Open Access

Meeting Lecture[#]

Precis. Nanomed. 2025, 8(ICRAN):1659-1662

Targeted Delivery of Raloxifene via RGD-functionalized Chitosan Nanoparticle Selectively Attenuates Breast Tumor Growth

Suryendu Saha[1], Amit S. Yadav[2], and Gopal C. Kundu[1,3*]

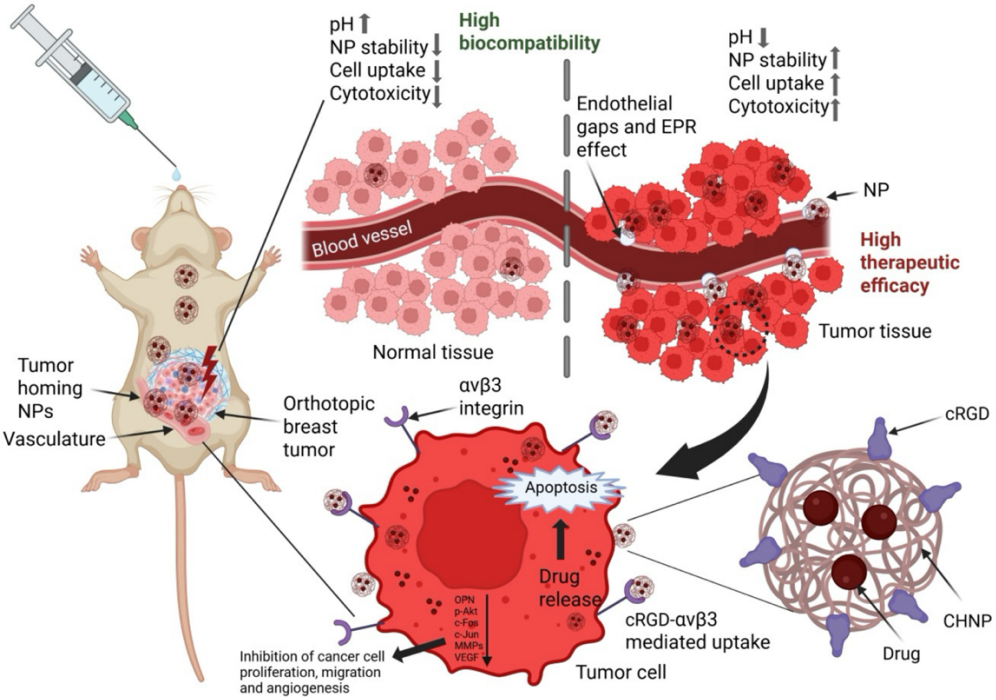
[1]*School of Biotechnology, KIIT Deemed to be University, Bhubaneswar, India 751024*

[2]*Associate Researcher, Chemical Biology and Therapeutics, Lund University, Sweden*

[3]*Kalinga Institute of Medical Sciences (KIMS), KIIT Deemed to be University, Bhubaneswar, India 751024*

Presented: February 21, 2025 Accepted: September 1, 2025 Published: December 6, 2025

Graphical Abstract



The pH-responsive behavior and RGD peptide–mediated targeting of drug-loaded CHNPs enable selective suppression of breast tumor growth and angiogenesis.

Abstract

Breast cancer is one of the most frequently diagnosed cancers among women around the globe. It is usually addressed through chemotherapy, radiation, and surgical interventions—methods that are often hindered by toxicity, non-specificity, and resistance to drugs. This study, presented at ICRAN 2025, introduces a nanotechnology-based strategy that uses RGD peptide-conjugated chitosan nanoparticles (RGD-CHNPs) for the targeted treatment of breast cancer. Raloxifene (Rlx), a selective estrogen receptor modulator, was incorporated into these nanoparticles to boost therapeutic effectiveness. The RGD-CHNPs demonstrated improved stability and cellular absorption in the acidic tumor environment typical of breast cancer. By targeting the αvβ3 integrin by the conjugation of RGD enhanced the efficient de-

[#] Presented at the International Conference on Recent Advances in Nanomedicine, KIIT University, Bhubaneshwar, Odisha, India, 21-22 February 2025. https://nanomedicineconference.com/

[*] Presented by Prof. Gopal C. Kundu, gopalc.kundu@kiit.ac.in

livery of Rlx to cancer cells, inducing apoptosis and inhibiting both migration and angiogenesis. In vivo imaging validated the selective accumulation of Cy5.5-labeled RGD-CHNPs within tumors, and the Rlx-RGD-CHNPs substantially decreased tumor growth without harming normal tissues. These results highlight the complementary advantages of pH responsiveness and RGD-mediated targeting, positioning RGD-CHNPs as an encouraging platform for safe and effective treatment of breast cancer.

