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Perspective

From data to decisions: Big data and AI are shaping the future of radiotherapy and individualized treatment of nasopharyngeal carcinoma

1. Introduction

Nasopharyngeal carcinoma (NPC) has an imbalanced geographical and ethnic distribution, with notably high incidence rates in Southeastern Asia and China. China accounted for 42.4% of the newly diagnosed cases worldwide in 2022.[1] NPC is sensitive to irradiation, and radiotherapy is the mainstay curative treatment modality.[2] The widespread use of intensity-modulated radiation therapy (IMRT) and image-guided radiotherapy (IGRT) has achieved great advances in survival outcomes and toxicity profiles among NPC patients.[1] In radiotherapy of NPC, the tumor's proximity to critical structures demands accuracy in tumor delineation in order to avoid radiation-induced toxicities. However, tumor target delineation for radiotherapy of NPC is labor-intensive and radiation oncologists' proficiency varied considerably.[3] In recent years, the advent of big data analytics and artificial intelligence (AI) has opened up new avenues for improving the precision and efficacy of radiotherapy and individualized treatment in NPC management.[3–6] In this article, we explored how big data, AI-assisted delineation, radiotherapy planning, and adaptive radiotherapy (ART) are transforming clinical decision-making in NPC treatment. We also provided an outlook on the historical development of AI and big data, their current dominance in oncological radiotherapy, and their projected impact on future clinical practice (Figure 1).

2. Current research into the use of big data and AI in NPC treatment

2.1 The use of big data analytics in the individualized treatment of NPC

Since advancements in radiotherapy technology have improved locoregional control of NPC, distant metastasis remains the main treatment failure of NPC. Over the past two decades, researchers have performed randomized controlled trials (RCTs) that have demonstrated the ineffectiveness of adjuvant strategies and the effectiveness of induction chemotherapy and metronomic capecitabine adjuvant therapy for decreasing distant metastasis.[7-10] However, RCTs are often time-consuming and costly, underscoring the need for a complementary approach, such as real-world studies. Big data are pivotal in this context. As of April 2024, we have established a comprehensive database that integrates over 1.9 million cancer cases, encompassing multidimensional data across common tumor types. This database not only standardizes and integrates multimodal data but also structures them through natural language processing (NLP), organizing the data chronologically.[11] In the NPC-specific database, 13 electronic health records (EHR) systems were integrated and 981 variables were defined.[12] This database includes comprehensive data on more than 90,000 NPC patients from 2000 to 2024. Thanks to the application of big data and AI in the management of this database and the patients it includes, 70% of patient follow-ups are now automated, which helps keep the database current, organized, and easily accessible. The big data platform has thus far supported 2,950 research projects and is expected to yield 30–50 publications every three years.

Previously, the use of big data analytics facilitated our investigation into rare phenomena observed in clinical practice among NPC patients. For instance, since there is an extremely low incidence of radiation-induced brainstem necrosis after radiotherapy of NPC, the condition was largely unknown and dose constraint recommendations varied. By using the big data platform, we identified 6,288 patients with regular magnetic resonance (MR) imaging follow-up of more than 12 months during 2009–2015; then, we identified 24

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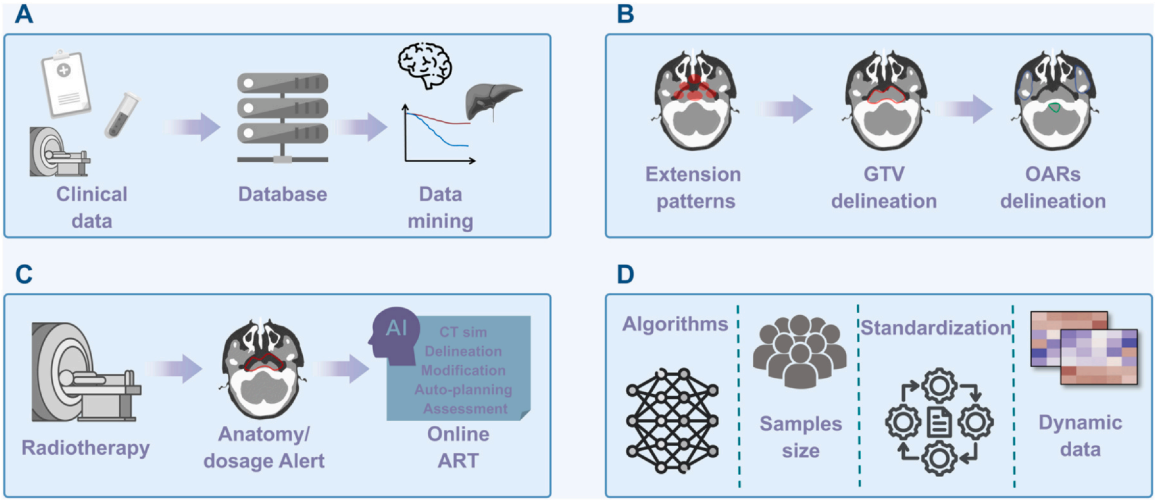


Figure 1. Big data and artificial intelligence in radiotherapy and individualized treatment of NPC. A: Big data in individualized treatment for NPC. **B**: AI in radiotherapy delineation. **C**: AI in online adaptive radiotherapy. **D**: Outlook for AI and big data in radiotherapy and individualized treatment of NPC. Abbreviations: 1. GTV: gross tumor volume 2. OARs: organs at risk.

