Gamma Radiation in Aid of the Population in Covid-19 Type Pandemics

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Abstract

In many countries of the world, the use of the technique of sterilization by means of gamma rays applied to specific sanitary equipment and tissues has become evident. In cases of extreme urgency, such as a global pandemic, the use of this technique with the appropriate doses could reduce costs at the human and equipment levels. The collapses produced in hospital centres due to the saturation of the multiple cases of people infected by Covid-19 and the lack of adequate health care equipment, in some cases reused, makes this technique very difficult to use because of the great benefits it provides. It is considered a very adequate procedure due to the total and uniform penetration of irradiation in health care products, as well as in the elimination of this type of virus.

Keywords: ionising radiation, viral diseases, sterilisation, medical equipment.

Introduction

As the pandemic continues to spread around the world, more and more scientists are joining forces to find out more about this microorganism. The more information
we have about SARS-VoV-2, the pathogen responsible for the coronavirus disease called Covid-19, the sooner we will be able to defeat the pandemic.

The spread of Covid-19, which appeared in Wuhan (China), is advancing inexorably; more than 1,700,000 people in 180 countries around the world have already been diagnosed with a new coronavirus and almost 110,000 have lost their lives. But while China is beginning to normalize the movement of its citizens, the pandemic is hitting Europe and North America - the United States particularly hard. In Europe, Spain and Italy are the countries with the most diagnosed cases of infected population and the highest number of deaths.

The pandemic produced by Covid-19 is putting a lot of pressure on the health systems of the affected countries. The high demand for health facilities and professionals threatens to leave some health systems overburdened, thus jeopardizing the proper functioning and effectiveness of their services. This has led to many field hospitals being improvised in sports halls, conference centres, etc., in order to relieve the pressure on health systems.

In some European countries, such as Italy and Spain, the lack of protective equipment only fuels the epidemic and hinders the ability to save lives. It is estimated that almost 10% of health workers in both countries became infected while tirelessly caring for the growing number of seriously ill patients requiring long-term hospitalization and specialized intensive care. Much of the equipment used by health workers has been reused, thereby encouraging the spread of the virus. This has led to the need for preventive measures to keep healthcare materials free of potential microbial contaminants before use. These measures are known as 'sterilization', which consists of the complete destruction of all forms of contaminating micro-organisms in health care materials.

For these processes of sterilization of health care equipment, at first, the microbicidal effects of typical physical agents such as dry or moist heat and certain chemicals (phenol, alcohol 70% and ethylene oxide) were used. However, these techniques require exposure of unpackaged medical devices to the sterilizing agent for a certain time, at a controlled temperature, humidity, pressure and vacuum to ensure homogeneous penetration and effects. Many factors must be taken into account, in addition to the fact that they must be effectively controlled.

Ionizing radiation is proposed as the most effective sterilizing agent in cases of pandemics in health care equipment, especially those based on radioisotope sources of Co-60. At world level, industrial radio-sterilisation plants are well established in the most technically advanced countries, Europe having the majority of these plants. In Spain, more than 432 companies dedicated to the sterilisation of products (sanitary, services, construction, etc.) have been detected in 32 provinces.
Spain has been one of the countries most punished by the Covid-19, perhaps if this type of technique had been taken into account, where Spain has many industrial plants, something more could have been done in the fight against the virus. The use of radio-sterilization techniques is proposed as a valid measure in the fight against this type of pandemic to sterilize material and equipment in general, but especially those of a sanitary nature.

**Materials and methods**

**Coronavirus**

Since the discovery of human coronaviruses (HCoV) in the 1960s, 6 viruses, including HCoV-229E, HCoV-OC43, HCoV-NL63, HCoV-HKU1, SARS-CoV (severe acute respiratory syndrome) and MERS-CoV, have been recognized as causative agents of a range of respiratory tract infections.

