North American Chinese Medical Physicists Association

NACMPA NEWSLETTER

Spring 2019
Volume 4 No. 1

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Inside this issue:

Message from President

Zhigang (Josh) Xu, Ph.D.
NACMPA President

This year, the 25th NACMPA Annual Meeting will be held in San Antonio, Texas on July 17, 2019 from 5:30PM – 9:30 PM. Our meeting will be held in the China Harbor, which is 14 miles away from the convention center. The bus transportation will be provided. The ticket is available at: *https://www.eventbrite.com/e/25th-nacmpa-annual-dinner-meeting-tickets-61407910714*. The meeting program for this year is great, offering Presidential and financial annual report, award ceremony, keynote speech, election of NACMPA Secretary and Board Member at Large, in addition the delicious seafood buffet. The meeting provides the perfect opportunity to connect with our NACMPA members. I can't wait to see you in San Antonio!

Once again, NACMPA members are cordially invited to participate in the 2019 Chinese Annual Meeting of Radiation Oncology Physics in Zhengzhou, China, on August 15-17, 2019. This meeting is organized by the Physics Group of Chinese Society of Radiation Oncology (CSTRO-PG) and sponsored by NACMPA. This meeting is intended to facilitate scientific exchange and to provide a platform for radiation oncology physicists worldwide to foster communications, collaborations and friendship. For meeting registration and hotel reservation, please follow: http://rtpam2019.medmeeting.org/cn

The NACMPA delegations, including both invited and proffered speakers, will present the latest developments in radiation oncology physics at the meeting. NACMPA member is encouraged to submit his/her abstract on the conference website and send a copy: nacmpa@yahoo.com, by July 10, 2019. Abstracts previously submitted or presented at AAPM or ASTRO are acceptable. All abstracts will be reviewed by the NACMPA Scientific Committee. Abstracts with acceptable scores will be selected as oral presentations in the meeting. Presentations either in Chinese or English are acceptable. Presenters of top-scored abstracts will receive travel awards of $500 each from NACMPA. All proffered presenters are required to register at the meeting website and to make their own travel arrangements.

Dates to Remember

7/10/2019: Abstract submission deadline
8/15/2019: Arrival and on-site registration
8/16 & 17/2019: Meeting programs

We look forward to seeing you in both San Antonio and Zhengzhou!

Seeking Contributors

NACMPA NEWSLETTER is published by the North American Chinese Medical Physicists Association on a semiannually schedule. We welcome all readers to send us any suggestions or comments on any of the articles or new features to make this a more effective and engaging publication and to enhance the overall readership experience. Next issue: July 2019.

Contact us: nacmpa@yahoo.com 欢迎大家投稿,并希望大家关注北美华人物理师公众号.

Editors: Brian Wang, Ph.D, Zhigang (Josh) Xu, Ph.D. , Chao Guo, M.S., Xiaoyu Duan, M.S.

25th NACMPA Annual Meeting, San Antonio, TX (July 17)

Meeting Agenda

5:30 pm

Members Arrival

6:30 pm

Introduction of Officers

Recognition of Local Organizers

Introduction of Guests

-Zhigang Xu (President)

Recognition of Sponsors

-Brian Wang (President-Elect)

Business

President's Report

-Zhigang Xu

Financial Report

-Yin Zhang (Treasurer)

7:00 pm dinner

Award Ceremony

Yu Chen Excellent Community Service

IJMPCERO Best Paper Award

NACMPA Best Paper Award

NACMPA Service Award

2019 NACMPA Hall of Fame Award

Keynote Speech

By 2019 Hall of Fame Awardee

8:00 pm

Election of Secretary

Election of Board Member at Large

-Brian Wang and Dengsong Zhu

8:30 pm

Sponsors' presentation

New Business

9:00 pm

Meeting Over

Executive Meeting After Dinner

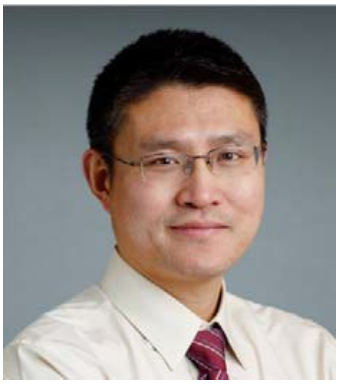
由中华医学会、中华医学会放射肿瘤治疗学分会主办，河南省肿瘤医院承办的“2019放射肿瘤物理学年会”，将于2019年8月15-17日在河南省郑州市召开。本次会议的主题是“发展技术应用、提高质量保证”，组委会将围绕肿瘤放射治疗物理技术的应用与质量保证、人工智能技术在放射治疗的应用、影像引导和自适应放射治疗技术研究进展等方面，以专题讲座和论文报告等形式交流学术研究的最新成果、更新放射治疗物理学知识与观念，提高临床应用技术水平与质量。本次大会将继续与北美华人医学物理师协会合作，举办“放射治疗技术进展与应用质控”专题报告会

大会欢迎从事肿瘤放射治疗临床与物理技术研究和应用的广大医师、物理师、治疗技师、以及相关专业的技术研发人员踊跃投稿交流成果，积极参会讨论研究，共同提高放射治疗技术水平和应用质量。我们期待在华夏文明重要发祥地之一的古商都郑州，与各位同道和新老朋友一起相聚相知、共同进步 . For meeting registration and hotel reservation, please follow: *http://rtpam2019.medmeeting.org/cn*

The NACMPA delegations, including both invited and proffered speakers, will present the latest developments in radiation oncology physics at the meeting. NACMPA member is encouraged to submit his/her abstract on the conference website and send a copy: *nacmpa@yahoo.com, by July 10, 2019.* Abstracts previously submitted or presented at AAPM or ASTRO are acceptable. All abstracts will be reviewed by the NACMPA Scientific Committee. Abstracts with acceptable scores will be selected as oral presentations in the meeting. Presentations either in Chinese or English are acceptable. Presenters of top-scored abstracts will receive travel awards of $500 each from NACMPA. All proffered presenters are required to register at the meeting website and to make their own travel arrangements.

