NACMPA
North American Chinese Medical Physicists Association

North American Chinese Medical Physicists Association

Spring 2023
Volume 8 No. 1

NACMPA NEWSLETTER

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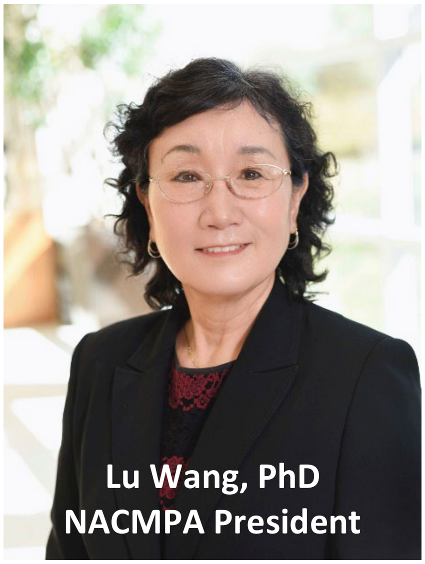
Seeking Contributors 欢迎大家投稿

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.

Contact us: nacmpa@yahoo.com

Newsletter Editor: Yi Rong, PhD

Message from the President



Lu Wang, PhD
NACMPA President

Welcome to the Spring 2023 Edition of the NACMPA newsletter!

I started my two-year term as the president in January of this year. I am excited, yet with a little bit nervousness, to take this new assignment/job. I will continue working with all members, especially closely with the Executive Committee officers to accomplish the tasks we are encountered. One of my major tasks for the year would be fund raising for our organization. This has also been a prime task for the leadership of NACMPA to maintain its current operation and long term vitality in recent years. Due to the impact of Covid-19 and international tension and Russian-Ukraine war, the whole world is experiencing economic shrinkage and financial difficulty. Thus, it has become tougher and harder to get sponsorships from vendors now. Nevertheless, I will strive and work hard with the ExCom officers together to overcome this challenge and keep the organization running in the positive cash flow.

The AAPM annual meeting is in-person again this year in Houston. Our NACMPA will continue to host the traditional annual dinner meeting in conjunction with the AAPM annual meeting on July 26th. I encourage you to register for the meeting ahead of time, and this will reduce the amount of work by our volunteers at the restaurant. If you change your mind, the registration is fully refundable. You can find the meeting program and registration information in this newsletter.

We have elections for two officers this year: secretary and board member at large. You can find an introduction of the candidates in this newsletter. Of note, a pair of imaging physicists are running for the seat of board member at large, to ensure an imaging physicist sitting in the ExCom committee. As the imaging specialty has grown tremendously, there is an increasing number of our members specializing in it. We believe this is the simple step to engage all medical physicists from both imaging and therapy specialties in our association. I believe it is just a matter of time when we will have an NACMPA president specializing in imaging physics!

Every year, NACMPA members receive prestigious awards from professional societies. This year, our long-time known friend, Dr. Lei Xing has received the Edith H. Quimby Lifetime Achievement Award. This is one of prestigious awards in the AAPM community! Special congratulations to Dr. Xing! In addition, Dr. Hao Gao received John S. Laughlin Young Scientist Award. The following members were elected as an AAPM fellow: Chia-Ho Hua, Xun Jia, Haibo Lin, Wei Liu, Kai Yang, Wensha Yang. Please join me to congratulate our colleagues!

Thank you to all the volunteers and officers! See you at our annual meeting!

North American Chinese Medical Physicists Association

Executive Officers (2023)

President: Lu Wang

President-Elect: Yi Rong

Secretary: Dandan Zheng

Treasurer: Dengsong Zhu

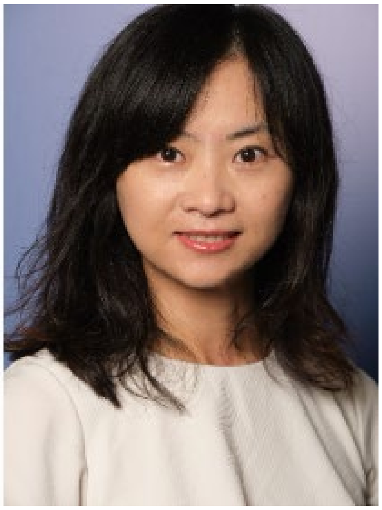
Board of Directors (2023)

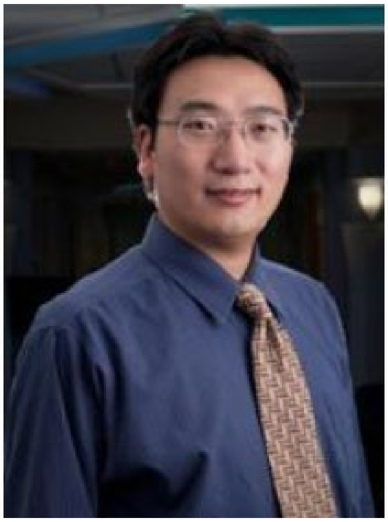
Brian Wang
Josh Xu
Lu Wang

Member-at-large: Kai Yang;

Nomination/Election Committee (2023)

Brian Wang
Josh Xu
Kai Yang





2023 NACMPA Awards

为了感谢和表彰华人物理师志愿者的奉献和鼓励更多医学物理师参与公益活动，NACMPA由陈昱纪念基金会赞助，从2018年起设立一个新的年度奖项-陈昱华人物理师最佳奉献奖。

评议过程主要以网上实名投票的方式进行，由大家投票选出。 2023年度的获奖者是Dr. Maria Chan。陈昱纪念基金会为获奖者准备一个奖状铭牌和美元现金奖励。

陈昱华人物理师最佳奉献奖

In Recognition of Your Outstanding Volunteering Work
For the American Chinese Medical Physics Community

Yu Chen Award of Excellent Community Contribution
2023 Recipient

Maria Chan, PhD

NACMPA Website Redesign and Migration

NACMPA Website
Redesign and Migration

- Many members has contributed to this special project to redesign and migrate the NACMPA website to wix
    - Drs. Yi Rong, Josh Xu, Chengyu Shi, Lu Wang, Mr. Dengsong Zhu, Francis Yu
- Long-time technical support: Mr. Jeff Luo
- Original website initiator and migration leader: Dr. **Raymond Wu**
- Designer, programmer, coordinator for new website. This project would not happen without her: **Yin Gao**!

IJMPCERO Best Paper Award

Scientific Research
Open Access

International Journal of Medical Physics,Clinical Engineering and Radiation Oncology

Presents the

NACMPA Award for Excellence to

Junfang (Jeff) Gao, PhD

For the Best Medical Physics Paper Published during 2022-2023 in

International Journal of Medical Physics, Clinical Engineering and Radiation Oncology

Distance to Isocenter Directly Affects Margin and Inappropriate Margin Increases the Risk of Local Control Failure in LINAC-Based Single-Isocenter SRS or SRT for Multiple Brain Metastases

$500 Voucher from *Scientific Research Publisher (SRP)* (Order # IJMPCERO0474; Expiry Date: July 26, 2024)

NACMPA
North American Chinese Medical Physicists Association

Scientific Research Publishing, Inc., USA
2007

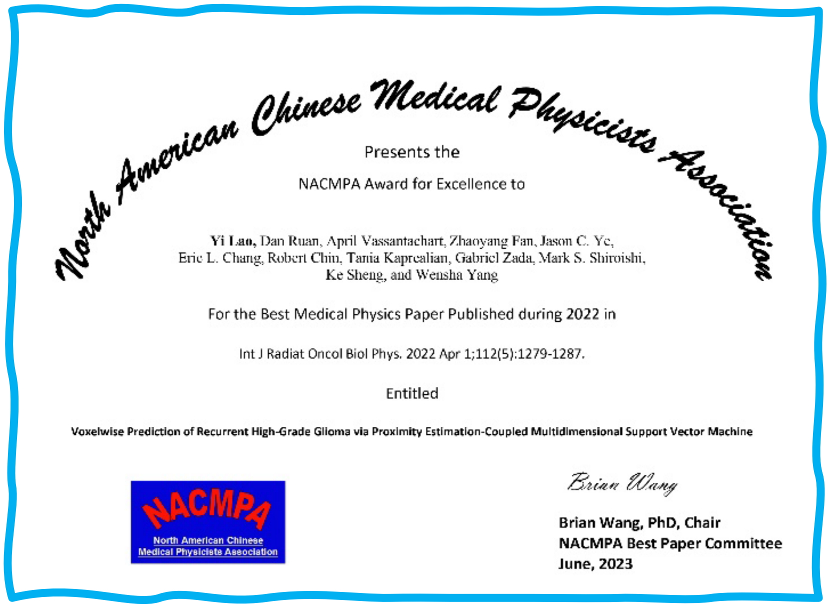
Ning J. Yue, PhD
Editor-in-Chief
July 26, 2023

The International Journal of Medical Physics, Clinical Engineering, and Radiation Oncology (IJMPCERO) was founded in 2012. The Editor-in-Chiefs have been Lei Xing, PhD (Stanford University), Huan Bosco Giap, MD, PhD (University of Miami), and Ning Jeff Yue, PhD (Rutgers Cancer Institute of New Jersey). The journal has been endorsed by the North American Chinese Medical Physicists Association (NACMPA) since the be-ginning. It is an Open Access (OA) journal, meaning that the publisher makes all articles and related content available for free on the journal's website. Since it was established, the journal has published over 300 articles with more than 1200 citations. Since it is an OA, there have been over 675,000 and 1,176,000 downloads and views of IJMPCERO articles respectively. For example, the first IJMPCERO best paper has been cited by peer-review journal articles more than 154 times based on Google Scholar Citation Tracking. The Best Paper Award ($500 voucher along with a framed official certificate) has been presented to the first author of the winning paper each year at the annual meeting of NACMPA since 2013. The meeting is held on Wednesday evening at the annual conference of the American Association of Physicists in Medicine (AAPM).

The criteria for best paper award selection, set by the NACMPA award committee, are the 1st or senior author must be a member of NACMPA and the paper was published in 2022. Congratulations to all the authors!

Maria Chan, PhD
NACMPA Liaison to IJMPCERO
Past President/Chair of Board, NACMPA

NACMPA Best Paper Award



North American Chinese Medical Physicists Association

Presents the

NACMPA Award for Excellence to

Yi Lao, Dan Ruan, April Vassantachart, Zhaoyang Fan, Jason C. Ye,
Eric L. Chang, Robert Chin, Tania Kaprealian, Gabriel Zada, Mark S. Shiroishi,
Ke Sheng, and Wensha Yang

For the Best Medical Physics Paper Published during 2022 in

Int J Radiat Oncol Biol Phys. 2022 Apr 1;112(5):1279-1287.

Entitled

Voxelwise Prediction of Recurrent High-Grade Glioma via Proximity Estimation-Coupled Multidimensional Support Vector Machine

NACMPA
North American Chinese Medical Physicists Association

Brian Wang

Brian Wang, PhD, Chair
NACMPA Best Paper Committee
June, 2023

NACMPA best paper award, established in 2018, aside recognizing the outstanding contributions to the medical physics field by the awardee(s), another goal of this award is to promote our society and hopefully draw more participations and contributions to NACMPA. Therefore, the criteria for best paper award selection, set by the NACMPA EXCOM, are

1. 1st author is a member of NACMPA
2. Publication was in 2022 and in a medical physics related journal.

The 2023 NACMPA best paper award goes to: Yi Lao, Dan Ruan, April Vassantachart, Zhaoyang Fan, Jason C. Ye, Eric L. Chang, Robert Chin, Tania Kaprealian, Gabriel Zada, Mark S. Shiroishi, Ke Sheng, and Wensha Yang: “Voxelwise Prediction of Recurrent High-Grade Glioma via Proximity Estimation-Coupled Multidimensional Support Vector Machine”

NACMPA Service Award

North American Chinese Medical Physicists Association

In recognition and appreciation of your outstanding services to the NACMPA, as an executive officer:

Brian Wang, PhD, DABR
President (2020-2022)

NACMPA
North American Chinese Medical Physicists Association

President
(July 2023)

North American Chinese Medical Physicists Association

In recognition and appreciation of your outstanding services to the NACMPA, as an executive officer:

Ke Nie, PhD, DABR
Treasurer (2021-2022)

NACMPA
North American Chinese Medical Physicists Association

President
(July 2023)

2023 NACMPA service awards go to Brian Wang and Ke Nie who have both completed extraordinary years of service to NACMPA. This service award is to recognize their contributions to our society.