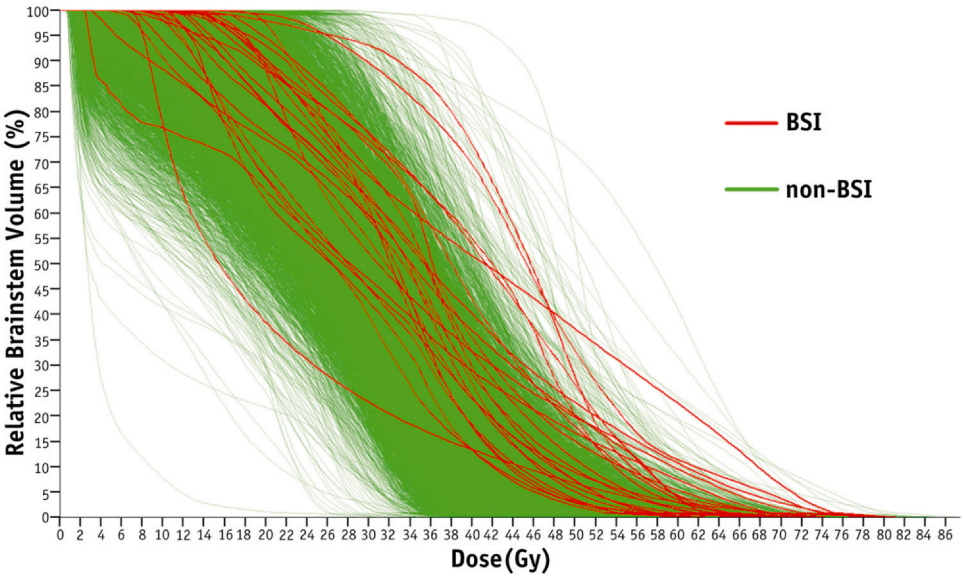


Figure 2. Dose–volume histogram (DVH) for 24 patients with brain stem injury (BSI) and 6,264 patients without brain stem injury (non-BSI).[a]

patients with brain stem injury (BSI) by reviewing the MR images. Based on the dosimetric data of these 24 patients with and 6,264 patients without BSI, a safe dosage threshold of IMRT to prevent BSI was proposed (Figure 2).[13] In a separate study, we found that hepatitis B virus (HBV) may be activated by chemotherapy in NPC patients. NPC patients who underwent HBV DNA tests before, during, and after chemotherapy were identified through corresponding variables provided in the big data platform, with 563 such patients identified among the 46,919 patients between 2008 and 2016. Among these, 51 patients were found to have experienced HBV activation. When analyzing these 51 patients, evidence was found in support of the introduction of HBV screening and prophylaxis for patients with chronic HBV infection on high-risk regimens.[14]

Furthermore, big data allow for the precise stratification of patients. For example, to investigate the prognostic significance of liquid biopsy tracking, medical records of 673 patients with longitudinal Epstein-Barr virus (EBV) DNA tests were retrieved from 10,126 cases between 2009 and 2015. Based on dynamic changes in EBV DNA, patients were stratified into different risk groups. Moreover, different

[a] Reprinted from *International Journal of Radiation Oncology Biology Physics*, Vol 105, Xiao-Dan Huang et al., Evolution and Dosimetric Analysis of Magnetic Resonance Imaging–Detected Brain Stem Injury After Intensity Modulated Radiation Therapy in Nasopharyngeal Carcinoma, Pages124–131, Copyright (2019), with permission from Elsevier.

forms of tumor biology were identified, leading to the proposal that distinct adaptive treatment strategies should be developed.[15] In these ways, the big data platform has empowered clinical research and promoted the individualized treatment of NPC.

Because of the focused geographical distribution of NPC, most big databases have been built in southern China. Chen et al.[16], for instance, constructed an NPC-specific big data platform based on EHR. Between 1999 and 2022, 11,617 patients of Nanfang Hospital, Southern Medical University were included. The data in the platform were shown to be complete and accurate, especially for social demographics, laboratory tests, and vital signs. There are, however, databases also to be found outside of China. In the US, for example, the Surveillance, Epidemiology, and End Results database compiled more than 13,000 NPC cases from 17 registries between 2000 and 2021. It provides detailed and comprehensive information on various aspects of patients, and it has supported numerous research.

Big data analytics have great potential to stratify patients with different risk levels and thereby support individualized treatment strategies. These analytics identify patterns and correlations that may not be apparent in smaller datasets. For instance, predictive modeling can be used to identify which patients are most likely to benefit from certain treatments based on their genetic profiles, tumor characteristics, and clinical histories. This personalized approach can promote treatment efficacy and reduce unnecessary side effects. Additionally, big data can facilitate the development of new treatment protocols and guidelines by providing robust evidence derived from real-world patients.

Big data can also enhance patient care by enabling more precise and timely interventions. For example, a dynamic monitoring system can be used to identify patients at a high risk of treatment-related complications, allowing for early interventions and management. Moreover, big data can aid in the development of decision-support tools that provide clinicians with real-time insights and recommendations based on the latest evidence and guidelines. These tools can assist clinical decision-making, reduce variability in care, and ultimately improve patient outcomes.