2018 NACMPA’s delegation

Candidates for Secretary



Ting Chen, PhD
NACMPA Member

Ting Chen PhD received his BE of Biomedical Engineering from Tsinghua University, Beijing, China in 1998, and PhD in Bioengineering from University of Pennsylvania in 2003. Dr. Chen joined New York University as a research scientist in the Department of Radiology from 2004 to 2008. He completed medical physics residency training in the radiotherapeutics branch at the Cancer Institute of New Jersey in 2010. He served as a faculty member at the Rutgers Cancer Institute of New Jersey until 2017. Currently Dr. Chen is a medical physicist and faculty member at the Radiation Oncology Department of New York University Perlmutter Cancer Center, where he conducts clinical support, translational research, and academic education/training activities in medical physics. Dr. Chen has been a prolific researcher and collaborator in the medical physics field over the last decade. His research interest includes motion modeling and monitoring in image guided radiation therapy, MRI based image analysis and modeling, and medical image segmentation & registration. Dr. Chen has published more than 40 academic research papers at various prestigious journals. He is an active reviewer for Medical Physics, International Journal of Radiation Oncology, Biology and Physics, and Radiotherapy and Oncology. He is currently served as an associate editor at JACMP. Dr. Chen has been an active AAPM member since 2008. He served as the president of the AAPM NJ chapter in 2013-2015, and is the sitting member at the AAPM board of directors representing the NJ chapter.

Dr. Chen has been a member of NACMPA since 2009. He has conducted multiple research collaborations with medical physicists and radiation oncologists from China.

Zhicong Huang, MS.
NACMPA Member

Zhicong got trained in Miami, lives and worked in San Diego for more than 10 years. The radiation oncology group he served merged with Scripps health system in 2014, they received the AMPEX accreditation in 2015. Since 2015 Zhicong actively participated involved in the MD Anderson affiliation project, Now became the Scripps MD Anderson Cancer Center. Zhicong is currently leading the physics and dosimetry teams of three Scripps MD Anderson radiation facilities locates at the San Diego North County. His team delivers comprehensive procedures including the IGRT, Cyberknife SRS, SBRT,XOFT, HDR and Accuboost. He have always gained newfound interest and confidence in advancing his career. His passion in this profession has also been the constant drive for him to continuously renew himself.

Candidates for Board Member at Large

Jun Yang, PhD.
NACMPA Member

Dr. Yang has been the chief physicist at the Philadelphia CyberKnife since 2006 and has served as the senior director of medical physics of Alliance oncology, a chain with near 40 radiation centers in the states, since 2013. He is a member of the AAPM Task Group #135 and #277. As an adjunct clinical associate professor of Drexel University, he has authored and co-authored many publications on medical physics with emphasis on Radiosurgery physics, radiobiology and clinical outcomes. Jun joined the Physics Committee of Radiosurgery Society (RSS) in 2011, the RSS Board of Directors in 2012 and has served as the chairman of the Physics Committee of RSS since 2013. Dr. Jun Yang also serves as CEO of Greater China for Alliance Oncology building multiple radiation oncology programs in China, and plays an active role in promoting the collaboration between the medical physics community in China and in U.S.

Dr. Yi Rong is an Associate Professor in the Department of Radiation Oncology at University of California Davis Comprehensive Cancer Center. She has earned her doctorate degree in Medical Physics Department at University of Wisconsin (UW) Madison in 2008. After that, she worked as a faculty in the Human Oncology Department at UW Madison. From 2011 to 2015, Dr. Rong worked at the Radiation Oncology Department in the Wexner Medical Center at the Ohio State University as an Assistant Professor. Dr. Rong has more than 50 high-quality peer-reviewed publications in the leading journals during the past years, as well as multiple invited lectures presented at national and international meetings. Dr. Rong has also been serving the editorial work for several high-impact journals in the field.

Yi Rong, PhD.
NACMPA Member

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Reflections and the future of medical physics in radiation therapy

John Wong, PhD.

NACMPA Hall of Fame 2018

I begin my reflection by expressing the great fortune that I have had for a most rewarding career. I am humbled to be recognized by my peers for doing what I consider natural for a medical physicist. We all have chosen this wonderful profession because at the core, we take great satisfaction to be directly involved in improving the human conditions through science, whether we are taking care of patients, or advancing our knowledge, or both. Medical physics has undergone amazing transformations in my nearly 40 years of practice. In radiation therapy, we have progressed from manual dose calculation, to 3D treatment planning, to the present era of IMRT, IGRT and real-time adaptive radiation therapy. It also appears that the new era of Artificial Intelligence (AI) is just around the corner. The complexities of our practice have also increased many folds; none is more obvious than our efforts devoted to personalized patient treatment and the associated quality assurance responsibilities. We have taken up, and justifiably so, the motto of "safety is no accident" as the singularly most important foundation of our profession. But somehow, we have fallen short in establishing the foundation principles to develop our safety practice. A case in point is IMRT; the reasonable QA methods we took to ensure safe delivery at the infancy of IMRT seemed to have morphed into self-imposed requirements. Some perhaps even feel that they help with our job security. So we are now all very busy!!! In reality, the millions of IMRT QA measurements we have made rarely pointed directly to a root cause for correction. In the eyes of others, physicists have become synonymous with technicians. As such, our roles are inevitably vulnerable for eventual replacement, perhaps by AI. I therefore applaud whole-heartedly the vision of the AAPM leadership on the Medical Physics 3.0 initiative to help define and re-invigorate our roles as medical physicists.

But allow me to take a somewhat different view from a historical perspective. Medical physics was founded by visionaries with widely varying expertise who wanted to apply scientific principles to innovate medicine technologies and their clinical use. These pioneers created our field. We have since evolved to support a broad spectrum of service, education and research. We have become mainstream. However, I have an uneasy sense that there is a subtle but increasing desire in the medical physics community to define our profession into separate entities of clinical practice and research. Such distinction is very dangerous as it will lead to isolation and discord in respect, compensation and expectation for the two. The distinction might have been wrongly associated with board certification which, to me, is meant to ensure competency and knowledge to address patient care. I believe that all medical physicists should attain board certification, whether we conduct research or deliver care. But all medical physicists should also be problem solvers, whether we pursue new scientific advances, or we develop effective clinical solution for a patient or patients. We must distinguish ourselves from being technicians. Back to IMRT QA or similar tasks, for the physicists, we must go further and base our acceptance criteria on sound scientific principles. If a physicist wants to pursue research, then the efforts need to have impact value for the field. The notion that board certification is relevant only for clinical practice has an undesirable consequence in discouraging the pursuit of medical physics by a wider pool of talented scientists, and in demotivating the desire to innovate. It is not far-fetched to imagine that these talents will find industries more attractive which, ironically, will be dictating how we practice as non-certified professionals.

I do not have a clear solution to the predicament of two seemingly distinct entities in medical physics. It is very encouraging that Medical Physics 3.0 is addressing many of the practice issues, although research is not one of its focuses. But we can be sure that there will be practice changes in the future. Medical physics will be better prepared for the future uncertainties by embracing the pursuit of both research and/or clinical practice excellence. To that end, we need to re-think how board certification can be inclusive for both researchers and clinicians in recognition of their contributions. We cannot have two distinct professional entities. We are one group.

