NACMPA North American Chinese Medical Physicists Association

North American Chinese Medical Physicists Association

Spring 2020
Volume 5 No. 1

# NACMPA NEWSLETTER

微信扫一扫
关注该公众号

## Inside this issue:

## *Message from President*

**Zhigang (Josh) Xu, PhD**
**NACMPA President**

We are living in unprecedented times. The human race is dealing with the outbreak of a disease—COVID-19—on a scale not seen in decades. As you may already know, there will not be a NACMPA dinner meeting this year. That unfortunately means we won't be able to see each other and enjoy the delicious food in Vancouver together. In place of the annual meeting, we will be using this newsletter and the WeChat online voting system to carry out the program in a hybrid format. Most official meeting agenda will be published in this newsletter and the election for the NACMPA President-elect and Treasurer will be carried out on July 15, 2020 on WeChat. I hope this virtual environment will create new opportunities for networking and help build friendships within our community even more so than before.

The highlights of this issue include: The announcement of the 2020 Yu Chen Excellent Community Service Award, the IJMPCERO Best Paper Award, the NACMPA Best Paper Award, the NACMPA Service Award, and the prestigious NACMPA Hall of Fame Award. Congratulations to all. The candidates running for President-elect and Treasurer are also introduced in this newsletter.

Each year at the AAPM meeting, physicists who have made outstanding contributions to the field are recognized with awards. Although we are unable to meet in Vancouver this year, let us all congratulate our Chinese physicist colleagues for their achievements.

*Edith H. Quimby Lifetime Achievement Award: George Xu, PhD*
*John S. Laughlin Young Scientist Award: Xiaofeng Yang, PhD*
*New Fellows: Harold Li, PhD, Lei Ren, PhD, Yi Rong, PhD, Chengyu Shi, PhD, Jie Zhang, PhD.*

I would like to give special thanks to the NACMPA volunteers and staff for their time and dedication. I look forward to seeing you all at the AAPM virtual annual meeting.

### *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.*

*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微信公众号.

*Editors: Brian Wang, PhD, Zhigang (Josh) Xu, PhD*

# 2020 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。 2020年度的获奖者是 Yi Rong。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。恭喜戎懿。

## 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**
**2020 Recipient**

**Yi Rong, PhD**

## 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

H Wang, JN Yang, X Zhang, J Li, SJ Frank, Z Zhao, D Luo, X Zhu, C Wang, S Tung, AS Garden, DI Rosenthal, CD Fuller, GB Gunn, AJ Ghia, JP Reddy, SM Raza, F De Monte, MS Chambers, PD Brown, S Su, J Phan

For the Best Medical Physics Paper Published during 2019-2020 in
*International Journal of Medical Physics, Clinical Engineering and Radiation Oncology*

Treatment-Plan Comparison of ThreeAdvanced Radiation Treatment Modalities for Fractionated Stereotactic Radiotherapy to the Head and Neck

$500 Voucher from *Scientific Research Publisher (SRP)* (Order # IJMPCERO0721; Expiry Date: July 15, 2021)

NACMPA
North American Chinese Medical Physicists Association

2007

Ning J. Yue, PhD
Editor-in-Chief
July 15, 2020

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 beginning. 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 250 articles with more than 765 citations. Since it is an OA, there have been over 573,000 and 929,000 downloads and views of IJMPCERO articles respectively. For example, the first IJMPCERO best paper has been cited by peer-review journals' articles more than 125 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 American Association of Physicists in Medicine (AAPM) except this year will be held virtually due to pandemic.

The criteria for best paper award selection, set by the NACMPA award committee, are the 1$^{st}$ or senior author must be a member of NACMPA and the paper was published in 2019. This year our award committee of NACMPA has selected the following paper as the Best Paper of IJMPCERO published in 2019 – He Wang, JN Yang, X Zhang, J Li, SJ Frank, Z Zhao, D Luo, X Zhu, C Wang, S Tung, AS Garden, DI Rosenthal, CD Fuller, GB Gunn, AJ Ghia, JP Reddy, SM Raza, F De Monte, MS Chambers, PD Brown, S Su, J Phan, "Treatment Plan Comparison of Three Advanced Radiation Treatment Modalities for Fractionated Stereotactic Radiotherapy to the Head and Neck", 8:106-120, 2019 (https://www.scirp.org/Journal/paperinformation.aspx?paperid=92609). Congratulations to all the authors!

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

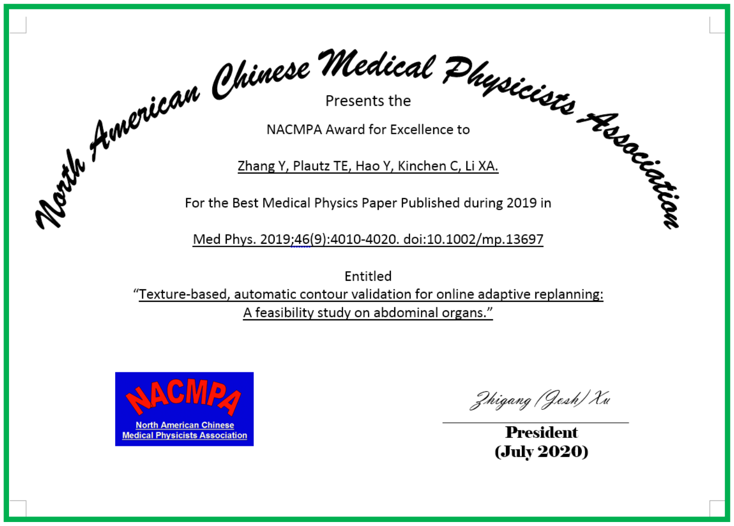
# NACMPA Best Paper Award

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 2019 and in a medical physics related journal.

The 2020 NACMPA best paper award goes to:

Zhang Y, Plautz TE, Hao Y, Kinchen C, Li XA. Texture-based, automatic contour validation for online adaptive replanning: A feasibility study on abdominal organs. Med Phys. 2019;46(9):4010-4020. doi:10.1002/mp.13697



North American Chinese Medical Physicists Association

Presents the

NACMPA Award for Excellence to

Zhang Y, Plautz TE, Hao Y, Kinchen C, Li XA.

For the Best Medical Physics Paper Published during 2019 in

Med Phys. 2019;46(9):4010-4020. doi:10.1002/mp.13697

Entitled

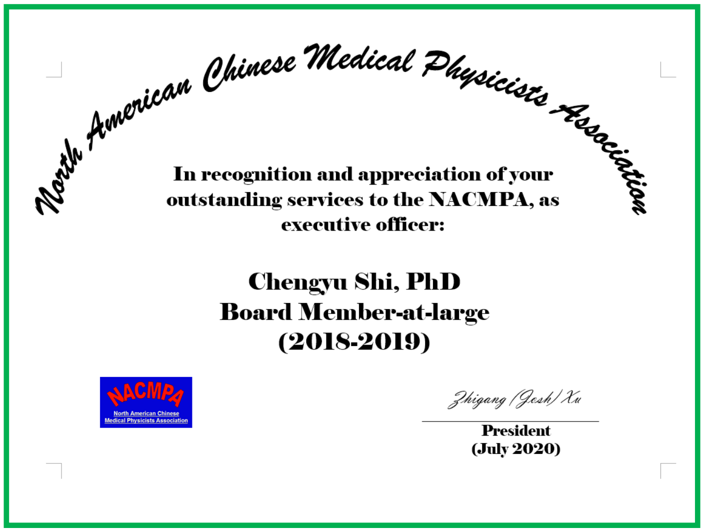
"Texture-based, automatic contour validation for online adaptive replanning: A feasibility study on abdominal organs."

NACMPA North American Chinese Medical Physicists Association

Zhigang (Gesh) Xu

**President**
**(July 2020)**

# NACMPA Service Award



North American Chinese Medical Physicists Association

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

**Chengyu Shi, PhD**
**Board Member-at-large**
**(2018-2019)**

NACMPA North American Chinese Medical Physicists Association

Zhigang (Gesh) Xu

**President**
**(July 2020)**

North American Chinese Medical Physicists Association

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

**Dengsong Zhu, MS**
**Secretary (2018-2019)**

NACMPA North American Chinese Medical Physicists Association

Zhigang (Gesh) Xu

**President**
**(July 2020)**

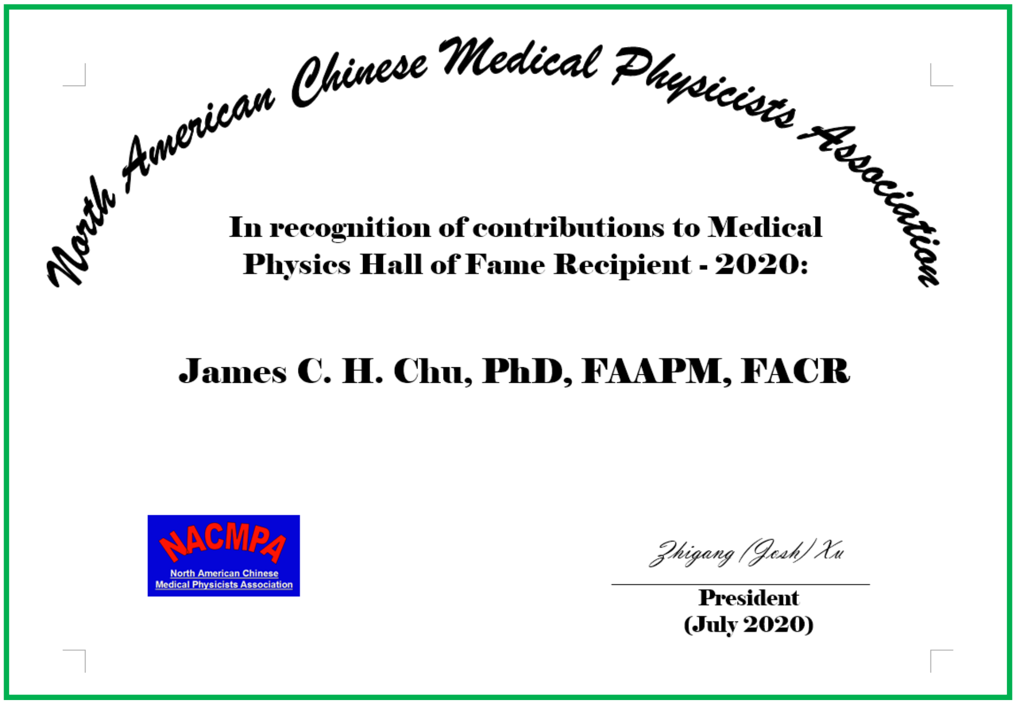
2020 NACMPA service awards go to Chengyu Shi and Dengsong Zhu, who have both completed two extraordinary years of service to NACMPA. Chengyu Shi is completing his term as a board member-at- large and Dengsong is concluding his position as board secretary at the end of 2019. Their contributions to the organization have been widely recognized.