2.2 The use of AI in the precision delineation of tumor targets and OARs in NPC radiotherapy

Precision delineation of tumor targets and OARs is crucial for the successful radiotherapy of NPC. Inaccuracies in tumor targets' and OARs' delineation may compromise survival and increase radiation-induced toxicities in head and neck cancer.[17] Tumor targets' delineation in the NPC field is built on the experience of radiation oncologists, but their delineation is labor-intensive and error-prone, with a contouring consistency of approximately 70% between an expert group and radiation oncologists with 1 − 3 years of experience.[3] Furthermore, there is considerable inter-observer variation among radiation oncologists, with an average contouring consistency of about 74%.[3] Against that background, the implementation of AI contouring can markedly reduce the variations that appear.

To achieve an accurate delineation of tumor targets and OARs, from 2009 to 2018, we focused on aligning the understanding of tumor targets for NPC and head and neck OARs among radiation oncologists. We identified patterns of locoregional tumor extension for NPC, including a decreased extension risk in cases of non-involvement of high-risk anatomical sites, six common pathways of primary tumor invasion, and the orderly spread of neck lymph node (LN) metastases from higher to lower neck levels.[18,19] We also established a regional LN distribution probability map and proposed NPC-specific improvements to the international guidelines for neck clinical target volume,[20] as well as established criteria for protecting 33 normal organs, which are now adopted in eight global guidelines (Figure 3).[21]

Utilizing these insights, we delineated ground truth contours of the primary GTV (GTVp) on multiparameter MR images from 1,021 NPC patients, and the nodal GTV (GTVn), clinical target volumes (CTVs), and head and neck OARs on plain CT images from approximately 500 NPC patients. Next, we developed and validated three-dimensional convolutional neural networks (CNNs) to achieve the automated delineation of target volumes and OARs. These automated delineation models were then integrated to establish an AI system. For GTVp, this AI system simulates tumor spread paths and identifies tumor margins on MR images with a state-of-the-art accuracy of 78% − 82%, surpassing the accuracy levels of half of the radiation oncologists (Figure 4).[3] Moreover, AI assistance promoted the contouring accuracy and reduced inter-observer variation by 50%, as well as reduced the delineation time by 40%.[3] For GTVn and high- and low-risk CTVs, the delineation accuracies were 74%, 93%, and 88%, respectively.[22] Besides, through the AI-assisted delineation of OARs, we expanded the number of protected organs from 15 to 43 in clinical routine delineation. When combining all tumor targets and OARs, the delineation efficiency is expected to increase fivefold. This AI system has been approved to be used in both tertiary and primary hospitals in China, and as of June 30, 2024, it has been used in over 500,000 patients across 296 hospitals in 31 provinces of China.

Beyond using images for tumor targets' delineation in NPC, Cai et al. combined clinical staging with deep learning algorithms to further enhance the average accuracy of GTVp delineation to 0.84.[23] Moreover, in another study, a 3D DenseNet model trained on more than 3,000 NPC patients exhibited a promising performance in detecting NPC (an overall accuracy of 0.98) and conducting automatic segmentation (an average accuracy of 0.77) of GTVp.[24] Elsewhere, radiotherapy treatment planning (RTP)-Net was trained on over 20,000 patients, achieving the delineation of whole-body OARs within 2 seconds, with the average accuracy reaching 0.95 (Figure 5).[25] The results of these studies, which have demonstrated that this approach enhances clinical efficiency and benefits both patients and radiation oncologists, lead us to propose that future research should integrate multimodal data and train on larger sample sizes, to achieve faster and more accurate tumor target or OARs delineation.

Integrating multimodal data into AI models is crucial for improving their delineation accuracy and efficiency. By combining imaging data, clinical diagnostic information, and molecular data, AI systems could provide us with a more comprehensive understanding of tumor characteristics and behavior. This holistic approach enables more precise and individualized treatment plans, reducing the risk of radiation-induced damage to normal tissues and strengthening patient outcomes. Future research should center on expanding the types and sample sizes of data used in AI models and developing algorithms that can seamlessly integrate these diverse and large amounts of data sources.

