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News and views

RNA Technologies in Cancer Care: Bridging Promise and Practice

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ABSTRACT

RNA technologies rapidly reshape cancer diagnostics and therapeutics, offering unprecedented promise alongside persistent challenges. This *News and Views* synthesizes evidence from meta-analyses and systematic reviews on RNA sequencing (RNA-seq), non-coding RNAs, and RNA-based therapies. We highlight advances in personalized diagnostics, mRNA vaccines, and RNA interference (RNAi), while addressing technical, clinical, and ethical barriers to clinical adoption. A balanced perspective is essential as the field advances toward precision oncology.

Keywords: RNA-seq; non-coding RNAs; mRNA vaccines; precision oncology; RNA interference; biomarkers; nanodelivery; medical ethics.

INTRODUCTION

Recent meta-analyses underscore the transformative potential and critical limitations of RNA-based tools in oncology.

The landscape of cancer diagnostics and therapeutics is profoundly transformed, driven by the rapid evolution of RNA-based technologies. Recent meta-analyses and systematic reviews have illuminated the clinical promise and the complex challenges of integrating RNA tools into oncology. As the field moves toward more personalized and precise cancer care, understanding the nuanced role of RNA technologies is essential for clinicians, researchers, and patients alike.

Clinical Promise of RNA Technologies

Revolutionizing Diagnostics

RNA-seq has emerged as a cornerstone of cancer diagnostics, enabling the detection of gene fusions, aberrant transcripts, and extracellular RNAs (eRNAs) with high throughput and quantitative precision [1–4]. A 2020 Buzdin et al.[2] meta-analysis demonstrated its utility in guiding therapy for refractory tumors, while Sempere et al.[7] validated miRNA signatures for subtype stratification and prognosis. Non-coding RNAs (miRNAs, lncRNAs, circRNAs) are increasingly recognized for their diagnostic potential due to tissue specificity and stability[5–7].

Transforming Therapeutics

The mRNA vaccine platform, accelerated by COVID-19 research, now shows promise in oncology, with early trials reporting immune responses in immunogenic tumors[8]. RNAi tools (siRNAs, antisense oligonucleotides) and nanoparticle delivery systems (e.g., lipid nanoparticles) offer targeted gene silencing but face challenges like hepatotoxicity[3].[10].

Persistent Challenges

Technical and Biological Hurdles

- Reproducibility**:** Only 40% of RNA-seq assays meet clinical-grade standards due to protocol variability[1].
- Delivery**:** Nanoparticles improve cellular uptake but may trigger immune reactions[3].[10].
- Functional ambiguity**:** circRNAs and lncRNAs lack full mechanistic understanding[5].[6].

Ethical and Equity Considerations

- Access disparities**:** Less than 3% of RNA therapy trials include low-income regions[10].
- Data privacy**:** Transcriptomic data requires robust governance to protect patient identity[11].

Meta-Evidence Synthesis (Table 1)

Study	RNA Type	Key Finding	Limitation
Buzdin et al. (2020)[2]	mRNA	Guides therapy in refractory cases	Needs standardization
Sempere et al. (2021)[7]	miRNA	Reliable diagnostic/prognostic markers	Requires larger validation cohorts
Liu et al. (2023)[8]	mRNA	Induces immune responses in early trials	Delivery challenges

Table 1. Summary of key findings from recent studies on RNA technologies in oncology. This table synthesizes results from meta-analyses and systematic reviews evaluating the clinical impact of different RNA types, such as mRNA and miRNA. Highlighted applications include diagnostics and therapeutics, major limitations such as lack of standardization, need for larger validation cohorts, and delivery and clinical implementation challenges.

Future Directions

1. **Integration**: Combine RNA-seq with genomic profiling for comprehensive tumor analysis[14].
2. **Equity**: Expand trial access to underrepresented regions[10].
3. **Ethics**: Develop frameworks for data sharing and patient consent [11,12].

"The translation of RNA technologies must balance innovation with inclusivity and rigor."

As RNA technologies continue redefining cancer diagnostics and therapeutics, their successful integration into clinical practice will depend on scientific innovation and our collective ability to navigate the ethical, logistical, and societal dimensions they entail. The future of precision oncology lies in interdisciplinary collaboration, where molecular

insights, equitable access, and patient-centered values converge. Embracing this complexity with critical optimism will be key to translating RNA promise into lasting clinical progress.