Introduction to the science of team science (A book summary)

Chi Lin, MD, PhD

In the book, "Enhancing the effectiveness of team science", the National Research Council reported that although an individual investigator can master and integrate knowledge from diverse disciplines, this process has become more difficult over the past half century because of the rapid growth of specialized knowledge in every field of science. A scientist interested in investigating questions that require knowledge beyond her or his narrow specialization may prefer to team up with colleagues to obtain complementary expertise, rather than spending years mastering another discipline.

In the first part of the book, the authors found that the growing scale of science has been accompanied by a dramatic shift toward collaborative research referred as "team science," which for all intents and purposes, can be defined as research conducted by more than one individual in an interdepartmental fashion, including research conducted by small teams (2 to 10 individuals) and large groups (10 or more individuals, could be many smaller teams). The share of all papers written by two or more authors increased from 80% in the year 2000 to 90% by the year 2013. More and more papers are found to have multiple first authors or corresponding authors. In addition, there is a rapid growth in team-based publications by authors from multiple institutions. Team science can rapidly advance scientific and technological innovation by increasing research impact, novelty, productivity, and reach.

They further noted that science teams and larger groups vary in the extent to which they include or integrate the knowledge of experts from different disciplines or professions to achieve their scientific and, when relevant, translational goals. These varying

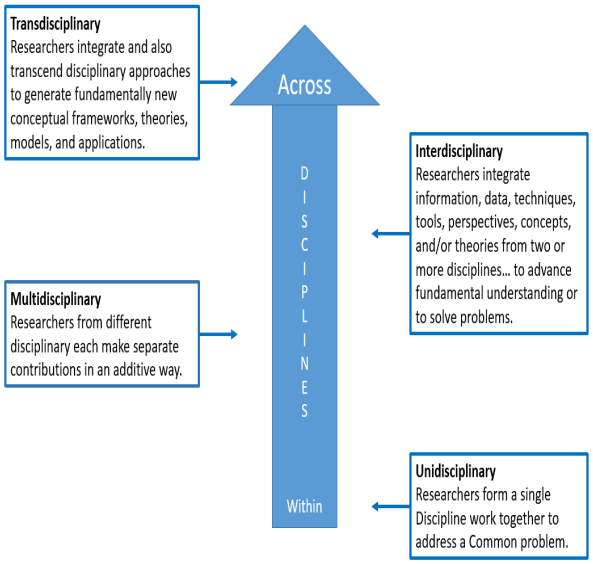


Figure 1 Levels of cross-disciplinary inte-

degrees of integration have been classified as unidisciplinary, multidisciplinary, interdisciplinary, and transdisciplinary research approaches (Figure 1).

Furthermore, although team science is growing rapidly, it can be more challenging. It requires an increased amount of time allotted for communication and coordination of work among a greater number of individuals. Key features that create challenges for team science include high diversity of membership; deep knowledge integration; large size; goal misalignment with other teams; permeable team and group boundaries; geographic dispersion and high task interdependence.

Last but not least, the council pointed out that the "science of team science" is a new interdisciplinary field that empirically examine the process by which large and small scientific teams, research centers, and institutes organize, communicate, and conduct research. In order to enhance the effectiveness of team science, understanding how teams connect and collaborate to achieve scientific breakthroughs unattainable by individual or simply additive efforts is critical.

Reference: Enhancing the effectiveness of team science by National research council of the national academies. ISBN 0-309-31685-5.

世界第一台临床使用的Zap Surgical机器之初期经验

Jason Yan, PhD.
NACMPA Member

跟第一台Zap机器一起折腾了大半年才开始治疗第一个病人，痛苦远多过激动，尤其是在人手原本就不足的情况下。几乎每周都有新问题，感觉我们物理师成了Zap公司的R&D部门的临床测试工作组似的，很多工作都是测试、发现问题、思考、再测试、不断循环。总之把最后临床的各个环节都摸顺了才行。很多事情从最后结果看往往索然无趣，所以本文从一个case study的角度来谈谈我们走过的弯路吧。

首先，SRS机器、包括伽玛刀赛博刀等、在任何医院都是一个管理层的难题。因为SRS病人特有的跨学科跨部门性质，通常需要脑外科医生和放疗医生密切配合决定治疗方案和细节、并合作参与到治疗的全过程中。我们的Zap机器还是physician group出钱买的，所以三角恋爱的状况出现了（注：美国的医生通常不是医院的职员）。为了分清三方的责任权力和成本利益之分配、会议开了无数次，终于在三个月后敲定各方的责权利细节和条款。所以机器安装好了之后我们三个月都没摸过、呆在那儿采集灰尘，但这似乎是必经之路。

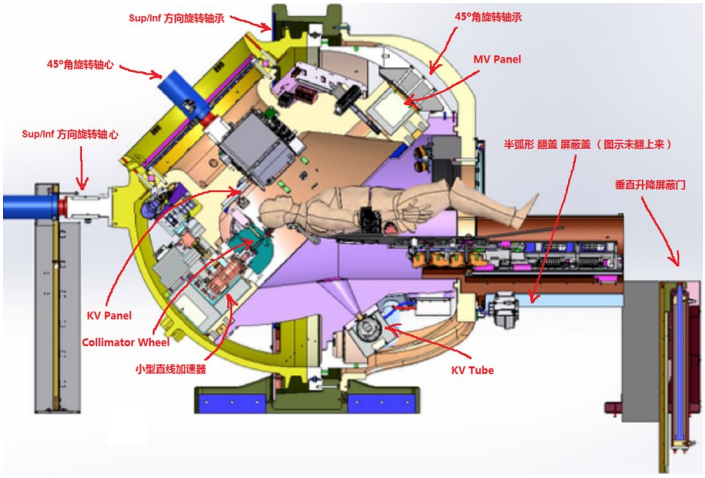
终于我们可以看见庐山真面目了：自屏蔽设计的Zap机器用2.7MV (fff beam, 1500 MU/min, 45cm SAD, dmax=7mm)的小型机头、固定在一个可以自转的圆环或轴承上(1 rpm)，此圆环之转轴以45度夹角固定于另一个可以自转的圆环上，类似于一个回转仪Gyroscope。通过这个回转结构，机头可以在192个空间角度等中心出束，两个圆环的45度夹角可以避免从头顶射向脚底那个范围的空间角度，所以跟伽玛刀的射束角度很类似。治疗床可以前后移动，pitch和yaw方向转动，此三个维度的床运动可以让等中心或者病人头部在大约20cm的3D范围内任意移动。准直器collimator集成在一个Tungsten Wheel里、每个不同尺寸的孔洞(4, 5, 7.5, 10, 12.5, 15, 20, 25mm)成径向分布并与beam CAX重合，圆盘可以通过转动来快速切换准直器尺寸。图像系统包括一个MV Panel (scintillator with PGR camera)和一个KV Panel。MV Panel可用于in-vivo dosimetry/control、或者192个空间角度里任意一个角度的Winston-Lutz测试。在不同方向上的两个KV Images可以定义病人头部三维空间位置。开始治疗病人之前，机头会旋转到10个不同的角度摄取KV图像、确认头部复位精确。开始治疗后，在用户定义的间隔时间例如每30秒会再次摄取KV图像、并与上一次的KV图像计算出新的头部位置。

