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An Overview of Noble Metal Nanoparticles and Their Application in the Treatment of Cancer Diseases

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ABSTRACT

Noble metals and their compounds have been used as therapeutic agents since ancient times in medicine to treat various infections. Recently, many advances have been made in the field of nanotechnology to develop different types of nanomaterials with a wide range of applications. Among metal nanoparticles, noble metal nanoparticles have shown potential biomedical applications. Due to their small size, nanoparticles can easily communicate with biomolecules both on the surface and inside cells and bring better targeting for diagnosis and treatment. Noble metal nanoparticles inspire researchers due to their significant role in the diagnosis and treatment of unpleasant diseases. In this review article, we focus on the biomedical applications of noble metal nanoparticles, especially silver, gold, and platinum, in cancer diagnosis and treatment.

Keywords: Noble metal nanoparticles, Treatment of cancer, Biomolecules, and Therapeutic agents.

INTRODUCTION:

Cancer disease and its various types are widely rumored and many people suffer from it. Currently, existing treatment methods such as chemotherapy, radiotherapy, etc., along with the treatment aspect, cause side effects that are unpleasant for the patient (Sugumaran *et al*., 2018). Therefore, scientists and researchers are looking for the development and improvement of treatment methods to deal with this deadly disease. In the meantime, nano science and nano technology has expanded greatly, and its various fields, including nanoparticles, have been widely used for various applications, especially for drug delivery and diagnostic and imaging cases (Sears, 2017). Currently, a large number of drug delivery systems are made of nanoparticles, and various substances are used as drug stimulants or enhancers to improve the effectiveness of treatment and the durability and stability as well as the safety of anticancer drugs. The materials used for the release of cancer drugs are divided into different categories of polymer, magnetic, and biomolecules. Also, these materials can provide changes and surface modifications, such as binding to antibodies and target ligands, so that the nanoparticles act in a targeted manner to increase the effectiveness of the treatment (Vlăsceanu *et al*., 2016).

Noble metals have the potential to significantly develop the applications of materials science based on nanomaterials in various fields such as catalysts, self-assembly, etc. It is predicted that these compounds will create a revolution in the field of pharmaceutical sciences, especially in the fields of identifying biological molecules, controlling the effectiveness of drugs and treating cancer (Pal *et al*., 2016). The most important properties of noble metals include exceptional resistance to corrosion of a wide range of gaseous and liquid substances and stability at high temperatures (Han *et al*., 2017). Noble metals include silver, gold, platinum, palladium, rhodium, rhenium, ruthenium, iridium and

osmium (Kajani *et al*., 2016). Nanoparticles of noble metals such as gold, silver, platinum, etc. have been increasingly used in industry and medicine. Their attractive physical and chemical properties, which are derived from their quantum properties and large surface area, have been noticed more than in the past in recent years (Zeng *et al.,* 2013). The non-toxic and safe nature of noble metal nanoparticles, the possibility of controlling the size, shape, as well as the possibility of connecting with biological molecules and drugs, have highlighted these nanoparticles for applications in the field of biotechnology. The surface properties of nanoparticles, which are mainly created by stabilizing agents and functional groups, are one of the most important parameters that determine the biological activity of nanoparticles (Selvan *et al*., 2009). Drug delivery systems that are designed based on nanoparticles of noble metals, more therapeutic effect, less toxicity, higher cellular absorption, increase the pharmacokinetics of the drug will follow the comfort and acceptance of the patient as well as the accumulation of the drug at the site of effect (Hainfeld *et al*., 2008). Noble metal nanoparticles, in particular, have a variety of biomedical applications, including their use in highly sensitive diagnostic tests (Xie *et al*., 2010), enhanced thermal discharge and radiation therapy (Bhattacharyya *et al*., 2011). In addition, systems based on noble metal nanoparticles can simultaneously perform diagnosis and treatment (Nishiyama, 2007). (**Fig. 1**). 1) Silver, 2) Gold, 3) Platinum, 4) Palladium, 5) Rhodium, 6) Rhenium, 7) Ruthenium, 8) Iridium, and 9) Osmium.