NACMPA Hall of Fame Award

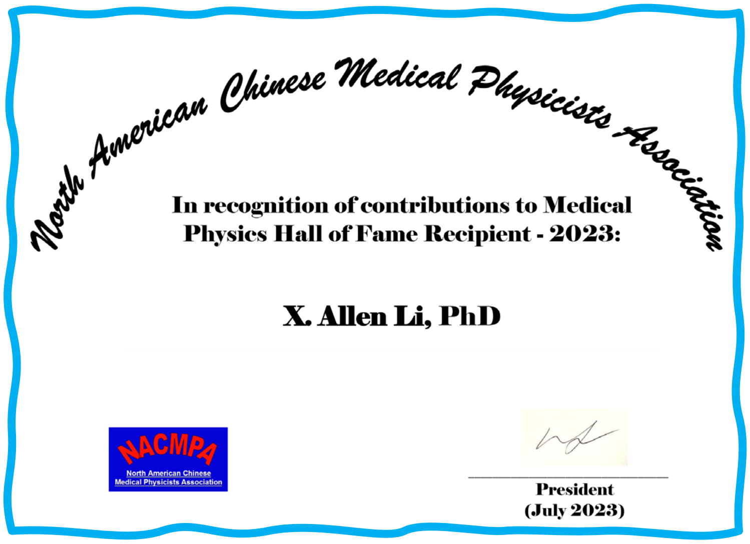
X. Allen Li, PhD, DABMP,

The NACMPA Hall of Fame award is an annual award to acknowledge the individual who made outstanding contribution to the field of medical physics through research or clinical work, or the individual who was outstanding in service in NACMPA. Due to the outstanding accomplishments and the significant contributions to NACMPA, Dr. X. Allen Li has been selected by NACMPA Awards Committee to receive the 2023 NACMPA Hall of Fame Award, the highest honor of NACMPA. Congratulation!

Dr. X. Allen Li received his Ph.D in physics and medical physics residency training in Canada. He is a tenured professor and has served as the Chief of Medical Physics in Radiation Oncology, Medical College of Wisconsin for nearly 20 years. He has over 30-years of experience in developing methodologies and technologies and providing clinical services in radiation therapy for cancer. Areas of his research cover adaptive radiation therapy, MRI-guided radiation therapy, and quantitative imaging for radiation response assessment. He has been frequently invited, for more than 100 times, to speak nationally and internationally on these topics. Dr. Li's bibliography includes more than 230 peer-reviewed papers, one textbook, 13 book chapters, and nearly 500 conference abstracts. He was the principal investigator for over 30 funded research projects and a co-investigator for 20 other funded proposals. Dr. Li has mentored 38 postdocs and has served as a grant peer reviewer for more than 10 funding organizations and as an associate editor or peer reviewer for 20 scientific journals.

Message from Dr. X. Allen Li

I am writing this message with immense gratitude and joy upon receiving the 2023 Hall of Fame of NACMPA. It is an incredible honor to be chosen as the recipient, and I wanted to take a moment to express my heartfelt appreciation. First and foremost, I would like to extend my deepest thanks to the members of the NACMPA selection committee for recognizing my efforts and accomplishments in the field of medical physics. This award holds great significance to me, and I am truly humbled by your decision. I would also like to express my sincere gratitude to all those who have supported and helped me along this journey. My heartfelt appreciation goes to my mentors, colleagues, trainees, and friends who have believed in me and provided guidance, encouragement, and unwavering support. Your expertise, wisdom, and willingness to share your knowledge have played a crucial role in my personal and professional development. Lastly, I am deeply grateful to my family for their staunch support, understanding, and encouragement throughout this journey.



North American Chinese Medical Physicists Association

In recognition of contributions to Medical Physics Hall of Fame Recipient - 2023:

X. Allen Li, PhD

NACMPA
North American Chinese Medical Physicists Association

President
(July 2023)

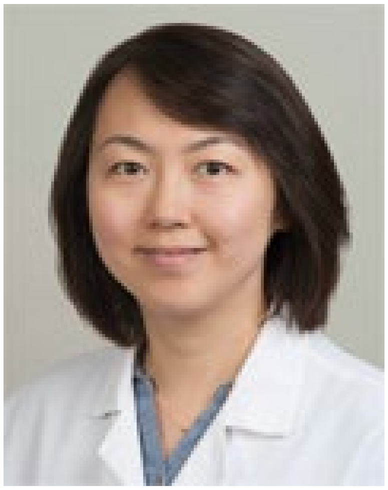
In conclusion, I am honored and privileged to receive this award, and I am truly grateful to each and every person who has contributed to my success.

X. Allen Li, Ph.D, DABR, FAAPM

Candidates for NACMPA Secretary 2023

Jinzhong Yang, PhD, NACMPA Member

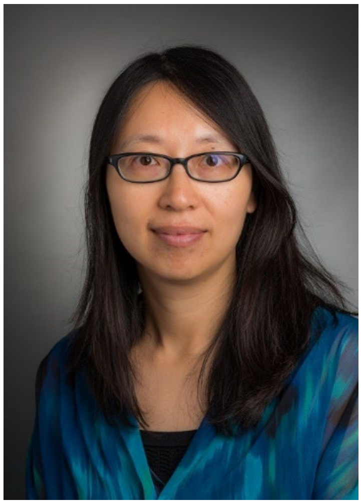
Dr. Jinzhong Yang is an Assistant Professor of Radiation Physics Department at the University of Texas MD Anderson Cancer Center. He is the lead physicist of the MR-Linac program at MD Anderson. Dr. Yang received his Ph.D. degree in Electrical Engineering from Lehigh University in 2007. He then completed a post-doc training in University of Pennsylvania. Dr. Yang has over 15 years of research in medical image registration and image segmentation, with a focus on translating novel imaging computing technologies into clinical radiation oncology practice. He has authored/co-authored more than 100 peer-reviewed publications and edited a book. He is currently a member of AAPM Workgroup of Grand Challenges and JACMP Board of Associate Editors.



Yingli Yang, PhD, NACMPA Member

Dr. Yingli Yang is a principal investigator at the SJTU-Ruijing_UIH Institute For Medical Imaging Technology, Ruijin Hospital, Shanghai, China. Before joining Ruijin, Dr. Yang has been an Assistant Professor, then an Associate Professor in the Department of Radiation Oncology at UCLA David Geffen School of Medicine for over ten years. She obtained her PhD in magnetic resonance spectroscopic imaging from Columbia University and finished her therapy medical physics residency training at the Memorial Sloan Kettering Cancer Center. Her research focuses on advanced development of multi-modality imaging techniques for Radiation Therapy, including dynamic multidimensional imaging for treatment planning and functional imaging for assessing tumor response to radiation.

Candidates for NACMPA Board member at larger 2023



Qin Lei PhD

NACMPA Member

Dr. Lei Qin is an Assistant Professor of Radiology at Harvard Medical School and the Director of medical physics at the Department of Imaging, Dana-Farber Cancer Institute. Dr. Qin completed her Ph.D. thesis at NIH and received her Ph.D. degree in Bioengineering from University of Maryland, College Park in 2009. She did her post-doc training at Brigham and Women's hospital, an affiliated hospital of Harvard Medical School. Her current job includes overseeing quality control of all imaging modalities and optimizing imaging protocols to improve image quality. Dr. Qin's has authored/co-authored over 50 peer reviewed publications. She is currently a member of AAPM online learning services subcommittee and diagnostic workforce sub- committee.

Troy Zhou PhD

NACMPA Member

Dr. Zhou joined Johns Hopkins Medicine in March 2021 and currently serves as the Chief Physicist for Johns Hopkins Radiology. In this role, he leads a team of medical physicists and oversees all aspects of medical physics in the radiology department. He is responsible for ensuring the safe and effective use of radiation in medical imaging and radionuclide therapy, as well as maintaining compliance with regulatory and accreditation requirements.

Prior to joining Johns Hopkins, Dr. Zhou had a successful career in medical physics spanning academia, industry, and consulting. He earned his Ph.D. in Engineering from Dartmouth College, where he gained expertise in radiation oncology physics. He then completed a post-doctoral research fellowship at the University of Pennsylvania, where he focused on advancing the field of radiation oncology physics. After his fellowship, he worked in industry as a scientific marketing director for Siemens Medical Solutions in Computed Tomography. He then moved into medical physics consulting, serving as the lead Imaging Physicist and Senior Director for Professional Services at Landauer Medical Physics. In 2019, he founded Zhou & Associates, LLC, where he served as their Principal Consultant.

Dr. Zhou is a board-certified medical physicist in Diagnostic Imaging Physics and Nuclear Medicine Physics, highlighting his deep understanding of the physics behind medical imaging and radionuclide therapy.

石成玉 PhD, DABR, FAAPM

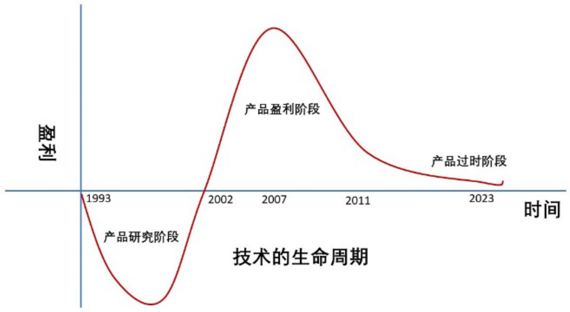
石成玉博士目前在加州橙郡希望之城（City of Hope, Orange County）担任资深医学物理师， 之前他曾经在纽约质子中心，纪念斯隆凯特琳等多家医院任职，并于2020年被AAPM 授予荣誉会士(Fellow)。他曾经参与制定AAPM TG 148 (TomoTherapy 质保)，AAPM TG 330（EPID质保）等多项工作，并担任JACMP编委一职，APEX认证巡查官，ABR第一部分考试出题官。同时发表90篇以上同行评议文章，并在AAPM年会多次做过报告。石成玉博士对蒙特卡罗模拟计算，人体建模，加速器质保等有很深入研究，并有近20年临床经验，同时多癌症医院建设，管理，日常运营，品质认证等都非常熟悉。

Dr. Shi is a senior physicist in the Department of Radiation Oncology at City of Hope National Medical Center. He also worked at the New York Proton Center as a senior physicist and at the Memorial Sloan Kettering Cancer Center as New Jersey's Lead Physicist before he joined the City of Hope. He was awarded the AAPM fellowship in 2020 and served in AAPM TG 148 for tomotherapy QA and TG 330 for EPID QA. He also serves as a member of the JACMP board of associate editors and published over 90 peer-reviewed papers. He also serves as the Apex surveyor, ABR part I question provider and member of the virtual training resource working group of AAPM. Dr. Shi's research interests are in Monte Carlo simulation, virtual human phantom development, and applications, quality assurance for LINAC, imaging-guided radiation therapy technologies, special treatment techniques including stereotactic body radiotherapy, stereotactic radiosurgery, and more. He has many years of experience in facility start-up, commission modalities, and maintenance of continued QA.

漫谈TomoTherapy对放疗领域的影响

TomoTherapy has a great impact on the radiation oncology field. Its hardware design and software potential shorten the follow-up product design efforts. The story of TomoTherapy founder, Rock Mickie, also inspired other medical physicists to devote themselves to new ventures of a high technology company. It also has insight look how we should develop future radiation oncology devices and learn lessons from the TomoTherapy story.