**James C. H. Chu, PhD**
**NACMPA Past President**

# NACMPA Hall of Fame Award

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. James Chu has been selected by NACMPA Awards Committee to receive the 2020 NACMPA Hall of Fame Award, the highest honor of NACMPA. Congratulation!

Dr. James C. H. Chu was born in Nanking, China and raised in Taipei, Taiwan. He received a BS in physics from Tunghai University, Taichung, Taiwan in 1970, a MS from University of Texas Southwestern Medical Center, Dallas, Tx, in 1975, and a PhD from MD Anderson Cancer Center, Houston, Tx, in 1978. Dr. Chu then joined the faculty of the University of Pennsylvania School of Medicine and received tenure there. After 12 years at Penn, which also included 6 years as chief physicist at Fox Chase Cancer Center, Dr. Chu joined Rush-Presbyterian-St. Luke's Medical Center, which is now known as Rush University Medical Center. From his arrival at Rush in 1990 until his retirement in 2017, Dr. Chu served as both the chairman of Rush's Department of Medical Physics, which later became the Department of Imaging Sciences, and the chief physicist in the clinic. Dr. Chu is certified in both therapeutic medical physics and diagnostic medical physics by the American Board of Radiology, and in radiation oncology physics by the American Board of Medical Physics. Dr. Chu has been active in education, research, and clinical services in medical physics throughout his career. He remains active after his retirement, working part-time on a NIH-funded image guidance project for lung cancer treatments. He feels very fortunate to have had help from many extremely talented and devoted mentors, friends, colleagues, and trainees, and the support of his family, particularly his wife Sherry and son Michael, over the years. He is very grateful and honored to receive this award.



North American Chinese Medical Physicists Association

**In recognition of contributions to Medical Physics Hall of Fame Recipient - 2020:**

**James C. H. Chu, PhD, FAAPM, FACR**

NACMPA
North American Chinese Medical Physicists Association

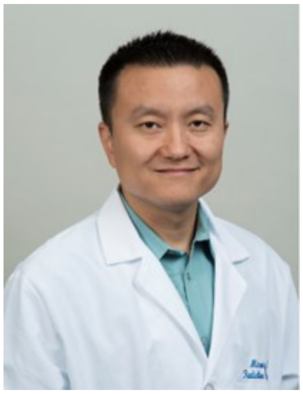
Zhigang (Josh) Xu

**President**
**(July 2020)**

# Candidates for President-Elect 2021-2022

**Lu Wang, PhD**
**NACMPA Past Treasurer**

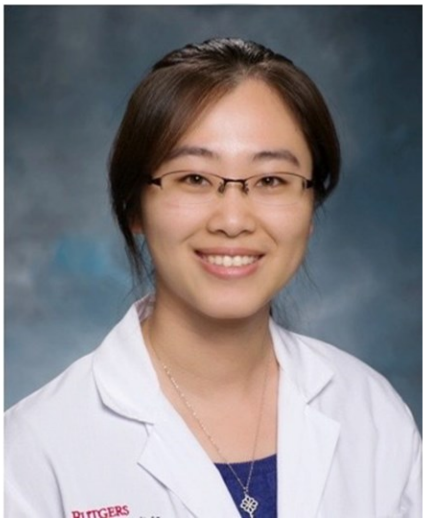
Dr. Lu Wang is a full professor in the Department of Radiation Oncology at Fox Chase Cancer Center (FCCC). She received her Ph.D. degree in Medical Physics in 1996 from the AAPM accredited program at Rush University. After graduating, she went to Memorial Sloan-Kettering Cancer Center in New York for post-doctoral training and conducted the research on accurate dose calculation in heterogeneity and authored the manuscript that first described the use of the Monte Carlo method for direct application in patient dosimetry. After post-doctoral training, she joined the Department of Radiation Oncology at the University of Pennsylvania (UPenn), School of Medicine in October 1998. While working at Penn, she implemented a Monte Carlo dose calculation algorithm for benchmarking of treatment planning systems and authored five peer-reviewed manuscripts during the three years of UPenn faculty term. In 2002, she joined the FCCC as a faculty member and had been instrumental in FCCC being an early pioneer in adoptive of stereotactic body radiation. Over the years, Dr. Wang has published over 45 peer-reviewed publications, more than 100 published abstracts, one book chapter, and was the co-author for the Report of AAPM Task Group 101. She was also a member of the Editorial Board of Medical Physics Journal and an associate editor for Journal of Applied Clinical Medical Physics for several years before she resigned. Moreover, she has been serving or served on five AAPM committees and three Working Groups. Besides these professional services, she was an invited speaker at several national and international meetings. Dr. Wang was the recipient of the AAPM/IPEM Medical Physics Travel Grant for 2010 and became an AAPM fellow in 2014. Dr. Wang has been a member of NACMPA since 1996. She served as the treasurer of the NACMPA between 2011-2012.



**Minsong Cao, PhD**
**NACMPA Member**

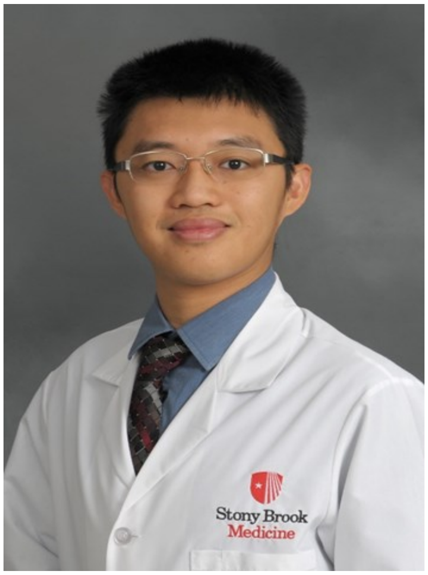
Dr. Minsong Cao is currently an Associate Professor, Associate Vice Chair of Education and Director of the Medical Physics Residency Program in the Department of Radiation Oncology at University of California, Los Angeles. He received his PhD in Medical Physics from Purdue University in 2007 and then joined Indiana University as an Assistant Professor. Dr Cao's primary research interests include MR guided radiotherapy and advanced treatment planning. He has authored over 70 journal articles and 4 book chapters and been invited to present at various national and international meetings. Dr. Cao has served in many capacities within AAPM. He is a member of multiple AAPM committees and currently the AAPM liaison to the Medical Dosimetry Certification Board. He had served as mentor for the Summer Undergraduate Fellowship Program and President of the Ohio River Valley Chapter of AAPM. He currently serves as Associate Editor for JACMP, Senior Associate Editor for the Red Journal and residency program reviewer for CAMPEP. He was elected as a Fellow of the AAPM in 2019. He has been actively involved in global outreach education and training of medical physicists in multiple developing countries including Vietnam, Brazil and China.

# Candidates for Treasurer 2021-2022



**Ke Nie, PhD**
**NACMPA Member**

Dr. Ke Nie is an Associate Professor in Department of Radiation Oncology at Rutgers-Cancer Institute of New Jersey. She received her BS degree from University of Science and Technology of China and PhD degree from University of California, Irvine. Following two years as Research Scientist at Carestream Health Inc., she accomplished her residency training at University of California, San Francisco in 2013. In the same year, she joined Rutgers and has worked there since then. She has published over 40 peer-reviewed papers, several book chapters and holds two US patents. Her work has received multiple awards as Science Council, Best-in-Physics, Science Highlights from AAPM and Best Paper from NRG Oncology. Her research has been supported by several research grants in which she is the principle investigator. At the same time, she has developed great passion in teaching students and physics fellows and serves as director of the medical physics residency program. Besides that, she is active in medical physics. Currently, she is the AAPM Board of Directors of NJ Chapter, and before that she was the president. She also serves on several committees at ASTRO and AAPM. Now she is looking forward an opportunity to serve the Chinese physicist community in North America.



**Siming Lu, MS**
**NACMPA Member**

Siming Lu received his BS degree in Physics from Zhejiang University, Hangzhou, China in 2012, and MS in Medical Physics from Duke University in 2014. He finished his medical physics residency training in Henry Ford Hospital in 2016. He is currently a medical physicist at Stony Brook University Hospital in New York. He has been academically active in different aspects in medical physics field. His research interest includes artificial intelligence in radiation treatment planning, film dosimetry and low dose CT reconstruction. He is also collaborating with Laboratory for Imaging Research and Informatics in Stony Brook University to conduct researches. Siming joined NACMPA since 2014 and he has been trying to contributing his efforts to help the medical physicist community in China by volunteering to answer questions and discuss online.