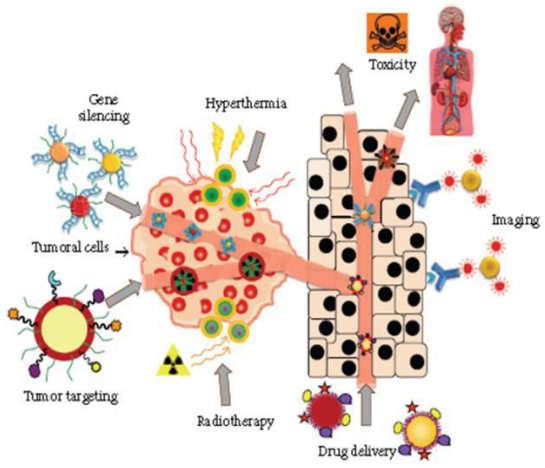

Fig. 1: Noble metal nanoparticles for cancer treatment. When the tumor is directly connected to the circulatory system, the nanoparticles can take advantage of the properties of the newly formed blood vessels and target the tumors.

The unique properties of noble metal nanoparticles, such as high surface area relative to volume, broad optical properties, and ease of synthesis, are used in the clinical field for cancer treatment (Chandra *et al*., 2010). Noble metal nanoparticles (e.g., gold, silver, or a combination of both) can be easily conjugated with various components such as antibodies, peptides, and DNA/RNA specifically for different cells and with environmentally friendly polymers (e.g., polyethylene glycol, and PEG). To increase the lifespan of drugs and genes in the body, they can be used (Bhaumik *et al*., 2016). In addition, they can convert light and radio frequency into heat, thus being able to thermally destroy target cancer cells (Chinen *et al*., 2015). In this review article, we focus on the medical applications of noble metal nanoparticles in cancer therapy.

Review of Literature

PubMed, Sciencedirect and Google Scholar databases were used to collect and summarize information. Related articles written on the use of noble metal nanoparticles in the treatment of various types of cancers were studied. It should be noted that the data analysis of this review study was done qualitatively.

Treatment

In biomedical applications such as drug delivery and imaging, size plays an important role in the efficiency and success of treatment. In biological applications, the macro size compared to the Nano size has limitations due to the size of cellular and subcellular components. For example, conventional micron-scale drug delivery methods used for cancer treatment suffer from transport inefficiencies, inappropriate targeting, toxic effects on healthy tissues, and perturbations transferred to tumor sites (Powell et al., 2010). At the beginning of drug delivery applications, there were different methods for drug administration, including oral, inhalation, transdermal, intravenous, etc. methods. Transmission by oral and inhalation methods increases the drug in the blood, and at the same time, the release profile of the drug is very weak. Skin transmission lacks targeting and damages healthy cells (Porcel *et al*., 2010). These challenges led to the development of (targeted pharmacology) as a solution to overcome transmission problems. However, micron-sized transporters cannot passively pass through cells and cell pores, and this includes tumor cells

whose pore size is 380 to 780 nm. As a result, the targeted Nano transfer system is considered an ideal system for biological applications (Minelli *et al*., 2010; Sharif *et al*., 2019).

Conventional methods of cancer treatment involve the use of agents that largely do not differentiate between cancer and normal cells, leading to systemic toxicity and severe side effects. Effective in vivo targeting to the heterogeneous mass of cancer cells and tissue still requires better selectivity and non-toxicity to surrounding healthy cells. However, targeting tumor cells is not always possible because some drugs cannot penetrate effectively and the stochastic nature of this method makes it difficult to control the process and may lead to multidrug resistance. The common manifestation of cancer often causes the destruction of healthy cells, which can cause toxic effects and side effects in the patient. For this reason, the need to find new ways to treat this disease is felt. In order to reduce the toxic effects of the drug on normal cells and to specifically deliver the drug to the cancerous tissue, new methods of delivering the drug to the tissue with the help of nanoparticles as a carrier can be used. The use of nanoparticles with a size of about 100 nm or less to deliver and target diagnostic and medicinal agents in medical projects related to cancer has become very widespread. Recently, noble metal nanoparticles have been used in targeted drug delivery to malignant tumor cells by reducing the systemic toxicity of anticancer drugs (Gupta *et al*., 2017; Uddin *et al*., 2022).

