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The anticancer effects of graphene oxide against digestive system cancers: Short reviewe

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Abstract: In recent years, advances in nanotechnology have enabled researchers in the field of diagnosis and treatment to use nanoparticles or complex multifunctional nanosystems for the diagnosis and targeted treatment of several diseases, including cancers. Graphene oxide is one of the most studied materials in the world. Due to its unique properties, it has been in the center of researchers' attention and has been named as a material for the future. Graphene oxide is made up of only carbon atoms, where each carbon atom is bonded to three other carbon atoms with sp2 hybridized orbitals, creating a honeycomb and hexagonal lattice. Graphene oxide is a layered carbon structure with oxygen-containing functional groups that are attached to both sides of the edge layer and also to the edges of the graphene oxide sheet. Due to its two-dimensional planar structure, chemical/mechanical stability, excellent sensitivity to light, excellent conductivity, high surface area and good biocompatibility, graphene oxide nanoparticles have been placed as a suitable candidate in the treatment of cancers. Graphene oxide can be used to make a drug delivery system for anti-cancer drugs such as paclitax, doxorubicin and methotrexate, and the drug can be directed to the desired location by loading it. This short review aimed to have an overview on the anticancer effects of graphene oxide on gastrointestinal cancers.

Keywords: Graphene oxide, Gastrointestinal cancers, Cytotoxic effects, Apoptosis

1 Introduction

1. 1. Graphene oxide

Among all the forms of graphite obtained, graphene oxide has recently gained interest in biomedical applications. Graphene oxide (GO) has unique inherent physical and chemical

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properties including large surface containing oxygen, better conductivity and excellent biocompatibilitygraphene oxide to be used as biosensor and in drug delivery systems (Verdejo et al., 2011). Graphene oxide is a two-dimensional nanosheet containing a single layer of carbon atoms. It is arranged in a hexagonal shape to increase the surface, diameter, thickness, hardness and conductivity (Deepa et al., 2022). Graphene has mechanical, electronic, thermal, biological and optical catalytic properties. Graphene is used for identification of biomolecules in molecular medicine. Graphene and its materials are widely used in antibacterial sensor compounds (Priyadarsini et al., 2018).

1. 1. 1. Apoptosis

The word apoptosis was first coined in 1972 to describe physiological cell death based on morphological changes (Kerr et al., 1972). Apoptosis is a major mechanism for cancer cell death. Apoptosis represents a regulated and evolutionarily conserved cell death program that performs key functions in normal physiological processes such as embryogenesis and adult tissue homeostasis, but is also known for its role as a tumor suppressor mechanism (Singh and Lim, 2022). Apoptosis permanently removes cancer cells. Cell death by apoptosis acts as a barrier against cancer progression (Basu, 2022). Chemotherapy drugs also induce apoptosis in cancer cells (Littlefield et al., 2003).

1. 2. Graphene oxide and cancer

GO is one of the derivatives of graphene and is an exceptional nanomaterial that has numerous physical properties that are used for vital biomedical applications (Campbell et al., 2019). In a study of GO and pyruvate as a nanocarrier for the delivery of anti-cancer drugs and a mixture for healing. Anti-cancer activity has been used. Laboratory studies have shown that nanoparticles of GO and pegylate can be effectively transferred to tumor cells, if they are highlighted, and cell apoptosis, necrosis, and growth inhibition are shown to be higher than drug delivery systems compared to drugs that are used freely (Pei et al., 2020).