In 2004 and 2005 the coronaviruses HCoV NL63 and HCoV HKU1 were discovered respectively, and together with HCoV 229E and HCoV OC43 are responsible for up to 35% of upper respiratory tract infections, usually in epidemic outbreaks. HCoV OC43 is the most prevalent and is detected mainly in children under 5 years of age. They are very frequently identified in co-infection with other respiratory viruses, which makes it difficult to know their true role. In addition, they have been described in association with more serious conditions, which require hospitalization generally for bronchospasm and especially in children with underlying pathology. Fatal cases of HCoV NL63 have been described in immunosuppressed patients (1-4).

In 2003, SARS-CoV was discovered in a unique epidemic in China, which caused more than 700 deaths, 20-30% of which required mechanical ventilation, with a 10% fatality rate, especially in patients with comorbidities. Later, in 2012, MERS-CoV appears for the first time, causing a similar clinical picture, but with a higher lethality (36%). This infection has not been extinguished and sporadic cases persist. Both are zoonoses transmitted to humans, the first through bats and the second originated in dromedaries, although human-to-human transmission is described, mainly in the health field, with low transmissibility (5).

Now the problem that the world population has is SARS-CoV2, which like other HCoVs, is a single-stranded RNA virus, with a diameter of 60-140nm, spherical or elliptical and pleomorphic shape (6). It has been reported to share (86.9-89%) the nucleotide sequences of the genome of a SARS-like coronavirus in bats (bat-SL-CoVZC45) (6,7). The nucleotide sequence of the main protein of the virus envelope is also highly consistent with that of bat-SL-CoVZC45 (84%) and SARS-CoV (78%).
Being so recent, the physicochemical properties of SARS-CoV2 are not fully clarified, but it is believed to be sensitive to UV radiation and heating. For example, according to research on SARS-CoV and MERS-CoV, the virus can be inactivated by heating it to 56°C for 30min and using lipid solvents such as 70% ethanol, disinfectants containing chlorine, peroxyacetic acid and chloroform, but not chlorhexidine (8).

Types of radiation

Depending on their energy, radiation is classified into ionising and non-ionising radiation (9). Non-ionising radiations are those that do not possess sufficient energy to tear an electron from the atom, i.e. they are not capable of producing ionisations, on the other hand, ionising radiations correspond to the radiations with the highest energy (lowest wavelength) within the electromagnetic spectrum. They have sufficient energy to tear electrons from the atoms they interact with, i.e. to produce ionisations. The latter radiation is of three types:

- Alpha Particles α: are helium nuclei (formed by two protons and two neutrons). Alpha particles are the ionising radiation with the greatest mass, so their capacity to penetrate into matter is limited, and they cannot pass through a sheet of paper or the skin of our bodies. Alpha particles are very energetic.

- Beta particles β: they are electrons or positrons and have a much lower mass than alpha particles, so they have a greater capacity to penetrate into matter. A beta particle can pass through a sheet of paper, but will be stopped by a thin sheet of metal or methacrylate and by clothing. They are less energetic than alpha particles.

- Gamma rays γ: they are electromagnetic radiation, so they have no mass or charge, which makes them have a great power to penetrate into matter. A thick layer of lead or a concrete wall is needed to stop them. Gamma rays and X-rays have the same properties, differing only in their origin. While gamma rays are produced in the nucleus of the atom, X-rays come from the outer layers of the atom, where the electrons are located.

In many technically advanced countries, supplies of radio-sterilised medical equipment have been introduced thanks to advanced promotional programmes such as the United Nations Development Programme and the involvement of relevant bodies such as the IAEA (International Atomic Energy Agency) (10).

In order to be able to determine more precisely the areas of the world that are potentially the most important in terms of helping with radio sterilisation platforms, a study has been carried out on the distribution of power plants
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There are clearly three important areas where nuclear power plants are accumulated: North America (USA and Canada), Northern, Western and Southern Europe and South-East Asia (China and Japan). To a lesser extent, the area of Eastern Europe (Russia) appears.

**Gamma Irradiator**

In the radio sterilization of medical devices in general, the gamma rays emitted by the Co-60 are the most used worldwide, with a greater capacity than electron accelerators and the most used by industrialized countries. Cobalt-60 is a metal that is characterized by emitting energy in the form of rays called gamma (γ). It is obtained from Cobalt in its natural state, called Cobalt 59, when it is exposed to a high speed flow of very small particles called neutrons. These neutrons are a constitutive part of the atoms that make up matter.