开始commission的时候我们有三个大目标：射野中心吻合精准度，机器输出剂量及投放剂量精准度，TPS本身以及与各环节集成度(包括安全措施和性能)。

我们用了Winston-Lutz (WL)、Star Shot、以及End-to-End (E2E)来做射野中心吻合度的测试。最初当WL测试结果在半毫米级别的时候，E2E结果就会达到2mm误差级别。如果根据E2E的结果来调整中心的话，WL测试的非同心度就会达到2mm级别。来回做了很多次、都显示出稳定的相差，互相矛盾，所以一定有问题。后来做Star Shot的时候我们通过它的pattern观察到它的非同心度是具体在哪个方向有偏差。于是狂做无数的star shot，各个平面的、各个collimator尺寸的，全部调校并且尽量split不同collimator的误差之后，终于所有的star shot结果的精准度大幅改善。再来做WL和E2E测试的时候，发现误差终于降到1mm以内。解决问题的期间我们同时也发现和解决了另一些问题，例如偶然发现TPS的缺省计算精度竟然是3mm，而且等剂量线是smooth过的、所以看不出它很粗的缺省值，TPS也没有地方显示计算精度。估计是程序猿用3mm快速调试软件功能，调完后忘了改回1mm。这期间Zap的硬件工程师和软件工程师也都在各个可以改良或者可能影响同心度的地方都做出了一定的改进。所以最后WL测试和E2E测试结果吻合较好的时候，我们也无法判断到底是那样改进起了决定性的作用、或者是综合改良。但是

Zap公司记录下了所有的技术细节，相信下一家Zap用户不会再碰到类似问题。

机器的输出因为测量条件限制、我们开始选择用TG-21做，后来为了双保险也做了转换后的TG-51，结果两者恒定相差3%左右，一定有问题。后来猜测是TG-21不应该在dmax=7mm处测量，而应该选择更深处测量，从



而避免buildup区域以及电子污染的干扰。我们让Zap公司重新制作提供了一个在44mm处测量输出的phantom，配合一维小水箱的TG-51测量(在极有限的机器内部空间设置水箱很困难)、胶片剂量测量、第三方IROC剂量验证等，才终于将3%的输出误差消除。此外，我们验证了机器在不同空间角度的输出相差在1%以内。治疗过程中的Leakage剂量也在可忽略的范围。

计划投放剂量、或者patient specific QA、用不同的detector做了很多次，也用了多种第三方验证机构的服务。选择的验证方式有Lucy Phantom里的EBT3胶片和PinPoint chamber、SRS Phantom for E2E (IROC提供)、以及PseudoPatient with 4 targets, filled with VIPAR polymer gel dosimeter for SRS/SRT (RTsafe提供)。在多方验证有相当的信心之后我们才开始治疗病人。我们前四个病人的film QA Gamma Index (2 mm, 2%) 平均通过率为 97.4% (范围94.0%-99.9%)， chamber跟TPS剂量相差1.4%(范围 0.6%-2.8%).

PDD的测量用不同的detector做了若干次，结果互相吻合的很好，no surprise。但是TMR的测量有些头痛。PTW公司特意给我们提供了适合于Zap有限内部空间的三维小水箱MP3-XS，但没有TMR功能。所以基本靠物理师施展软骨功，在狭小空间里倒腾水箱、水、detector、调水平、对准中心和水面等。此外，随着手动不断的加水制造出不同TMR深度的时候，逐渐变重的水箱会让治疗床下沉最大8.3mm，导致TMR结果最多3.7%的修正。修正后的TMR跟理论计算的TMR相比较，最大误差为1.4% (范围-0.25%±0.53%)，也算是对PDD测量的再验证。此外，Output Factor (OF)的测量、比较、和确认等比较耗时，但是并没有太大的技术挑战。

关于辐射安全的测量我们测过三次。第一次是在开始commission之前、室内室外屋顶地下隔壁等等地方都测量。第二次是测量机器的leakage。第三次是在实际开始治疗病人的时候，实测“室内”控制台处的工作人员的辐射剂量。全部都符合NRC的辐射安全相关规定，亚利桑那州的辐射安全机构也有他们自己的标准，他们来亲测和检查各种文件两次，也都通过合格并给我们颁发了运营执照。

其他的还有一些开始没有预料到的，例如TPS 没有DICOM输入界面、也无法DICOM输出，如何预测和预防机头不会碰撞病人头部或者immobilization装置，如何做靶区在脑内不同区域的E2E测试。这些都在我们commission期间得到大幅改善和解决。

还有其他的例如计划质量跟伽玛刀赛博刀比较、射野半影尺寸比较、治疗时间长短比较、机器长时间治疗之稳定性等等，篇幅所限就不细谈了，我们已经有7篇Abstract被AAPM年会接受、谈及更全面的话题。

总体来说，Zap Surgical机器各方面性能和精度完全可以达到伽玛刀和赛博刀相等的水平。目前Zap公司仍然在不遗余力的进一步改善，相信未来在SRS领域一定会大放异彩，其亲民的价格、以及自屏蔽无需专用机房的优势也会把最优的性价比带给广大用户，尤其是在发展中国家、甚至不发达国家可能都会开辟出一片新市场。发明人Dr. John Adler也期望SRS技术因为亲民的价格能在全世界范围内替代更多的脑外科手术。

Flash-RT：放疗技术中的“秒杀”术

Haibo Lin, PhD.
NACMPA Member

Flash-RT技术

放射治疗（放疗）作为肿瘤治疗的重要手段之一，其技术的发展将致力于保护正常器官的同时降低放疗并发症的发生。考虑到放疗手段的多样化，通常按照剂量率可分为：正常剂量率的常规放疗（0.03Gy/s）、高剂量率的近距离放疗（HDR，0.3Gy/s）、体部立体放射治疗（SBRT，1Gy/s）等。近年来，随着科学技术的发展，直线加速器能够提供的剂量率也在不断提升，如无均整器的直线加速器，其剂量率则可提高约4倍，从而为患者提高放疗疗效及其治疗手段的多样化搭建了平台。曾有多个动物预临床实验结果表明，在相同剂量照射的条件下，与传统放疗相比，采用超高剂量率的电子束放疗(剂量率≥40 Gy/s，亦称为Flash-RT)，能有效地降低放疗并发症的产生，并在控制肿瘤生长方面展示了相同的结果。Flash-RT作为一种全新、革命性的外放射治疗技术，具有非侵入性、超高速治疗（<1s）和低分割（1~3次治疗）等特性；Flash对剂量率的要求不同于传统放疗，图1比较了不同放疗技术使用的束流剂量率（数据来自瓦里安）。