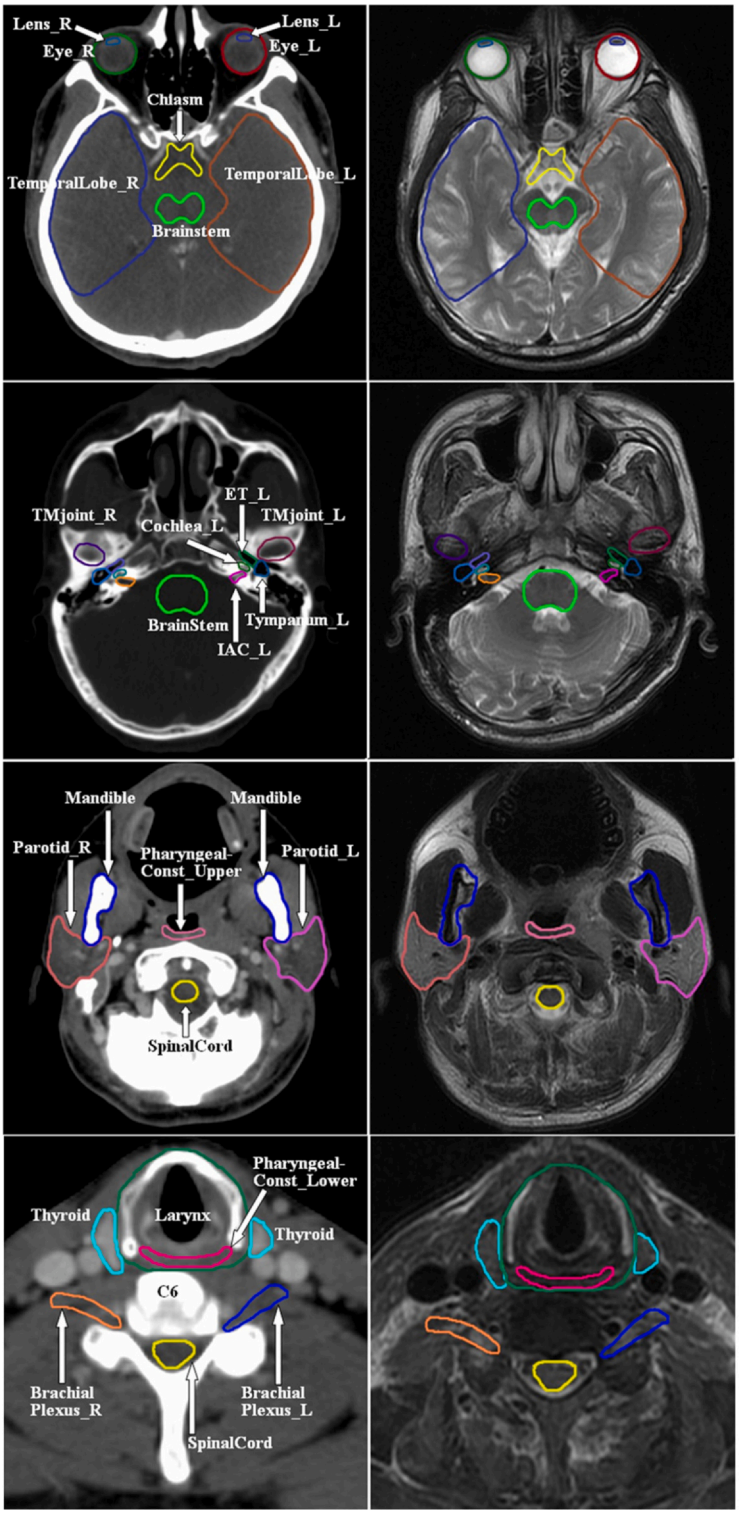


Figure 3. Examples of proposed OARs atlas in NPC.[b]

[b] Reprinted from *Radiotherapy and Oncology*, Vol 110, Ying Sun et al., Recommendation for a contouring method and atlas of organs at risk in nasopharyngeal carcinoma patients receiving intensity-modulated radiotherapy, Pages 390–397, Copyright (2014), with permission from Elsevier.