Keywords:

Breast cancer, RGD targeting, Chitosan NPs, Raloxifene, estrogen receptor, dual targeting

Introduction

Breast cancer, a leading global malignancy, faces challenges like drug resistance, off-target toxicity, and limited therapeutic selectivity [1-3]. Conventional treatments such as chemotherapy and endocrine therapy often cause systemic side effects and lack tumor specificity. Nanotechnology-based drug delivery systems, particularly chitosan nanoparticles (CHNPs), offer promising solutions due to their biocompatibility, biodegradability, ease of surface modification, and cationic pH-sensitive nature [4].

Discussion

The current study, presented at the International Conference on Recent Advances in Nanomedicine 2025 (ICRAN 2025), highlights the work of Yadav et al. on RGD-functionalized chitosan nanoparticles (RGD-CHNPs) loaded with raloxifene (Rlx)—a selective estrogen receptor modulator with known anti-proliferative and anti-angiogenic potential [5]. The central objective was to achieve dual targeting through pH-responsiveness and αvβ3-integrin receptor-mediated recognition, thereby enhancing therapeutic efficacy while minimizing systemic toxicity.

Figure 1: Prof. Gopal C. Kundu (Director R & D, KIIT Deemed to be University), delivering a talk at ICRAN 2025 as one of the three distinguished speakers (Prof Rodney Hill, and Dr. B. Saravanakumar) during Technical Session-IV.

Experimental Design and Key Findings

Nanoparticle Preparation and Characterization

Stable formulations of Rlx-loaded CHNPs and RGD-conjugated CHNPs were synthesized via ionic gelation. Physicochemical characterization confirmed:

- Narrow size distribution with average diameter ~150–200 nm
- Positive surface charge and excellent stability under physiological and mildly acidic conditions
- Enhanced zeta potential and colloidal stability at acidic pH mimicking the tumor microenvironment [5].

pH-Dependent Uptake and Cytotoxicity

In vitro studies revealed that nanoparticle uptake was significantly increased under acidic pH (6.5), consistent with the tumor milieu. RGD conjugation enhanced integrin-mediated uptake of raloxifene, increasing intracellular accumulation and apoptosis over non-targeted formulations [5].

Anti-Migratory and Anti-Angiogenic Effects

Functional assays demonstrated that Rlx-RGD-CHNPs markedly inhibited cell migration and suppressed angiogenesis in endothelial co-culture systems. This inhibition correlated with reduced VEGF expression and Akt phosphorylation, highlighting interference with the angiogenic and tumor-promoting signaling cascades [5].