Flash-RT预临床动物实验的初步结果

来自法国和瑞士的研究学者最近报道了在Black 6小鼠身上实施Flash-RT的研究结果。研究实验中采用了由法国PMB-Alcen公司生产的Oriatron 6E (6MeV)和Kinetron型加速器（4.5MeV）的原型样机，该样机可提供平均剂量率为0.1~ 1000Gy/s的电子束，对应于每个电子脉冲提供0.01~ 10Gy的剂量。本实验中研究者首先利用4.5 MeV电子和g射线，分别以束流剂量率为1.8Gy/min对小鼠的胸腔实施总剂量为17Gy的常规照射，其结果表明两种射线在造成肺纤维化中的作用相似（即传统放疗剂量15Gy通常会造成小鼠的肺纤维化），而且通过小鼠的实验发现，两种射线对原发性肺癌、乳腺癌及头颈部肿瘤的控制疗效也类似。当采用高剂量率（60 Gy/s = 3600 Gy/min）Flash RT技术，实施单次17Gy超快（<500ms）电子束的照射；重复上述实验时发现，与常规剂量率治疗相比(相同的总剂量)，Flash治疗后36周随访的肺纤维化率同比降低了60%，而肿瘤控制方面，两种治疗方法的疗效基本相当。单次30Gy的Flash-RT结果表明，肺纤维化程度与传统照射17Gy（总剂量）的结果类同。而另一组总剂量为10Gy的小鼠全脑照射对比研究中发现，小鼠的空间记忆功能在Flash-RT中能完好地保留下来，而相比之下，在采用常规剂量率照射组中小鼠出现了记忆功能受损的现象。

该研究小组还利用同一样机在迷你型小猪身上研究了在Flash-RT和传统放疗下的皮肤反应。实验过程中小猪处于麻醉昏迷状态，分别通过传统放疗（5Gy/min）和Flash-RT（300Gy/s）两种照射方式在猪的背部沿脊柱对称区域进行多次辐照，辐照直径为26mm，在12mm深度处接受剂量为22~34Gy，并通过胶片和丙氨酸剂量计进行了剂量确认。辐照的急性并发症主要表现为脱毛，Flash-RT辐照3周后猪出现了脱毛反应，持续4周后开始恢复。而传统放疗则出现了永久性脱毛，6个月后仍未观察到有修复的迹象。此外，在辐照后36周的随访结果显示，严重的皮肤纤维化坏死只出现在传统放疗辐照区域，而分析对Flash-RT照射区域的皮肤组织表明，其皮肤状态和没有受到辐照区域皮肤的状态保持了一致，皮肤毛囊在Flash-RT辐照中成功地得到了保留。

Flash-RT束流的产生和剂量测量

除了上面提到的样机能提供4.5~6MeV电子的Flash-RT

外，来自斯坦福大学的团队通过改造瓦里安21EX直线加速器，也实现了9MeV和20MeV的Flash-RT技术。为了保留加速器的临床应用功能，该设备采用了备用控制电路板来定制Flash所需的脉冲网络电压、输入电流、剂量校准和快速束流的控制。考虑到在高剂量率下的饱和效应，监测电离室和束流位置监测系统都会被禁用，而剂量控制则通过连接在门控界面上的Arduino Uno 微控系统来实施，通过对整个控制系统进行优化，以及增加电子枪电流和射频强度，实现了稳定的高剂量率束流。为了减小平方反比对剂量率的影响，摆放小动物的平台可以放在三个不同位置：监测电离室、反光镜和内部铅门。通过对9MeV能量的测量显示，在以上三个位置10mm深度处的剂量率随位置变化较大，从74Gy/s降为5.5Gy/s，而有效射野直径从9.6mm 增加为74mm。而对于20MeV而言，在反光镜位置处可以实现在10mm深度处大于4cm射野内（90%剂量均整度），并可达到220Gy/s的 剂量率，适用于动物的实验。实验中剂量测量使用了Gaf EBT2胶片和PTW针尖电离室，并通过FLUKA蒙特卡洛模拟计算进行核对。

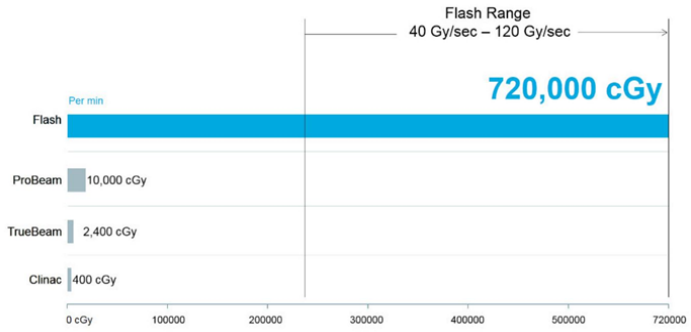


图1. 瓦里安放疗设备剂量率范围（数据来自瓦里安官网）

可以看到，在以上电子束Flash的临床前动物实验中，有几种剂量仪可用于剂量的测量，最常见的是Gaf EBT2和EBT3 胶片。 临床中胶片通常被用于相对剂量的测量和分析，考虑到电子能量在1~100MeV范围内，没有发现胶片对电子能量和剂量率（平均剂量率≤3000Gy/s，脉冲剂量率≤9.0×10^{12}Gy/s）有依赖性，因此胶片被广泛用在Flash-RT的剂量测量中，并常常与其他不依赖于剂量率的计量测量工具比如热释光剂量计（TLD）、丙氨酸剂量计进行比对，其测量结果一致性较好。传统的电离室在Flash环境中会出现饱和现象，从而会造成较大的剂量误差，需要在使用中加以注意。

