STATE-OF-THE-ART OF NUCLEAR MEDICINE AND MOLECULAR IMAGING IN CHINA: AFTER THE FIRST 66 YEARS (1956–2022)

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This is a historical event. The five of us (Xiaoli Lan, Li Huo, Shuren Li, Jing Wang, and Weibo Cai) are thrilled and extremely proud to announce the publication of a European Journal of Nuclear Medicine and Molecular Imaging (EJNMMI) special issue entitled “State-of-the-Art of Nuclear Medicine and Molecular Imaging in China: After the First 66 Years (1956–2022)”, thanks to the tremendous support from the Editor-in-Chief of EJNMMI, Prof. Arturo Chiti from Humanitas University in Milan, Italy. With a total of more than 40 articles, including review articles, research articles, and this editorial, we sincerely hope this special issue will be a good snapshot in time of the State-of-the-Art of Nuclear Medicine and Molecular Imaging in China, which has witnessed exceptional growth and development over the last several decades. We are truly grateful to all the authors, reviewers, editors, patients, and EJNMMI editorial staff for their invaluable contribution of time and expertise, and we are convinced that this special issue will be very well-received by readers in Europe and China, as well as around the world.

One might say that in some way, this special issue originated on 1/6/2021, when Weibo Cai was invited by Prof. Chiti to become an Associate Editor of EJNMMI, in recognition of the increasing number of manuscript submissions to EJNMMI each year, especially from countries outside of Europe which clearly indicated the ever-increasing global impact and influence of EJNMMI in the field of nuclear medicine and molecular imaging. Needless to say that Cai gladly accepted the invitation and agreed to devote significant amount of time to help further increase the global impact of EJNMMI. On 1/16/2021, Prof. Chiti emailed all Associate Editors of EJNMMI to welcome any suggestions for further initiatives or “special issues”, aiming at capturing the state-of-the-art and/or emerging topics of the field. With such a special issue in mind for several years already, Cai immediately replied with a brief proposal of a EJNMMI special issue entitled “State-of-the-Art of Nuclear Medicine and Molecular Imaging in China”. Prof. Chiti was very delighted to receive the proposal with such a quick turnaround time, and enthusiastically encouraged Cai to “proceed with the proposal” on 1/17/2021.

Cai immediately discussed this proposal with several professors about guest editing the special issue together: Department Chairs of the top 2 Nuclear Medicine departments in China (Li Huo from Peking Union Medical College Hospital and Xiaoli Lan from Union Hospital in Wuhan, China) and editors-in-chief of 2 Nuclear Medicine journals in China (Shuren Li and Jing Wang). We also extended an invitation to key experts from 2 European countries (we are grateful to Arturo Chiti’s invitation that made this special issue to focus on China and the Asia-Pacific region). The guest editors then invited more than 10 associate editors from different countries to join in this special issue. Finally, the editors invited more than 40 authors to submit manuscripts, and the issue was accepted by the editorial board of EJNMMI.

The publication of this issue is a historical event in China and the Asia-Pacific region, and it is a great honor for us to present this special issue to the readers of EJNMMI. We believe that this issue will be well-received by readers in Europe and China, as well as around the world. We would like to express our gratitude to all the authors, reviewers, editors, patients, and EJNMMI editorial staff for their invaluable contribution of time and expertise. We are convinced that this special issue will be very well-received by readers in Europe and China, as well as around the world.
affiliated with Huazhong University of Science and Technology), Jing Wang (President-Elect of the Chinese Society of Nuclear Medicine, Chair of Department of Nuclear Medicine, Xijing Hospital), and Shuren Li from Medical University of Vienna. Together, the 5 guest editors are located in China, Europe, and USA with a very good gender balance (60% female). After a few rounds of discussion over the logistic details, on 1/21/2021, about 50 invitation emails to potential senior authors were sent out to invite them to consider contributing manuscript(s) to this special issue. Considering the time difference among Europe/USA/China, this special issue was kick started with lightning speed: everything was done in a matter of just a few days during the surging waves of the COVID-19 pandemic [1, 2].