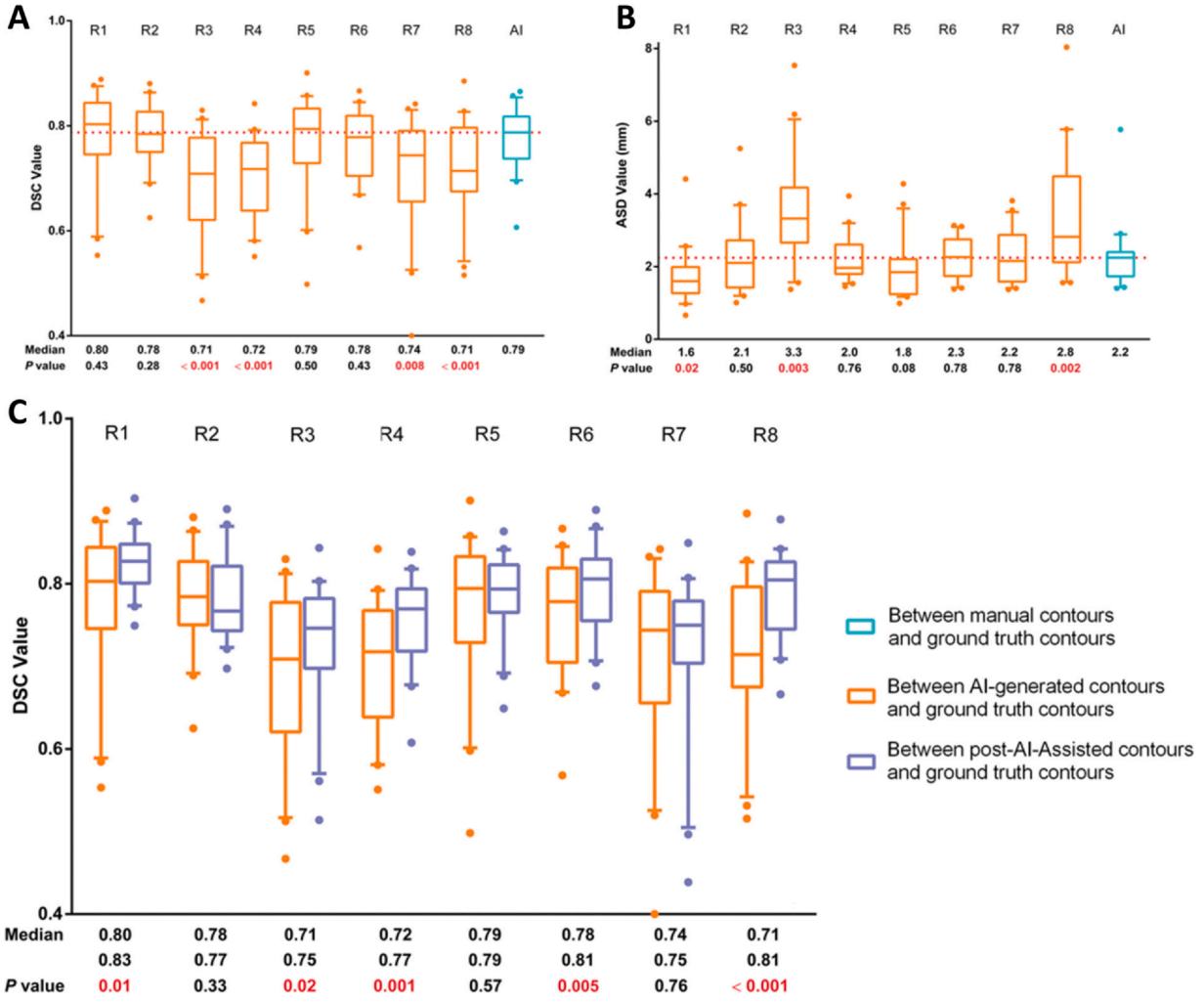


Figure 4. Performance of automated contouring system for NPC[c]. A: Dice similarity coefficients (DSCs) of eight radiation oncologists and AI-generated contours. **B**: Average surface distance (ASD) of eight radiation oncologists and AI-generated contours. **C**: Comparison of DSCs of post-AI-assisted contours and manual contours.

2.3 The use of AI in radiotherapy planning for NPC

After delineating tumor targets and OARs, planning is then needed in the workflow of radiotherapy. Traditional radiotherapy planning relies heavily on the expertise of medical physicists and oncologists, which can be time-consuming and subject to inter-individual variability. As an alternative or complement, the advent of AI, particularly deep learning, has offered predictive models that can automate and optimize treatment plans. Recent studies have explored the integration of AI in NPC radiotherapy planning, focusing on predicting dose distributions and optimizing treatment plans. The primary goal is to generate individualized treatment plans that maximize target coverage while minimizing doses to OARs.

Some studies have predicted the 3D dose distribution using CT image and contour masks.[26,27] Chen et al.[28] further combined distance information to predict dose distributions with CNNs model. This model outperformed traditional anatomical models, with lower mean absolute errors and higher DSCs, indicating that it had an improved accuracy in dose prediction.

In addition, dosimetric and geometric information can be used to draw up DVHs.[29] Bai et al.[30] developed a knowledge-based system for IMRT planning. Utilizing overlap volume histograms and target volume histograms, this approach significantly reduced the planning time required and maintained plans' quality comparable to manual plans. In addition to improved efficiency, the dose prediction model was also proven to support quality control in radiotherapy planning.[31]

Research on the integration of AI into NPC radiotherapy planning have shown promising results. Nonetheless, before we see its early implementation in clinical practice, larger sample sizes and more robust validation studies are still needed. Seamless integration

[c] Used with permission of Radiological Society of North America, from Deep Learning for Automated Contouring of Primary Tumor Volumes by MRI for Nasopharyngeal Carcinoma, Li Lin et al., *Radiology*, Volume 291, 2019; permission conveyed through Copyright Clearance Center, Inc.