质子Flash-RT现状和面临的挑战

当前，临床前动物实验大多基于直线加速器所产生的高能电子束，治疗时间通常在亚秒或更短的范围。之所以选择电子而不是光子，主要基于以下两个原因：电子束由于不需要经过靶区，更容易达到所需要的剂量率；而更重要的一点是电子束无法保护皮肤，其深度剂量(均匀的浅表剂量)更适合小动物实验。虽然电子束可以满足小动物（如老鼠）或浅表靶区的临床前放疗实验，但其有限的射程将限制Flash-RT在人体肿瘤治疗中的临床应用。与之比较而言，质子治疗近些年有了较快的发展，全球有70+家中心提供质子治疗，由于不同于X光的物理特性，通过调节质子的能量，可控制质子不同的深度以释放出杀灭肿瘤细胞的能量；由此不但确保对靶区肿瘤细胞造成最大的杀伤，同时也可保护周围正常组织及器官。这在再程放疗和儿童肿瘤放疗方面显示出较大的优势。此外，质子系统具有提供超高剂量率的潜能，比如近期瓦里安和IBA都在其临床质子系统上实现Flash-RT技术。

去年，法国居里研究所采用IBA质子系统，在138~198MeV能量范围内通过设计单散射系统并利用脊形滤线器（ridge filter），不但达到Flash-RT所需的剂量率（40Gy/s），还在$12\times12mm^2$射野内实现了质子90%射野内的平坦度。美国马里兰大学质子中心首次在瓦里安ProBeam进行了质子Flash-RT预临床动物实验，其结果显示，在相同的治疗剂量下，与传统质子放疗比较，Flash-RT可以有效地降低正常肺组织的损伤（25~30%），从而减小放疗引

起的肺纤维化率，同时，治疗过程中可有效降低辐照区域内皮肤皮炎的发病率（35%）。今年3月，IBA宣布其在荷兰格罗宁根大学医学中心 (Groningen – UMCG)质子临床系统上成功演示了Flash-RT技术，并实现了高达200Gy/s的剂量率。同一天，瓦里安在美国亚特兰大举行了第一次Flash-RT前沿技术研讨会，参会的主要学者主要来自14家瓦里安ProBeam质子中心，大会首先回顾了现有Flash-RT相关的成果，介绍了几个由瓦里安主导的Flash-RT临床前实验项目的状态，分组（临床、放射生物、物理）讨论并总结了Flash-RT面临的挑战以及迫切需要解决的问题，并着重阐述了瓦里安在未来几年内对Flash-RT临床实验的支持计划，以及对Flash-RT最终在临床中应用的展望。 要真正实现质子Flash-RT的临床应用，我们还要面临许多与物理相关挑战：

1. 需要统一定义Flash-RT的剂量率。这对综合分析和比较来自不同研究中心的研究数据尤为重要，这样可以降低由于不同剂量率标准而造成的数据不一致性以及分析难度。
2. 现有质子系统无法直接提供Flash-RT。比如在当前广泛使用的笔形扫描束治疗系统中，扫描磁铁的横向(x, y)扫描质子束提供合适的射野尺寸，能量调节器调整能量保证质子束能达到治疗所预期的深度，这些功能在临床应用上都是必须的；但这两个过程都需要时间来完成，而Flash-RT又需要维持超短治疗时间，从而保持超高剂量率，因此当前质子笔形扫描束治疗系统无法同时提供Flash-RT需要的高剂量率和临床在横向与纵向上所需的剂量展宽。此外，质子治疗系统内的有些重要部件，也因Flash-RT技术需要考虑升级；比如，现有质子系统里的监测电离室（monitor chamber）在Flash的高剂量率环境中会出现饱和，因而也需要更新。
3. 现今质子Flash-RT的研究仅限于使用穿透患者的高能质子束，使用其近端（非布拉格峰区域）剂量进行治疗，并未有效地利用质子有限射程的物理优势和布拉格峰附近高放射生物效应的生物优势。此外，当前治疗系统能提供的最高质子能量并不能在所有角度上穿透人体的各个部位，这种方法会大大地限制Flash-RT可选择的治疗角度。
4. 质子治疗的放射生物效应一直是临床上关注的一个焦点。在Flash-RT应用于临床之前，需要清楚地了解其放射生物效应，并考虑将这种效应计算到治疗计划的优化过程中，从而确保治疗计划的精确性。
5. 在线图像引导技术。考虑到Flash-RT是低分割甚至是单次治疗，而且治疗时间很短，高精准的在线图像引导技术至关重要；图像引导系统应该同时具备实时跟踪肿瘤靶区和引导摆位，并具备触发治疗射线的功能。
6. 现有质子中心的辐射屏蔽需要在Flash-RT环境中进行再次的评估，以确保治疗环境的安全性。

除此之外，还有许多生物和临床相关的问题均有待解决。比如，至今为止，我们始终无法找到Flash-RT的放射生物机理。为了理解Flash现象，研究人员提出了各种不同的解释。 在Flash-RT过程中，当含氧的正常组织受到高剂量率照射时该组织来不及富含氧气，造成了在照射区域内引起的氧耗尽现象，从而增强了该局部区域内正常组织的抗辐射性；肿瘤内部本身则处于乏氧状态，其与氧含量相关的抗辐射性并不会因为辐照而变化，而Flash-RT的剂量递增会增强对肿瘤组织的破坏性。换而言之，Flash-RT过程中正常组织能更好地耐受治疗中的高剂量，而肿瘤组织却保持着与传统放疗类似的抗辐射性，这就是我们所看到的Flash效应 。也有学者从免疫学角度解释了Flash-RT现象，超快的Flash辐照降低了循环血细胞中受到辐照的比例，因此对整个免疫系统的伤害小于传统大分割放疗。由于循环血中淋巴细胞的染色体畸变完全由受辐照的细胞比例以及辐照时间所决定，

Flash-RT超短的治疗时间将使大量的循环免疫细胞避免受到照射，由此减少了治疗相关的并发症，而这种效应无法在传统的大分割放疗中观察到。对于如何从放射生物学角度去解释我们在动物Flash-RT中观察到的实验现象，还需要通过设计更系统且有针对性的实验，分析并探讨更多的动物模型及实验结果以寻求最终的答案。这则需要各方的共同努力，一起去揭开Flash-RT现象背后的真实故事。

北美物理师协会（NACMPA）微信公众号总结

Chengyu Shi, PhD. NACMPA Board Member-at-large

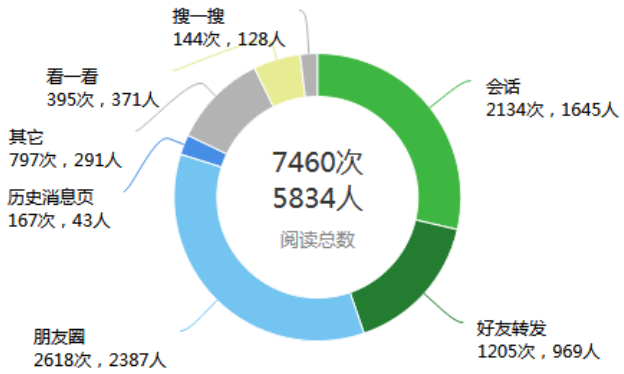
“再小的个体，也有自己的品牌”这是微信公众号的口号。同样道理：“再小的组织，也有自己的宣传渠道。”回忆起我们北美物理师协会(NACMPA)开微信公众号的感觉，就如我们还在中学时候第一次办班级版报，初恋的感觉。2017年8月8日，在经过调研和“折腾”了几次后，我们终于第一次发出了“相约重庆，我们用奖金支持你”的第一篇公众号。它标志着北美物理师协会的网络宣传途经诞生了，从此，我们有了自己的品牌。

