INPLASY

Deep Learning for Nasopharyngeal Carcinoma Segmentation in Magnetic Resonance Imaging: A Systematic Review and Me-ta-analysis

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ADMINISTRATIVE INFORMATION

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Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 27 March 2024 and was last updated on 27 March 2024.

INTRODUCTION

Review question / Objective Population (P): Adults diagnosed with Nasopharyngeal Carcinoma. Intervention (I): Application of deep learning models for the segmentation of NPC in MRI scans. Comparison (C): Traditional segmentation methods, including manual segmentation. Outcomes (O): The primary outcome is the accuracy of tumor segmentation, as measured by Dice similarity coefficients. Secondary outcomes include the time efficiency of segmentation processes and the reproducibility of segmentation results. Study design (S): The review will include randomized controlled trials (RCTs), cohort studies, case-control studies, and cross-sectional studies utilizing DL for NPC segmentation in MRI.

Condition being studied Nasopharyngeal carcinoma (NPC) is a type of cancer that occurs in the nasopharynx, which is located at the upper part of the throat behind the nose. This region acts as an air passageway from the nose to the throat. NPC is distinct from other cancers of the head and neck in its occurrence, causes, clinical behavior, and treatment. It is significantly more prevalent in certain parts of East Asia, North Africa, and Alaska, indicating a combination of genetic susceptibility, environmental factors, and the Epstein-Barr virus (EBV) as contributing factors to its development.
NPC often presents challenges in diagnosis and treatment due to its deep location within the head and its proximity to critical structures such as the skull base, cranial nerves, and the brain. Symptoms may include a lump in the neck due to swollen lymph nodes, blood in saliva, nasal blockage or bleeding, hearing loss, and frequent ear infections. Advanced imaging techniques,

particularly Magnetic Resonance Imaging (MRI), play a crucial role in the accurate staging and assessment of the disease, influencing treatment decisions and prognostic evaluations.
The condition is treated with a combination of radiation therapy and chemotherapy, with the treatment approach depending on the stage of the disease at diagnosis. Early detection and precise delineation of the tumor extent are vital for effective treatment planning and improving patient outcomes. The advent of deep learning models in medical imaging presents a promising avenue for enhancing the accuracy of NPC segmentation in MRI scans, potentially improving diagnostic and treatment processes for this complex condition.

METHODS

Participant or population Adults diagnosed with Nasopharyngeal Carcinoma.

Intervention Application of deep learning models for the segmentation of NPC in MRI scans.Adults diagnosed with Nasopharyngeal Carcinoma.

Comparator Traditional segmentation methods, including manual segmentation.

Study designs to be included Randomized Controlled Trials (RCTs), Cohorts, Case-Control Studies.

Eligibility criteria Inclusion Criteria:* Study Design: The review will include randomized controlled trials (RCTs), cohort studies, case-control studies, cross-sectional studies, and retrospective analyses that have utilized deep learning (DL) models for the segmentation of Nasopharyngeal Carcinoma (NPC) in Magnetic Resonance Imaging (MRI) scans.* Participants: Studies involving adult participants (age ≥ 18 years) diagnosed with Nasopharyngeal Carcinoma.* Interventions: Studies that have implemented deep learning algorithms for NPC segmentation in MRI, including but not limited to Convolutional Neural Networks (CNNs), U-Nets, and their variants.* Comparators: Studies that compare DL models against traditional methods of tumor segmentation, such as manual segmentation * Outcomes: Studies must report on the accuracy of NPC segmentation, measured by metrics such as Dice similarity coefficients, and may also report on secondary outcomes like time efficiency and reproducibility.* Language: Studies published in English..

Information sources PubMed, Embase, and Web of Science.

Main outcome(s) Effectiveness of DL Models: This will be measured by the accuracy of tumor segmentation as compared to the standard or ground truth established by expert radiologists. The primary measure will be the Dice similarity coefficient (DSC), a statistical tool used for comparing the similarity of two samples.

Quality assessment / Risk of bias analysis Checklist for Artificial Intelligence in Medical Imaging (CLAIM): The CLAIM checklist will be utilized for assessing the quality and reporting transparency of studies involving DL in medical imaging. It covers essential aspects such as dataset description, model development, and validation processes, ensuring comprehensive evaluation criteria that are pertinent to artificial intelligence research in the medical imaging domain.
Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2): For studies focusing on the diagnostic accuracy of DL models in NPC segmentation, the QUADAS-2 tool will be applied. This tool is specifically designed for assessing the quality of diagnostic accuracy studies. It evaluates the risk of bias and applicability concerns across four key domains: patient selection, index test, reference standard, and flow and timing. Each domain is assessed in terms of risk of bias, and the first three domains are also assessed regarding their applicability to the review question.

Strategy of data synthesis Descriptive Analysis: Initially, a descriptive synthesis will be conducted to outline the characteristics of the included studies, such as study design, sample size, DL models used, MRI sequences analyzed, and main outcomes reported. This will provide an overview of the research landscape and the range of approaches used in NPC segmentation.
Quantitative Synthesis (Meta-analysis): For studies providing comparable quantitative data, a meta-analysis will be performed to synthesize effect sizes across studies. The primary outcome will be the accuracy of NPC segmentation, measured by metrics such as Dice similarity coefficients. Secondary outcomes may include time efficiency and reproducibility of segmentation results.
A random-effects model will be used to account for the expected heterogeneity among studies due to variations in DL models, MRI protocols, and patient populations.
Heterogeneity will be assessed using the I^2 statistic and the Chi-squared test. Substantial heterogeneity will be explored through subgroup analyses and meta-regression based on predefined study characteristics (e.g., DL model type, MRI sequence, and study quality).

Subgroup analysis Subgroup analyses will be conducted based on key variables such as the type of DL model (e.g., CNN, U-Net variants), MRI sequence used. This will help identify potential sources of heterogeneity and determine if the effectiveness of DL models varies across different conditions.

Meta-regression analyses will be performed to investigate the impact of continuous variables, such as sample size , on the main outcomes.

Sensitivity analysis Sensitivity analyses will be conducted by excluding studies with a high risk of bias to assess the robustness of the findings.

Country(ies) involved Taiwan.

Keywords Nasopharyngeal Carcinoma (NPC). Deep Learning (DL). Magnetic Resonance Imaging (MRI). Segmentation, Convolutional Neural Networks (CNNs).

Contributions of each author

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