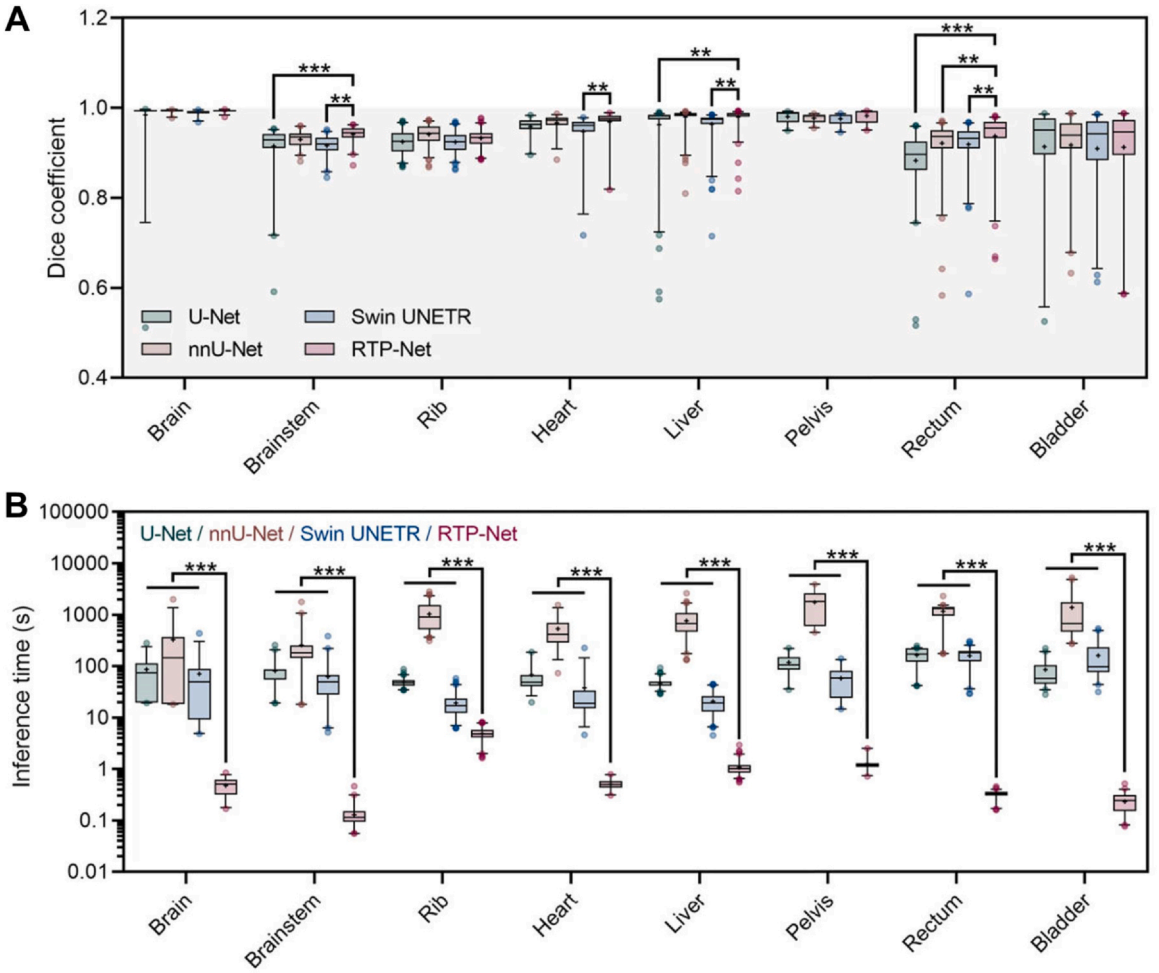


Figure 5. Segmentation performance of RTP-Net in Dice coefficient and inference time[d]. **A**: Dice coefficients of eight segmentation tasks performed by RTP-Net, U-Net, nnU-Net, and Swin UNETR. **B**: Mean inference times in segmenting eight OARs using four methods.

of AI models into clinical workflows is essential for the application of AI planning. Also, AI models with real-time feedback and adjustments during planning could further enhance plan quality and efficiency. With developments predicted in the above directions, AI planning is expected to play a greater role in NPC radiotherapy in the coming years.

2.4 The use of AI-powered online adaptive radiotherapy in NPC

Although AI can provide accurate delineation and planning at the outset of treatment, NPC radiotherapy faces the challenge of daily changes in tumors and normal tissue sizes and locations due to weight loss and tumor shrinkage.[32] This creates the risk of undertreating tumors and overexposing normal tissues to irradiation, which highlights the need for ART, where the treatment plan can be adjusted dynamically in response to real-time changes in the patient's anatomy or tumor or due to setup errors during the treatment course.[33]

Previous research demonstrated that offline replanning during IMRT improved not only local-regional recurrence-free survival[34,35] but also quality of life.[36] An early experience of using online ART shows that it is feasible for head and neck cancers, with an average process time of within an hour, an improvement in target coverage, and a modest decrease in doses to several OARs.[37]

In a previous study, to fully leverage the capabilities of AI in adaptive radiotherapy for NPC, we introduced an AI-powered, multi-step integrated radiotherapy workflow. This provides one-stop radiotherapy services to patients by seamlessly integrating a CT scan, AI contouring, manual modification, AI planning, plan evaluation, IGRT, in vivo patient-specific quality assurance, and beam delivery in one visit. Within a median time of 23 minutes, this plan achieved a median accuracy of 0.84 in GTVp and 0.98 in GTVn.[38] Through

[d] Used under a Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/) from Deep learning empowered volume delineation of whole-body organs-at-risk for accelerated radiotherapy, Feng Shi et al., *Nature Communications*, Volume 13, 2022.

the implementation of AI, the workflow greatly promotes efficiency, and it offers an alternative to the norm in clinical practice by introducing the use of online ART for NPC.

Online ART involves real-time reimaging, registration and evaluation, recontouring, and replanning based on the daily patient anatomy, which is assessed by immobilizing the patient on the treatment table, in order to effectively address anatomical variations and setup errors. By continuously adjusting the patient's radiation plans to adapt them to their anatomy on the day, AI-powered online adaptive radiotherapy significantly enhances the treatment of NPC. This approach effectively targets the tumor and minimizes damage to normal tissues, resulting in better patient outcomes and reduced side effects. AI-powered online ART thus has great potential to become the leading treatment modality for NPC. As such, the future looks promising for advancements in AI algorithms and real-time imaging technologies, which will further refine adaptive radiotherapy. As these technologies evolve, AI-powered online adaptive radiotherapy is poised to become the new standard of care in personalized cancer treatment, raising both efficacy and the quality of life for patients.

3. Outlook

The historical development of big data and AI has been marked by rapid growth and innovation, particularly in the field of oncology. Today, these technologies are at the forefront of radiotherapy for tumors, including NPC. Looking ahead, it seems big data and AI are poised to continue revolutionizing clinical decision-making in NPC treatment. We anticipate further enhancements in treatment personalization, improved patient outcomes, and a deeper understanding of tumor biology and treatment responses. The integration of big data and AI into radiotherapy and individualized treatment is not just a trend but a transformative force shaping the future of cancer care.

Future research should focus on several key areas in order to further advance the integration of big data and AI into NPC radiotherapy and individualized treatment. First, more sophisticated AI algorithms are needed to handle the complexities of multimodal data integration and real-time treatment adaptation. Second, large-scale, multicenter studies are key to affirming the effectiveness and safety of AI-driven adaptive radiotherapy protocols and big data analytics in diverse patient populations. Third, enhancing the interoperability and standardization of data across institutions and healthcare systems will facilitate data sharing and collaboration. Additionally, the potential for dynamic data to be generated during radiotherapy still needs further exploration, including radiomics, dosiomics, and contours of tumors and OARs. In these ways, the efficacy and toxicity of treatment may be better predicted, guiding adjustments and individualization.