In terms of the specific topic of this EJNMMI special issue, the five guest editors all agreed that we likely would not have enough high-quality manuscripts on any specific and focused topic such as artificial intelligence, new tracers, fibroblast activation protein inhibitor (FAPI), immunotherapy, total-body PET, or targeted radionuclide therapy. Hence, we all felt it was more suitable to include all areas of nuclear medicine, including but not limited to new tracer development/validation/optimization, first-in-human studies, clinical trials, therapy, theranostics, etc., as well as non-nuclear medicine molecular imaging studies (e.g., nanotechnology, image-guided drug delivery, other imaging modalities). With a broad scope, we were confident that we would be able to get excellent quality manuscripts in sufficient quantity that will not only meet the high standard of EJNMMI, but also be able to increase the exposure of EJNMMI in closely related biomedical fields.

With regard to who we should invite to contribute to this special topic issue, the process was highly selective. We tried to cover a large number of major research groups in China in the field, and only invited those who have published in top-quality journals (such as EJNMMI, Journal of Nuclear Medicine, or above), those (who may not be in the nuclear medicine field per se) with the potential to publish in these journals, as well as young rising stars to foster/promote the next generation of translational researchers. Even though this special issue is by invitation only, if there are accepted manuscripts in EJNMMI that fit the scope of the special issue, Dr. Chiti agreed that we could also cherry-pick and include these articles in our special issue.

The initial deadline of manuscript submission was set as 9/30/2021, with earlier submission highly encouraged in the invitation emails. Each manuscript underwent the standard quality control, and subsequent peer-review process immediately if it passed quality control. Accepted manuscripts were published online within a few days after manuscript acceptance, and generally would only be assigned specific issue and page numbers when the special issue is published. Considering the unpredictable global pandemic situation, which undoubtedly delayed some research/clinical activities, the guest editors left sufficient wiggle room for manuscript submission. In reality, the manuscript submission deadline was around 12/31/2021, aiming at completing all peer-review process by 3/31/2022. In total, approximately 60 authors were invited to contribute to the special topic issue, and the vast majority of those invited authors agreed to contribute and submitted manuscript(s).

Research and clinical activities of nuclear medicine in China has come a very long way [3, 4]. Figure 1 shows some of the representative landmark events over the last 70 years since the People’s Republic of China was founded on October 1st, 1949. The first course of nuclear medicine was officially offered in China in 1956, which represented the beginning of the field of nuclear medicine in China. However, the next 2 decades were very challenging for both researchers and the general population of China, with many devastating events happening during this period. With the Chinese Society of Nuclear Medicine (CSNM, a branch of the Chinese Medical Association) founded in 1980, and the Chinese Journal of Nuclear Medicine (CJNM) published in 1981, the field of nuclear medicine in China has got back on the right path and slowly, but steadily, started the arduous journey. With the first single-photon emission computed tomography (SPECT) system installed in China in 1983, the 1st PET and medical cyclotron in China installed in 1995, the 1st microPET in China installed in 2000, and the 1st PET/CT in China installed in 2002, the field of nuclear medicine and molecular imaging in China has steadily gained momentum and tremendous progresses have been made. After a decade (2000–2010) of learning, accumulation, investment, and hard work, the field of nuclear medicine and molecular imaging in China has entered the fast track in the 2nd decade of the twenty-first century, with the 1st PET/MR system in China installed in 2012, the “one nuclear medicine department per county” initiative established in 2016, and the 1st total-body PET/CT installed in 2019 [5]. In the same year, the 23rd International Symposium on Radiopharmaceutical Sciences (ISRS) was successfully held in Beijing, which was the first large-scale international conference in the field of nuclear medicine hosted by China.