NACMPA is a great organization that has been improving the communication in our Chinese physicist community and accomplishing many meaningful tasks. It would be an honor and privilege to contribute to this community.

# 文献搜索的小经验

**Chengyu Shi, PhD**
**NACMPA Past Board**
**Member-at-large**

It is essential but important to do a literature search before you start to do the research. There are two major literature search methods: keyword and author. Google search engine can be used to do the literature search in the beginning. You can further refine your search by searching a special journal, such as medical physics. Other search methods, such as searching cited literatures in the reference lists, were also introduced.

文献搜索是做研究的最基础步骤。“知己知彼，百战不殆”，我们需要知道想要做的研究目前的总体状况如何？有哪些机构和研究者在做这方面的研究？而我们能够做的研究对比别人已经做过的研究有什么新意和局限性呢？这些问题都需要通过文献搜索来回答，也是最开始有了研究想法就应当着手做的事情，而且是需要深入扎实做的事情。千万不要忽视文献搜索，不扎实不完全的文献搜索，会给后面的工作带来巨大的负担。翔实的文献搜索会避免很多研究的弯路和能够顺利地完成你未来文章的发表。

文献搜索一般可以按照**关键字搜索**，也可以按照**研究者搜索**。目前网络已经很发达了，基本上不需要到专业的数据库进行搜索了。当然，Google scholar(https://scholar.google.com/) 搜索的范围已经包含了专业的数据库。但是，我一般还是喜欢用普通的Google引擎，原因是我们目前的研究基本上都是时效很快的研究，有些想法可能还没有人发表或者发表很少，甚至是一些会议摘要，或者某次学术沙龙的口头交流，而这些在Google scholar中可能没有收入，所以用普通的Google引擎就可以搜索到不错的结果。当然，我们使用关键字搜索时候，不能期望一次就获得自己想要的结果，需要不断变换关键字来进行相似论题的搜索。一般我喜欢一个关键字搜索后，翻页Google页面到第10页（第10个”o”），并把相关的pdf文件，或者摘要出处等保存下来，然后变化关键字进一步搜索。为什么翻页到第10页呢？没有其它的原因，主要是经验，同时也保证有足够的页面资源，避免遗漏。**关键字需要合适，不能太广，也不能太精确**。太广了会获得很多结果，导致你需要大量翻页才能找到合适的信息。太精确了又结果很小，也不能获得相关信息。例如：如果我们想研究一种新型胶片的特性，如果用film作为关键字，则太广了。如果用 gafchromic film 也还是比较广。合适的是gafchormic film, radiation therapy。

在第一轮关键字搜索之后，相信你已经获得一些相关研究者的信息，这时候可以进行作者搜索。一般研究都是有连续性的，研究者很少“打一枪换个地方”，作者搜索会获得有关这个作者的更多关于这个研究的文章。这里作者一般指第一作者，资深作者和通讯作者。有时候可以访问该资深或者通讯作者的网页，可能获得更多的信息。作者搜索还可以使得我们“认识”这些作者，他们可能是你未来文章的审稿人，需要了解他们的工作和目前进展，以免在审稿时候忘记引用该作者的文章而导致你的文章有局限性。

在关键字和作者搜索之后，我们应当了解了这个论题的大概情况和发表的**期刊**情况。这时候要进行进一步的搜索，则不能使用Google了，毕竟Google不是专门为研究而设立的。如果可能，需要到关键的期刊网站进行搜索，例如我们这个领域的medical physics期刊，搜索近5年以内的相关论题，尤其是相关作者的文献。选出3－5个重要的期刊进行搜索，以便获得更多的信息。

另外一个搜索的渠道是重要文章**引用的文献**。重要文章已经帮助你进行了一些搜索工作，尤其是introduction一般会综述前期的工作，这些文献关联性很高，需要“按图索骥”，准确性更高。一般搜索到2级（引用文献中再引用的文献）就可以了。

另外，文献搜索是动态的。不是一次就完成的，可能需要多次不断的搜索，甚至在你的研究成稿时候还需要进一步搜索，毕竟文章成稿需要一定的时间，而这段时间可能有研究者又发表了新的文章。同时，养成爱看期刊和收集资料的习惯，保证自己的信息不断更新和累积，这样就知道到哪里去寻找相关的信息。

总之，文献搜索是小事，但是也是大事。正是这一块块文献砖头，才能垒砌研究的大厦。希望此小文给你的研究一些启示和帮助。

# Deep Learning in Medical Physics

**Xiaofeng Yang, PhD**
**NACMPA Member**

In recent years the trend has been witnessed that machine learning, especially deep learning, is being increasingly used in medical physics field. Various types of Artificial Intelligence (AI) methods have been borrowed from computer vision field and adapted to specific clinical tasks. The most commonly employed deep learning models such as convolutional neural network (CNN), recurrent neural network (RNN) and generative adversarial network (GAN), have been shown to have very promising results in tasks involving both imaging and treatment. Numerous studies demonstrated the potential applications of deep learning models to clinical problems combined with the ongoing efforts toward introducing medical physics into the era of big data analytics. Deep learning is poised to revolutionize the fields of medical physics and radiation oncology. A few articles provide overviews of the commonly used deep learning methods, which can be a good start for researchers new to this field, as well as give in-depth discussions and outlook on its achievements and challenges. Here we would briefly summarize the recent applications of deep learning in medical physics from the three aspects: medical image synthesis, segmentation and registration, each of which is a very active field that tens of articles have been published in the recent two or three years.

### *Image Synthesis*

Image synthesis between different medical imaging modalities/protocols is of great clinical interest in radiation oncology and radiology. It aims to facilitate a specific clinical workflow by bypassing or replacing a certain imaging procedure when the acquisition is infeasible, costs additional time/labor/expense, has ionizing radiation exposure, or introduces uncertainty from multimodal image registration. Deep learning is dominating in this field in the past several years. Deep learning utilizes neural network with many layers containing huge number of neurons to extract useful features from images. Various networks have been proposed for better performance on different tasks. Compared with conventional model-based methods, deep learning-based methods are more generalizable since the same network for a pair of image modalities can be re-trained and applied to different pairs of image modalities with minimal adjustment. This allows rapid and wide spread of image synthesis to a variety of clinical applications and imaging modalities.

Current studies can be categorized into two main groups based on their study objectives: inter-modality (56%) and intra-modality (44%). Inter-modality applications included studies about the image synthesis between two different imaging modalities. Intra-modality applications included studies that transform images between two different protocols of a same imaging modality, such as between different MR imaging sequences, or the restoration of images from low quality protocol to high quality protocol. Based on the  image modalities, studies in inter-modality group were further divided into 4 subgroups, including MR-to-CT, CT/CBCT-to-MR, CBCT-to-CT and PET-to-CT. Image synthesis from MR to CT is one of the first applications that have been explored using deep learning, and remains the most common topic in this field. The main clinical motivation of MR-based synthetic CT is to replace CT by MR acquisition. The image quality and appearance of the synthetic CT results in current studies are still considerably different from real CT, which prevents it from direct diagnostic usage. However, many studies demonstrated its utility for non- or indirect diagnostic purpose, such as MR-based treatment planning for radiation therapy, PET attenuation correction in PET/MR scanner, and CT-MR image registration. As shown in Fig. 1, MR-to-CT synthesis, including its applications in radiation therapy, PET and image registration, accounts for about 2/3 of all studies and more than half of inter-modality studies. CT/CBCT-to-MR synthesis is proposed to utilize the superior soft tissue contrast of MR in applications that are sensitive to soft tissue contrast, such as segmentation. CBCT and CT share a common basic physics principle, while CBCT suffers from severe artifacts from scatter photons and distorted HU value range. Image synthesis of CT from CBCT is then proposed to correct and restore the CBCT HU values to be close to those of CT, which can be useful for adaptive radiation therapy where CBCT images are used for re-contouring and dose re-calculation. PET-to-CT synthesis is another way to generate attenuation coefficient map for PET attenuation correction for either PET/MR or standard-alone PET scanners.

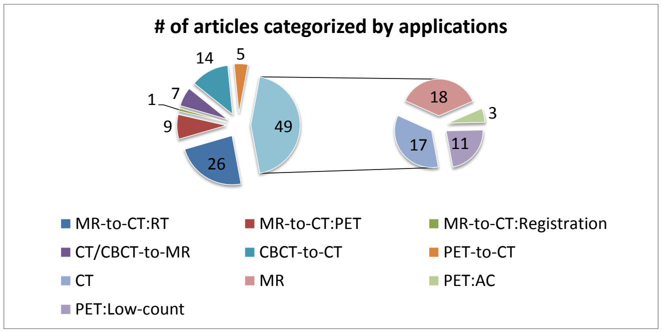


*Figure 1. Pie chart of numbers of articles in different categories of applications. MR-to-CT: RT, MR-to-CT: PET and MR-to-CT: Registration represent MR to CT image synthesis used in radiotherapy, PET and image registration, respectively. PET: AC and PET: Low-count represent PET image synthesis used in attenuation correction and low-count to full-count, respectively.*

Studies in intra-modality group can be further divided into CT, MR and PET groups. For CT, synthesis techniques are found useful in restoring low-dose or low-sampled CT acquisition to full dose CT images. Such low-dose restoration strategy also works for low-count PET. In addition, the direct mapping from non-attenuation-corrected PET to corrected PET without any anatomical image guidance are also found feasible. For MR, various applications are proposed, such as imaging translation among different sequences, converting low-tesla MRI to high-tesla MRI, and restoring under-sampled acquisition. The motivation of converting a low-tesla MRI to high-tesla MRI is to take advantages of the high spatial resolution and good contrast of a cutting-edge high-tesla scanner when only normal low-tesla MRI scanner is accessible. The image synthesis among different sequences and restoring under-sampled acquisition can both shorten the acquisition time.