"Everything has a beginning has an end" 这句话讲述了事物的发展规律：都有产生，发展，高潮和消亡的过程。而这个过程往往是波浪式前进，螺旋式上升的。 当Rock Mackie于1993年发表了"TomoTherapy: A new concept for the delivery of dynamic conformal radiotherapy"[1] 的时候，TomoTherapy还是在原始概念阶段，不过已经具备了最开始的模式。真正的机器大约于10年后才出现，这时候TomoTherapy已经进入了发展阶段，而且是很快的发展阶段（图1大致描述了TomoTherapy的发展曲线）。Rock Mackie自己可能也没有预料到当时的想法会对放疗领域有着深刻的影响，而且这种影响还在继续着。



TomoTherapy技术发展的大致周期。

笔者最开始接触TomoTherapy是2004年， 当时的TomoTherapy还处于非常原始的阶段，大约是十几台机器在临床运行，而订单却如雪片般飞来（据说几百台的订单）。这时候的TomoTherapy已经成立了公司，并且正处于生产数量赶不上订单的局面。当笔者于2005年春参观TomoTherapy公司的时候，每个月该公司也就能够生产1~2台机器，而调试安装需要的相关人员还没有完全到位。所以公司正处于如火如荼发展的前端，面临着市场极大需求，处于技术领先的头羊地位。当时市场上能够做到调强放疗的设备很少，很多还是外挂的多页光栅。面对TomoTherapy这样一体化集成的设备，而且其软件产生的计划是如此之"美丽"，当然就引起业界恐慌和兴奋。恐慌的是如何对抗这个强大的技术对手？尤其是像Varian这样的老牌厂商心里更是焦急，暗中发展了Halcyon的雏形和VMAT技术。而兴奋的是放疗有了很大的技术突破，以前

很棘手的肿瘤位置也能够进行放疗了，这对于放疗行业发展来说是好事，毕竟这个领域需要技术的进步来引导。而当时也正是放疗物理师辉煌的时代，极大吸引了其它领域的人才进入放疗物理师的领域，给这个领域带来了崭新的力量，当然，也是鱼龙混杂的时代，这也引出了医学物理的日后规范化。这种局面大约在2007~2008年开始有了改变，这就不得不提及Cedric Yu于1995提出的另外一个概念”Intensity-modulated arc therapy with dynamic multileaf collimation: an alternative to tomotherapy”[2]， Varian公司终于有了VMAT的雏形，并利用效率这个口号来对抗TomoTherapy，号称2分钟实现放疗。当然，这种口号只是市场化的一种策略了，不过的确效率是TomoTherapy的一个短板，毕竟它需要旋转多圈才能实现放疗的完成，这需要时间的。另外一个方面，TomoTherapy也随着上市的市场化，导致了公司的技术发展出现了限制，后面的发展没有太革命性的进展。如果当时的TomoTherapy能进行Reflexion[3]或者MRIlinac [4]相关技术的研发，不知道市场又是何种情况？

市场没有如果，只有结果。后期的TomoTherapy当然也有很多技术改进，但是革命性的技术没有出现。不过当我们回顾TomoTherapy的发展，同时看到目前流行的技术，你同样会发现TomoTherapy对放疗领域的影响是深刻的。基本上有如下几点：

首先是**图像引导和放疗的一体化**。TomoTherapy概念源于CT的概念，因此它自带图像引导的功能。其所自带的MVCT虽然质量有些差，但是对于放疗定位来说也是足够的。后期很多IGRT技术都是或多或少受到了TomoTherapy的影响，成为一台机器必带的功能了。例如添加MRI, 添加PET，添加kVCT等。其次是**旋转式设计**。后期的很多机型都是旋转式设计，这可以实现多个平面叠加的三维效应。实现了没有死角的三维效果，同时可以无缝治疗长的靶区。再次就是**FFF和单能**(6X)的选择，这不但提高了剂量率，同时还使得设计简单，对日后的SBRT/SRS治疗时间的缩短和机器价格的下降打下基础。另外一个方面，机器本身设计采用了**射线自吸收**的功能，这样就降低了对放疗室的防护要求，节约了用户成本。同时也有了移动式放疗的概念，这些观点对zap[5]和PHASER[6]机型的设计或多或少都有影响。

除了上述硬件上的影响，软件上的**标准化建模**也是一个特点，为日后的金标准数据提供了基础。TomoTherapy的机器软件模型都是一致的，需要调节的参数不多。而需要做的是调节机器参数使得其与软件模型匹配。这为日后的标准化打下基础，也为放疗效果的对比打下物理基础。另外，机器本身添加了**自适应和自检**能力，使得机器更加“智能”, 如果添加了AI功能，我们将会得到更加自能化的机器。这也是Ethos[7]机器和日后机器设计的一个方向。

我们知道，放疗计划系统的核心是：1. 剂量计算的准确性；2. 计划优化的高效率。对于第一点，Rock Mackie以前就提出Superposition/Convolution的算法，已经非常接近Monte Carlo算法的精度了。而对于第二点，经过了很多博士论文的研究，TomoTherapy的优化算法是非常高效率的，其产生的计划在满足靶区标准的前提下，能够很好地降低危机器官的剂量。这归咎于TomoTherapy本身就类似CT的概念，可以实现不同空间位置的调强。另外一个原因就是当时采用的并行算法，给极大寻解空间提供了可能性，后来的GPU应用使得优化更加迅速了。优化基本上取决于原始输入值，优化算法和约束条件。其中优化算法一般是计划系统固化的。好的优化算法是决定一款计划系统优劣的关键。在这一点上，TomoTherapy基本上实现了用户所求。 如果你没有得到想要的结果，这必然是you don’t know what you don’t know，即提出了完全不可能的要求来难为计划系统。

TomoTherapy另外一个很重要的影响就是**Rock Mackie本人**的故事激励了医学物理师投身到技术创新型企业的创立。相信日后很多投身创业的医学物理师都是从TomoTherapy的故事获得了启迪。

笔者同TomoTherapy的渊源是有幸参与了AAPM TG 148[8]的工作。后期的TomoTherapy也经历了很多变化，例如Tomo3D, TomoEDGE, Radixact等等，这也导致了TG 306[9]的出现。这些工作都对TomoTherapy的质量保证提供了一定的参考。2023年的春天，终于实现了一个小小的心愿，同Rock Mickie先生同框了。TomoTherapy的故事还远远没有结束，上面的观点也是笔者自己的观点。有不当之处，万望海涵。后代机器的设计至少可以从TomoTherapy学习到这些：系统和功能更加复杂和全面，但是操作更加容易和智能。几何灵活度需要更高，也可能集成多个粒子和图像功能。甚至是更加生物化和普及。这将为对抗癌症事业提供利器，为人类战胜疾病和生活更美好提供保障。

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2023 mid-winter meeting dinner of invited speakers and chapter officer. From left and clockwise: Zhilei (Julie) Shen, Chengyu Shi, Steve J. Goetsch, Qihui Lyu, Amy Yu, Xiaoyu Liu, David Hoffman, Cally Warren. John Adler. Catherine Gilmore-Lawless . Rock Mickie. Marianne Plunkett. Varun Sehaal.

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Scripting 在放射治疗工作中的应用

Ping Yan, PhD, Montefiore Medical Center

Dr. Ping Yan is an assistant professor and senior medical physicist at the Department of Radiation Oncology, Montefiore Medical Center in New York. Dr. Yan is interested in developing tools to automate clinical processes to reduce treatment errors, boost efficiency and communication, and create a better clinical workflow. She is also interested in clinical software development for physics QA, image-guided radiation therapy, and image-processing tools.

谈到scripting，大家首先想到的就是利用Aria写的API接口ESAPI（Eclipse Scripting API)写的程序。ESAPI提供给用户一个接口来读取数据库的值，这样就不用通过对数据库的查询来得到信息，大大减少了编程的工作量。

利用ESAPI写的大家比较熟悉的商用软件有RadFormation 的 ClearCheck, EZFluence 。ClearCheck是一个帮助物理师自动检查治疗计划的一个软件，可以减少人为导致的错误并且节省检查计划的时间。它包括对Dose Constraints, Structure, Plan parameter, Prescription, Collision的检查，并且能自动生成报告。EZFluence主要是用来自动生成3D的治疗计划，可以提高治疗计划的普遍水平，以及节省时间。另外很多物理师也会自己通过ESAPI来写一些小程序，让工作中的一些步骤自动化。

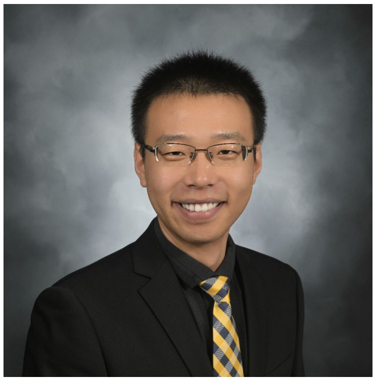
如果仅仅通过ESAPI接口，所读取的数据非常有限，大部分数据只是和治疗计划本身相关，在Aria里的数据，比如说billing, plan scheduling等等, 就无法获取，而这些也是在检查治疗计划中的一部分，还特别容易被忽略。如果需要读取更多的数据，直接通过对数据库的访问是最好的方式。但是在美国大部分医院，对数据库的访问权一般只在医院的IT部门，作为物理师很难有权限访问数据库。

ESAPI主要是用软件Microsoft Net.C#. 也有人写了python的接口，这样你也可以用python来写。Varian有一个文档叫Varian APIs，这是一个很好的起步文档。另外有一些很好的网站资源，有的可以讨论问题，有的有一些免费的程序可以参考：https://www.reddit.com/r/esapi/ ，https://github.com/VarianAPIs/Varian-Code-Samples ，https://github.com/redcurry，https://github.com/Kiragroh/ESAPI_Showcase_ComplexScripts

最后我大概介绍一下我所写的帮助放射治疗的软件，我觉得对工作有很大的帮助。第一个主要软件和ClearCheck差不多的功能，用于自动检查治疗计划，查collision，以及打印报告。还有一些小软件比如说自动生成setup note，这样减少人为输入的错误，也减轻物理师检查的工作。另外一些软件没有通过ESAPI的接口，直接访问数据库，每天或者每周自动运行，来检查是否医生完成PTV的勾画，完成 tasks等等，如果超过时间还没有完成，将自动发email告诉医生尽快完成。这些我觉得非常有帮助，不仅减少了人力，还加快了治疗准备过程。一些病人错过了follow up，也可以通过这些信件得到及时的沟通，重新安排。还有比较有用的是whiteboard，虽然很多地方用care path，但是care path还是不够直观。Whiteboard把每个病人的治疗计划流程都排列出来，非常容易看到计划是否按时完成，避免因为治疗计划没有完成导致的拖延。我的Whiteboard是用python-django写的，好处是django本身已经有很多模板，所以界面比较容易，但是python要求装很多软件包，有许多没有太多用处。相比之下，ASP可能是一个更好的选择。

很多物理师觉得越来越多的商业软件出现，没有必要in-house软件，但是我觉得各有利弊。商用软件必须满足大部分人的需求，因此导致检查的项目太多太杂，每个地方检查的项目不同，商业软件无法满足客户所有的要求。如果有自己in-house软件，可以按照需求随时更改，也会更有效率。但是in-house的软件维护和更新不如商业软件方便，软件的维护也是一个不太小的工作量，到底要怎么安排工作时间？是否需要雇佣专门的人员来维护？如果写软件的人离开，是否能交接好，保证软件能继续运行？我个人的经验是非常重要复杂的软件还是应该采用商用软件，一些辅助简单的工作可以采用in-house软件，还有就是没有商业软件的领域，只能用in-house软件。所以最好的方式是大家根据自己的需要，同时采用商业软件和in-house软件。

FLASH radiotherapy presents exciting opportunities for medical physicists



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Memorial Sloan Kettering Cancer Center (MSKCC); New York Proton Center (NYPC)

Yunjie Yang, PhD, is currently a Medical Physics Resident at the Memorial Sloan Kettering Cancer Center (MSKCC). Before joining MSKCC, Yunjie was a Postdoctoral Research Fellow at the New York Proton Center (NYPC). At NYPC, Yunjie worked on multiple projects in proton FLASH radiotherapy, focus on the experimental measurement and validation. Before transitioning to medical physics, Yunjie obtained his PhD in experimental particle physics from the Massachusetts Institute of Technology and his bachelor's degree in physics from the University of Michigan. During his training in particle physics, Yunjie searched for as-yet-unknown phenomena, such as the axion-like particles, and worked on various particle detectors, such as a novel Cherenkov-based detector for particle identification.

Recent years have witnessed a rapid growth of interest among the medical physics community in the so-called FLASH radiotherapy (RT). This current enthusiasm started with a publication by Favaudon et al. in 2014 [1], which also kickstarted the use of the term FLASH to refer to ultra-high dose rate irradiation of greater than 40 Gy/s (versus ~ Gy/min in conventional RT). This work and numerous subsequent studies suggest that these ultra-high dose rate irradiations seem to produce less normal tissue complication while maintaining equivalent tumor control compared to irradiations delivered at conventional dose rates currently employed in clinical practice. Figure 1 shows an example of such studies by Vozenin et al. (2019) [2]. This improved normal tissue protection and similar tumor control under such ultra-high dose rate irradiations is termed the FLASH effect.

If the FLASH effect could be demonstrated clinically in humans, it could have paradigm-shifting implications for the field of radiation oncology as we know it in terms of clinical indications of radiation therapy, dose fractionation schemes, payment models, and even more. Commensurate with these significant implications are the excitement and rapid research and development activities in the preclinical and clinical translation realms, exemplified by the ASTRO meeting survey results as shown in Figure 2. Active research investigations into a wide range of topics related to FLASH radiotherapy range from fundamental radiobiology investigations into its underlying mechanism(s), to the physics and engineering development of delivery and monitoring platforms, and all the way to human clinical trials.