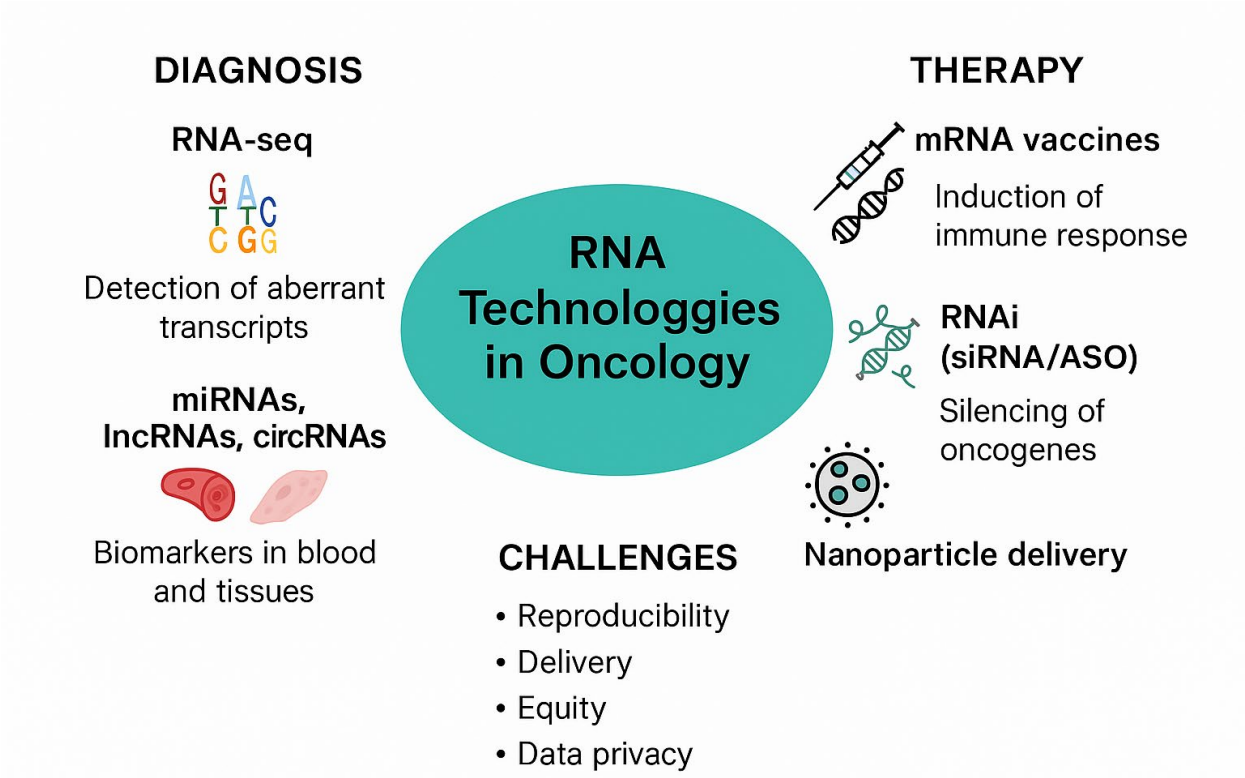

Figure 1. Overview of RNA technologies in cancer care, highlighting their roles in diagnosis and therapy and key implementation challenges. Diagnostic tools include RNA-seq and non-coding RNAs (miRNAs, lncRNAs, circRNAs), while therapeutic approaches feature mRNA vaccines and RNA interference. Nanoparticle delivery systems enhance RNA-based interventions but raise technical and safety concerns. Persistent challenges include reproducibility, delivery optimization, data privacy, and equitable access.

CONCLUSIONS

RNA technologies are poised to become central pillars of cancer diagnostics and therapeutics. The clinical promise is substantial, with the potential to improve early detection, guide therapy selection, and enhance patient outcomes. Yet realizing this promise requires coordinated efforts to overcome technical, biological, and ethical hurdles.

Meta-analyses and systematic reviews provide a roadmap for future research, illuminating areas of strength and identifying gaps that must be addressed. A balanced perspective—critical and hopeful—will be essential as the field advances. Integrating RNA technologies into oncology can transform cancer care, but that transformation must be guided by scientific rigor, ethical foresight, and a commitment to equitable, patient-centered outcomes.

Author Note

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Conflict of Interest Statement

The author declares no conflict of interest.

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