The reviewed studies showed the advantages of deep learning-based methods over conventional methods in performance as well as clinical applications. Deep learning-based methods generally outperform conventional methods in generating more realistic synthetic images with higher similarity to real images and better quantitative metrics. In implementation, depending on the hardware, training a model usually takes several hours to days. However, once the model is trained, it can be applied to new patients to generate synthetic images within a few seconds or minutes. Conventional methods vary a lot in specific methodologies and implementations, resulting in a wide range of run time. Iterative methods such as compressed sensing were shown to be unfavorable because of slow computation and intense resource consumption.

In the training stage, most of the reviewed studies require paired datasets, i.e. the source image and target image need to have pixel-to-pixel correspondence. This requirement poses difficulties in collecting sufficient datasets, as well as demands high accuracy in image registration. Some networks such as cycle generative adversarial network (cycle-GAN) can relax the requirement of the paired datasets, which can be beneficial for clinical application in enrolling large number of patient datasets for training.

### *Image Segmentation*

The task of medical image segmentation is typically defined as assigning each voxel of the medical images to one of several labels that represent the objects of interest. Deep learning-based medical image segmentation techniques represent a significant innovation in daily practices of radiation therapy, expediting the segmentation process, enhancing contour consistency and promoting compliance to delineation guidelines. Furthermore, rapid multi-organ segmentation could facilitate the online re-contouring process in adaptive radiotherapy to improve clinical outcomes. Recently, over 180 articles have been published on deep learning-based medical image segmentation, among which over 40 publications are closely related to multi-organ segmentation.

Deep learning-based multi-organ segmentation methods can be divided from different aspects according to its properties such as network architecture, training process (supervised, semi-supervised, unsupervised, transfer learning), input size (patch-based, whole volume-based, 2D, 3D) and so on. Based on network architectures, recent deep learning-based multi-organ segmentation methods can be grouped into 6 categories, including 1) auto-encoder (AE), 2) convolutional neural network (CNN), 3) fully convolutional network (FCN), 4) generative adversarial network (GAN), 5) regional convolutional neural network (R-CNN) and 6) hybrid deep learning-based methods. A detailed overview of deep learning-based medical image multi-organ segmentation methods with their corresponding components and features is shown in Fig. 2.

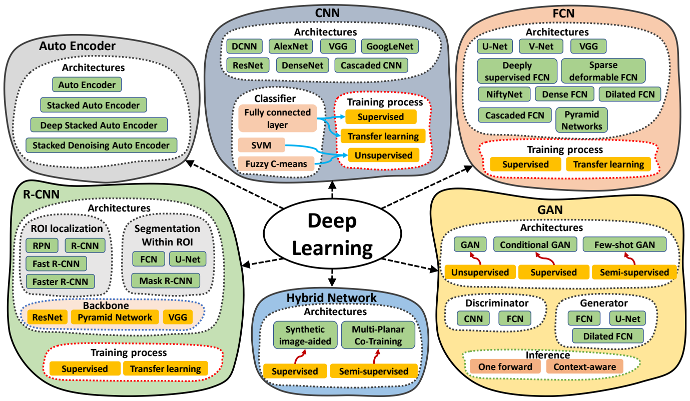


*Figure 2. Overview of six categories of deep leaning-based methods in medical image segmentation.*

Depending on the task complexity and training datasets available, deep learning-based medical image segmentation methods may suffer from training datasets shortage, leading to overfitting which refers to a model that has good performance on the training dataset but not new dataset. Large number of labels for training are difficult to obtain, because expert manual delineation is time-consuming, laborious and sometimes error prone. Dropout layers and data augmentation could be used to fight overfit. When training complex neural networks with limited training data, care should be taken to alleviate over-fitting. Another challenge of deep learning-based medical image segmentation is the class imbalance problem. The class imbalance problem refers to scenario when the objects to be segmented are significantly different in volumes/sizes, resulting an unbalanced loss among these objects. For example, the esophagus and spinal cord are often much smaller than the lung in the segmentation of thorax organs. Small metastasis tumors are much smaller than its surrounding tissues. Training a network with such a class imbalanced problem could result in biased segmentation model towards the classes of large organs if loss function is not properly defined.

Training a sophisticated deep learning model with large input image size, complex network structure and huge number of learnable parameters can be challenging. In order to avoid GPU memory overflow and speed up the training and inference, one can start with simple networks and gradually increase the network complexity if necessary. Moreover, inter-observability in ground truth label generation by physicians could introduce additional errors in segmentation, such as physicians contouring style as system error, and contouring uncertainty as random error. Inferior image quality, such as low contrast, low signal-to-noise ratio, could also affect the multi-organ segmentation accuracy. Several techniques can be used to overcome these challenges, such as deep supervision, deep attention and synthetic image-aided techniques.

### *Image Registration*

Image registration, also known as image fusion or image matching, is the process of aligning two or more images based on image appearances. Medical image registration plays an important role in radiation oncology applications such as image guidance, motion tracking, segmentation, dose accumulation, image reconstruction and so on. Different applications and registration methods face different challenges. Recently, deep learning-based methods have changed the landscape of medical image processing research and achieved the-state-of-art performances in many applications. Deep learning-based registration methods can be classified according to deep learning properties, such as network architectures (CNN, GAN etc.), training process (supervised, unsupervised etc.), inference types (iterative, one-shot prediction), input image sizes (patch-based, whole image-based), output types (dense transformation, sparse transformation on control points, parametric regression of transformation model etc.) and so on. Roughly, they can be classified into seven categories, including 1) RL-based methods, 2) deep similarity-based methods, 3) supervised transformation predication, 4) unsupervised transformation prediction, 5) GAN in medical image registration, 6) registration validation using deep learning, and 7) other learning-based methods. GAN was mostly used in combination with supervised or unsupervised transformation prediction methods as an auxiliary regularization or image pre-processing step. Supervised and unsupervised methods were combined for dual supervision in some works. RL and deep similarity-based methods are iterative whereas supervised and unsupervised based methods are non-iterative. For iterative methods, multiple works have reported that deep similarity metrics have superior performance to handcrafted intensity-based image similarity metric. For non-iterative methods, deep learning-based methods have yet to outperform traditional deformable image registration (DIR) methods.

Take lung registration for example, the best performing deep learning-based methods are only comparable to the-state-of-art traditional DIR methods in terms of TRE. However, deep learning-based direct transformation methods are generally order of magnitude faster than traditional DIR methods. This is mainly due to the non-iterative nature and the powerful GPU utilized. A common feature that is used in both traditional DIR and deep learning-based methods is multi-scale strategy. Multi-scale registration could help the optimization avoid local maxima and allow large deformation registration. Regarding network generality, several studies have showed that network trained using one set of datasets could be readily applied to an independent set of datasets given that the two image domains are close to each other. Fig. 3 shows the percentage distributions of many attributes including input image pair dimension, transformation model, image domain, patch-based training, deep learning frameworks and sites of the current registration works.

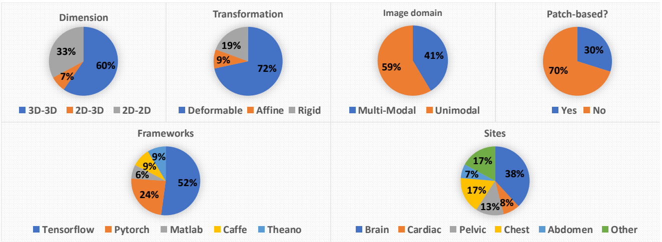


*Figure. 3 Percentage pie charts of various attributes of deep learning-based image registration methods*.

One of the most common challenges for supervised deep learning-based methods is the lack of training datasets with known transformations. This problem could be alleviated by various data augmentation methods. However, the data augmentation methods could introduce additional errors such as the bias of unrealistic artificial transformations and image domain shifts between training and testing stages. For unsupervised methods, efforts were made to combine different kinds of regularization terms to constrain the predicted transformation. However, it is difficult to investigate the relative importance of each regularization term. Researchers are still trying to find an optimal set of transformation regularization terms that could help generate not only physically plausible but also physiologically realistic deformation field for a certain registration task. This is partially due to the lack of registration validation methods. Due to the unavailability of ground truth transformation between an image pair, it is hard to compare the performances of different registration methods. Therefore, registration validation methods are equally important as registration methods. More research on registration validation methods is desired in order to reliably evaluate the performances of different registration methods under different parametric configurations.

There is a clear trend of direct transformation prediction for fast image registration. So far, supervised and unsupervised transformation prediction methods are almost equally studied with close number of publications in either category. Either supervised or unsupervised methods have its own advantages and disadvantages. GAN-based methods have gradually gaining popularity since GAN could be used to not only introduce additional regularizations but also perform image domain translation to cast multi-modal to unimodal image registration. New transformation regularization techniques have always been a hot topic due to the ill-posedness of the registration problem.

### *Discussion*

Although the advantages of deep learning-based methods have been demonstrated, it should be noted that its performance can be unpredictable when the input test patient are very different from its training datasets. In most of the reviewed studies, unusual cases are excluded. However, these unusual cases can happen from time to time in clinic, and should be dealt with caution. For example, it is not uncommon to see patient with hip prosthesis in pelvis scan. The hip prosthesis creates severe artifacts on both CT and MR images; thus, it can be of clinical interest to see the related effect of its inclusion in training or testing dataset, which has not been studied yet. Similar unusual cases can also be seen in other forms in all imaging modalities and are worth investigation, including all kinds of implants that can introduce artifacts, obese patients that present much higher noise level on image than average, and patients with anatomical abnormality.