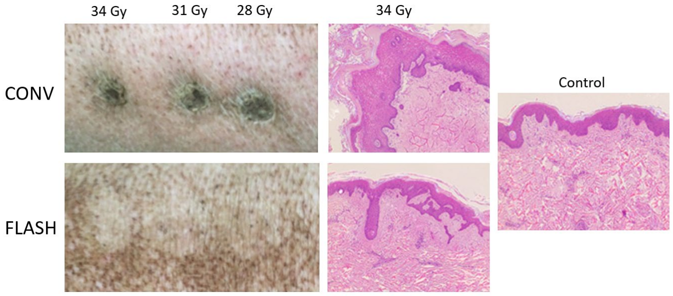

Figure 1. Pig skin FLASH vs CONV results adapted from Vozenin et al. (2019).

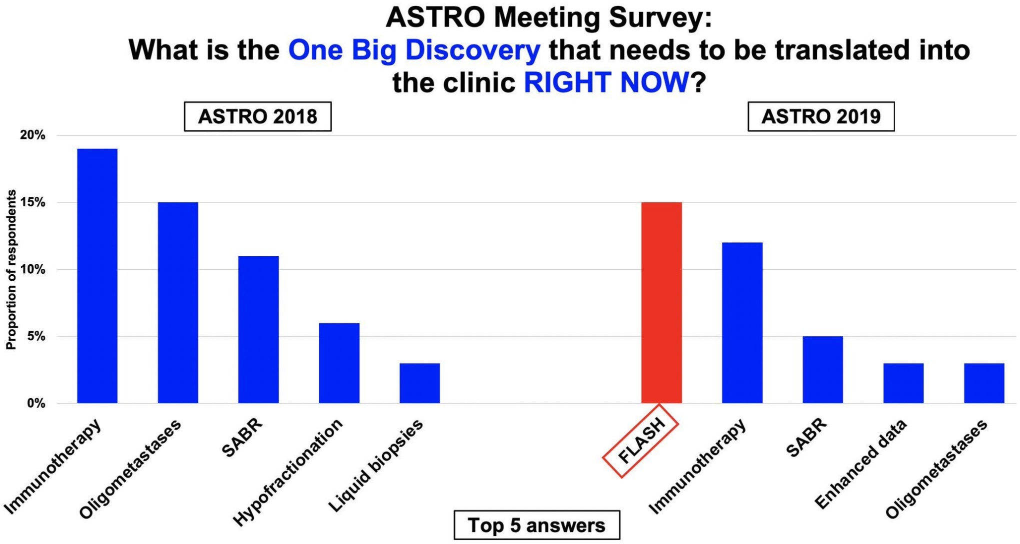

Figure 2. Survey data from ASTRO Meeting.

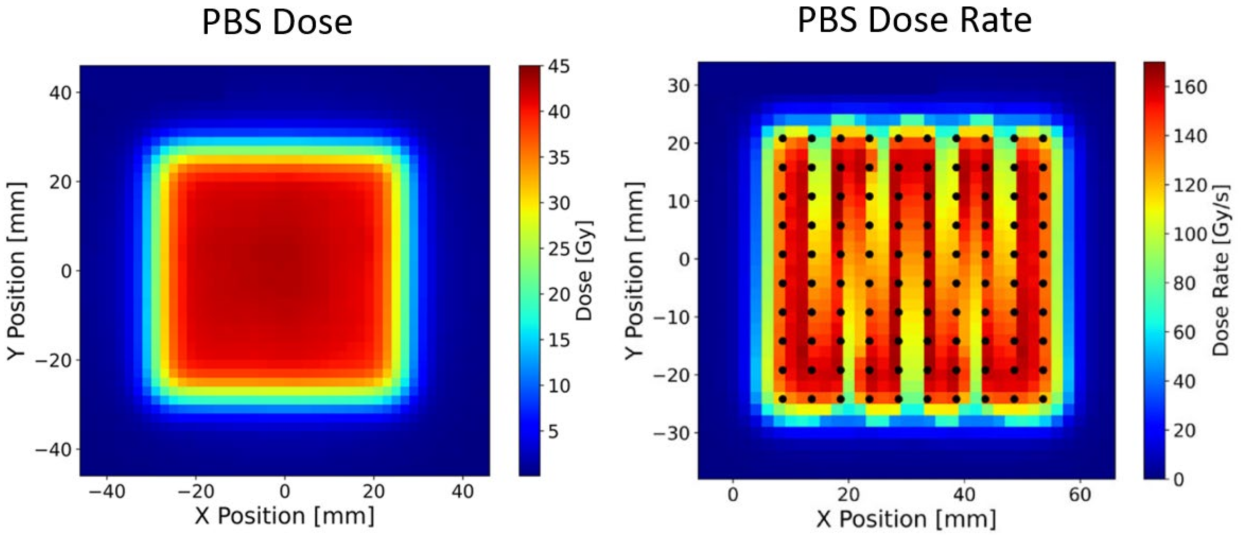

Figure 3. Dose (left) and Dose Rate (right) distributions of a proton PBS FLASH irradiation at a nozzle current of 215 nA.

Despite all the excitement and research activities, the underlying mechanism(s) of the FLASH effect is still very much debated and under active investigation. Some experts in the field are not even convinced, quite understandably, of its existence. Given that extensive literature already exists and that radiobiology is not our expertise, we refer the interested reader to high-quality review articles on this topic [3]. Instead, in this article, we would like to argue that there are excellent research and development opportunities for us as medical physicists to invest in this endeavor regardless of whether the FLASH effect is real. We believe that these newly opened research opportunities are intellectually rewarding (because they present new unsolved problems) and that such research and development endeavors can lead to scientific and technological advances that might still be beneficial even if FLASH radiotherapy eventually did not translate into clinical practice.

As its core foundation, FLASH radiotherapy entails the delivery of therapeutic doses of radiation therapy at much higher dose rates, regardless of the particles used for treatment. The commonly quoted 40 Gy/s dose rate threshold to achieve the FLASH effect is a number with arguably plenty of wiggle room, but it does point to the roughly two to three orders of magnitude difference in dose rates compared to what is routinely delivered in the current clinical practice. This drastic difference in dose rate presents a whole range of directly physics-relevant challenges and opportunities to the delivery platforms, from machine capability (e.g., stability and monitoring) to dosimetry (e.g., methodology and instrument). In addition, the critical role that dose rate plays in triggering the FLASH effect means that dose rate should be an important parameter to be integrated into the entire workflow, from clinical indication and patient stratification to treatment planning, optimization, and plan evaluation, and also quality assurance and so on. The inclusion of dose rate effectively adds a new dimension to consider when it comes to treatment planning, optimization, and plan evaluation, and it presents a host of new problems that need to be answered. Many groups, including New York Proton Center, pursued questions in both directions, from treatment planning studies to machine characterization and dosimetry measurement. Figure 3 shows an example measurement of the dose and dose rate distributions of a proton pencil beam scanning (PBS) FLASH irradiation field measured by a newly designed strip ionization chamber array detector with high spatial and temporal resolution [4].

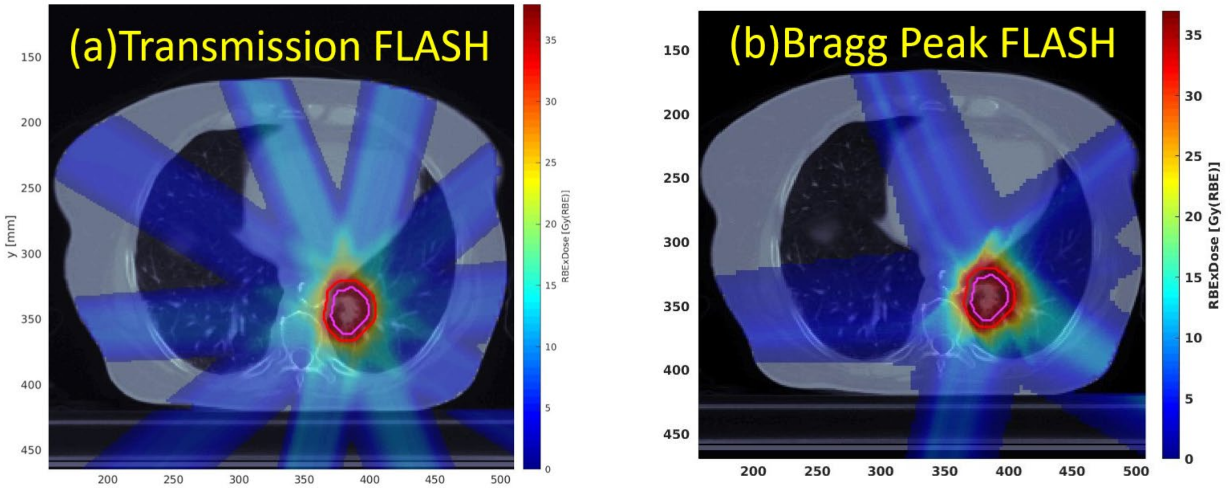

Figure 4. Treatment planning of PBS proton FLASH RT for a lung cancer patient: (a) transmission FLASH planning; (b) Bragg peak FLASH planning.

Up to this point, we have not even mentioned the specifics of the delivery platforms that have been investigated for FLASH radiotherapy in both preclinical and clinical translation settings. Essentially, FLASH started with electron beams because they are widely available in preclinical settings, as exemplified by the seminal work by Favaudon et al. in 2014. However, clinically used electron beams with energies up to 20 MeV have limited clinical translation capabilities due to their limited range in tissue (there is active research into the so-called Very High Energy Electron (VHEE) platforms in large national labs as a potential avenue). Photon-based FLASH platforms currently still remain challenging because of their stricter requirement on machine capability due to inefficient Bremsstrahlung production. Proton-based platforms emerged as a potentially appealing option for early clinical translation due to their tissue penetration capability and the minimal modifications needed to the existing clinical machines. For example, in a cyclotron-based proton system in a clinical setting, the typical beam current that reaches the treatment room is up to 1 nA or less, depending on the proton energy. However, the beam current at the cyclotron itself can reach several hundreds of nA. With minor configuration changes only to the energy selection and beam transport system, reaching 200 nA or higher beam current at the end of the treatment nozzle is applicable using the highest proton energy from the cyclotron (minimizing the fluence loss from the energy degrader). This readily available nature of the proton FLASH platform is exemplified by the Varian-sponsored FAST-01 and FAST-02 FLASH human clinical trials, which use a cyclotron-based ProBeam proton system. Most of the current applications of PBS FLASH RT are based on the proton transmission geometry (Figure 4(a)), and more recent research attention is shifted to the Bragg-peak base proton FLASH RT (figure 4(b)). In essence, each delivery platform, or even variations of a similar platform (e.g., isochronous cyclotron vs. synchrocyclotron proton FLASH systems), presents unique challenges. Each platform leads to implications and opportunities for investigations into all the issues mentioned above, such as machine capability, monitoring, dosimetry, treatment planning and optimization, quality assurance etc.

While the normal tissue-sparing effect is the main selling point for FLASH which generated excitement around it, it is worth noting that even if only the equivalent tumor control (without worse normal tissue toxicity) is demonstrated, its drastic reduction in treatment time can also lead to significant implications to our clinical practice. Therefore, all the tools we will have developed for ultra-high dose rate radiation therapy delivery will be invaluable as the technological foundation for translating this type of treatment.

In conclusion, the foundational component of FLASH radiotherapy is the safe and high-quality delivery of radiation at ultra-high dose rates, which inherently entails substantial physics involvement. The recent excitement about and investment in FLASH radiotherapy presents excellent opportunities for us as medical physicists to make significant contributions to the research and development of this emerging technology. Even if some of the radiobiological effects of FLASH might not necessarily translate into eventual clinical practice, the technological advancement from these R&D effects will likely advance our field and benefit our patients in meaningful ways.