Cobalt-60 (60Co) is a synthetic radioactive isotope of cobalt, with a half-life of 5.27 years. 60Co decays by beta disintegration to the stable isotope nickel-60 (60Ni). In the process of decay, 60Co emits an electron with an energy of 315 keV and then the activated 60Ni nucleus emits two gamma rays with energies of 1.17 and 1.33 MeV, respectively. The equation of neutron capture and decay is as follows:

![Nuclear Power Plants in the World](image)
\[
\frac{59}{27}\text{Co} + n \rightarrow \frac{60}{27}\text{Co} \rightarrow \frac{60}{28}\text{Ni} + e^- + V_e + \text{gamma irradiation} \quad (1)
\]

Gamma radiation (ionising energy or irradiation) acts by interrupting the processes that lead to the decomposition of organic substances. Its function is to kill the bacteria by breaking the chains of the genetic material in the nucleus, so that the division of the bacteria does not take place. In turn, yeasts and fungi are destroyed, and parasites, insects or their eggs and larvae are inactivated or rendered sterile.

Another important feature to consider is the activity of the source, that is, the amount that reflects its potency. This activity in the International System (IS) is measured in becquerel (Bq), which is equivalent to the number of radioactive disintegrations per second, or in curie (Ci), which is the activity of one gram of 226Ra (11.12).

The use of the curie, a unit of measurement that does not belong to the SI, still prevails in the irradiation treatment industry. The relationship between the two units is as follows:

\[
1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq} \quad (2)
\]

Since radionuclides are constantly disintegrating, their activity changes continuously, so the value of the activity must be associated with a date. The initial activity value given in the source certificates established by your supplier should be used as a reference. It should be explicitly stated how the irradiator operator modifies the processing times to take into account the disintegration. The half-life of 60Co is 1925.2 days, which means that at the end of this period the activity is reduced to half of the initial activity. Activity \( A \) after 'd' days of decay can be obtained from initial activity \( A_0 \) using the following equation:

\[
A = A_0 \exp\left(-\frac{\ln 2 \times d}{1925.2}\right) \quad (3)
\]

The disintegration rate is approximately 1% per month, which is much less than the uncertainty in routine dosimeters. Therefore, a monthly readjustment of the processing times is sufficient to take into account the source disintegration.

A third feature is the operating mode of the irradiator, which can be either continuous or batch. Other defining characteristics are the type of container that can be irradiated and the way it moves to and from the source. The products to be irradiated may be in their usual transport boxes, in plastic boxes or stacked on a pallet which will be transported to and from the irradiator on overhead carts or roller conveyors. Gamma radiation (ionising energy or irradiation) acts by interrupting the processes that lead to the decomposition of organic substances. Its function is to kill the bacteria by breaking the chains of the genetic material in the nucleus, so that the division of the bacteria does not take place. In turn, yeasts and fungi are
destroyed, and parasites, insects or their eggs and larvae are inactivated or rendered sterile.

**Irradiation plant**

The radio-sterilization plant consists mainly of the radiation source located in a concrete chamber, an automatic transport system (belt) where the infected material is deposited. This material, which comes in hermetically sealed containers, is deposited in normal boxes of dimensions in accordance with the spaces that they travel on the conveyor belt so that they can be moved normally. The belt moves at a controlled speed, so that the boxes enter the chamber and can be irradiated precisely in several passes and come out again to be loaded and distributed to the different centres (13,14).

![Figure 2. Product movement in an irradiation chamber.](image)

As shown in the figure above, virus-infected products are passed through the irradiation source by conveyor belt and, once virus-free, are loaded onto trucks for redistribution to the sites where they are required.

After the irradiation source, the most important thing in a radio sterilization plant is the conveyor belt for the product. Performance and optimal dose distribution will depend on the trolleys or trays on the belt, as well as their maximum and minimum speed. The dose to be applied to the product is controlled by the total irradiation time, which in turn is controlled by the speed of the belt.