Such dazzling development and tremendous growth over the last 2 decades were clearly evidenced by high-quality publications in the field. On 2/22/2022, we conducted a PubMed search of “Eur J Nucl Med Mol Imaging” [jour] AND “China” [Affiliation] and the results over the last 20 years were shown in Fig. 2. During the 1st decade of the twenty-first century, there were very few publications with Chinese affiliation, often only 0–2 per year. The first 5 years of the 2nd decade witnessed a significant increase in number of publications in EJNMMI; however, still no more than 10 a year (< 3% of all EJNMMI publications). Starting from 2016, the numbers increased steadily each year, reaching
22.2% in 2021 (158 out of a total of 712 EJNMMI publications have at least one Chinese affiliation). Such an increase can be attributed to a combination of many factors: the steady and unprecedented economic growth of China over the last several decades, much better hardware (e.g., scanners) than before in terms of both clinical practice and scientific research, tremendous financial investment in research and infrastructure by the Chinese government (national, provincial, and local), global recruitment of numerous established investigators and rising stars back to the country, increasing number of international collaborations and students/scientists studying abroad (before the pandemic), among many others. We predict that the upward trajectory will remain in the foreseeable future, although the slope of increase will certainly slow down to a certain extent.

With such a dramatic increase in number of (EJNMMI) publications with Chinese affiliation(s) over the last 5 years, it is perfect timing for this special issue. With ~60 invitations, we received manuscript submissions from the vast majority of invited senior authors (some with multiple submissions). All manuscripts underwent rigorous peer-review process with at least 2–3 reviewers, and a significant percentage was rejected based on reviewer’s comments. In the final published special issue, there are more than 40 articles total, which include 6 review articles [4, 6–10] and this editorial, with the remaining being research articles. According
to the standard EJNMMI list of topics, these research articles were divided into the following categories: advanced image analyses [11–13], preclinical imaging [14–26], translational research [27–30], neurology [31, 32], cardiology [33], and oncology [34–47]. Due to the large number of accepted manuscripts, which is significantly more than the typical number of articles per EJNMMI issue, many invited contributions were published in various issues before this EJNMMI special issue, which include 2 review articles [48, 49], many research articles [50–62], and 1 invited editorial [63]. In addition to the original goal of highlighting some of the emerging research trends and advances in nuclear medicine and molecular imaging from China, this special issue also aims to reflect the diversity of nuclear medicine and molecular imaging research in China and its interface with various disciplines of science and technology. The scope of this special issue is very broad, which includes nuclear medicine research, non-radionuclide-based imaging/therapy, as well as nanobiotechnology. Many of the hot topics of recent research and clinical practice were also adequately represented, such as PSMA and FAPI (many articles of this special issue), artificial intelligence, exosome, cancer immunotherapy, PET/MR, total-body PET, among others.

Currently, there are > 1000 Departments of Nuclear Medicine, > 400 PET/CT, > 20 PET/MR, > 300 SPECT, ~ 500 SPECT/CT, > 10 total-body PET, and > 120 cyclotrons in China [64]. The number of annual PET/CT scans have reached 1 million, annual SPECT scans have surpassed 2.5 million, and the total number of nuclear medicine professionals have reached 12,000 (with > 5400 as nuclear medicine physicians). With such a large body of workforce, state-of-the-art preclinical/clinical equipment, and increasing funding support from various entities to nuclear medicine and molecular imaging research, we are living in the best era in the history of nuclear medicine and molecular imaging, not only in China, but also internationally. We look forward to future exciting developments in this vibrant area, and the future is brighter than ever. The golden age of nuclear medicine and molecular imaging in China has arrived, and it is here to stay.

EJNMMI is the leading forum for the exchange of clinical and scientific information for the nuclear medicine community and allied professions involved in the functional, metabolic, and molecular investigation of various diseases. The journal highly emphasizes translational work, with a very broad scope that covers all areas of molecular imaging. With the dazzling speed of development and tremendous advances of nuclear medicine and molecular imaging in China over the last 2 decades, the findings/results obtained by the Chinese clinical and research community should be of high value to the international readers of EJNMMI. In addition to top-quality work performed at some of the leading hospitals and academic institutions, which is certainly of high interest to most researchers/clinicians/workers in the field, the 1.4 billion population of China can also be further explored for various scientific and clinical discoveries. With such a large population base, there are many different types of rare diseases with significant number of patients (may not be the case in Europe, North America, and other developed countries), which will provide numerous opportunities for future biomedical research as well as clinical patient management.