The representativeness of training/testing dataset needs special attention in clinical study. The missing of diverse demographics may reduce the robustness and generality in the performance of the model. Most of the studies trained model using data from a single institution with a single scanner. As replacing/equipping with new scanner is common in practice, it is interesting to know how the trained model would perform on another scanner of different model or vendor when the image characteristic cannot be exactly matched. Further studies could include datasets from multiple centers and adopted a leave-one-center-out training/test strategy in order to validate the consistency and robustness of the network.

Before being deployed into clinical workflow, there are still a few challenges to be addressed. To account for the potential unpredictable results that can be caused by noncompliance with imaging protocols as training data, or unexpected anatomic structures, additional quality assurance (QA) step would be essential in clinical practice. The QA procedure would aim to check the consistency on the performance of the model routinely or after upgrade by re-training the network with more patient datasets, as well as to check the results of patient-specific case.

**Reference:**

Fu Y, Lei Y, Wang T, Curran W, Liu T, and Yang X. Deep Learning in Medical Image Registration: A Review. Physics in Medicine & Biology. 2020.

Lei Y, Fu Y, Wang T, Curran WJ, Liu T, and Yang X. Deep Learning in Multi-organ Segmentation. arXiv e-prints. 2020.arXiv:2001.10619.

Wang T, Lei Y, Fu Y, Curran WJ, Liu T, and Yang X. Medical Imaging Synthesis using Deep Learning and its Clinical Applications: A Review. arXiv e-prints.

## *Coping with Coronavirus Disease 2019 (COVID-19)*

**Yi Rong, PhD, NACMPA Board Member at Large**

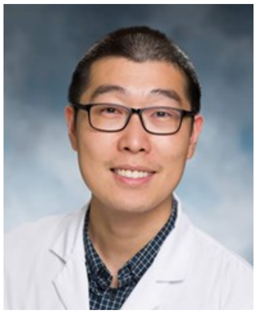
Coronavirus disease 2019 (COVID-19) is an unprecedented pandemic that has already reached over 7 million confirmed cases globally and 2 million confirmed cases in the United States, with at least 405 thousand deaths globally and 110 thousand deaths in the Unites States, as reported by the World Health Organization (WHO) as of June 8th, 2020. This disease has touched and affected everyone's life, directly and indirectly. Scientists around the world have a crunching timeline in finding potential treatments and vaccines for this disease. In an effort of ensuring safety and quality for cancer patients, radiation oncologists and medical physicists globally have devoted their efforts in establishing safety measures, quality-ensured workflows, personnel guidelines, and even publishing scientific papers in sharing their thoughts, knowledge, and experience. Both ASTRO (https://www.astro.org/Daily-Practice/COVID-19-Recommendations-and-Information) and AAPM (https://w3.aapm.org/covid19/) have timely launched websites for pooling experts' recommendations and journal articles pertaining experience with Covid-19. Medical physicists and radiation oncologists from China and United States have been working closely together in sharing information and experience, in order to provide the best option for patients and safest workplace for personnel as well. Covid-19 is an unmatched threat posing to our mankind. All human being should work closely together for a common good and hopefully we will resume to our normal life in no time.

冠状病毒病（COVID-19）是前所未有的大流行疾病，全球已确诊病例超过700万，美国已确诊病例200万。 截至2020年6月8日，根据世界卫生组织（WHO）数据，全球至少有40.5万例死亡和美国11万例死亡。这种疾病直接或间接地触并影响着每个人的生活。世界各地的科学家在寻找针对这种疾病的潜在治疗方法和疫苗。为了确保癌症患者的安全和质量，全球放射肿瘤学家和医学物理学家致力于建立安全措施，质量有保证的工作流程，人员指南，发表科学论文以分享他们的思想，知识和经验。

ASTRO (https://www.astro.org/Daily-Practice/COVID-19-Recommendations-and-Information）和AAPM（https://w3.aapm.org/covid19/）都及时创建网站，以汇集有关Covid-19的专家经验和期刊文章。实际上，中美两国的医学物理学家和放射肿瘤学家密切合作，共享信息和经验，以便为患者提供最佳选择，并为人员提供最安全的工作场所。Covid-19对我们人类构成的无与伦比的威胁。全人类应为共同的利益紧密合作，希望我们能尽快恢复正常生活。

# 北美华人医学物理师协会募捐支持抗击新冠病毒疫情情况汇报

**Zhigang (Josh) Xu, PhD**
**NACMPA President**



**Yin Zhang, PhD**
**NACMPA Treasurer**

Since the emergence of the new coronavirus epidemic in Wuhan, the resulting hardships have attracted great attention and empathy from Chinese people living overseas. In an effort to contribute to the fight against the epidemic in Wuhan, the North American Chinese Medical Physicists Association (NACMPA) organized a fund raiser in North America from February 3-9, 2020. The total amount of fund raised by the NACMPA

NACMPA Help Wuhan to Fight Coronavirus

$20,550 raised

The organizer has currently disabled new donations to this fundraiser.

图1. GoFundMe平台截图

$19920 was thereafter transferred to the Overseas Chinese Language and Cultural Education Foundation. With the help of Chinese Medical Association, the fund was delivered to two local hospitals in Wuhan for purchasing the necessary protective equipment. This story has been published on the website of the Overseas Chinese Language and Cultural Education Foundation. To learn more, please visit: https://mp.weixin.qq.com/s/oOqdV__TcZdlb2jNsVYEnw

2020年初中国国内新型冠状病毒引发的疫情，引起了海外华侨华人高度关注，一直牵动着大家的心，大家都希望能为武汉抗击疫情尽绵薄之力。为此2020年2月3日北美华人医学物理师协会(NACMPA)通过微信面向北美会员发起了募集资金向湖北疫区捐助医疗物资的活动。会员们收到捐助倡议后，积极踊跃地进行捐资。募捐活动是在美国东部时间星期日2/9/2020晚上10点结束。募捐一共116笔捐款，总

Fees

| | |
|---|---|
| **Total raised online:** | $20,550.00 |
| **Total fees:** | ($630.76) |
| Transaction (2.9% + 0.30): | ($630.76) |
| **Remaining total:** | $19,919.24 |

图2. GoFundMe平台手续费

公益事业捐赠统一票据

100050219
票据代码: 100050219
电子票据代码: 00050119
交款人统一社会信用代码:
交款人: 北美华人医学物理师协会NACMPA

№ 0000009707
票据号码: 0000009707
电子票据号码: 0005019979
校验码: EfpYda
开票日期: 2020-02-20

| 项目编码 | 项目名称 | 单位 | 数量 | 标准 | 金额（元） | 备注 |
|---|---|---|---|---|---|---|
| 991010 | 捐赠款 支持武汉抗击新型冠状病毒肺炎 | 元 | 1 | | 139,206.94 | 美元19920 |

金额合计（大写） 壹拾叁万玖仟贰佰零陆元玖角肆分 （小写） 139,206.94

其他信息

收款单位（章）:
复核人: 熊军飞
收款人: 井英

第一联 收据

图3. 中国华文教育基金会收据

募捐$20550。GoFundMe平台收费标准每笔2.9% + $0.3，总手续费为20550*2.9% + 116*$0.3 = $630.76，去除手续费后一共收入为$19920。全部资金$19920即可转账到中国华文教育基金会，由华文教育基金会将$19920美元换成人民币139206.94元后，全数拨付给武汉市武昌医院和金银潭医院，用于抗疫第一线。 相关报道请看：【海外华文学校、华人社团抗疫报道之三十九】不计回报，大爱无疆。

1.中国华文教育基金会微信公众号：https://mp.weixin.qq.com/s/oOqdV__TcZdlb2jNsVYEnw
2.中央统战部网站：http://www.zytzb.gov.cn/hwqbzxd/326726.jhtml
3.中国新闻网：https://m.chinanews.com/wap/detail/zw/hr/2020/02-28/9107969.shtml
4.中国侨网：http://www.chinaqw.com/qbapp/zwShare.html?id=894-5-247282&type=zw&from=singlemessage&isappinstalled=0
5.国务院侨办网站：http://www.gqb.gov.cn/news/2020/0228/47660.shtml
6.中国华文教育网：http://www.hwjyw.com/info/content/2020/02/28/35692.shtml

中國華文教育基金會
CHINESE LANGUAGE AND CULTURE EDUCATION FOUNDATION OF CHINA

捐赠证书

北美华人医学物理师协会：

为支持中国抗击新冠肺炎疫情，贵会捐款折合人民币139206.94元，资金已拨付湖北武汉金银潭医院、武汉武昌医院。

贵会的善举为抗击疫情提供了有力支持，中国华文教育基金会对此表示衷心感谢！

中国华文教育基金会
二〇二〇年三月二十日

图4. 中国华文教育基金会颁发给NACMPA的捐赠证书

中国华文教育基金会联合中华医学会于1月26日发布支持抗击新冠肺炎疫情募捐公告，3月6日募捐活动截止。至3月16日，共收到来自国内外的捐款折合人民币54,924,439.07元，已全部拨付医院或相关机构用于支持抗疫工作，基金会未收取任何管理费用。相关情况汇总公示请查阅（NACMPA donation is on the list #125)：中国华文教育基金会抗疫捐赠明细表: http://www.clef.org.cn/news/2020/0316/5/3057.shtml