Tumor targeting

It is predicted that the greatest gains in therapeutic selection will be achieved by a combination of multiple targeting strategies that are able to simultaneously target and deliver different therapeutic agents, while avoiding the biological and biophysical barriers of organisms (Gupta *et al*., 2017). Strategies for targeting nanoparticles to cancer tissues focus on passive and active targeting. In passive targeting, because the presence of multiple tumors creates defective tumors and poor lymphatic drainage due to the rapid growth of solid tumors, noble metal nanoparticles can penetrate into the underlying tumor tissue through antigenic vessels. For active targeting, nanoparticles can be easily functionalized with various types of antibodies, peptides, and DNA/ RNA for extracellular and intracellular receptors or pathways (Sperling *et al*., 2008). The use of nanoparticles coated with multiple peptides or antibodies such as single-cell antibodies successfully targeted specific cell proteins or receptors on cancer cells and resulted in tumor cell death with minimal damage to healthy cells (Raji *et al*., 2011). In nanoparticles used together with nucleic acid, DNA and RNA macromolecules can simultaneously target and apply genetic therapy (Giljohann *et al*., 2009).

Heat therapy (hyperthermia)

Heat therapy is based on the effect of increasing temperature on living cells, and it is obvious that above 42 ˚C, cell viability is greatly reduced. In fact, the effects of heat therapy can range from the blood coagulation factor and extracellular proteins to the induction of apoptosis, and above 50°C, it leads to cell death and tissue destruction. Heat therapy is used in cancer through direct irradiation or suitable temperature carrier such as metal nanoparticles (Kaur *et al*., 2016). Nanoparticles heat cancer cells above their temperature tolerance, which is lower than normal healthy body tissue, killing them selectively due to poor blood supply. This can be achieved by placing the entire patient or target area in an alternating magnetic field, an intense light source, or a radio frequency that generates heat in the nanoparticles and discharges the heat to destroy the tumor. Magnetic nanoparticles have been introduced into the body through magnetic delivery systems or local injection into the affected area (O'Neal *et al*., 2004). The first *in vivo* trials of nanoparticle heat therapy were performed in Germany in 2005 by injecting biocompatible magnetic nanoparticles into prostate cancer patients (Johannsen and Gneveckow, 2005).

Noble metal nanoparticles have been used as a photothermal agent for in vivo cancer treatment. For this purpose, it is composed of two components: (a) a light source such as a laser with a spectral range of 650-900 nm (Blanco-Andujar *et al*., 2018) for deep tissue penetration and (b) optical absorption of nanoparticles that converts the light beam into heat in the picosecond time scale, so they cause photothermal degradation (Haba *et al*., 2007). The wavelength of light absorbed by gold nanoparticles depends on their shape and size. If solid spherical gold nanoparticles with a size of 40 nm and maximum absorption in the wavelength range of 530 nm are exposed to laser radiation with a wavelength