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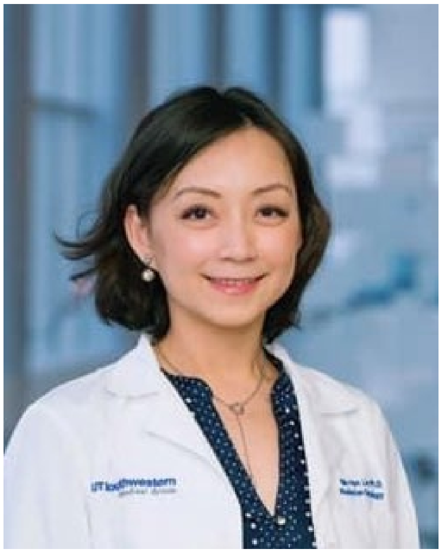
Clinical Implementation of kV CBCT Based Online Adaptive Therapy

Mu-Han Lin, Ph.D. University of Texas-Southwestern Medical Center



Mu-Han Lin is an associate professor and the Director of Treatment Planning at the Department of Radiation Oncology, University of Texas Southwestern Medical Center. Dr. Lin also serves as the lead physicist of Ethos adaptive therapy service. Her research focus is translating and implementing artificial intelligence models and automations to improve clinical workflow. She and the team at UTSW have successfully implemented the AI malignancy prediction, AI synthetic CT, AI segmentation, and AI dose prediction modes into routine clinical use. She is also actively involved in the society such as the AAPM working group on treatment planning (WGTP) and the Task Group No. 395, X-Ray based Online Adaptive RT: Guidelines for quality assurance and clinical implementation.

Adaptive therapy is a conventionally complex and labor-intense workflow. Advances in automation and artificial intelligence have enabled accelerated workflows that are more streamlined and require minimal human intervention during the online adaptive therapy (oART) process. Nowhere is this more evident than kV CBCT based online adaptive therapy system (Ethos, Varian), whereby artificial-intelligence and deformable-image-registration automate the contour generation and daily adapted plan generation. These new features reduce human intervention, but also introduce many 'black box' steps that the clinical team – largely led by medical physicists – must manage quickly while the patient is on the treatment couch. UTSW started kV CBCT based oART service in June 2021 and has treated over 2800 fractions of adaptive treatment. This article will provide overview of the workflow, new challenges, and practical solutions and suggestions for the clinical implementation.

1. Overview of X-Ray based oART Process

Ethos automatic oART process was made possible by users setting the contour and optimization strategies at the pre-plan phase and the system will use exactly the same parameters to generate auo-contour and auto-plan during oART process. All oART steps in Figure 1 are performed in single user interface (e.g. no image/contour/plan transfer needed) to allow the users focus on the task on the screen. Ethos oART process starts with the CBCT acquisition for online planning. Contrast and/or motion management or can be considered to improve the image quality and reduce motion. User would verify the image quality, scan length, and iso-center location prior to proceed the

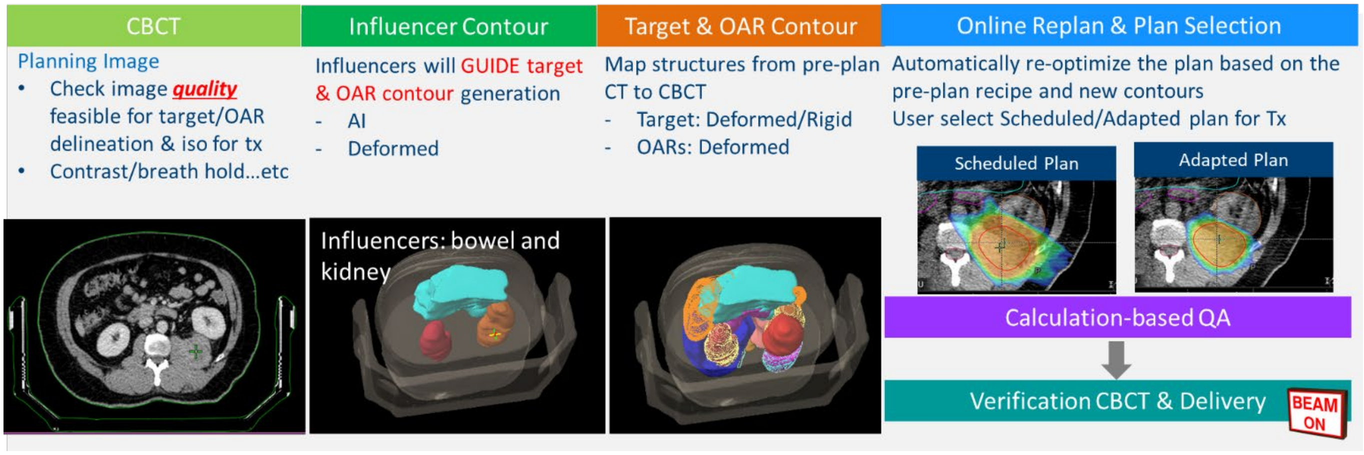


Figure 1. Online adaptive therapy process

contour step. One unique step of Ethos workflow is the 'influencer' step. Influencers are structures that are in the closest proximity to the target(s) and have the biggest impact on their shape and position. They are pre-defined by the site-specific planning template selected by the planner during the pre-plan phase. This 'influencer' step is intended to get user's early input of the key anatomy of the treatment site to 'anchor' the main structures and guide the generation of the remaining structures. User will be offered the target and OAR contours to review and, the derived structures (e.g. PTV and tuning structures) will be generated based on the formulas setup at pre-plan phase. Subsequently, system will start re-calculating of the reference plan (physician approved plan generated at the pre-plan phase) on the anatomy of the day ('scheduled' plan) and re-optimizing the plan based on pre-determined optimization strategy and the day ('adapted' plan). The calculation-based quality assurance will be automatically triggered upon the plan generation completion. User will review the scheduled and the adapted plans and select one plan for treatment delivery. Despite each re-optimized plan considerably considerably different from the reference plan, calculation QA for the ART plan alone, which takes the inhomogeneity in patient body into account, is sufficient for patient-specific QA of Ethos oART (1,2).

2. Clinical applications and evidences

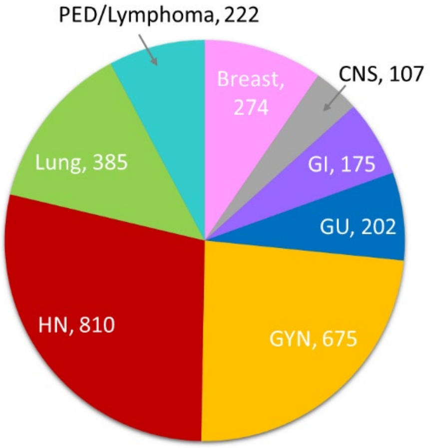


Figure 2. Applications of kV CBCT based adaptive therapy

Figure 2 shows the number of adaptations for individual treatment sites. The application covers a wide range of body sites, and the key is the visibility of target and OARs on the CBCT. We will describe the indications in the two sub-sections.

The candidate selection process started from the time physicians order the simulation and physicists are often time involved to assist physician to make clinical decision. The main criteria include:

- visibility of tumor & high impact OARs on CBCT(3,4)
- technical feasibility such as tumor size/length/depth/off-axis
- clinical feasibility
    - can patient stay on table for longer time? how likely we will see the changes of tumor and when? …etc.
- adaptive treatment frequency, margin and dosimetry benefit
- insurance reimbursement for IMRT

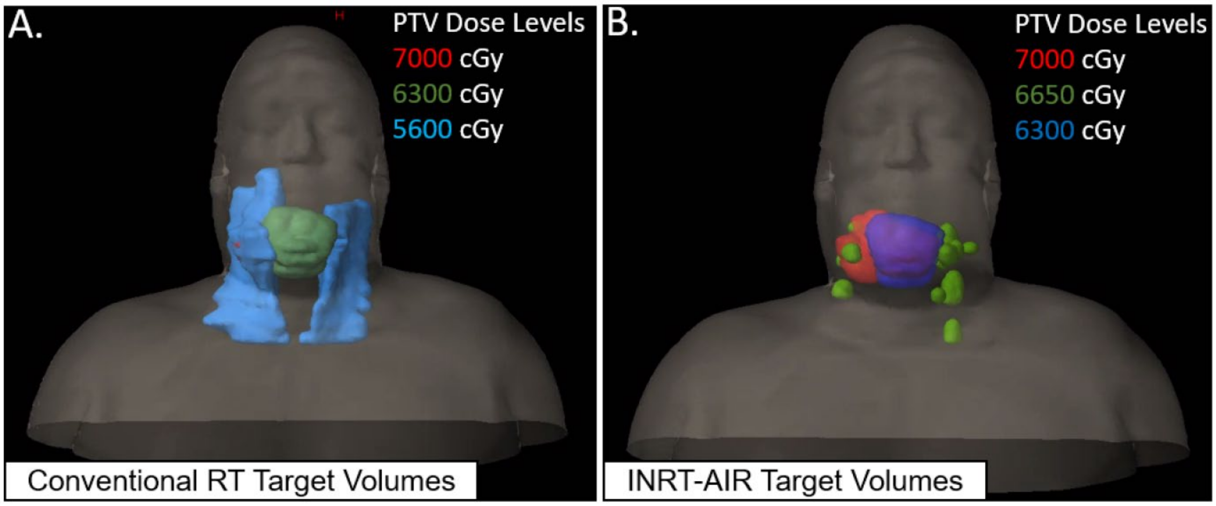


Figure 3. 3D visual of Conventional (A.) and INRT-AIR (B.) PTV dose levels. Note the significant reduction of target volumes (blue) still allows for clear visualization on CBCT during oART.

2.1 Daily adaptive therapy

As the system defaulted to '**daily adaptation'**, the cervix, bladder, pancreas, prostate, rectum, which prone to daily anatomy variation, are feasible to be treated with daily oART(5-8). In addition, women with breast cancer who qualify for APBI are ideal candidates for ART. Lumpectomy cavity changes occur during radiation treatment and the breast setup can be variable resulting in large inter-fraction movement of the target. Our center have been treating stereotactic partial breast irradiation (SPBI) with online adaptive therapy(9). These applications are often time implemented with a reduced PTV margin. Early adopters have reported significant dosimetry benefit with the margin reduction.

The inter-fractional motion was conventionally compensated by large PTV expansions. The daily adaptive therapy opens up the opportunity of margin reduction(10). However, the oART process also takes longer time than conventional IGRT that may compromise the target coverage. Yen et. al., reported change in bladder volume were significantly correlated to CTV coverage when >30 minutes time between planning CBCT and verification CBCT (11). Therefore, the margin reduction should be carefully validated, especially when a reduced margin was derived based on the CBCTs of non-adaptive C-arm linacs since patient will stay longer time on the table to allow online replanning.

Daily oART can also aid to de-escalate the treatment

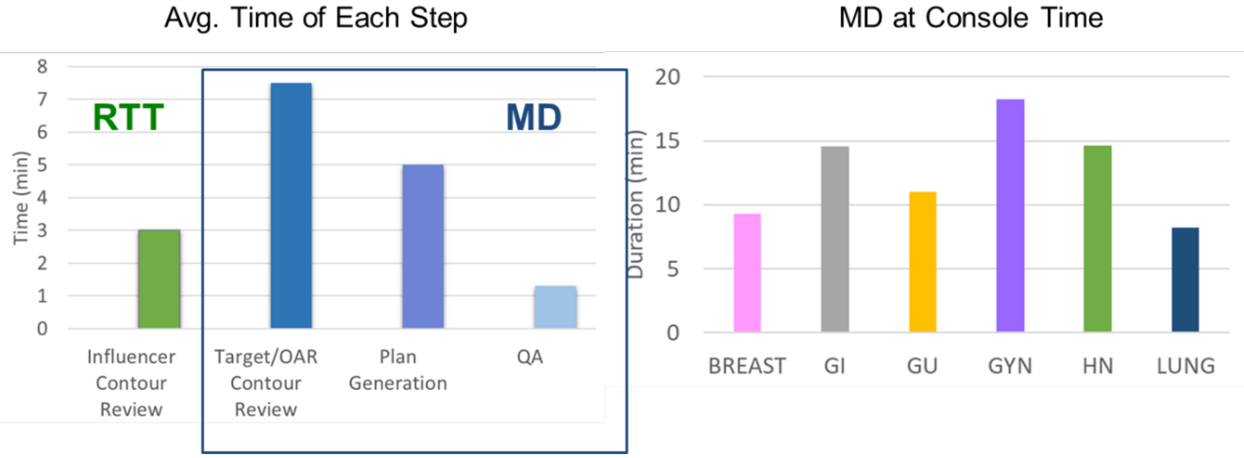
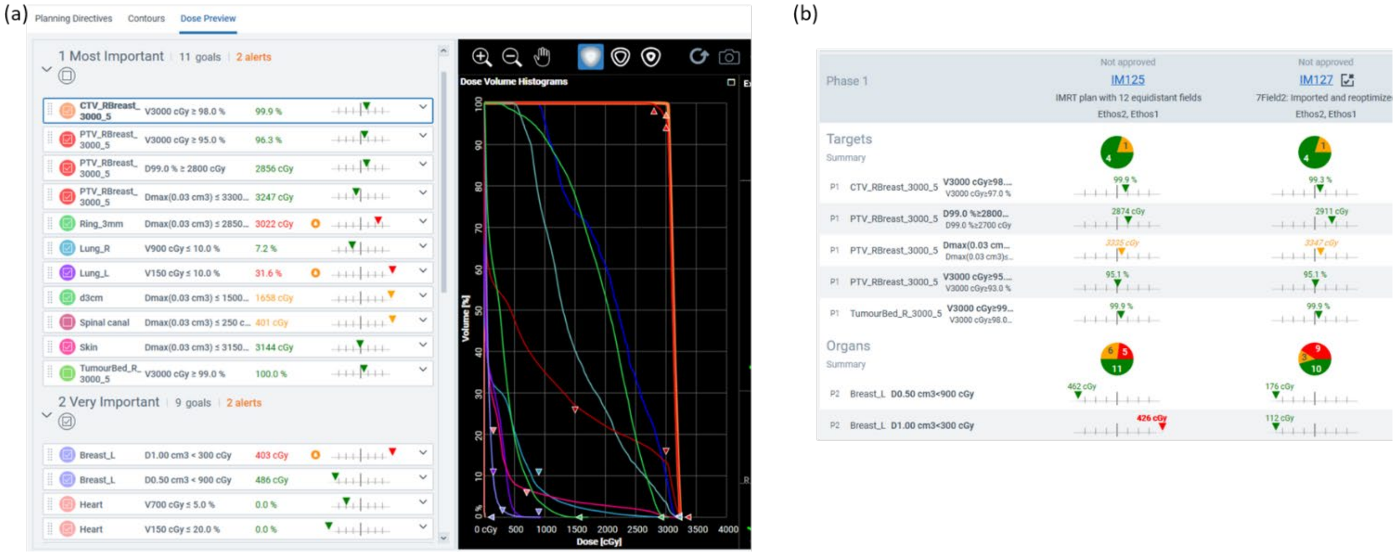