到目前为止，我们北美物理师公众号共有2945人关注，共发了236篇公众号文章， 平均每月11篇文章，或者说平均3~4天一篇，对于只有一个人维护的公众号来说，已经非常高产了。公众号最近一个月的消息统计图如下：

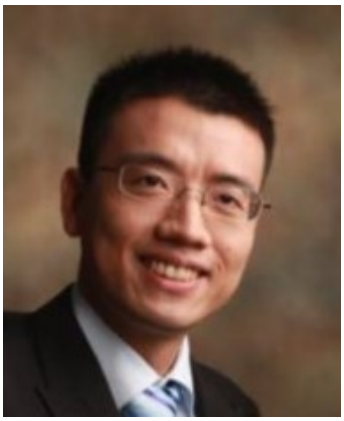
目前公众号的文章主要还是由我本人负责内容和质量。内容主要包括：物理师的报告文献，会议消息，协会消息，中美节日感悟，我本人娱乐大家的小故事和杜撰，期刊文章的总结等等。质量目前参差不齐，主要是我个人时间也有限，有时候为了赶进度，有一些错别字和错误的引用。发文的频率从最开始的有了就发，一日一发，到目前基本稳定的一周一发和必要了才发的比较规律的频率。

公众号的发展和维护离不开关注公众号的人的支持，此公众号持续有朋友点赞，且有留言互动，这正是我们所需要的动力，也是我尽力办好的动力。没有人关注和反馈的公众号就如黑洞，连光都发不出来，是多么悲哀的事情啊，所以，请看到这篇文章的朋友，扫描上面的二维码，关注我们，并积极留言，我个人保证回复您的留言，并尽力把公众号办好。

最后，再次感谢朋友们的支持。这个公众号是我个人发声的领地，也是协会发声的领地，更是您的发声领地。让我们一起努力，让这个声音更大声，让我们的品牌虽小但响亮!



中国医学物理与人工智能方面的研究进展



复旦大学附属肿瘤医院
胡伟刚

近年来，人工智能受到越来越多的关注，已被广泛应用于工业和学术领域，具有良好的发展前景[1]。有文献报道称，人工智能的研究经费要从2016年的80亿美元增加到2020年的470亿美元，以每年大约55%的增速上涨[2]。人工智结合生物技术和纳米技术的突破性进展被世界经济论坛(The World Economic Forum)称为第四次产业革命的主导力量[3]。

人工智能目前主要应用于目标分类[4]、自然语言处理[5]、语音识别[6]和图像处理[7]等领域，其表现已经接近人类的水平。鉴于目前人工智能在计算机视觉方面取得的巨大成功[8]，医学物理作为与医学影像息息相关的学科，其与人工智能的结合必然会推动医学的发展。纵观现有研究，人工智能与医学物理的结合大多集中在医学影像分割、疾病的诊断与分期预测以及与放射治疗相关的勾画、计划、预后预测和质控等方面。本文简要介绍国内研究者在医学物理方面的研究进展和相关的产业发展状况。

机器学习应用于医学领域辅助医生诊断（Computer-aided diagnosis, CAD）可以提高效率、准确率，可信度。 机器学习可以从患者的影像信息、临床信息、基因组信息等提取出某些人类未知的特征或规律用于预测预后，从而指导治疗，提高患者的生存质量。常用于医学诊断以及预测预后的机器学习算法有：支持向量机（Support Vector Machine, SVM），随机森林(Random Forest, RF) ,朴素贝叶斯法(Naive bayes), K最近邻算法(kNN，k-NearestNeighbor)，人工神经网络（Artificial Neural Network, ANN）包括常用于影像特征提取的卷积神经网络(Convolutional Neural Network, CNN)。这类用于诊断或预测预后的机器学习模型的输入一般是与疾病相关的各种特征：通常包括临床特征,病理特征，影像学特征（强度特征，形状特征，纹理特征）或者基因组学特征。因此，机器学习通常涉及特征的提取和筛选。如吉林大学的Hui-Ling Chen，Bo Yang[9]等人利用RS(Rough Sets)约简算法作为特征选择工具与支持向量机SVM相结合，对乳腺癌诊断的准确率平均值达到96%以上，并且还检测出了五个与诊断最相关的特征（肿块厚度，细胞形状的均匀性，边缘粘附，裸核，有丝分裂），可为乳腺内科医生提供重要线索。

卷积神经网络（CNN）作为计算机视觉领域最成熟的算法，是提取影像特征用于诊断的绝佳工具。利用CNN可以跳过手动提取和筛选特征这一步，实现端到端的算法模型。将CNN应用于医学诊断著名的工作有2016年谷歌[10]研究者基于视网膜眼底照片自动识别糖尿病视网膜病变的研究，2017年斯坦福研究发者表在Nature[11]上基于皮肤病图像的皮肤癌诊断研究以及2017年发表在JAMA[12]基于病理图像的乳腺癌淋巴结转移诊断研究。这些研究都显示CNN在诊断上的表现与专科医生同等水平，甚至高于医生平均水平。国内相关研究有2017年中国科学院的Wei Shen[13]等人利用卷积神经网络实现基于CT图像的肺结节良恶性分类，准确度达到87.14%，AUC达到0.93。 将机器学习应用于预后预测的研究思路与诊断相似，算法也通用。目前国内相关的研究工作有2017年中国科技大学Dongdong Sun[14]等人将DNN与SVM相结合建立了基于基因组学数据的乳腺癌预后模型，准确率为0.698，优于单独使用CNN或SVM。

图像分割是深度学习尤其是卷积神经网络技术具有极佳表现的领域。近年来卷积神经网络研究发展迅速，特别是U-net和对抗神经网络的应用使得人工智能在图像分割领域的表现接近甚至超过人工勾画。中国研究者在人工智能与图像分割结合的领域也颇有建树。在技术层面上，通过设计开创性的卷积神经网络结构[15]，损失函数，衡量指标[16]甚至是独特的卷积核结构[17]来优化自动分割图像的精度；在应用层面上图像分割的研究也涉及到了各种部位例如头颈[15]，乳腺[17]，肺[16, 18-19]，直肠[20]等以及各种类型的影像数据包括CT[16, 18-19]，MRI[20]，超声图[17]像等。这些研究不仅在衡量指标上，例如DSC，HD等达到了令人印象深刻的高度，而且对实际应用中的可视化（包括三维可视化）做出了适合临床直观