---

## *NACMPA thanks to our sponsors*

*Platinum Sponsor*　　*Gold Sponsor*

MEVION medical systems　　varian

# *Silver Sponsors*

SUN NUCLEAR corporation

STANDARD IMAGING

visionrt

# *Bronze Sponsors*

healthcare for everyone TeamBest Your True Partner

RAD formation

Elekta

UNITED 联影 IMAGING

QFix

.decimal The benchmark for custom radiation therapy

LAP LASER

RIT

LinaTech Providing Superior Products for Cancer Treatment

SHIELDING CONSTRUCTION SOLUTIONS, INC.
VAULT BUILDERS

MISSION SEARCH

# 旋转伽玛刀介绍 Jinsheng Li, PhD-西安大医集团有限公司

Comparing to Gamma Knife System, Rotating Gamma System (RGS) performs treatment with multiple rotating radioactive sources beyond their common feature on beam focusing. Several different rotating gamma systems have been developed in China and United States suitable for intracranial, extracranial and whole body treatment. Multi-million patients have been treated with such kind of system in the past 20 years. Recent development focuses on the integration with image guidance. A pair of kV image systems has been integrated with RGS for head and body treatment. Most advanced RGS is the system with integrated kV cone beam CT (CBCT) system having same isocenter with treatment, it can perform 3D image guided localization and real-time imaging guided intrafractional motion monitoring and corrections. Image guidance ensures the treatment accuracy and lead the RGS to non-invasive treatment by replacing the frame-based immobilization and localization technique. Combining with LINAC system is another innovative idea trying to utilize the advantages of both modalities for patient treatment. It has advantages on saving a treatment vault and cost of operation comparing with having two individual systems. It can also provide combined treatment based on the clinical needs, such as using different treatment techniques for different targets at the same time, or dose escalation to part of target with RGS during conventional treatment with LINAC. To conclude, RGS has been developed and extensively used in clinic for patient treatments, it has great potential to be used more widely when combined with advanced imaging technique and other treatment modalities in the coming stereotactic radiotherapy era.

## 1. 旋转伽玛刀技术介绍

瑞典神经外科专家Dr. Leksell 于1951年提出了立体定向放射外科（SRS）概念，并于1968年发明了首台静态聚焦伽玛刀。随后的几十年中，伽玛刀几度更新换代，但始终传承静态聚焦技术[1,2]。

中国的宋世鹏先生在1993年首先提出了伽玛射线旋转聚焦的概念，即旋转伽玛刀技术，该技术有两大主要特点：多源聚焦和旋转治疗。其中多源聚焦是静态伽玛刀和旋转伽玛刀的共有特点，在立体定向定位技术的辅助下，把多个放射源产生的多束伽玛射线，通过几何聚焦的方式照射于同一焦点，即等中心点，从而在该处产生一个陡峭的高剂量区，一次性地摧毁病灶。旋转治疗则是旋转伽玛刀相较于静态伽玛刀的一大主要特点，通过围绕等中心点旋转放射源，伽玛射束形成若干以焦点为共同顶点的旋转锥面，将原来静态聚焦下的多点照射改变为有限射束的多圈(muti-arc) 照射，就像图1展示的两个例子一样。

旋转治疗使周边剂量得到更大的分散，靶区边沿剂量梯度更加陡峭，周围组织所受的辐射剂量更低，这样在保证治疗效果的同时可以更好地保护正常组织。图2展示了多源聚焦伽玛射束绕人体旋转照射的剂量分布与6MV加速器旋转照射的比较，周边剂量高低有明显的区别，主要体现了多源聚焦带来的优势

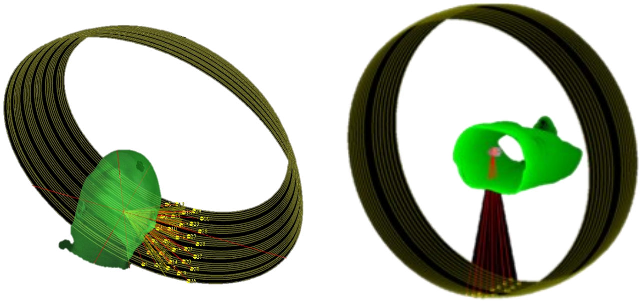


图1. Co60多源聚焦旋转照射

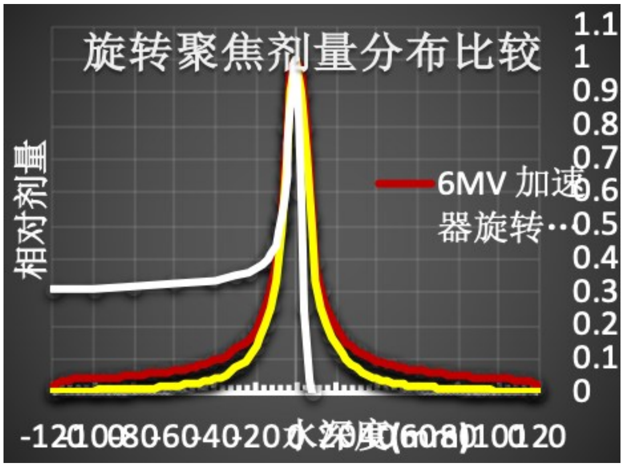


图2. Co60多源旋转照射和其剂量分布与6MV射线旋转照射及单能质子束的比较

。这一旋转照射技术可以减少放射源数量，能够带来更好的经济效益和环保效益。旋转照射还可以通过改变转速和旋转角度范围来增加治疗的灵活性，对剂量场进行调制，完成更加适形的治疗。

## 2. 旋转伽玛刀发展历程

伽玛刀的发展先从头部治疗开始，旋转伽玛刀也是从头部治疗开始的，后经发展新的机型也用于体部治疗，头部和体部都可以用的旋转伽玛刀也在中国得到了一定的推广应用。

### 2.1 头部伽玛刀

旋转式头部伽玛刀利用伽玛射线动态旋转聚焦来实现对人体头部颅内和颅外的病变组织进行治疗，适应症包括脑血管畸形、各种颅内原生肿瘤和转移瘤、鼻咽癌、三叉神经痛、帕金森病、癫痫等。对患者采用的固定方式为头钉和头架，治疗多采用单分次治疗。

中国深圳市奥沃医学新技术发展有限公司于1995年研发出了世界上第一台旋转式头部伽玛刀-OUR Model RGS system，于1997年获得FDA注册证并在美国三家机构装机[3,4]。奥沃公司经过一段时间的沉寂后于2014年推出升级版的旋转式头部伽马刀-Snipeay；2017年研发出首台具备图像引导功能、可以摆脱头钉头架定位方式完成无创治疗的头部伽玛刀-AimRay，2018年又推出了AimRay的升级版-Supeay。中国另外一家伽玛刀公司，玛西普医学科技发展（深圳）有限公司，在1999年推出了第一代旋转式头部伽玛刀-SRRS，2010年推出第二代产品-Ifini/SRRS+。还有几家从奥沃分化出来的公司也推出了类似的产品，和奥沃一起分享当时并不算大的中国市场。一家美国公司American Radiosurgery，Inc (San Diego, CA) 在2000 年也推出了用于头部治疗的一套类似的旋转伽玛刀产品-RGS GammaART-6000，后改名为RGS Vertex360[5]。

### 2.2 体部伽玛刀

用于体部治疗的旋转式伽玛刀首先由深圳市奥沃医学新技术发展有限公司在已有旋转式头部伽玛刀研发的基础上在1998年推出，该系统整体采用四根立柱支撑结构，装载多颗放射源的治疗头在患者体部上方进行旋转照射。该系统在2005年获中国国家科技进步二等奖。玛西普体部伽玛刀GMBS也在2005年研发成功并进入临床，与奥沃体部伽玛刀相比，去掉了侧面两柱，治疗空间更加开放。2015年奥沃公司推出了新一代旋转式体部伽玛刀-“大医伽玛刀”，在原来体部伽玛刀的基础上进行了优化升级，新增正交成像图像引导模块，是第一套带有图像引导功能的体部伽玛刀，图像引导功能的增加大大提高患者摆位精度，把体部伽玛刀治疗带入了一个新的阶段。

### 2.3 全身伽玛刀

既可以用于头部肿瘤立体定向放射治疗或放射手术也可以用于体部肿瘤治疗的伽玛刀叫做头体合一伽玛刀或全身伽玛刀。深圳海博公司在2002年推出第一台头体合一的旋转伽玛刀-“超级伽玛刀”，其放射源呈扇形排列，可随机架绕患者做一周的旋转，是首款采用拉弧聚焦技术的伽玛刀产品。西安一体医疗在2003年推出“月亮神

*图3. SupeRay®整机造型*

”，机架成半圆形，通过治疗头在机架上的运动完成拉弧聚焦治疗，通过摆动治疗床改变拉弧（arc）的方位，该设备采用矩形准直孔，通过拉弧聚焦可在焦点形成饼状高剂量区。上海伽玛星公司在2004年研发成功“陀螺刀”，治疗头在随滚筒式机架进行拉弧治疗的同时也会绕自身轴线旋转，完成陀螺式运动，同时实现了旋转和拉弧两种聚焦模式。西安大医集团股份有限公司在2019年推出的最新头体合一伽玛刀-CybeRay，具有多源聚焦、拉弧治疗和非共面拉弧三重聚焦照射能力，也是世界上第一套同时具备CBCT图像引导和实时图像引导功能的立体定向放射治疗设备。