Figure 4. UTSW adaptive therapy efficiency data. The contour review time includes the contour generation time, which is typically within 1 min. (a) The average time the users spent on individual steps for all treatment site. (b) MD at console time: from target/OAR contour review to QA approved.



1 Most Important | 11 goals | 2 alerts

CTV_RBreast_3000_5	V3000 cGy ≥ 98.0 %	99.9 %
PTV_RBreast_3000_5	V3000 cGy ≥ 95.0 %	96.3 %
PTV_RBreast_3000_5	D99.0 % ≥ 2800 cGy	2856 cGy
PTV_RBreast_3000_5	Dmax(0.03 cm3) ≤ 3300...	3247 cGy
Ring_3mm	Dmax(0.03 cm3) ≤ 2850...	3022 cGy
Lung_R	V900 cGy ≤ 10.0 %	7.2 %
Lung_L	V150 cGy ≤ 10.0 %	31.6 %
d3cm	Dmax(0.03 cm3) ≤ 1500...	1658 cGy
Spinal canal	Dmax(0.03 cm3) ≤ 250 c...	401 cGy
Skin	Dmax(0.03 cm3) ≤ 3150...	3144 cGy
TumourBed_R_3000_5	V3000 cGy ≥ 99.0 %	100.0 %

2 Very Important | 9 goals | 2 alerts

Breast_L	D1.00 cm3 < 300 cGy	403 cGy
Breast_L	D0.50 cm3 < 900 cGy	486 cGy
Heart	V700 cGy ≤ 5.0 %	0.0 %
Heart	V150 cGy ≤ 20.0 %	0.0 %

Phase 1		Not approved IM125 IMRT plan with 12 equidistant fields Ethos2, Ethos1	Not approved IM127 7Field2: Imported and reoptimize Ethos2, Ethos1
Targets Summary		4 / 1	4 / 1
P1 CTV_RBreast_3000_5	V3000 cGy≥98.... V3000 cGy≥97.0 %	99.9 %	99.3 %
P1 PTV_RBreast_3000_5	D99.0 %≥2800... D99.0 %≥2700 cGy	2874 cGy	2911 cGy
P1 PTV_RBreast_3000_5	Dmax(0.03 cm... Dmax(0.03 cm3)≤...	3335 cGy	3347 cGy
P1 PTV_RBreast_3000_5	V3000 cGy≥95.... V3000 cGy≥93.0 %	95.1 %	95.1 %
P1 TumourBed_R_3000_5	V3000 cGy≥99... V3000 cGy≥98.0...	99.9 %	99.9 %
Organs Summary		6 / 5 / 11	9 / 3 / 10
P2 Breast_L	D0.50 cm3<900 cGy	462 cGy	176 cGy
P2 Breast_L	D1.00 cm3<300 cGy	426 cGy	112 cGy

Figure 5. (a) Example of 'dose preview' interface in Ethos TPS. Planners adjust the ranking of the goals and the IOE will translate these goals into the optimization parameters in the background and operate the plan optimization. As a result, (b) planner will be offered plans for review.

volume to gain extra dosimetry benefit. One example is head and neck treatment. Treatment de-escalation is actively investigated for patients with head and neck cancer patient receiving definitive RT. With sensitive staging studies and artificial intelligence (AI), our ability to identify occult lymphadenopathy is greatly improving. Our institution investigated the efficacy and tolerability of eliminating elective neck irradiation (ENI) and strictly treating involved and suspicious lymph nodes (LN) with intensity modulated radiation therapy with 5 mm margin and reported favorable outcomes – INRT-AIR (12). With the ability to adjust the dose delivery every day, we launched a prospective study of Daily Adaptive Radiotherapy to Better Organ-At-Risk Doses in Head and Neck Cancer (DARTBOARD) to treat this cohort of patient with near marginless (ML) setup margins with the daily adaptive therapy and evaluate whether daily adaptive radiation therapy can help reduce xerostomia. Our emulation study demonstrated up to 10 Gy mean dose reduction to the submandibular gland comparing to 5 mm INRT-AIR IGRT treatment. We recently completed the enrollment of all patients in May 2023 and the patient outcome to be followed.

2.2 Adapt with flexibility: Adaptive on Demand

There are diseases with gradual changes of tumor response or patient anatomy and the cost-benefit of daily oART maybe dimmed. Hence, we offer ***adaptive on demand workflow*** that leverages Ethos as a simulation-omitted replan platform to update treatment plan and patient will continue IGRT treatment on either Ethos or Halcyon with the adapted plan after Ethos oART. This workflow creates the flexibility of oART frequency. We routinely treat the locally advanced lung cancer patients with pre-scheduled weekly oART and the conventional definitive HN patients with on demand oART triggered by physician’s clinical observation. The workflow has been demonstrated clinically feasible with improved tumor coverage with improved OAR doses(13).

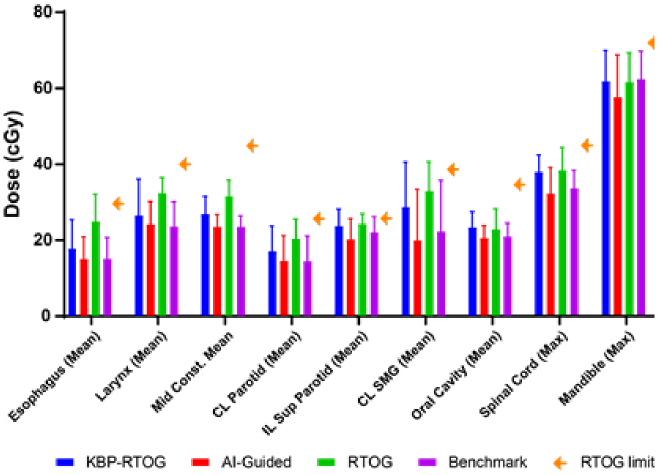


Figure 6. Ethos generated plans with three different approaches comparing to the benchmark plan generated with AI guidance and RTOG limits.

2.3 Team building and oART Efficiency

The requirement of physicians to be at the console is a common barrier to widespread implementation. There are various setup of the person reviewing and editing the contours during oART (adapter). The adapter needs to be familiar with anatomy, contour tools, basics about planning and decision-making & issue escalation process. Dosimetrists, or physicists appear to be natural fit for this adapter role. However, it is also demonstrated that with careful training and credentialing process, radiation therapist can also serve this role(14).

In our institution, we have therapists serve as adapter and edit the ‘influencer’ contours. The physician will be at console from target/OAR contour step to the QA review step. One physicist at the console serves as the ***quality checker*** to cross verify the accuracy of contours with therapist & physician and the ***facilitator*** to guide the therapist and physician to focus the contour edit on the high dosimetry impact area and answer any planning & technical question immediately. With the presence of physicists, we have an average 92% rate that physicians selected the adapted plan for treatment. The fractions physicians selected scheduled plan are mostly due to minimal changes of anatomy/dosimetry benefit or the anatomy/image quality of the day is not feasible for adaptive workflow. The failure of oART plan quality is extremely rare as physicist reviews the consistency of contour strategy in time and resolve any warning and issue. We are moving toward to train the therapists edit the target/OAR contours to further reduce physician’s time at the console.

Figure 4a shows the average time for individual step from the cases adapted at UTSW. The target/OAR contour editing apparently the step takes the longest time. Figure 4b shows the MD at console time for each treatment site. For lung, GU and breast SPBI patients (with surgical clips), the tumor and OARs are very visible, and the physicians only spend ~10 minutes or less at the console. In the opposite, the soft tissue tumor & OARs in GI take slightly longer time due to the lower soft tissue contrast of CBCT and the physician spend ~14 minutes at console. Despite of the numerous OAR contours in HN area, the auto-contour quality of Ethos is decent and hence the MD at console time is about 15 minutes. GYN is the treatment site taking longer time due to the fact that most of the most GYN cases treated at UTSW are patients' nodal involvement and we treat these patients with simultaneous integrated boost approach. There are usually several target volumes to be reviewed and edited.

3. Promises and pitfalls of the automatic planning workflow

The Ethos system features automatic contour and re-optimization during online adaptive process, which result in efficient and smooth workflow. However, similar to other automation tools, the auto-segmented structures or plans may be lacking the 'flavor' of the individual practice styles (5,15). The pre-plan is the key step that sets up the 'script' of automatic online replan process. This includes the selection of 'physician intent' template to define the 'influencers' contour, formulas of target and tuning structure generation, clinical goals, and the plan normalization method. Ethos leverages a novel intelligent optimizer engine (IOE) for automating the pre-plan optimization process. The IOE provides a dose distribution preview to allow the planners to adjust priority rankings and clinical goals. IOE will then translate the clinical goals into optimization parameters and automatically generate plans for the planners to review. However, the IOE does not permit planners to visualize the cost function and modify optimization hyperparameters dynamically. Planners need to iteratively revise the clinical goals/priority for the IOE to generate a new plan, which is not intuitive when the planner is blind to the hyperparameters of plan optimization.

Learning to interact and manipulate the IOE is a common learning curve for new users. Ethos planning is very different from traditional planning. There is no more "pushing" structures or volumes that planners can add on the fly since they can't be easily reproduced during the oART. Instead, the planner needs to formulate the optimization problem as much as possible and make a clear marching order to IOE. Any conflicting goals will impact the reproducibility of the oART plan quality and increase the optimization time.

Several groups already demonstrated that the Ethos/IOE auto-planning can generate comparable plan quality with the Eclipse manual planning(9,16,17). IOE will work on the target and OAR objectives based on the priority and the clinical goals and it has imbedded logic to use the normal tissue objectives (NTO) and cropping structures for optimization. However, the OAR goals based on the national guidelines are usually not difficult to meet, without further input, IOE will not be able to customize the dose distribution style, such as polarizing the dose conformity in the lateral direction to achieve shaper dose fall-off to the rectum. In general, the ring structures derived based on the target and OAR contours are very useful to aid to the OAR goals and guide the IOE to achieve the dose falloffs matching individual institutions' expectation. In the above-mentioned scenario, planner can firstly crop rectum from the PTV with a margin and generate the ring based on the cropped volume to achieve an asymmetric dose fall-off.

In addition, data-driven tools such as knowledge-based-planning (KBP) or artificial-intelligence (AI) dose predictor can also assist IOE to navigate the 'best achievable' plan quality of individual case to meet individual institution's practice style and eliminate the ring structures. One can use the Ethos provided feature to import the existing KBP models into Ethos to assist the IOE plan optimization. It is worth to mention that unlike KBP in Eclipse, IOE does NOT use KBP predicted goals for optimization directly. IOE uses KBP prediction as reference to know if IOE should/can push OAR doses harder.