of 514 nm, they will cause cell death in laboratory conditions. The noteworthy point is that spherical nanoparticles absorb only ultraviolet and visible light. This wavelength range is not suitable for heat therapy due to the limitation of tissue penetration. Near-infrared waves (800 nm) are a favorable wavelength for this purpose due to their high permeability in the tissue (Spirou *et al*., 2018). Heat therapy induces apoptotic death in many tissues. This method is usually used with other treatment methods such as radiotherapy and chemotherapy in order to increase the therapeutic benefit. In this method, the heat obtained from microwave and radio frequency waves is transferred externally to the tissue with ultrasound waves. The most important problem for heat production in the mentioned methods is the lack of specific tumor selection (Wust *et al*., 2002). Recent advances in nanomedicine have made it possible to selectively use noble metal nanoparticles in cancerous tissue. By using an energy source that produces non-ionizing electro-magnetic waves (such as a laser), the conduction band electrons of gold nanoparticles can be excited. Excited electrons in conduction bands lose their energy in the form of heat and transfer to the surrounding environment; therefore, it is possible to selectively heat the desired area by using nanoparticles of noble metals (Hilger, 2018). Huang and his colleagues showed that gold nanorods are effective photothermal agents due to their longitudinal absorption band in the NIR due to their SPR fluctuations (Huang *et al*., 2010). Small diameter gold nanorods are used as near-infrared (NIR) photothermal transducers for in vivo applications due to their high cross-sectional absorption beyond the tissue absorption spectrum. Since NIR light is easily transmitted through human skin and tissue, these nanorods can be used as components to eliminate cancer (Kuo *et al*., 2010). Other gold nanostructures such as gold nanoshells (Loo *et al*., 2005), Au-nanocages (Xia *et al*., 2011) and spherical gold nanoparticles (Huang *et al*., 2008) have also shown photothermal destruction of cancer cells and tissue. Silver-gold nanorods require six times less laser radiation power for cell death compared to gold nanoshells or nanorods. Gold is also used with magnetic or paramagnetic materials to increase the photothermal effect and increase cancer cell death (Hedayatnasab *et al*., 2017). In their research, Hinfield *et al*. showed that near infrared waves (800 nm) are strongly absorbed by nanoparticles with silver core and gold coating, and placing these nanoparticles in the mouse tumor causes its heating and erosion (Hainfeld *et al*., 2014). According to the results of Hirsch *et al*.'s study, the highest accumulation of gold-coated nanoparticles in cancer cells occurs after 24 hours. In their study, it was shown that the waves emitted from the laser cause an increase in the temperature of 37 degrees Celsius in the tumor, while the increase in temperature in the control tumor was 9°C. Increasing the tumor temperature to 37°C caused the survival of the gold nanoparticle group without tumor recurrence (Hirsch *et al*., 2003; Islam *et al*., 2020).

Drug Delivery

The vast majority of drugs used to treat cancer are low molecular mass compounds that rapidly diffuse into healthy tissues, have a short half-life in the bloodstream, and a high clearance rate. Relatively small amounts of the drug reach the target site and distribution to healthy tissues leads to severe side effects (Zhang *et al*., 2012). Poor drug delivery and residual drug at the target site lead to important complications such as multidrug resistance (Dreaden *et al*., 2012). As mentioned, nanoparticles can be used as vectors to target cancer tissue/cell in order to optimize the biodistribution of drugs. The performance of nanoparticles as drug carriers depends on the size and surface characteristics of the particles, the rate of drug release, and particle disintegration (Conde *et al*., 2012). Gold nanoparticles are currently used to deliver anticancer drugs, such as platexyl-based drugs (Gibson *et al*., 2007) or platinum (Pt-)-based drugs (such as cisplatin, oxalplatin, etc.) (Dhar *et al*., 2009). Gibson et al described the first example of 2 nm gold nanoparticles with the chemotherapeutic drug platexyl (Gibson *et al*., 2007). Gold-gold sulfide nanoshells coated by a thermosensitive hydrogel matrix have been designed as a photothermal drug delivery system (Sershen *et al*., 2000).

Radiotherapy

Radiotherapy uses ionizing radiation to treat cancer to control the proliferation of malignant cells. However, delivering a lethal dose of radiation to the tumor while surrounding healthy tissues is the biggest challenge in radiation therapy (Conde *et al*., 2012). Noble metal nanoparticles can act as antennas that provide increased targeting of radiation with lower radiation doses, thereby preventing damage to

healthy tissues. Radiation may also be used to activate nanoparticles and release their cytotoxic activity. Gold nanoparticles with X-ray irradiation can act as dose enhancers and generate radicals that damage cancer cells and induce cell apoptosis. The use of this strategy has led to improvements in the treatment of breast cancer cells. The use of platinum nanoparticles compared to metal atoms as radiation sensitizers in cancer radiotherapy treatment showed a strong increase in the biological activity of radiation, which caused an increase in lethal damage in the DNA of tumor cells (Raji *et al*., 2011).

