچکتر را نسبت به آشکارسازهای سی تی سی سی سینتیلاتور و فوتودیود معمولی ممکن می سازد. (v)، بهبود وزن انرژی فوتون های کم انرژی که منجر به تضعیف و کنتراست CT بالاتر در بافت می شود. و (vi)، فضای مرده بین آشکارسازها وجود ندارد. این جنبه‌های فنی ویژگی‌های مهم جدیدی را برای تصویربرداری بالینی به ارمغان می‌آورد که عبارتند از: (i)، وضوح فضایی بالاتر: تابع انتقال مدولاسیون بالاتر (MTF) در محدوده معمول ۰-۱۵ lp/cm و قدرت قابل‌توجه در گسترش تا ۳۰ lp/cm. ; (ii)، کاهش نویز در دوز پایین، زیرا شمارش فوتون‌ها کف نویز الکترونیکی ندارد. (iii)، کاهش نویز در تجزیه دو ماده پایه از تعداد بیشتری از مخازن انرژی شناسایی و ذخیره شده در داده ها. (IV)، امکان تجزیه بیش از دو ماده پایه از مخازن انرژی چندگانه. (v)، بهبود یافته، تضاد بازسازی سازگارتر از سطل های انرژی متعدد. و (vi)، امکان نگاشت مواد لبه K (مانند گادولینیوم، طلا یا بیسموت) با تخصیص پویا در نرم افزار.

به سمت تصویربرداری بالینی

در طول پنج سال گذشته، زمینه SPCCT با اجرای PCD با قابلیت‌های نرخ بالای شمارش در پلتفرم‌های CT با سوراخ، پیشرفت قابل‌توجهی داشته است. تا کنون، این تغییر با دو سیستم پاکسازی شده توسط FDA (یعنی یکی با سوراخ برای همه کاربردها) و دیگری با سوراخ کوچک برای تصویربرداری از سر موفقیت آمیز بوده است، با این حال، علیرغم انتخاب های فنی مختلف تولیدکنندگان مختلف، بسیاری از موارد قبل -مطالعات بالینی و بالینی شواهدی ارائه کرده اند که SPCCT را می توان به عنوان آینده تصویربرداری CT طیفی در نظر گرفت.

جدول1-3: ویژگی های اصلی سیستم های CT شمارش فوتون طیفی فعلی مناسب برای تصویربرداری بالینی.



# نتیجه گیری

تصویربرداری CT طیفی یک زمینه دائماً در حال توسعه است که با استفاده از سیستم‌های CT با انرژی دوگانه در عمل بالینی بیست سال پیش مورد توجه قرار گرفت. علیرغم انتخاب های مختلف سازنده از نظر زنجیره تشخیص، منبع اشعه ایکس، زنجیره بازسازی و سایر پارامترها، همه آنها امکان بهره مندی از وابستگی انرژی بافت را از طریق تصاویر تک رنگ مجازی و تجزیه مواد به آب، ید و غیره در اختیار رادیولوژیست ها قرار می دهند. مواد. با این وجود، میدان تصویربرداری CT طیفی هم در غلبه بر محدودیت‌های CT با انرژی دوگانه و هم در کاوش رویکردهای جدید در تصویربرداری CT از طریق پیشرفت‌های جدید مانند تصویربرداری با لبه K در فناوری CT شمارش فوتون طیفی، از تکامل بازمانده است.

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issn = {00942405},

keywords = {Cancer, Digital mammography, Image analysis, Image quality, Mammography, Medical X‐ray imaging, Medical image noise, Medical imaging, Tissue structure, Visual medical imaging, X‐ray imaging, cancer, diagnostic radiography, digital mammography, dual‐energy subtraction imaging, image resolution, mammography, medical image processing, microcalcifications, signal‐to‐noise ratio}

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issn = {00942405},

keywords = {ALUMINIUM, Aluminium, BIOMEDICAL RADIOGRAPHY, BONE TISSUES, Biomedical imaging, Biophysical techniques (research methods), COMPTON, COMPUTERIZED TOMOGRAPHY, Calcium, Compton scattering, Data visualization, Medical imaging, Non‐ionizing radiation equipment and techniques, Optical/infrared radiation effects, PHANTOMS, PHOTOELECTRIC EFFECT, Polynomials, Radiofrequency/microwave fields effects, Radiography, TISSUES, TISSUE−EQUILVANENT MATERIALS, VISUALIZATION, Visualization, WATER, X RADIATION}

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keywords = {EPID, MTF, NPS, ideal observer, multi-layer detector, portal imaging}

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