Our group evaluated Ethos plans generated with fixed RTOG clinical goals, RTOG goals + KBP, and AI dose predictor to generate patient specific clinical goals. We also compared the plans generated with all three approaches with the RTOG goals and our benchmark plans generated with Eclipse TPS and AI predicted goals(18). It is shown all three methods result in plans compliant with the RTOG guidelines. While AI-guided plans were the highest quality, both KBP-enabled and RTOG-only plans are feasible approaches as clinics adopt ART workflows. Similar to constrained optimization, the IOE is sensitive to clinical input goals, and we recommend comparable input to an institution's planning directive dosimetric criteria. AI-guided plans are very comparable with our benchmark plans, which were also generated based on the same predicted doses.

4. Peer-review of oART strategy prior to physician's plan review

Robust plan optimization strategy and consistent contour method are the keys to ensure the quality of adapted plan since the users cannot change the optimization approach or normalization during the oART. Unlike traditional planning which generates one static plan to be used for several fractions, oART pre-planning requires additional thought to ensure the optimization approach is robust against the uncertainty of anatomy change and evaluate the plan quality can be reproducible with quick online adaptive planning.

Formalized peer-review of planning Intent, contours and objectives for optimization is very effective to pick up the deficiency of oART strategy and receive feedback/expertise from all team members can help to ensure high quality oART plans while minimizing last-minute corrections that can be stressful to staff and subject to more errors or failure of oART (ex. unable to generate plan, or plan quality not as expected) while patient is on the table. In our institution, all adaptive plans will go through physicist peer-review prior to the physician's plan review.

Figure 7. Physics team training therapy to use surface guided system for breast ART setup and oART contour with a 3D printed breast on Rando phantom

We learned the physic peer-review has significantly cut down on the number of replans and post FX1 modifications. The periodic conversation of contouring and planning strategies between the planners and physicists can foster more in-depth discussions about the technical and the clinical aspects that impact plan quality. This type of plan quality rounds also helped unite the team members on expectations, potential challenges, and solutions. In our experience, our plan quality is very reproducible during oART and 92% chance our physicians selected adapted plan for treatment.

5. Enhancing physicists' role in oART implementation

AI empowered kV CBCT oART system provides an automated and streamlined process to re-optimize the plan while patient is on couch. However, it also introduce new learning curves in resource coordination and in technology learning. There are many knobs from simulation and pre-planning controlling the quality and efficiency of oART. Physicists' technical insights and clinical knowledge can tailor the workflow to individual institutions' need and facilitate more robust, high quality and efficient oART. In addition, one can also identify opportunity for improvement and build additional automations to reduce the resources.

Building a collaborative environment between the multi-disciplinary members (physicians, planners, therapists, nurse, billing team) can help all parties to understand the clinical need, resources constraint, and perform the reality check of what are technically and clinically feasible and practical for your institution and design a better master plan for implementation. Physicists can work with physicians, planners, and therapists and lead the effort of developing site-specific physician intent templates, which carries the prescriptions, contour strategies, clinical goals, formulas of target/tuning structures, and planning approach for oART. Dry run/tests in the emulator or phantom on couch can train the team members to be familiar with the oART workflow and get the team member's feedback/idea to further improve the contour/planning strategy design and progressively reduce the oversight and build confidence. Keeping this communication loop open is crucial for future process refine.

Whether the physicists should be planning adaptive cases may be controversial, our experience suggests physics involvement planning and peer-review of adaptive intent is very beneficial for the planners to get used to the automated IOE planning and strike key elements for high quality oART. While training in treatment planning is an essential component of therapy physics residency programs, there exists a wide range of involvement and expertise in treatment planning among different institutions and practicing physicists. Physicists are encouraged to increase the exposure of treatment planning and the automation/artificial intelligence tools to better prepare for future applications of oART.

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An Artificial Intelligence Driven Brain Metastases Stereotactic Radiosurgery Management Platform

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Hao Jiang, Ph.D., is a renowned figure in the field of medical imaging and radiation therapy, known for his groundbreaking contributions and innovative research. With a strong background in experimental nuclear physics and nuclear engineering, Hao has spent over two decades at the forefront of cutting-edge technology and its applications in healthcare. His expertise and passion have led to significant advancements in the field, making him a respected AI research physicist and entrepreneur. With a Doctor of Philosophy degree in Nuclear Engineering and Radiological Sciences from the University of Michigan, Ann Arbor, Hao possesses a solid academic foundation. However, it is his practical experience and relentless pursuit of knowledge that truly set him apart. Hao has dedicated his career to designing, developing, and optimizing medical imaging devices and radiation therapy software. His expertise ranges from the development of radiation detectors to the design and characterization of advanced imaging technologies, such as x-ray active-matrix flat-panel imagers (AMFPIs) and CMOS imagers. Hao's contributions extend beyond the academic realm. As the Founder and CEO of NeuralRad LLC., Hao leads a team of talented professionals focused on the development of innovative medical solutions. His leadership has led to the creation of state-of-the-art proton and photon treatment planning systems, leveraging ultrafast GPU Monte-Carlo dose engines and deep learning-based structure delineation. Furthermore, Hao's expertise has been instrumental in the design and development of a multi-brain metastases stereotactic radiosurgery software platform, as well as a proton quality assurance device and software for proton Flash therapy.

Brain metastases (BMs) represent the most common brain cancers with a median survival of 11 months. Current data estimate ~200,000 new patients develop BMs annually and most of patients has clinical manifestation of multiple BMs (mBMs)[1,2]. Historically, whole brain radiotherapy was the standard radiotherapy care for mBMs patients; however, multiple clinical trials (JRSOG99-1, NCT00548756, EORTC22952-26001, NCCTGN0574) have shown that WBRT is associated with a neurocognitive decline and quality of life (QoL) decrease[3-5]. Stereotactic radiosurgery (SRS) offers high BM local control by delivering biologically potent dose to the target, while having the rapid dose fall off to limit radiation exposure to surrounding normal brain to lower neurological and neurocognitive damage[6]. SRS has increasingly become one of standard cares for mBMs[7-11]. However, the management of mBMs with SRS poses several challenges: 1) mBMs, as named are many and often small and scattered around the brain. Thus, manual identification and delineation could be labor-intensive and error prone. 2) Treating mBMs in close proximity to one another leads to an increased dose to normal brain, potentially increasing the risk of necrosis. Also, for GammaKnife and Cyberknife SRS, a single session treatment of multiple metastases may last several hours, causing significant patient discomfort. 3) Routine SRS treatment follow-up to track multiple lesions is also a tedious task. To overcome the challenges, our group developed an artificial intelligence (AI) driven mBM SRS management platform. Figure 1 illustrates the overall framework of AI-driven mBM SRS management platform. The platform consists of a front-end web client and a back-end server. The front-end web interface enables access to the patient data base and displays contours, plans, and follow-up images. The backend is AI-driven computational modules including AI-based auto-segmentation/labelling module and spatial-temporal BMs distribution module. The platform operates in the following manner: Users can access it via any secure browser. Upon logging in, they are directed to the patient database. After selecting the patient data, the Contour module processes the information using our in-house AI-based algorithms for auto-segmentation, false-positive reduction, and labeling in the background. The results are then displayed. Once the segmentation is confirmed, the Group module uses the spatiotemporal BMs planning module to auto-distribute the BMs into different treatment sessions. The distribution is visualized in 3D view, with BMs of the same color assigned to the same treatment session. Next, the Plan Review module allows users to review plan properties such as prescription, shots, and grouping information with the contours. The Follow-up module offers treatment follow-up image comparison and multi-course treatment dose tracking. Key components of the platform are detailed in the following.

1. Web Client

The web client or web interface is developed with HTML and JavaScript. It can be launched with any common web browsers. Once under the institutional internal network, certified users can access the web client via the server IP/Port address. This web-based design allows the users to utilize the developed tools without software installation on local computers. The web client enables user interaction such as database access, image visualization and task selection. Meanwhile the web client also communicates with the back-end server, which is responsible for executing tasks, for instance, data format conversion, BMs segmentation and labeling, post-processing, etc.

2. Database

Database design is crucial in constructing this platform for managing patient data. Patient data usually contains two main components in clinics: DICOM images and non-

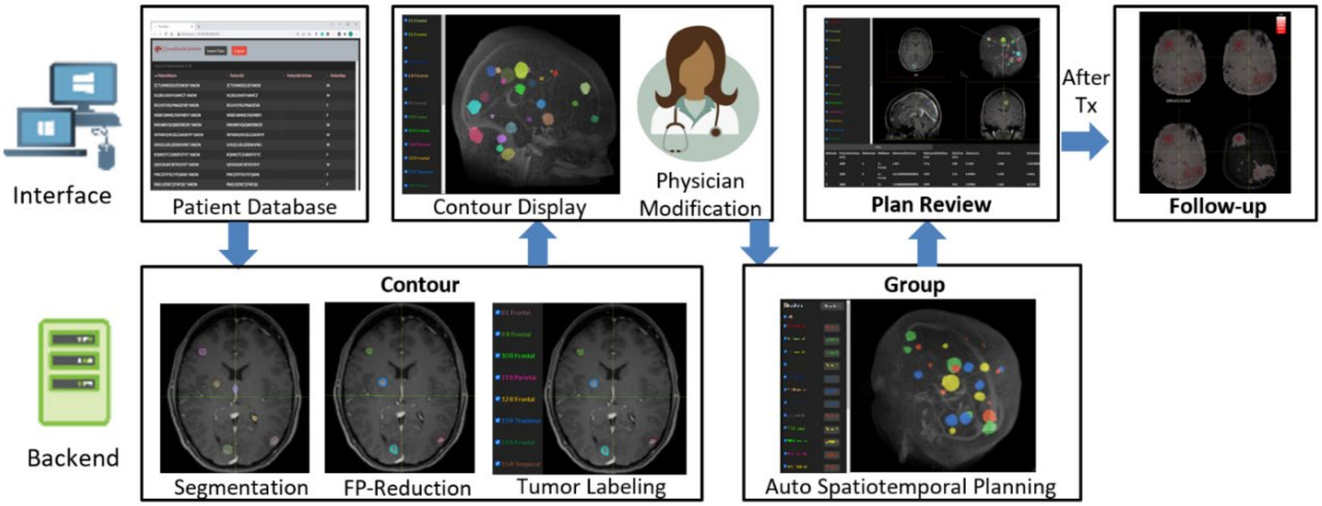

Figure 1 The workflow design of the AI-based mBMs SRS management platform.

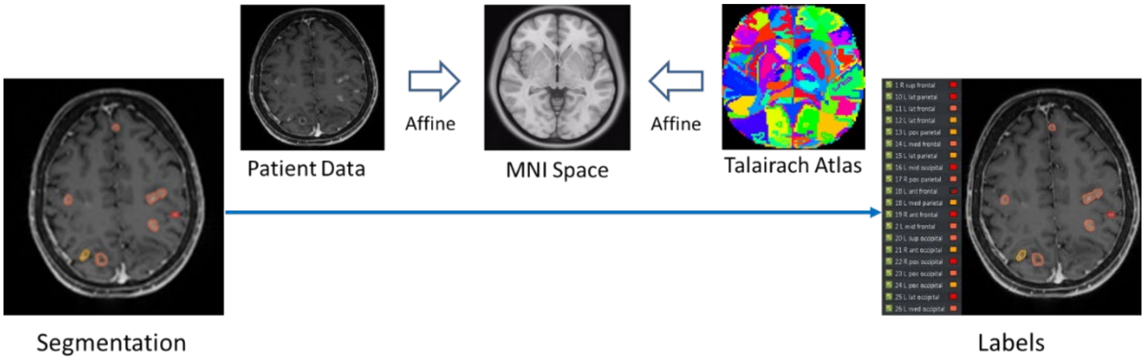

Figure 2 The automatic BMs labeling process.

image clinical parameters. These two components support each other and are inseparable for clinical use. To manage the database efficiently, two kinds of database structures are implemented in this platform: NeuralRad DicomServer and SQL-based database. NeuralRad DicomServer is a commercial-grade custom-developed, lightweight, and standalone DICOM server for healthcare and medical research. Our platform utilizes NeuralRad DicomServer to store the DICOM images. For clinical data, another open-source SQL database is implemented. SQL database is powerful in processing clinical parameters. Clinical parameters such as primary histology, prior SRS, prior WBRT are usually non-relational and unstructured data, making the JSON format preferred in our implementation. Within the database, data is stored as key-value pairs. Patient ID is set as the key to connect these two databases and link all clinical parameters. Once uploaded to this platform, patient data will be stored in the platform database. Users can import images from this database or local folders for different tasks. In addition, this database also allows users to conduct follow-up evaluations utilizing patient treatment history stored in the database. For patient confidentiality and data security purposes, web client access is required to be under a secured network environment with valid individual credentials.