Gold nanoparticles

Gold nanoparticles have attracted the attention of many researchers in the fields of imaging and therapy due to their special optical, physical and quantum properties, high chemical stability, ease of synthesis and high bioavailability (Alkilany and Murphy, 2010), the special optical and physical-quantum properties of nanoparticles Gold has increased the contrast of various imaging and therapeutic methods (Cai *et al*., 2008). Gold and silver nanoparticles are ineffective except metal nanoparticles. These nanoparticles have attracted a lot of attention due to the behavioral characteristics that they show when exposed to tour, easy synthesis and high chemical stability (Chugh *et al*., 2018). Most in vitro studies have shown that gold nanoparticles are non-toxic to cells. In fact, the toxicity of these nanoparticles depends on their size, shape and surrounding ligands. It has also been mentioned in many articles that spherical gold nanoparticles are more suitable for biomedical applications (Coradeghini *et al*., 2013). Some contrast agents can be combined with optically active nanoparticles. Gold and silver nanoparticles provide a strong source of scattered light to create contrast in wide areas and cause high resolution imaging. The scattering signal emitted from a single nanoparticle has been shown to be about 1 million fluorophores (Thekkek *et al*., 2008).

Gold nanoparticles have many special properties that have led to their many applications in cancer treatment. The most important characteristics of these particles are their small size and high permeability to the body; so that they accumulate in tumor cells. In addition, gold nanoparticles have a high ability to bind to many proteins and drugs that actively target cancer cells (Kuttner *et al*., 2018). The high atomic number of gold nanoparticles causes more X-ray absorption in the diagnostic range and provides higher contrast than standard contrast agents. When exposed to a tour with a specific wavelength, a resonance phenomenon occurs, which is called surface plasmon resonance. Surface plasmon resonance produces heat that can be used for tumor-specific thermotherapy. In addition, the plasmon resonance of gold nanoparticles can be used to form photoacoustic images and improve Raman imaging. On the other hand, studies have shown that gold nanoparticles can increase the radiosensitivity of cancer tumors in the range of kilovoltage and megavoltage (Jain *et al*., 2011). According to recent research, this phenomenon in the ether is the production of a cascade of secondary electrons and Auger electrons and as a result of the beam hitting these particles (Zheng *et al*., 2008). Of course, determining the exact mechanism of this phenomenon requires more biological, chemical and physical studies. According to the studies, the optical and physical-quantum properties of gold nanoparticles show a high potential in improving and increasing the benefit of cancer diagnosis and treatment methods (Xiao *et al*., 2011), before using gold nanoparticles at the bedside, many questions need to be answered to be given. Factors affecting the pharmacokinetics of gold nanoparticles and the distribution and toxicity of these particles in the body are not completely clear. Considering the high potential of gold nanoparticles in cancer treatment and the global interest in nanotechnology, especially in the field of medicine, it is obvious to get answers to these questions in the near future. Li P and colleagues showed that pegylated retinoic acid attached to gold nanoparticles compared to unbound pegylated retinoic acid can have a better treatment on cervical cancer. This result is due to the binding of gold nanoparticles to cells that express the alpha estrogen receptor on their surface; therefore, it works more effectively in targeted drug delivery to the desired tissue. This study showed that the growth of cells treated with RA-PEG-SH-AuNPs is inhibited after 12 and 24 hours of incubation; therefore, the treatment of cervical cancer with retinoic acid attached to a variety of nanoparticles can be a good strategy for the treatment of this type of cancer (Ye and Song, 2015). A researcher Designed smart gold nanoparticles to accumulate in the relatively acidic environment of the cell. Considering that the size of these particles was very small (10 nm), their entry

into the internal environment of cancer cells was easily done. These nanoparticles had both negative and positive charge on their surface. The electrostatic state between the charges of the cell caused the accumulation of these nanoparticles in the space inside the cell. The entry of nanoparticles into the cell was monitored using a dark field microscope and it was observed that this accumulation and the effects of heat. Their mesh causes the destruction of cancer cells (Nam *et al*., 2009).