In many cases the lifting, in part of the state of confinement, results in the different companies not being able to provide the individual protective equipment to the workers when they return to their jobs. In Spain, this circumstance has occurred,
and over 95% of the personnel who have had to go to work have found themselves in situations of this type. The only thing this entails is that the population increases the number of infections and the redistribution of the virus in the population.

**Radio-sterilizing dose**

To determine the selection of the radio-sterilizing dose to be applied to medical products and equipment, attention should be paid to research carried out in scientific fields related mainly to microbiology, virology and immunology.

In order to combat the virus, it is necessary to know the sensitivity relating to the irradiation of the virus. Some data on lethal doses are as follows:

<table>
<thead>
<tr>
<th>Viruses</th>
<th>Sporulated Bacteria</th>
<th>Bacteria</th>
<th>Parasitic Insects</th>
<th>Mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-200 KGY</td>
<td>10-50 KGY</td>
<td>0,5-10 KGY</td>
<td>0,01-0,5 KGY</td>
<td>0,005 KGY</td>
</tr>
</tbody>
</table>

Table 1. Relative sensitivity to irradiation of different living beings.

Absorbed dose, or dose, is the amount of energy of ionizing radiation applied to a unit of mass of a specified material. The SI unit for absorbed dose is gray (Gy), where 1 Gy is equivalent to the absorption of 1 J/kg. This is the amount used both to specify the irradiation process and to control it (15). In the irradiation process, no single dose is applied to a whole product, but a dose continuum as shown in Figure 2.

![Dose distribution in Covid-19](image)

Figure 2. Dose distribution in Covid-19

Gamma irradiation has been used worldwide for many years to address a number of biosafety, food safety and pharmaceutical issues. In general terms, the more complex the organism (higher chromosome structure), the greater the effect of gamma irradiation. Very low doses (0.2-0.7 kGy) are used to sterilize insects (fruit flies); moderate doses (~10 kGy) are used for some foods to lower the level of vege-
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tative bacteria (i.e. bacteria that are in the growth and reproduction stage); higher doses are used when higher levels of assurance of freedom from contamination are needed. In particular, 25 kGy or more is used to sterilize medical equipment and pharmaceutical products when "bacterial sterility" is required. Viruses are considerably more resistant to irradiation than vegetative bacteria.

The minimum sterilization dose (SD) for medical devices to reach the desired sterility assurance level (SAL) is usually determined by using validation methods based on bacterial bioburden. The desired SAL is usually set at 106, which provides assurance that there is less than a one in a million chance of viable contamination in any unit. A minimum SD of 25 kGy is normally used, although there are numerous products identified by the health industry that require a SD of up to 40 kGy. Gamma radiation at doses greater than 10 kGy (virus clearance between 10 and 100 kGy), could have a lethal effect on the reduction of RNA from CoV2 in the virus mono-chain. It could be that as the radiation dose increases, the proteins of the CoV2 particles, as well as the abundance of their genes, could be degraded, directly affecting fewer infections. However, for the sterilisation of medical devices, the range of doses to be applied is between 25 and 40 KGy (the minimum dose in this case is the standard international dose and reference point for any evaluation of the applicability of this technology) (16,17). This opens up a situation of compromise between the margins for eliminating the virus and the margins for not damaging the irradiated medical material, since the 40 KGy could not be exceeded, and the virus in question could survive beyond that measure.

Many viruses have $D_{10}$ values exceeding 5 kGy. There is often considerable variation between published research results, possibly attributable to viral strain differences, environmental factors (for example, media, temperature and water content) and laboratory and titration method. There are also the occasional high,
and probably anomalous, D10 results reported such as 13 kGy for foot-and-mouth disease virus (FMDV) when irradiated in the frozen state (18).

A table with estimated gamma radiation D10 values for coronavirus is given below (19).

<table>
<thead>
<tr>
<th>Family</th>
<th>Virus structure</th>
<th>Presence of an envelope</th>
<th>Virion size (Daltons)</th>
<th>Diameter (nm) of the virion</th>
<th>D10</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronoviridae</td>
<td>ssRNA</td>
<td>Yes</td>
<td>400x10^6</td>
<td>120-160</td>
<td></td>
<td>&lt; 2</td>
<td>&lt; 3.6</td>
</tr>
</tbody>
</table>

Table 2. Estimated gamma radiation D10 values for coronavirus.