## 3. 旋转伽玛刀最新发展

### 3.1 图像引导无创治疗

原来的头部伽玛刀都是用头钉和头架来完成患者固定和治疗定位的，头钉给患者带来的痛苦和创伤是深刻的。不用头钉头架而采用面膜固定患者的无创治疗需要图像引导来确定治疗定位精度。同时，图像引导也是保证体部立体定向放射治疗（SBRT）定位精度的有力手段。图像引导在放疗中的应用已经很普及，对伽玛刀也不例外。图像引导功能在伽玛刀上的实现，摆脱了对头钉头架的依赖，不仅解除了头部患者的痛苦和创伤，也为头部多分次治疗提供可行性，这将有助于对治疗副作用的控制和治疗效果的提高。

Elekta AB（Stockholm, Sweden) 在2015年推出的带有CBCT图像引导的头部伽玛刀Icon®还是以多源静态聚焦照射为基础。在旋转式头部伽玛刀方面，目前中国国内市场最新的设备是深圳奥沃的SupeRay®（图3）。SupeRay®采用双kV正交成像精确定位技术，在国内率先突破了影像引导下伽玛刀自动化定摆位和低分次立体定向伽玛刀放射外科治疗技术，解决了头部伽玛刀分次治疗时患者重复定位过程中的诸多难题，可实现影像引导下的低分次立体定向放射外科治疗。SupeRay®支持头架和面膜两种患者固定方式，兼具“有创”和“无创”两种治疗模式，支持SRS与SRT两种治疗技术的实现，能够为临床提供更广阔的治疗选择和更灵活的治疗流程，对于佩戴头架有恐惧心理或不适宜佩戴头架的患者，以及脑部病灶数量较多、难以单次完成放射治疗的病症，具有较大的临床意义。

头部伽玛刀Icon®和SupeRay®的图像引导系统都处于治疗腔外，影像和治疗不在同一等中心，图像引导摆位完成以后，需要移动一个预设的固定距离到治疗位。美国伽玛刀新秀Akesis公司最新推出的旋转式伽玛射束立体定向放射外科系统-Galaxy® RTi（work in progres for FDA Clearance，图4），内置kV级影像系统，可完成CBCT成像和kV/kV配对成像，其影像中心与治疗等中心在同一点，因此，该系统可以在线

*图4. Akesis Galaxy® RTi (from akesis.com)*

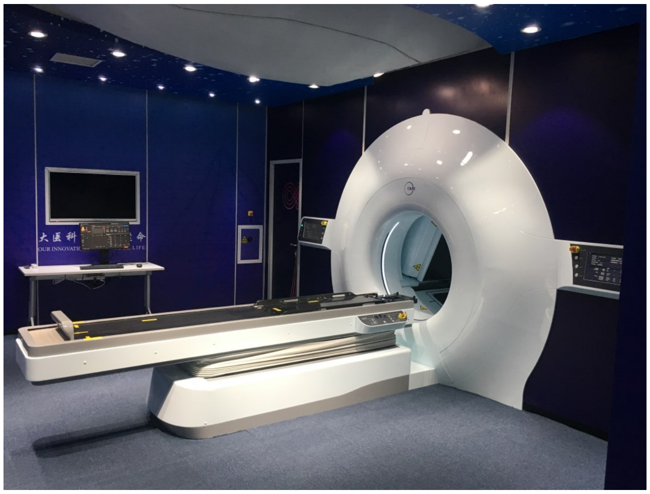
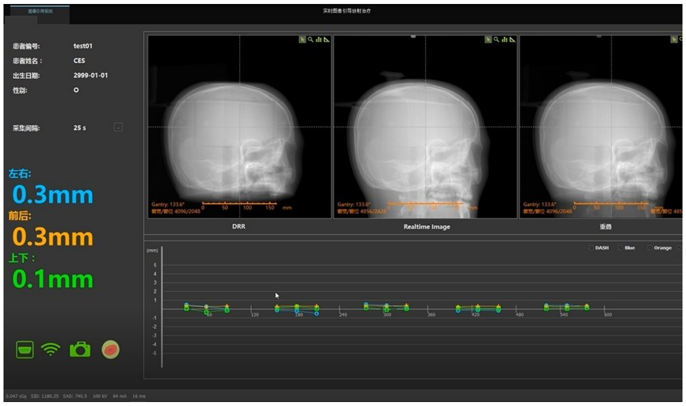


图5. CybeRay®整机造型

图7. TaiChi多模式一体化放疗系统

提供三维和二维图像来引导精确摆位，也能实现治疗中的实时图像引导来消除分次内定位误差。该系统同时支持有创和无创分次治疗方式。西安大医集团最新推出的多源聚焦旋转照射全身伽玛刀-CybeRay®采用kV级影像系统，同时支持基于CBCT的治疗前摆位和基于kV平面成像的治疗中位置确认和修正。两排沿经向作扇形排布的多颗放射源具有相同的源焦距，放射源至于源匣内，通过源匣的旋转实现开关源，开源时射线通过准直通道聚焦在等中心点。源匣、准直系统和自屏蔽材料共同组成治疗头，治疗头和影像系统共同搭载在一个圆筒形机架并随之旋转，共享同一等中心点。治疗头还可以围绕等中心在经向做不大于35度的非共面摆动，完成多种形式的治疗。整机造型和实时图像引导界面如图5和图6所示。



患者编号: test01

患者姓名 : CES

出生日期: 2999-01-01

性别: O

采集间隔: 25 s

左右: 0.3mm

前后: 0.3mm

上下 : 0.1mm

0.047 cGy SID: 1180.25 SAD: 740.5 100 kV 64 mA 16 ms

图6. CybeRay®实时图像引导界面

## 3.2 和加速器的结合

旋转伽玛刀采用多源聚焦旋转照射的治疗方式，用于精确立体定向放射治疗和手术有其独特性，但在大型肿瘤的常规分次治疗上它又有局限性。和医用直线加速器的结合将能充分发挥二者的优势，提供更多的应用和更好的治疗效果。加速器与伽玛刀结合起来的治疗方案越来越多见于临床，并且取得了优于单治疗模式的效果。加速器和伽玛刀联合治疗脑转移瘤的临床数据表明，多模式联合治疗可提高肿瘤局部控制率，延长平均生存时间，降低放射副反应等[6-9]。但这种联合治疗方式都是在两台设备上实现的，存在误差大、效率低的缺点。因此西安大医集团有限公司提出了多模式一体化放疗设备的概念，其主要特点是集成不同类型的治疗系统和图像引导系统于一体，同机实现多模式引导和多模式治疗。如图7所示，目前首台多模式一体化放疗设备-TaiChi产品样机已经通过NMPA和FDA的型检，准备进入临床试验。

TaiChi产品通过在空间布局、控制系统、临床流程以及安全性和可靠性等方面的创新设计，在有限的

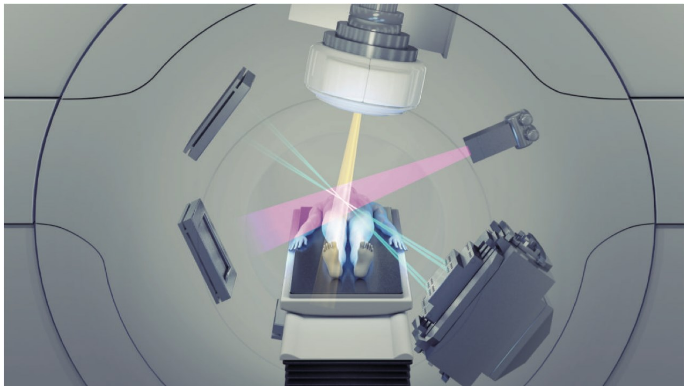


*图8. TaiChi主要部件布局示意图*

空间内实现了多源γ射线和X射线治疗头同机一体化，有机整合了可实现立体定向放射治疗的多源聚焦旋转伽玛刀系统和可实现旋转调强放疗的加速器系统。同时配套了kV级影像引导系统和基于MV级EPID的剂量引导系统，以保证精准的治疗定位和精确的治疗剂量投放。如图8所示，两套治疗系统和两套引导系统均搭载在一个等中心精度达到0.15mm的连续旋转滑环机架上，运动精度高，长期稳定性好。

Taichi产品配套了目前全球首个支持多模式治疗的全自动自适应TPS，以高速GPU和蒙卡算法为内核，可最大程度地挖掘多模式引导立体定向与旋转调强一体化放射治疗系统的潜能，充分发挥γ-X双源同机一体化的优势。可以单独用加速器治疗头完成对大肿瘤的常规分次治疗，也可以单独用伽玛刀治疗头完成对小肿瘤的立体定向治疗。情况较复杂的患者，在对原发灶进行旋转调强常规治疗的同时，可对转移瘤或远端病灶进行立体定向治疗；或对大肿瘤进行旋转调强常规治疗的同时，对肿瘤细胞密集区和乏氧区进行立体定向治疗来进行剂量增强治疗。

## 结论

旋转伽玛刀利用多源聚焦和旋转治疗的原理提供了快速跌落的剂量分布、高精度的等中心治疗、更好的经济效益等优势，加上同机一体化图像引导所带来的可视化定位精度保证和无创治疗将会扩展其临床应用，为更多患者提供治愈性治疗。和其它放射治疗模式的结合，将会是一种治疗上的加强和补充，对治疗效果的提升将会有所帮助。

## References

1.Leksell L. Cerebral radiosurgery. I. Gammathalanotomy in two cases of intractable pain. Acta Chir Scand. 1968;134(8):585-95.

2.Leksell L. Sterotaxic radiosurgery in trigeminal neuralgia. Acta Chir Scand. 1971;137(4):311-4.

3.Goetsch SJ, Murphy BD, Schmidt R, Micka J, De Werd L, Chen Y, et al. Physics of rotating gamma systems for stereotactic radiosurgery. Int J Radiat Oncol Biol Phys. 1999;43(3):689-96.