Silver nanoparticles

Currently, it is believed that silver nanoparticles can be used as a therapeutic agent, in addition to fighting bacteria and wound healing, to fight AIDS, viruses, and especially cancer (Hekmat *et al*., 2012). Recently, the use of silver nanoparticles as a promising anticancer agent has been considered (Govender *et al*., 2013). Studies have shown that silver nanoparticles can cause apoptosis through the release of oxygen free radicals in laboratory conditions; also, their anti-tumor, anti-proliferative and anti-angiogenic effects have also been investigated in laboratory conditions (Gurunathan *et al*., 2013). There are various studies that prove that silver nanoparticles are able to enter the body through textiles, skin products, etc. In medicine, silver nanoparticles are part of the nanoparticles that have antimicrobial effect. This effect has caused everyone's attention to this nanoparticle and its widespread use (Greulich *et al*., 2011). Research has shown that silver directly interacts with the cell membrane and causes the cell membrane to open. There are many studies that prove that the presence of silver in the cell inhibits the cell's respiratory mechanism through the production of active oxygen and ultimately causes cell death (Foldbjerg *et al*., 2011). Also, studies have shown the effect of toxicity depending on the size of silver nanoparticles as well as their concentration, and these effects have been evaluated on fibroblast, epithelial and melanoma cells Kim *et al*., 2009. Silver nanoparticles in the concentrations of 11-36 micrograms/ml decrease mitochondrial function. Similar results have been reported for animal liver cells at concentrations of 10-50 µg/ml and for skin fibroblast cells in mice at 30 µg/ml (Samberg *et al*., 2009). Although studies are still ongoing to discover the exact mechanism of silver nanoparticles' cytotoxicity, as mentioned before, the most important things that can be pointed out are the accumulation in mitochondria, the reduction of its efficiency, and the production of oxygen free radicals (Liu *et al*., 2010). This increase in the amount of active oxygen can cause the DNA molecule to break, which itself leads to cell death (Asha *et al*., 2017). According to the reports, there is an increase in the accumulation of nanoparticles in the cell and a decrease in mitochondrial function. They stated in their article that by increasing the concentration of silver nanoparticles, the rate of mitochondrial function decreases and cell death increases (Ahamed *et al*., 2010). Also, this result is stated by Hussain *et al*., they also considered the decrease in mitochondrial function and increase in cell death as a result of increasing the concentration of silver nanoparticles, but the concentration determined for this toxicity effect is different from the concentration reported in the current research. The reason for this difference is the size of nanoparticles used. In their study, they used nanoparticles with a diameter of 15 nm, while in this research; nanoparticles with a diameter of 20 nm were used. Arora *et al*., in the two studies they conducted, reported an increase in cell death due to an increase in the concentration of nanoparticles, but the amount of this increase was different from the results of the present study. The reason for this difference is in the type of cell tested, the diameter of nanoparticles Also, the difference is in the choice of concentrations (Arora *et al*., 2008). This result was published by Mukherjee *et al*., who conducted an experiment to determine the toxicity of silver nanoparticles on Wix's head cancer cells, which is consistent with the results of the present study. They reported that cell death increases with an increase in the concentration of silver nanoparticles (Mukherjee *et al*., 2012); the results obtained in this study can attract the attention of researchers in the field of cancer treatment who are looking for new treatment methods to reduce treatment complications and increase effectiveness. Attract Khorasani et al investigated the apoptotic effects of silver nanoparticles coated with Shirazi thyme leaf extract on HepG2 cell line. They treated HepG2 cancer cells with different concentrations of AgNPs in 24 and 48 hours. Cell viability and inhibitory concentration (IC50) were calculated by MTT test. In order to investigate the induction of apoptosis in HepG2 cells, they used DAPI staining, acridan orange-propidium iodide and flow cytometry analysis of annexin 5-propidium iodide. The results of the MTT test showed that AgNPs decrease the proliferation of

HepG2 cells in a concentration- and time-dependent manner. IC50 during incubation times of 24 and 48 hours was determined as 40 and 30 µg/ml, respectively ($P<0.05$). DAPI staining results showed that AgNPs can lead to nuclear DNA breakage. Also, Acriden Orange-propidium iodide staining and Annexin 5-propidium iodide test showed an increase in the percentage of apoptotic cells in the treated cells. AgNPs coated with Shirazi thyme leaf extract have the ability to induce apoptosis in HepG2 cancer cells. According to their results, the use of AgNPs can be considered as a promising strategy in the treatment of liver cancer (Khorasani *et al*., 2016).