With the ever-increasing scientific and clinical caliber of research personnel and clinicians in China, we firmly believe their findings will greatly benefit the international nuclear medicine and molecular imaging community, and this special issue (as well as potentially future special issues) will undoubtedly increase the global impact of EJNMMI in the long run. We sincerely hope you will enjoy reading this special issue as much as we do, and that you will find useful and usable information for your research enterprise and daily clinical practice. If the feedback of this EJNMMI special issue is overwhelmingly positive (please feel free to reach out to us to provide feedback, and we welcome all comments/suggestions, regardless of whether they are positive or negative), we may consider organizing and guest editing another special issue on a suitable topic in 3–6 years.
3. Wang SC, Chou CE. A brief overview of nuclear medicine in China. Semin Nucl Med. 1989;19:144–51. https://doi.org/10.1016/s0001-2998(89)80008-x.

4. Hu J, Li H, Sui Y, Du J (2021) Current status and future perspective of radiopharmaceuticals in China. Eur J Nucl Med Mol Imaging. 1–17. https://doi.org/10.1007/s00259-021-06515-6.

5. Badawi RD, Shi H, Hu P, Chen S, Xu T, Price PM, et al. First Human Imaging Studies with the EXPLORER Total-Body PET Scanner. J Nucl Med. 2019;60:299–303. https://doi.org/10.2967/jnumed.119.226498.

6. Song W, Song Y, Li Q, Fan C, Lan X, Jiang D. Advances in aptamer-based nuclear imaging. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05726-8.

7. Zhang Z, He K, Chi C, Hu Z, Tian J. Intraoperative fluorescence molecular imaging accelerates the coming of precision surgery in China. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05730-y.

8. Shi Z, Zhang Z, Liu Z, Zhao L, Ye Z, Dekker A, et al. Methodological quality of machine learning-based quantitative imaging analysis studies in esophageal cancer: a systematic review of clinical outcome prediction after concurrent chemoradiotherapy. Eur J Nucl Med Mol Imaging. 2021. https://doi.org/10.1007/s00259-021-05658-9.

9. Li M, Younis MH, Zhang Y, Cai W, Lan X. Clinical summary of fibroblast activation protein inhibitor-based radiopharmaceuticals: cancer and beyond. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05706-y.

10. Huang Z, Wu Y, Fu F, Meng N, Gu F, Wu Q, et al. Parametric image generation with the EXPLORER total-body PET/CT system through deep learning. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05731-x.

11. Liu G, Yu H, Shi D, Hu P, Hu Y, Tan H, et al. Short-time total-body dynamic PET imaging performance in quantifying the kinetic metrics of (18)F-FDG in healthy volunteers. Eur J Nucl Med Mol Imaging. 2021. https://doi.org/10.1007/s00259-021-05500-2.

12. Zhang Y, Hu P, He Y, Yu H, Tan H, Liu G, et al. Ultrafast 30-s total-body PET/CT scan: a preliminary study. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05838-1.

13. Zhang Y, Cheng H, Chen H, Xu P, Ren E, Jiang Y, et al. A pure nanoICG-based homogeneous lipiodol formulation: toward precise surgical navigation of primary liver cancer after long-term transcatheter arterial embolization. Eur J Nucl Med Mol Imaging. 2021. https://doi.org/10.1007/s00259-021-05654-z.

14. Xu J, Cai F, Luo Z, Fan W, Dai J, Cui J, et al. Design, synthesis, and preclinical evaluation of a novel bifunctional macrocyclic chelator for theranostics of cancers. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05750-8.

15. Hu G, Zhu W, Liu Y, Wang Y, Zhang Z, Zhu S, et al (2022) Development and comparison of three (89)Zr-labeled anti-CLDN18.2 antibodies to noninvasively evaluate CLDN18.2 expression in gastric cancer: a preclinical study. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05739-3.

16. Huang L, Fang J, Hong S, Liu H, Zhu H, Feng L, et al. MicroPET imaging of bacterial infection with nitroreductase-specific responsive (18)F-labelled nitrogen mustard analogues. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05710-2.

17. Hou Z, Zhou M, Ma Y, Xu X, Zhan Z, Lai S, et al. Size-changeable nanoprobes for the combined radiotherapy and photodynamic therapy of tumor. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05830-9.

18. Qian R, Jing B, Jiang D, Gai Y, Zhu Z, Huang X, et al. Multiantitumor therapy and synchronous imaging monitoring based on exosome. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05696-x.

