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Background

Cancer is a leading health concern in Malaysia, with its incidence rising steadily each year, placing a growing burden on the healthcare system. Radiotherapy remains a critical treatment modality for approximately 50% of cancer patients, playing essential roles in curative, palliative, and adjuvant settings. However, its effectiveness is often hindered by challenges in delivering accurate doses to tumours while sparing surrounding healthy tissues. Anatomical changes during treatment, such as tumour shrinkage, organ motion, or variations in patient positioning, can result in deviations from planned doses, potentially leading to suboptimal tumour control or increased toxicity to healthy tissues.

Adaptive radiotherapy (ART) addresses these challenges by enabling treatment plan modifications based on changes in patient anatomy. Unlike conventional radiotherapy, which relies on a static treatment plan, ART evolves throughout the treatment course. Early forms of ART were applied offline, making adjustments based on cumulative data from previous sessions, but they lacked real-time adaptability. Online ART (oART), enabled by advancements in artificial intelligence (AI), deformable image registration, and imaging technologies like cone-beam CT, allows clinicians to make real-time adjustments during each session. Emerging evidence suggests that oART enhances treatment precision, improving tumour targeting, reducing planning margins, and minimizing exposure to surrounding healthy tissues, offering a more personalized approach to cancer care.

Objective

The objective of this review is to assess the effectiveness, safety, cost-effectiveness, and organisational impact of online adaptive radiotherapy (oART) using the Varian Ethos system for the treatment of cancer patients.

Methods

A systematic search was conducted on the following databases with restriction on English and Human. The Ovid interface: Ovid MEDLINE(R) and Epub Ahead of Print, In-Process, In-Data-Review & Other Non-Indexed Citations and Daily 1946 to July 2024. Searches were also run in PubMed databases. Google was used to search for additional web-based materials and information. The last search was conducted on 15th July 2024.

Results and conclusion:

Efficacy/ effectiveness

There was moderate quality evidence showing that online adaptive radiotherapy (oART) may improve target coverage while reducing normal tissue exposure, palpable by superior dosimetric benefits in many observational studies. However, additional clinical data is needed to fully evaluate its clinical impact especially in term of clinical goal such as tumour control and organ toxicity. Across the evidence retrieved, oART is feasible to be done in clinical setting with treatment time reported ranging 13.9 – 34.5 minutes.

Safety

There was limited evidence reporting on safety aspect of online adaptive radiotherapy. Ethos therapy by Varian has received 510(k) clearance from U.S Food and Drug Administration (FDA) and CE mark in February 2023.

Organisational issues

Organisational issue highlighted in implementing online adaptive radiotherapy (oART) includes;

1) increased time required per treatment session,
2) requires a highly skilled multidisciplinary team with additional staff training,
3) careful patient selection,
4) compatibility issue with existing infrastructure or system,
5) additional infrastructure needed
6) risk of algorithm bias in Artificial Intelligence (AI)-driven plan generation.

Economic implication

There was no retrievable evidence on the cost or cost-effectiveness of online adaptive radiotherapy using Ethos therapy in cancer population. However, there was one study in United States concluded that incremental cost per additional adaptive fraction is $103.58.

Conclusion

There is moderate quality of evidence from observational studies showing that online adaptive radiotherapy (oART) improves short-term dosimetric outcomes, such as target coverage and organ sparing, in patients with head and neck, lung, bone metastases, and pelvic cancer. However, adaptive treatment time requires an additional 13 to 34 minutes for plan re-optimization based on the patient's anatomy of the day. In terms of safety, there is limited evidence available on the safety aspects of oART. Regarding cost and cost-effectiveness, no retrievable evidence exists on the economic impact of using Ethos therapy for cancer treatment. From an organizational perspective, implementing oART necessitates a multidisciplinary team with additional training in editing and validating AI-driven contouring. Considerations must also be given to ensuring interoperability for seamless integration into the existing healthcare ecosystem.