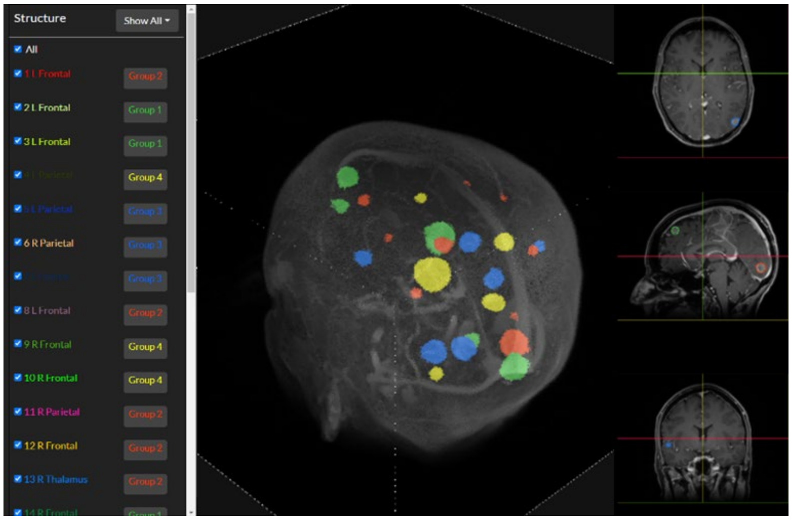

Figure 3. mBM automated distribution visualized on the platform, different color represents different groups.

3. AI-based BMs segmentation

Our group developed an automatic BMs segmentation algorithm with a deep learning algorithm, En-DeepMedic, based on T1c image only. Concentric local and global 3D image patches will be extracted from the input image volumes and then utilized in the En-DeepMedic CNN architecture to accurately segment mBMs. We incorporate the above segmentation algorithm along with other necessary preprocessing procedures into this platform, thus ensuring this platform is robust for conducting the BMs auto-segmentation task in clinical SRS cases. The segmentation workflow implemented in the platform can be described in the following steps: 1) Convert the original DICOM images into Nifti format and resample into the resolution of $1mm^3$; 2) Strip Skull using a robust learning-based MRI brain extraction system (ROBEX); 3) Segment BMs with the En-DeepMedic network; 4) post-processing to remove false positives. AI-based mBM segmentation algorithm and AI-false positive reduction algorithm are detailed in the reference[12,13]. The accuracy of AI-segmentation module was initially evaluated on 10 clinical cases with number of BMs varied from 11-81. The overall operation takes about 4-5 minutes for each patient. The segmentation accuracy is

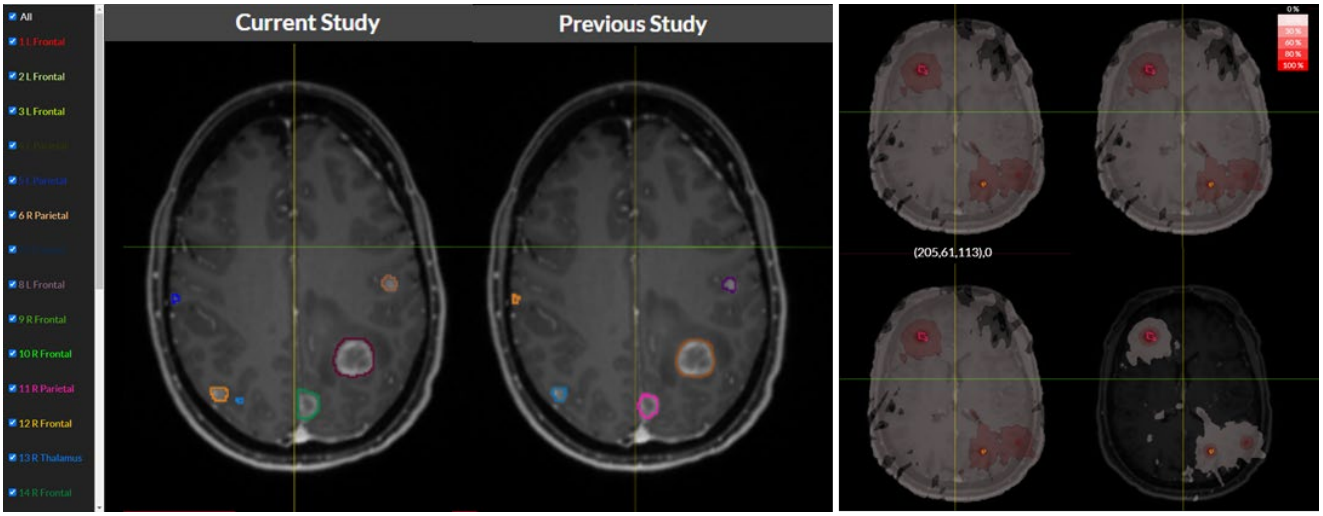

Figure 4. The Follow-up module provides the follow-up image comparison (on left) and multi-course dose tracking (on right).

measured between the manual contour and the automatic segmentation with averaged center of mass shift (COMS) as 1.65±0.29 mm, Hausdorff distance (HD) as 3.09±0.50 mm, the mean of surface-to-surface distance (MSSD) as 1.12±0.27 mm and the standard deviation of SSD (SDSSD) as 0.82±0.14 mm, and the initial averaged false-positive rate (FPR) and false-negative rate (FNR) before post-processing as 0.47±0.17 and 0.18±0.15, respectively. After post-processing with default parameters, the averaged FPR and FNR are 0.29±0.17 and 0.20±0.15, respectively.

4. BMs labeling

In clinical practice, physicians label each BMs contour based on its anatomical location within the brain. This process is essential for treatment planning and treatment follow-up by identifying each tumor. To mimic and automate this manual labeling process, we designed an affine registration-based algorithm to automatically label BMs contours. The general idea of this algorithm is to map the patient's brain into a common brain atlas and to label each BM based on its location in the atlas. In this platform, we utilized the Talairach (TAL) atlas 36 as the template for BMs labeling. The TAL atlas is a 3-dimensional coordinate system of the human brain that can be used to map the orientation of brain structures independent of individual variations in size or shape. It provides a hierarchy of anatomical regions based on volume-occupant with corresponding labels indicating the hemisphere level, lobe level, gyrus level, tissue level and cell level correspondence. Considering the actual clinical need in radiation oncology, in this platform, the original five-level label from the TAL atlas is condensed to a two-level label indicating only the hemisphere and lobe of the BM location in the TAL atlas.

Accurately mapping patient data into the TAL atlas is crucial for the BMs labeling process. However, the TAL atlas is not an MRI-like intensity-based brain atlas, which can cause errors when registering patient images with the TAL atlas. Considering this potential problem, we incorporate another commonly used brain atlas into the labeling process, which is the MNI standard space. The MNI space is a brain atlas model generated by averaging 305 T1 MRI brains. The transformation between the MNI space and the TAL space has already been investigated by many research groups. Therefore, using the MNI space as a co-registration bridge between TAL space and patient data could obtain more accurate transformation than directly registering TAL space and patient data together. In the registration process, affine registration is chosen in this task for time-efficiency's sake and avoiding unexpected distortion caused by inaccurate deformation in certain regions. Detailed labelled implementation can be found in the reference[14]. Figure 2 illustrates the workflow for the automated BMs labeling strategy.

5. mBMs distribution

The distributed mBMs SRS approach aims to keep the single-shot dose to the target to preserve tumor control probability while fractionating the dose to the organs at risk to minimize the radiation toxicity. To facilitate mBM distributed SRS, we develop a mBMs distribution algorithm that models the intuition behind the clinic's strategy. The problem of distributing BMs can be described as the following: given a set of BMs to be treated, a complete treatment plan including delivery information for all BMs in the set, and the number of treatment sessions, the aim is to find a BM distribution (session assignment) that satisfies the following conditions: 1) every BM is assigned to only one session, 2) close BMs are separated into different sessions, with more emphasis placed on larger BM volume, and 3) the delivery time for each treatment session is approximately equal, without significant variation. To address the BM distribution problem, we formulated it using the field potential framework and transformed it into an optimization problem that can be solved automatically. The electric charge distribution problem becomes a mixed-integer quadratic programming problem with binary variables to be solved. Our approach shows that the automated distribution has a lower energy objective than the manual distribution, making it the optimized solution. Figure 3 illustrates mBMs automated distribution results visualized on our platform.

6. Image Follow-up and Dose Tracking

Using the follow-up T1c MRI images to assess the size and location of tumors, making it a useful tool for tracking tumor growth or shrinkage over time. By comparing T1c images taken at different points in a patient's treatment, clinicians can monitor the effectiveness of therapies and make informed decisions about treatment adjustments. In addition to T1c imaging, tracking the delivered radiation dose to the tumor over multiple courses of treatment is also important for ensuring effective treatment outcomes and minimizing potential side effects. By combining T1c imaging with dose information, clinicians can track both tumor size and dose distribution, allowing for a more comprehensive understanding of the treatment response and facilitating personalized treatment planning. Out platform integrates the image follow-up and dose tracking capabilities in the SRS workflow shown in Figure 4.

In summary, our web-based platform can segment, label and group mBMs with high accuracy in only 4-5 minutes. In addition, it also incorporates multiple functions as follow-up comparison, post-processing, and allows various user interactions. The implementation of this platform in clinics will greatly benefit the clinical efficiency of the brain metastases SRS treatment.

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业余学画的心得

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Dr. Ping Yan is an assistant professor and senior medical physicist at the Department of Radiation Oncology, Montefiore Medical Center in New York. Dr. Yan is interested in developing tools to automate clinical processes to reduce treatment errors, boost efficiency and communication, and create a better clinical workflow. She is also interested in clinical software development for physics QA, image-guided radiation therapy, and image-processing tools.

开始学画是2019年9月份，之前的我从来没有学过画，一切从零开始。我是跟着网络课程学习的，从一开始的素描，水粉，到水彩，彩铅，油画。很多朋友问我，成年人如何开始学画，我觉得最好的办法是报名一个网课，或者实体课。因为工作和家庭，要想在百忙之中抽空出来学画画，非常非常难，只有报名了课程，才会有压力让你坚持下去。成年人学画不一定要按孩童学画的方式。第一，成人的理解力比孩童好，但是想象力不如孩童，所以可以直接从技巧下手；第二，成人以兴趣为重，素描基础非常重要，但是如果你真的对素描不感兴趣，可以先学习别的画种，再慢慢摸索素描关系；第三，找到自己喜欢和擅长的画种，做自己喜欢做的事情。

学习画画之前，我并不喜欢画画，只是偶然的机遇，让我拿起了画笔，画着画着就喜欢上了。经过几年的学习，我发现自己最喜欢油画。油画有很多种类，我偏向喜欢写实油画。我也喜欢水彩和彩铅，但是我水彩一直都很难提高，非常打击信心，所以我觉得选择自己擅长的画种可以减少挫败感。彩铅大部分都是写实，可以画到非常逼真，相比油画，它会更容易达到非常细腻的效果，特别是你如果对调色并不是很了解的话。但是彩铅画大幅的作品，非常耗时耗精力。素描是所有画种的基础，如果按照很多科班出身的老师要求，至少要画上一年的素描才可以画其他画种，除非你对素描特别热爱，不然兴趣很容易被磨灭。其实在彩铅，油画中也是可以学到素描的，一般画画开始都是色彩的素描，要先把明暗关系画出来。另外youtube上也有很多教画画的视频非常好，但是初学画画还是应该跟老师学，因为一般youtube不会系统地教一些基本知识。

画画开始主要以临摹为主，到后面可以慢慢开始创作，平时收集一些觉得好看的图片，或者自己拍摄的照片，可以以这些为素材进行创作。很多人认为写实画就是照抄照片，这种理解是错误的，写实画也是一种再创作，好的写实画应该会比照片更有震撼力。

另外谈谈为什么学画画，成人学画画主要是要自己喜欢。除了可以自己画喜欢的画以外，画画带来的另一个好处是审美能力的提高。其实这是一件非常有趣的事情，你会发现你看事物的方式角度和以前完全不同。以前看名画并不能真正欣赏，而现在感受的程度比以前深很多，这种感受是只有你亲自去实践才有的。以下是我画的一些画，分别是水彩，彩铅和油画。