4.罗光华，王宇田．立体定向放射外科的新发展—旋转式伽玛刀．海南医学．2005(05):114-6.

5.Yang KM, Madsen SJ, Chen WL, Kuan WP, Young RF, Chen C. Dosimetry of a novel rotating gamma system for stereotactic radiosurgery. J Radiosurg SBRT. 2011;1(3):183-96.

6.曹永珍，姜炜，吕仲虹．143例脑胶质瘤立体定向加常规放疗的疗效观察．中华放射肿瘤学杂志．2006;15(5):375-8.

7.李珠明，崔玉琴．三维适形放疗与立体定向放射外科治疗脑胶质瘤初步临床分析．现代肿瘤医学．2006;14(1):12-3.

8.Aoyama H, Shirato H, Tago M, Nakagawa K, Toyoda T, Hatano K, et al. Stereotactic radiosurgery plus whole-brain radiation therapy vs stereotactic radiosurgery alone for treatment of brain metastases: a randomized controlled trial. JAMA. 2006;295(21):2483-91.

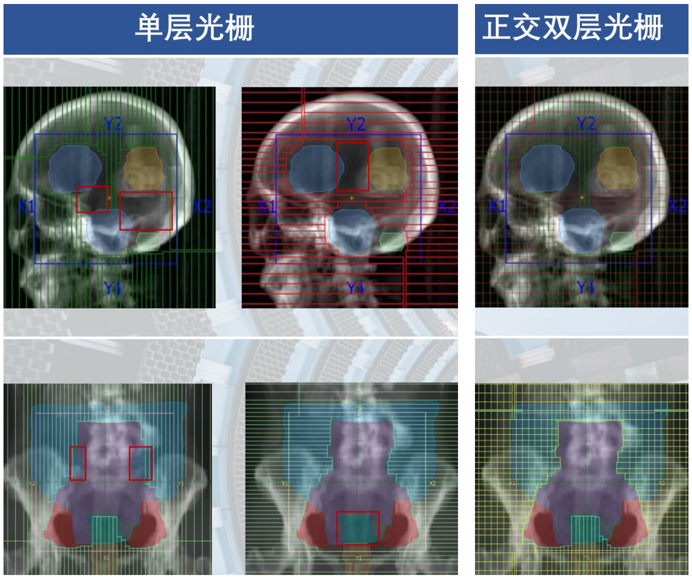
9.Valenciaga Y, Chang J, Schulder M. Evaluating the Use of Combined Gamma Knife/Linac Stereotactic Radiosurgery (SRS) Treatments in Patients with 10 or More Brain Metastases. Int J Radiation Oncology Biol. 2018;102(3):e520.

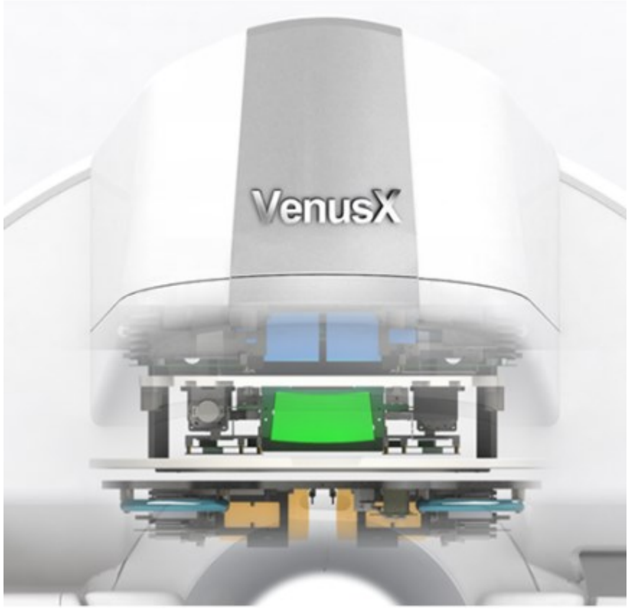
# *VenusX 医用电子直线加速器* ***Johnason Yao, PhD—雷泰医疗（LinaTech）***

The VenusX is an newly developed Linac by LinaTech, which has the treatment head incorporated with the novel dual layers cross aligned MLC and dual ring CBCT design. The VenusX has been successfully installed in Tianjin Cancer Center and Beijing 301 Hospital. Both are ready for treating cancer patients.

雷泰医疗（LinaTech）自主研发的VenusX医用电子直线加速器，通过了中国国家药品监督管理局（NMPA）的创新医疗器械特别审查申请，进入特别审查程序“绿色通道”。VenusX现已成功安装于天津市肿瘤医院和北京301医院并收治肿瘤患者。

## 一、VenusX医用电子直线加速器主要技术特点



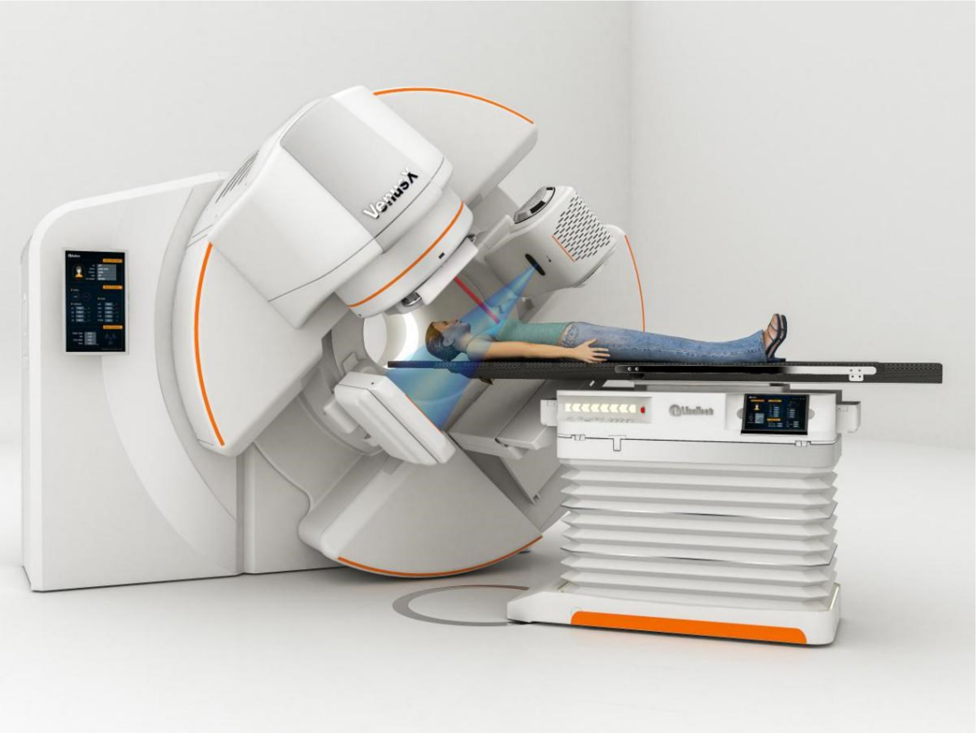


（1）基于成熟的6MV微波技术，具有高稳定性和0.15MU高分辨率的束流输出，并提供最高达1000cGy/Min的剂量率，保证了精确放射治疗所需的剂量精度并大幅提升临床治疗效率。

（2）拥有专利技术的双层（或三层）正交多叶准直器系统，叶片最薄至4mm，能显著增强治疗射野的适形能力，降低准直器剂量透漏射，提升治疗执行效率，更好的保护危及器官。同时，最大40cm×40cm的射野范围，光栅叶片最大运动速度90mm/s，到位精度≤1mm可更好满足大范围肿瘤照射治疗的临床需求。

（3）配备业界最清晰的MV级验证影像，分辨率高达2816×2816，不仅骨性标记清晰，软组织信息也十分丰富，可为图像配准提供更多的参考，精确帮助临床应用完成病人摆位。

（4）创新的独立滑环式高分辨率图像引导系统，采用大面积高分辨率非晶硅数字化X射线探测器，提供三维CT影像，其空间分辨率高，操作简单快捷。同时独立滑环影像技术能在治疗过程中快速、多角度成像，实时动态跟踪放射治疗过程中的靶区运动位移，能结合产品配置的可见光体



表扫描技术等多模态影像、正交双层光栅图像引导系统，实现了靶区实时跟踪治疗、自适应治疗等临床需求。

（5）放疗结合人工智能技术的智能勾画/摆位/计划/追踪。结合人工智能和大数据技术，在危及器官及靶区勾画、治疗计划设计、患者治疗摆位、动态靶区跟踪治疗等环节，能更好的提供个性化治疗方案，实现放射治疗质量的提升，有效提高治疗效率和治疗水平。

### 二、创新正交双层光栅具有显著的临床价值

根据近百例临床病例的研究，其中包括多发脑转移、鼻咽癌、乳腺癌等疑难病例的近千个统计样本的临床数据分析和剂量验证，正交双层光栅可以提高靶区剂量适形度及剂量均一性，大幅降低了多叶准直系统的透漏射率，从而提供更有效的危及器官剂量保护。从经过验证的临床数据的统计结果可以看出，正交双层光栅比单层光栅的靶区适形度、均一性更优，且对危及器官剂量保护率提高12.2%以上。

雷泰医疗VenusX医用电子直线加速器是一款拥有国际先进技术的中高端放疗设备，能充分满足临床所需要。产品已进入创新医疗器械特别审查程序，未来该产品在国内上市后，将有助于国产中高端加速器在临床的普及和应用，推动国产大型医疗器械及其相关产业链的发展，为医院提供高性价比的加速器设备选择机会，造福更多肿瘤患者。