Meta et al investigated the cytotoxic effects of silver nanoparticles synthesized with aqueous extract of Abutilon indicum plant in the 205 COLO (human colon cancer) cancer cell line in vitro and observed that silver nanoparticles inhibited growth in a concentration-dependent manner. 205 cancer cells are COL0. They also stated that in all cells treated with silver nanoparticles, morphological changes such as chromatin density and changes in the cell membrane are seen, and these changes eventually lead to the induction of apoptosis in these cells (Mata *et al*., 2015). Zheng *et al*. to investigate the mechanism and The role of silver nanoparticles and gold nanoparticles in the growth process of HepG2 cancer cells in vitro and found that both of these nanoparticles decrease HepG2 cancer cells in a concentration-dependent manner. Silver nanoparticles have a stronger inhibitory effect (Zheng *et al*., 2013). Orteqa *et al*. also investigated the antitumor activity of silver nanoparticles released by yeast in MCF-7 and T-47D breast cancer cell lines as well as MCF10-A normal breast cells. The results of cytotoxicity and MTT test in both cancer cell lines that were treated with silver nanoparticles showed a concentration-dependent decrease in the number of cells, but silver nanoparticles did not have a significant effect in inhibiting the growth of normal cells, which can be attributed to Intracellular activity is higher in cancer cells compared to normal cells (Ortega *et al*., 2015). Vasant et al investigated the anticancer activity and apoptosis induction ability of silver nanoparticles synthesized with Moringa oleifera stem bark extract on human cervical cancer cells and observed that the percentage of apoptotic cells in the cells treated with silver nanoparticles compared to the group control increases (Vasanth *et al*., 2014). Regarding silver nanoparticles, it can be said that they have a wide range of applications in medical purposes and water purification. The unique property of surface plasmon resonance in them has caused them to be considered in the field of biosensors and imaging. Evidence of their therapeutic properties has also been discovered, including the interaction of these nanoparticles with the HIV-1 virus. In vitro, this interaction prevents the virus from binding to the host cells. However, research has shown that silver nanoparticles have the ability to induce toxic effects on cells derived from different body organs. In addition, these nano-particles cause toxic effects on the germline of stem cells by reducing the mitochondrial function and inducing cell leakage through the membrane and apoptosis (Samberg *et al*., 2009).

CONCLUSION:

Considering that the use of conventional tumor detection and imaging methods has disadvantages and limitations, the use of nanotechnology is a new method for cancer diagnosis and treatment. The main challenge in cancer chemotherapy is side effects and unwanted effects of drugs. A single dose or a short period of use of these drugs can have serious risks for human health, but the use of biodegradable nano-sized particles for a long time or even a treatment period can cause unwanted harmful effects; therefore, there are still challenges and limitations for the use of nanoparticles in medicine. It is hoped that in the near future, synthesis costs will decrease and pharmacokinetic properties will increase to increase the productivity of nanoparticles and overcome the limitations of their use. In this study, noble metal nanoparticles, their benefits and applications in cancer diagnosis and treatment were discussed. Most of the therapeutic approaches of noble metal nanoparticles are based on gold nanoparticles because of their non-toxicity. The widespread use of core/shell or alloyed noble metal nanoparticles, which enable them to combine the advantages of each noble metal within a single carrier, continues. In general, using the lowest possible dose of nanoparticles to obtain the most favorable response in the shortest period of time with high biocompatibility is the goal of cancer treatment with nanoparticles. Noble metal nanoparticles are a powerful tool against cancer treatment that must be characterized and optimized to understand their potential.

Author Contributions

B.N. conceptualization, writing the manuscript. W.M.; and A.M.H. contributed investigation, visualization. B.N.; and K.J. finally checked the manuscript and editing, Funding acquisition, and Formal Analysis. All authors who are involved in this research read and approved the manuscript for publication.

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CONFLICTS OF INTEREST:

The authors declare no conflicts of interest.

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