While the integration of big data and AI into NPC radiotherapy holds great promise, several challenges must also be addressed. These include concerns over data privacy and security, the need for robust validation and clinical trial evidence, and the potential for algorithmic bias. To overcome these challenges, stakeholders must collaborate to develop clear guidelines and frameworks for the ethical and responsible use of big data and AI in healthcare. Ongoing education and training for clinicians and researchers are also crucial, to ensure they are equipped with the skills and knowledge needed to effectively utilize these technologies. Lastly, ethical and regulatory considerations must be addressed to ensure that big data and AI technologies are used responsibly and equitably in clinical practice.

4. Conclusions

The integration of big data and AI into NPC radiotherapy represents a paradigm shift in cancer treatment. To date, big data have been leveraged to optimize treatment strategies and facilitate groundbreaking research. Meanwhile, AI-assisted delineation has improved the precision and efficiency of tumor targets, reduced variability among radiation oncologists, and protected more OARs. Furthermore, AI-assisted planning enhances the quality and efficiency of NPC radiotherapy planning. Beyond that, AI-powered online adaptive radiotherapy offers real-time treatment adjustments, which may lead to improved patient outcomes. Looking ahead, we forecast that the continued evolution and integration of these technologies will result in even more significant advancements in the treatment of NPC and beyond.

CRediT authorship contribution statement

C.Y.F.: Writing – review & editing, Writing – original draft, Conceptualization. **L.L.:** Writing – review & editing, Writing – original draft, Conceptualization. **J.M.:** Writing – review & editing, Writing – original draft, Conceptualization. **Y.S.:** Writing – review & editing, Writing – original draft, Supervision, Funding acquisition, Conceptualization. **Z.C.Z:** Writing – review & editing, Writing – original draft, Conceptualization. **Y.X.Y.:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT in order to improve its language. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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References