19. An S, Zhang D, Zhang Y, Wang C, Shi L, Wei W, et al. GPC3-targeted immunoPET imaging of hepatocellular carcinomas. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05723-x.

20. Xu H, Wang Y, Zhang J, Duan X, Zhang T, Cai X, et al. A self-triggered radioligand therapy agent for fluorescence imaging of the treatment response in prostate cancer. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05743-7.

21. Li H, Ye S, Li L, Zhong J, Yan Q, Zhong Y, et al. (18)F- or (177)Lu-labeled bivalent ligand of fibroblast activation protein with high tumor uptake and retention. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05757-1.

22. Yu F, Li M, Wang Q, Wang J, Wu S, Zhou R, et al. Spatiotemporal dynamics of brain function during the natural course in a dental pulp injury model. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05764-2.

23. Wang G, Li W, Shi G, Tian Y, Kong L, Ding N, et al. Sensitive and specific detection of breast cancer lymph node metastasis through dual-modality magnetic particle imaging and fluorescence molecular imaging: a preclinical evaluation. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05834-5.

24. Wang X, Zhou M, Chen B, Liu H, Fang J, Xiang S, et al (2022) Preclinical and exploratory human studies of novel (68)Ga-labeled D-peptide antagonist for PET imaging of TIGIT expression in cancers. Eur J Nucl Med Mol Imaging. 1–11. https://doi.org/10.1007/s00259-021-05672-x.

25. Fu Z, Lin Q, Xu Z, Zhao Y, Cheng Y, Shi D, et al. P2X7 receptor-specific radioligand (18)F-FITM for atherosclerotic plaque PET imaging. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05689-w.

26. Luo H, Yang C, Kuang D, Shi S, Chan AW. Visualizing dynamic changes in PD-L1 expression in non-small cell lung carcinoma with radiolabeled recombinant human PD-1. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05680-5.

27. Lu D, Zhou H, Li N, Wang Y, Zhang T, Wang F, et al. Galectin expression detected by (68)Ga-galectracer PET as a predictive biomarker of radiotherapy resistance. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05711-1.

28. Wei Y, Zheng J, Liu L, Liu X, Xu S, Wang S, et al. [(18)F]ALF-NOTA-FAPI-04: FAP-targeting specificity, biodistribution, and PET/CT imaging of various cancers. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05758-0.

29. Wu Y, Zhang X, Zhou H, Xu B, Tian J, Sun S, et al. Synthesis, preclinical evaluation, and first-in-human study of Al(18)F-PSMA-Q for prostate cancer imaging. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05775-z.

30. Wang J, Yang H, Cui B, Shan B, Lu J. Effects of MRI protocols on brain FDG uptake in simultaneous PET/MR imaging. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05703-1.

31. Zhao Y, Wu P, Wu J, Brendel M, Lu J, Ge J, et al. Decoding the dopamine transporter imaging for the differential diagnosis of parkinsonism using deep learning. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05804-x.

32. Xie B, Wang J, Xi XY, Guo X, Chen BX, Li L, et al. Fibroblast activation protein imaging in reperfused ST-elevation myocardial infarction: comparison with cardiac magnetic resonance imaging. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-021-05674-9.