理解的工作。

人工智能在放疗中的应用主要集中于以下几个方面，对于危及器官的勾画，Sun Y等开发了一种先定位后分割（FLTS）的精准分割方法[21]，Ren X等利用交错多个3D卷积神经网络[22]，提高了在头部和颈部 CT 图像勾画的准确率。结合训练好的 DCNN 模型和 GPU 硬件加速，可以实现对放疗图像的组织器官快速分割，精确地自动勾画靶区及危及器官结构，促进精准放疗技术的进一步发展。除图像分割及勾画外，也可以用深度学习的方法作剂量分布预测，如Fan J等和Liu Z等利用U-ResNet-D网络分别现了鼻咽癌肿瘤在直线加速器IMRT和HT上的3D 剂量分布预测[23-24]。

除科研外， “人工智能”已经成为传统医疗巨头和互联网科技公司等未来发展战略方向，西门子医疗、通用医疗、飞利浦医疗、联影医疗以及东软医疗等设备公司纷纷成立智能医疗部门。谷歌、阿里巴巴、腾讯、复星医药等企业均表示会将医疗领域作为本企业AI的发力点，成为公司未来战略的重要组成部分。同时很多新生的AI公司比如联影智能、推想科技、科大讯飞、深睿医疗、慧医汇影、图玛深维、依图科技等也在着力研发AI医疗影像产品。为医院和医师提供全产链条等智能服务。AI医疗影像产品已涵盖从计算机辅助监测、计算机辅助诊断、计算机精准诊断、计算机量化随访、到计算机精准治疗全流程。

综上所述，中国研究者对于将人工智能运用于医学物理尤其是放疗物理中具有极高的热情，并且在图像分割、靶区勾画、诊断及预后预测等放疗相关领域都做出了突出贡献。而这股将AI运用于医学物理中的研究热潮在未来几年仍将持续增涨。但人工智能在医疗领域的应用具有特殊性，包括病例的复杂程度和多样性，这导致目前人工智能算法还未能达到理想的精准度。目前想要把人工智能与医疗大规模结合并应用到临床还难以实现。相关研究人员[20]认为，要实现真正的AI落地，需要解决数据共享、数据和算法的准确性和透明度、患者的安全、数据标准化、嵌入现有临床工作流程、经济考量和人才配备的问题等。在医学物理领域，人工智能技术的运用也存在着同样的问题。不过随着技术的发展和数据的积累，相信这些问题会逐步得到解决。

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医学物理词汇中英对照表(第四部分) 郭超 段晓雨 徐志岗 编缉

A

Acidophilic cell adenoma

嗜酸性细胞腺瘤

Acute Myelocytic Leukemia （AML）

急性髓细胞性白血病

Adenomatous polyp

腺瘤性息肉

Aneurysm

动脉瘤

Anteroposterior

前后位

Apudoma

胺前体摄取与脱羧细胞瘤

Astrocytoma

星形细胞瘤

Automatic gain contro

自动增益控制

Axial

轴位

B

Basal cell carcinoma

基底细胞癌

Benign tumor

良性肿瘤

Bilateral

双侧

Biopsy needle

活检针

C

Central neurocytoma

中枢神经细胞瘤

Cervical adenocarcinoma

子宫颈腺癌

Cervical epithelial dysplasia

子宫颈上皮非典型增生

Chondrosarcoma

软骨肉瘤

Chronic Myelogenous Leukemia (CML)

慢性髓性白血病

Colorectal cancer

结肠直肠癌

Comedocarcinoma

粉刺性癌

Contralateral

对侧

Contrast enhancement

对比增强

Coronal scan

冠状面扫描

Coronary Arteriography

冠状动脉造影

Cystic

囊状

Cysticfibrosis

囊性纤维变性

D

Differentiation

分化

Digital subtration angiography （DSA)

数字减影血管造影

Dysgerminoma

无性细胞瘤

Dysplasia

异生

E

Echo time

回波时间

Embryonal adenoma

胚胎性腺瘤

Enhancement scan

增强扫描

F

Frame rate

帧率

G

Giant cell glioblastoma

巨细胞型胶质母细胞瘤

Glio Blastoma Multiform (GBM)

多形性胶质母细胞瘤

Glioma

神经胶质瘤

H

Heterogeneous intensity

混合信号

Hyperintensity

高信号

Hypointensity

低信号

I

Image post-processing

图像后处理

Image reconstruction

图像重建

Interventional therapy

介入治疗

Intravenous bolus injection technique

静脉团注法

Intravenous rapid infusion
静脉快速滴注法
Intravenous rapid infusion
静脉快速滴注法
Invasion
浸润
Invasion ductal carcinoma
浸润性导管癌
Invasion growth
浸润性生长
Invasion lobular carcinoma
浸润性小叶癌
Ipsilateral
同侧
Islet cell adenoma
胰岛细胞腺瘤
Isointensity
等信号

L

Leiomyoma
平滑肌瘤
Lipoma
脂肪瘤
Lobulated
分叶的
Lower Vein Angiography
下肢静脉造影
Lucency
透亮
Lymphatic metastasis
淋巴道转移

M

Malignant meningioma
恶性脑膜瘤
Maximum intensity projection (MIP)
最大强度投影
Mesothelioma
间皮瘤
Molybdenum target radiography
钼靶X线摄影
Motion artifact
运动伪影
Mottling
斑点状

N

Neurilemoma
神经鞘瘤
Neurofibroma
纤维神经瘤

O

Oblique
斜位
Oblong
椭圆形
Occlusion
闭塞

P

Papillary carcinoma
乳头状癌
Patchy
片状
Penetration depth
穿透深度
Phase contrast
相位对比法
Pitch
螺距
Posteroanterior
后前位
Punctual
点状

R

Relaxation time
弛豫时间
RenaleelI
肾细胞癌
Repetition time
脉冲重复间隔时间
Rhabdomyosarcoma
横纹肌肉瘤
Rim enhancement
边缘增强

S

Sonogram echogram
声像图
Spiculated
毛刺状、针状
Stenosis
狭窄

T

Tangential
切线位
Teleradiology
远程放射学
Tumor in situ
原位癌

U

Upper Vein Angiography
上肢静脉造影
Urothelial carcinoma
尿路上皮癌

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