1. Bray F, Laversanne M, Sung H, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2024;74(3):229–263.
2. Chen YP, Chan ATC, Le QT, et al. Nasopharyngeal carcinoma. *Lancet.* 2019;394(10192):64–80.
3. Lin L, Dou Q, Jin YM, et al. Deep learning for automated contouring of primary tumor volumes by MRI for nasopharyngeal carcinoma. *Radiology.* 2019;291(3):677–686.
4. Chen ZH, Lin L, Wu CF, et al. Artificial intelligence for assisting cancer diagnosis and treatment in the era of precision medicine. *Cancer Commun (Lond).* 2021;41(11):1100–1115.
5. Wang CK, Wang TW, Yang YX, et al. Deep learning for nasopharyngeal carcinoma segmentation in magnetic resonance imaging: a systematic review and meta-analysis. *Bioeng (Basel).* 2024;11(5): 504.
6. Zhong L, Dong D, Fang X, et al. A deep learning-based radiomic nomogram for prognosis and treatment decision in advanced nasopharyngeal carcinoma: A multicentre study. *EBioMedicine.* 2021;70:103522.
7. Chen L, Hu CS, Chen XZ, et al. Concurrent chemoradiotherapy plus adjuvant chemotherapy versus concurrent chemoradiotherapy alone in patients with locoregionally advanced nasopharyngeal carcinoma: a phase 3 multicentre randomised controlled trial. *Lancet Oncol.* 2012;13(2):163–171.
8. Chen YP, Liu X, Zhou Q, et al. Metronomic capecitabine as adjuvant therapy in locoregionally advanced nasopharyngeal carcinoma: a multicentre, open-label, parallel-group, randomised, controlled, phase 3 trial. *Lancet.* 2021;398(10297):303–313.
9. Sun Y, Li WF, Chen NY, et al. Induction chemotherapy plus concurrent chemoradiotherapy versus concurrent chemoradiotherapy alone in locoregionally advanced nasopharyngeal carcinoma: a phase 3, multicentre, randomised controlled trial. *Lancet Oncol.* 2016;17(11):1509–1520.
10. Zhang Y, Chen L, Hu GQ, et al. Gemcitabine and cisplatin induction chemotherapy in nasopharyngeal carcinoma. *N Engl J Med.* 2019;381(12):1124–1135.
11. Feng C, Liu M, Liu Q, et al. Exploration of hospital data quality evaluation model and monitoring management mode under the background of big data. *J Med Inf.* 2022;43(7):26–31.
12. Lin L, Liang W, Li CF, et al. Development and implementation of a dynamically updated big data intelligence platform from electronic health records for nasopharyngeal carcinoma research. *Br J Radio.* 2019;92(1102):20190255.
13. Huang XD, Li YC, Chen FP, et al. Evolution and dosimetric analysis of magnetic resonance imaging-detected brain stem injury after intensity modulated radiation therapy in nasopharyngeal carcinoma. *Int J Radiat Oncol Biol Phys.* 2019;105(1):124–131.
14. Lv JW, Chen YP, Huang XD, et al. Hepatitis B virus screening and reactivation and management of patients with nasopharyngeal carcinoma: A large-scale, big-data intelligence platform-based analysis from an endemic area. *Cancer.* 2017;123(18):3540–3549.
15. Lv J, Chen Y, Zhou G, et al. Liquid biopsy tracking during sequential chemo-radiotherapy identifies distinct prognostic phenotypes in nasopharyngeal carcinoma. *Nat Commun.* 2019;10(1):3941.
16. Chen ZK, Wang XQ, Xiao LL, et al. Construction and application of nasopharyngeal carcinoma-specific big data platform based on electronic health records. *Am J Otolaryngol.* 2024;45(3):104204.
17. Chen AM, Chin R, Beron P, et al. Inadequate target volume delineation and local-regional recurrence after intensity-modulated radiotherapy for human papillomavirus-positive oropharynx cancer. *Radio Oncol.* 2017;123(3):412–418.
18. Li WF, Sun Y, Chen M, et al. Locoregional extension patterns of nasopharyngeal carcinoma and suggestions for clinical target volume delineation. *Chin J Cancer.* 2012;31(12):579–587.
19. Liang SB, Sun Y, Liu LZ, et al. Extension of local disease in nasopharyngeal carcinoma detected by magnetic resonance imaging: improvement of clinical target volume delineation. *Int J Radiat Oncol Biol Phys.* 2009;75(3):742–750.
20. Lin L, Lu Y, Wang XJ, et al. Delineation of neck clinical target volume specific to nasopharyngeal carcinoma based on lymph node distribution and the international consensus guidelines. *Int J Radiat Oncol Biol Phys.* 2018;100(4):891–902.
21. Sun Y, Yu XL, Luo W, et al. Recommendation for a contouring method and atlas of organs at risk in nasopharyngeal carcinoma patients receiving intensity-modulated radiotherapy. *Radio Oncol.* 2014;110(3):390–397.
22. Lin L, Wei Z, Jia LC, et al. Automated contouring of cervical lymph nodes and clinical target volumes for nasopharyngeal carcinoma based on deep learning and experience constraints. *Int J Radiat Oncol Biol Phys.* 2023;117(2):e598.
23. Cai M, Wang J, Yang Q, et al. Combining images and T-staging information to improve the automatic segmentation of nasopharyngeal carcinoma tumors in MR images. *IEEE Access.* 2021;9:21323–21331.
24. Ke L, Deng Y, Xia W, et al. Development of a self-constrained 3D DenseNet model in automatic detection and segmentation of nasopharyngeal carcinoma using magnetic resonance images. *Oral Oncol.* 2020;110:104862.
25. Shi F, Hu W, Wu J, et al. Deep learning empowered volume delineation of whole-body organs-at-risk for accelerated radiotherapy. *Nat Commun.* 2022;13(1):6566.
26. Liu Y, Chen Z, Wang J, et al. Dose prediction using a three-dimensional convolutional neural network for nasopharyngeal carcinoma with tomotherapy. *Front Oncol.* 2021;11:752007.
27. Liu Z, Fan J, Li M, et al. A deep learning method for prediction of three-dimensional dose distribution of helical tomotherapy. *Med Phys.* 2019;46(5):1972–1983.
28. Chen X, Zhu J, Yang B, et al. Combining distance and anatomical information for deep-learning based dose distribution predictions for nasopharyngeal cancer radiotherapy planning. *Front Oncol.* 2023;13:1041769.
29. Jiao SX, Chen LX, Zhu JH, et al. Prediction of dose-volume histograms in nasopharyngeal cancer IMRT using geometric and dosimetric information. *Phys Med Biol.* 2019;64(23): 23NT04.
30. Bai P, Weng X, Quan K, et al. A knowledge-based intensity-modulated radiation therapy treatment planning technique for locally advanced nasopharyngeal carcinoma radiotherapy. *Radiat Oncol.* 2020;15(1):188.
31. Chen X, Yang J, Yi J, et al. Quality control of VMAT planning using artificial neural network models for nasopharyngeal carcinoma. *Chin J Radio Med Prot.* 2020;40(2):99–105.
32. Tan W, Li Y, Han G, et al. Target volume and position variations during intensity-modulated radiotherapy for patients with nasopharyngeal carcinoma. *Onco Targets Ther.* 2013;6:1719–1728.
33. Yan D, Vicini F, Wong J, et al. Adaptive radiation therapy. *Phys Med Biol.* 1997;42(1):123–132.
34. Luo Y, Qin Y, Lang J. Effect of adaptive replanning in patients with locally advanced nasopharyngeal carcinoma treated by intensity-modulated radiotherapy: a propensity score matched analysis. *Clin Transl Oncol.* 2017;19(4):470–476.
35. Zhou X, Wang W, Zhou C, et al. Long-term outcomes of replanning during intensity-modulated radiation therapy in patients with nasopharyngeal carcinoma: An updated and expanded retrospective analysis. *Radio Oncol.* 2022;170:136–142.
36. Yang H, Hu W, Wang W, et al. Replanning during intensity modulated radiation therapy improved quality of life in patients with nasopharyngeal carcinoma. *Int J Radiat Oncol Biol Phys.* 2013;85(1):e47–e54.

37. Avkshtol V, Meng B, Shen C, et al. Early experience of online adaptive radiation therapy for definitive radiation of patients with head and neck cancer. *Adv Radiat Oncol.* 2023;8(5):101256.
38. Zhou G-Q, Yang Y-X, Yang X, et al. First implementation of artificial intelligence empowered all-in-one radiotherapy workflow for nasopharyngeal carcinoma. *J Clin Oncol.* 2024;42(23):134.

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