33. Xu J, Tian Z, Zhang Y, Ji H, Sun J, Wang X, et al. (18)F-Alfatide II for the evaluation of axillary lymph nodes in breast cancer
patients: comparison with (18)F-FDG. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-021-05333-z.
35. Zhang Z, Jia G, Pan G, Cao K, Yang Q, Meng H, et al. Comparison of the diagnostic efficacy of (68) Ga-FAP1-04 PET/CT and (18)F-FDG PET/CT in patients with pancreatic cancer. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05792-5.
36. Gu B, Liu X, Wang S, Xu X, Liu X, Hu S, et al. Head-to-head evaluation of [(18)F]FDG and [(68) Ga]Ga-DOTA-FAP1-04 PET/CT in recurrent soft tissue sarcoma. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05700-4.
37. Jiang C, Li A, Teng Y, Huang X, Ding C, Chen J, et al. Optimal PET-based radiomic signature construction based on the cross-combination method for predicting the survival of patients with diffuse large B-cell lymphoma. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05717-9.
38. Sun K, Shi L, Qiu J, Pan Y, Wang X, Wang H. Multi-phase contrast-enhanced magnetic resonance image-based radiomics-combined machine learning reveals microscopic ultra-early hepatocellular carcinoma lesions. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05742-8.
39. He K, Li P, Zhang Z, Liu J, Liu P, Gong S, et al. Intraoperative near-infrared fluorescence imaging can identify pelvic nerves in patients with cervical cancer in real time during radical hysterectomy. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05686-z.
40. Chen X, Liu X, Wang L, Zhou W, Zhang Y, Tian Y, et al. Expression of fibroblast activation protein in lung cancer and its correlation with tumor glucose metabolism and histopathology. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05754-4.
41. Yang G, Nie P, Yan L, Zhang M, Wang Y, Zhao L, et al. The radiomics-based tumor heterogeneity adds incremental value to the existing prognostic models for predicting outcome in localized clear cell renal cell carcinoma: a multicenter study. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05773-1.
42. Lin R, Lin Z, Chen Z, Zheng S, Zhang J, Zhang J, et al. [(68) Ga]Ga-DOTA-FAP1-04 PET/CT in the evaluation of gastric cancer: comparison with [(18)F]FDG PET/CT. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05799-5.
43. Zhao X, Liang YJ, Zhang X, Wen DX, Fan W, Tang LQ, et al. Deep learning signatures reveal multiscale intratumor heterogeneity associated with biological functions and survival in recurrent nasopharyngeal carcinoma. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05793-x.
44. Zhou X, Wang S, Xu X, Meng X, Zhang H, Zhang A, et al. Higher accuracy of [(68) Ga]Ga-DOTA-FAP1-04 PET/CT comparing with [(18)F]FDG PET/CT in clinical staging of NSCLC. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05818-5.
45. Sun T, Wang Z, Wu Y, Gu F, Li X, Bai Y, et al. (2022) Identifying the individual metabolic abnormalities from a systemic perspective using whole-body PET imaging. Eur J Nucl Med Mol Imaging. 1–11. https://doi.org/10.1007/s00259-022-05832-7.
46. Qiu DX, Li J, Zhang JW, Chen MF, Gao XM, Tang YX, et al. Dual-tracer PET/CT-targeted, mpMRI-targeted, systematic biopsy, and combined biopsy for the diagnosis of prostate cancer: a pilot study. Eur J Nucl Med Mol Imaging. 2021. https://doi.org/10.1007/s00259-021-05636-1.
47. Hu K, Wang L, Wu H, Huang S, Tian Y, Wang Q, et al. [(18) F]FAP1-42 PET imaging in cancer patients: optimal acquisition time, biodistribution, and comparison with [(68) Ga]Ga-FAP1-04. Eur J Nucl Med Mol Imaging. 2021. https://doi.org/10.1007/s00259-021-05646-x.
48. Qin X, Jiang H, Liu Y, Zhang H, Tian M. Radiouclide imaging of apoptosis for clinical application. Eur J Nucl Med Mol Imaging. 2022;49:1345–59. https://doi.org/10.1007/s00259-021-05641-4.