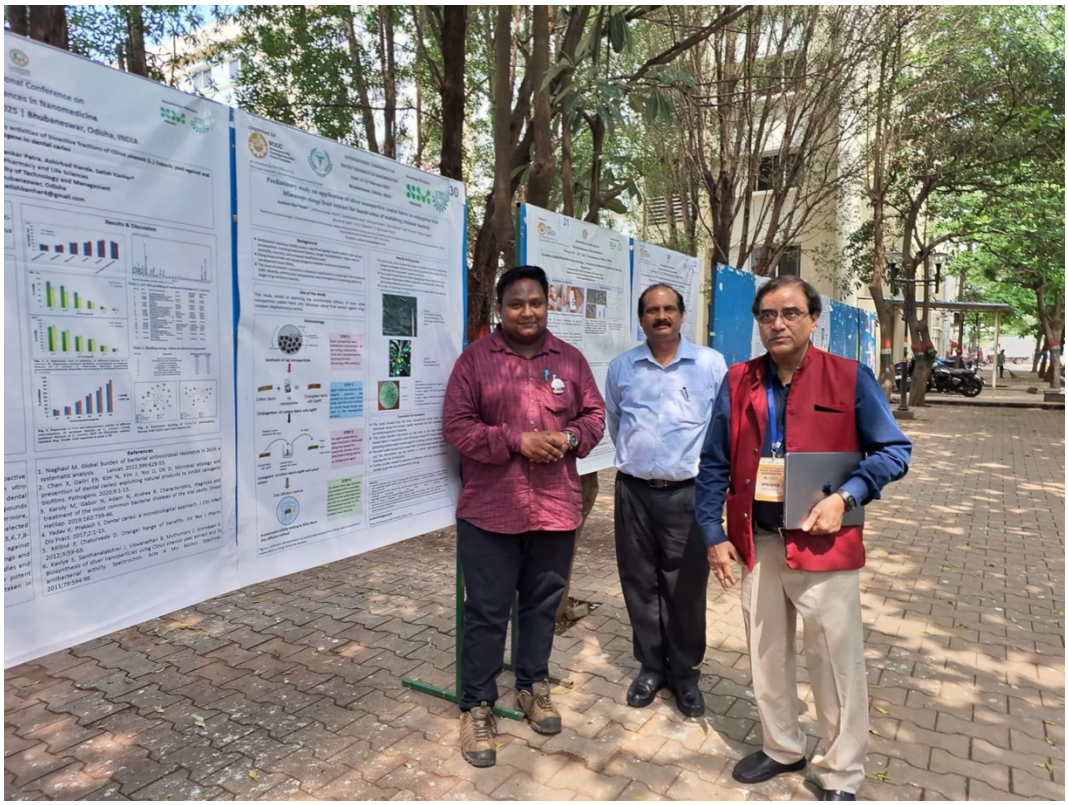


Figure 2: Prof. Gopal C. Kundu with two of the participants during the poster session at ICRAN 2025.

In Vivo Tumor Targeting and Therapeutic Efficacy

In murine breast tumor xenografts, Cy5.5-labeled RGD-CHNPs selectively accumulated within tumor tissues, providing real-time optical visualization of nanoparticle localization. Treatment with Rlx-RGD-CHNPs resulted in substantial tumor regression without detectable systemic toxicity. Hematological and biochemical analyses confirmed normal liver and kidney function, validating the biosafety of the formulation [5].

Mechanistic Insights

The study demonstrates a synergistic mechanism combining:

pH-responsive release: Acidic tumor microenvironment enhances drug release kinetics from CHNPs.

Integrin-targeted delivery: RGD ligands mediate selective binding to αvβ3 integrins, which are abundantly expressed on the tumor vasculature and metastatic cells.

Molecular signaling inhibition: Downregulation of Akt phosphorylation and VEGF expression suppresses tumor progression and angiogenesis, respectively [5].

Conclusions

The findings presented in this session underscore the translational potential of RGD-functionalized chitosan nanoparticles for precision drug delivery in breast cancer. The dual-targeted Rlx-RGD-CHNPs demonstrated:

- High tumor selectivity
- Efficient intracellular drug delivery
- Significant inhibition of angiogenesis and tumor growth
- Excellent biocompatibility and minimal systemic toxicity

This study highlighted RGD-functionalized chitosan nanoparticles as promising integrin-targeted, pH-responsive nanocarriers for raloxifene delivery, offering tumor-specific efficacy across diverse breast cancer subtypes with reduced systemic toxicity. The convergence of bio-responsive materials, peptide targeting, and advanced imaging tools signifies a milestone toward precision-guided and personalized therapeutics. As the community moves forward, continued collaboration among researchers, clinicians, and regulatory bodies — as fostered by platforms such as ICRAN — will be essential to translate these promising nanotechnologies into clinical reality.

Acknowledgments: The presenting author, Gopal C. Kundu, acknowledges all contributions.

Conflicts of Interest: The author declares no conflict of interest. For a written statement, please contact the journal office.

Quote this meeting lecture as Saha, Suryendu, Amit S. Yadav, and Gopal C. Kundu, Targeted Delivery of Raloxifene via RGD-functionalized Chitosan Nanoparticle Selectively Attenuates Breast Tumor Growth, Precis. Nanomed. 2025, 8(ICRAN):1659-62, https://doi.org/10.33218/001c.147875.

References

[1] F. Bray *et al.*, "Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries," *CA Cancer J Clin,* vol. 74, no. 3, pp. 229-263, May-Jun 2024.

[2] S. Saha *et al.*, "Decoding breast cancer treatment resistance through genetic, epigenetic, and immune-regulatory mechanisms: from molecular insights to translational perspectives," *Cancer Drug Resist,* vol. 8, p. 36, 2025.

[3] A. Lin *et al.*, "Off-target toxicity is a common mechanism of action of cancer drugs undergoing clinical trials," *Sci Transl Med,* vol. 11, no. 509, Sep 11 2019.

[4] S. M. Bashir *et al.*, "Chitosan Nanoparticles: A Versatile Platform for Biomedical Applications," *Materials (Basel),* vol. 15, no. 19, Sep 20 2022.

[5] A. S. Yadav *et al.*, "RGD functionalized chitosan nanoparticle mediated targeted delivery of raloxifene selectively suppresses angiogenesis and tumor growth in breast cancer," *Nanoscale,* vol. 12, no. 19, pp. 10664-10684, May 21 2020.