1. 2. 1. Graphene oxide and digestive system cancers

1. 2. 1. 1. Graphene oxide and gastric cancer cells

In fact, timely diagnosis and high sensitivity to cancer cells are very important for clinical diagnosis and cancer treatment. Through electrochemical cytosensors based on GO platform with gold nano star to detect gastric cancer cells, researchers were able to make a faster diagnosis for gastric cancer (Zhang et al., 2022). In a study through the biosynthesis of graphene nanosheets coated with sorafenib, it has been used to treat gastric cancer in patients. Sorafenib is a known tyrosine kinase inhibitor anticancer drug that targets the Ras/Raf/Mek/Erk cascade pathway and blocks cell proliferation. Tumors are effective against many cancers, especially stomach cancer. In this study, GO along with sorafentib and ascorbic as a green reducer were used in the treatment of stomach cancer (Xu et al., 2019). Also, through biomimetic GO quantum dot nanoparticles, they targeted photothermal chemotherapy for gastric cancer, because the direct use of chemotherapy drugs in the treatment of gastric cancer often leads to systemic side effects. GO has been reported to decrease the side effects of chemotherapy in gastric cancer treatment (Lei et al., 2023).

1. 2. 1. 2. Graphene oxide and colon cancer cells

Colorectal cancer (CRC) is among the leading causes of cancer death worldwide. Amine GOhas been considered as a potential new treatment for colorectal cancer. In a study, GOhas been aminated and these nanosheets have shown to be therapeutic potential for CRC (Krasteva et al., 2019). Because GO along with doxorubicin (DOX) have low toxicity and make it easier to carry the drug and provide a suitable surface. The anticancer effects of GO-DOX against HCT-116 human CRC cells have been compared with pure GO and DOX compounds, and it has been found that GO-DOX exerted anticancer effects on HCT-116 colon cancer cells through the induction of apoptosis and autophagy. It has a therapeutic effect (Banoon and Ghasemian, 2021). Reduced GO along with nanocomposites of chitosan, 5-fluorouracil and curcumin showed therapeutic effects against human colon cancer cell lines and made the drug release more effective and had a more effective effect on inhibiting the growth of colorectal cancer cells (Dhanavel et al., 2020).

1. 2. 1. 3. Graphene oxide and pancreatic cancer cell

Pancreatic cancer is a type of malignant tumor with high mortality. Many patients are not eligible for surgery to remove the tumor after their disease is diagnosed, so treatment options are important for those patients. It has been shown in research that reduced GO has photothermal effects on pancreatic cancer. These results show that the reduction of GO with 980 nm laser can have an ideal thermal killing effect against pancreatic cancer cells (Wu et al., 2018). Also, in another study using the green synthesis method of reduced GO (RGO) by sage plant extract has shown that reduced GO has significant destructive power for pancreatic cancer cells (Yang et al., 2021). The therapeutic effect of GO nanoparticles functionalized with graphene oxide-polyethylene glycol-folic acid-1-pyrene methylamine hydrochloride through RNA interference of HIF-1α gene in human pancreatic cancer cells has been also reported. The data of this study showed that HIF-1α gene silencing inhibits pancreatic cancer cells growth (Wan et al., 2019).

1. 2. 1. 4. Graphene oxide and hepatic cancer cells

Hepatocellular carcinoma (HCC), or liver cancer, is one of the most common malignancies diagnosed in the liver and is the third most common cause of cancer-related deaths worldwide. Amination of graphene oxide has been reported to increase the cytotoxicity in liver cancer cells (Georgieva et al., 2020). The use of graphene oxide-based fluorescent DNA apta sensor has been researched for the diagnosis and treatment of liver cancer. Due to its extraordinary fluorescent sensitivity and ability to identify the target, these nanomaterials are promising in bioassays and detecting the liver cancer cells (Ma et al., 2021).

2 Conclusion

Based on the studies and research conducted on graphene oxide, it was observed that this nano material has inhibitory effects on some carcinogenic agents and cancer cells, and it is also effective in early detection of cancer cells and their screening. It has been shown that graphene

oxide together with other drugs or other substances or can induce apoptosis in many types of cancer cells in gastrointestinal cancers. However, more and more detailed clinical studies are needed to prove the effect of graphene oxide nanomaterial on cancers, especially gastrointestinal cancers.

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Conflict of interests

The author has no conflicts of interests to declare.

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