49. Xie B, Ding YF, Shui M, Yue L, Gao C, Wyman IW, et al. Supramolecular biomaterials for bio-imaging and imaging-guided therapy. Eur J Nucl Med Mol Imaging. 2022;49:1200–10. https://doi.org/10.1007/s00259-021-05622-7.
50. Duan X, Cao Z, Zhu H, Liu C, Zhang X, Zhong J, et al. (68) Ga-labeled ODP-URA-based PSMA agents in prostate cancer: first-in-human imaging of an optimized agent. Eur J Nucl Med Mol Imaging. 2022;49:1030–40. https://doi.org/10.1007/s00259-021-05486-x.
51. Zhu W, Jia R, Yang Q, Cheng Y, Zhao H, Bai C, et al. A prospective randomized, double-blind study to evaluate the diagnostic efficacy of (68) Ga-NODAGA-LM3 and (68) Ga-DOTA-LM3 in patients with well-differentiated neuroendocrine tumors: compared with (68) Ga-DOTATATE. Eur J Nucl Med Mol Imaging. 2022;49:1613–22. https://doi.org/10.1007/s00259-021-05512-y.
52. Kang L, Li C, Yang Q, Sutherlin L, Wang L, Chen Z, et al. (64) Cu-labeled daratumumab F(ab’)2 fragment enables early visualization of CD38-positive lymphoma. Eur J Nucl Med Mol Imaging. 2022;49:1470–81. https://doi.org/10.1007/s00259-021-05593-9.
53. Zhang P, Xu M, Ding J, Chen J, Zhang T, Huo L, et al. Fatty acid-conjugated radiopharmaceuticals for fibroblast activation protein-targeted radiotherapy. Eur J Nucl Med Mol Imaging. 2022;49:1985–96. https://doi.org/10.1007/s00259-021-05591-x.
54. Wang G, Hong H, Zang J, Liu Q, Jiang Y, Fan X, et al. Head-to-head comparison of [(68) Ga]Ga-P16-093 and [(68) Ga]Ga-PSMA-617 in dynamic PET/CT evaluation of the same group of recurrent prostate cancer patients. Eur J Nucl Med Mol Imaging. 2022;49:1052–62. https://doi.org/10.1007/s00259-021-05539-1.
55. Guo K, Wang J, Wang Z, Wang Y, Cui B, Zhao G, et al. Morphometric analysis program and quantitative positron emission tomography in presurgical localization in MRI-negative epilepsies: a simultaneous PET/MRI study. Eur J Nucl Med Mol Imaging. 2022;49:1930–8. https://doi.org/10.1007/s00259-021-05657-w.
56. Zhao L, Pang Y, Wang Y, Chen J, Zhang Y, Zhang J, et al. Somatic-tatin receptor imaging with [(68)Ga]Ga-DOTATATE positron emission tomography/computed tomography (PET/CT) in patients with nasopharyngeal carcinoma. Eur J Nucl Med Mol Imaging. 2022;49:1360–73. https://doi.org/10.1007/s00259-021-05667-0.
57. Liu W, Gu S, Chen X, Fan W, Tang LQ, et al. A radiolabeled DARPin for the imaging of CD38-positive lymphoma. Eur J Nucl Med Mol Imaging. 2022;49:1052–62. https://doi.org/10.1007/s00259-021-05633-4.
58. Liu T, Wu Y, Shi L, Li L, Hu B, Wang Y, et al. Preclinical evaluation of [(99m)Tc]Tc-labeled anti-EpCAM nanobody for EpCAM receptor expression imaging by immuno-SPECT/CT. Eur J Nucl Med Mol Imaging. 2022;49:1810–21. https://doi.org/10.1007/s00259-021-05670-z.
59. Chen X, Liang YJ, Zhang X, Wen DX, Fan W, Tang LQ, et al. Longitudinal evaluation of five nasopharyngeal carcinoma animal models on the microPET/MR platform. Eur J Nucl Med Mol Imaging. 2022;49:1497–507. https://doi.org/10.1007/s00259-021-05634-4.
60. Wang Z, Bai Y, Jin X, Tian Y, Li X, et al. Longitudinal evaluation of five nasopharyngeal carcinoma animal models on the microPET/MR platform. Eur J Nucl Med Mol Imaging. 2022;49:1497–507. https://doi.org/10.1007/s00259-021-05634-4.
62. Zhang Z, Chen X, Wan Q, Wang H, Qi N, You Z, et al. A two-stage cardiac PET and late gadolinium enhancement MRI co-registration method for improved assessment of non-ischemic cardiomyopathies using integrated PET/MR. Eur J Nucl Med Mol Imaging. 2022. https://doi.org/10.1007/s00259-022-05681-4.

63. Younis MH, Malih S, Lan X, Rasaei MJ, Cai W. Enhancing fibroblast activation protein (FAP)-targeted radionuclide therapy with albumin binding, and beyond. Eur J Nucl Med Mol Imaging. 2022;49:1773–7. https://doi.org/10.1007/s00259-022-05766-0.

64. China Nuclear Imaging Market - growth, trends, and forecasts (2020 - 2025): mordor Intelligence; 2020.

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