The dose range is wider in a commercial load, such as equipment and medical supplies in a large box on a pallet, than in a single product. The dose range, or dose interval, increases as the size or density of the treated material increases. Accurate measurement of the absorbed dose in a consignment is essential to determine and control efficacy and to ensure consumer safety.

Figure 3 shows the regions of maximum and minimum dose in a rectangular product (box with medical material) of homogeneous density after electron beam irradiation from two sides (top and bottom) and the cumulative dose distribution. The pattern will vary according to the density.

Since absolute radio sterilization is complicated, it is easier to approach the problem from the point of view of the rate of destruction than from the point of view of the time needed for the total destruction of the virus.
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Dosimetry system

Such a system consists of a series of dosimeters that serve to measure the absorbed dose according to a series of procedures and standards. The dosimeters are used to determine the amount of ionizing radiation to which the product, in this case, medical equipment, has been exposed. The selection and use of specific dosimeters is given by the standard ISO/ATM 51265:2013 (20).

However, as it could not be otherwise, these measurement systems are not exempt from certain uncertainties due to environmental factors, situation of the routine dosimeter, variation in the source of exposure, measurements of the weight and thickness of the dosimeters, etc. The uncertainty value becomes necessary to interpret the dose mapping data in small variations in the measured dose, to interpret and establish the routine dosimetry data to ensure that it is between the minimum and maximum limits. Each batch of dosimeters must be properly calibrated or the corresponding calibration curves obtained. The priority is to establish a sufficient number of dose points in the recommended dose range to eliminate the virus in order to avoid very large ranges. It is necessary to determine a dose mapping by placing a series of dosimeters appropriately located on the medical devices in order to determine the amount of irradiation that has reached them. To obtain statistically positive results, an adequate number of dosimeters must be placed. If the loads to be placed have gaps, the dosimeters should be placed in locations where variations in composition or density may affect the maximum or minimum dose regions. The total number of dosimeters will depend on the volume of the load and the information to be obtained. Ideally, the distance between dosimeters should be a maximum of 20 cm, but the highest number of dosimeters can also be placed in the areas of highest and lowest dose and a smaller number in intermediate areas.

![Medical equipment for irradiation (a) and placement of dosimeters (b).](image)

Figure 4. Medical equipment for irradiation (a) and placement of dosimeters (b).

Figure 4a shows a box with sanitary equipment (elevation), while Figure 4b is a top view (plan view) of the box showing the arrangement of a dosimeter erie to measure the rate of irradiation reaching the box at those sites.
Results

Data on the SARS-Cov-2 pandemic reported by Spain in recent days indicate that a slowdown is beginning, with a reduction in secondary infections from contacts with those infected in the first instance. Although very cautious, a new phase is beginning to enter for which the government is starting to work on a plan to progressively regain economic and social activity.

The first analyses of SARS-CoV 2 indicated that it was a new betacoronavirus belonging to the same family as SARS-CoV and MERS. Previous research found that SARS-CoV was transmitted from civet cats to humans and MERS-CoV from camels and dromedaries to humans. Also, SARS-CoV-2 is the seventh coronavirus known to infect humans; SARS-CoV, MERS-CoV, and SARS-CoV-2 can cause severe disease, while HKU1, NL63, OC43, and 229E are associated with mild symptoms (21,22).

A study published in the journal Nature Medicine reviews and compares all the genomic data that have been analyzed so far on the new pathogen and hypothesizes about the scenarios in which it could have emerged: natural selection in an animal host before zoonotic transfer; and natural selection in humans after zoonotic transfer.

The first thing the researchers point out is that they rule out the possibility of a pathogen being manipulated in the laboratory. In the research paper prepared by Kristian G. Andersen, Department of Immunology and Microbiology, Scripps Research Institute (USA) and colleagues, he comments that "The RBD (receptor binding domain) of SARS-CoV-2 is optimized to bind to human ACE2 with a different efficient solution than those previously tested". The same team notes "that if genetic manipulation had been performed, one of the several reverse gene systems available for betacoronaviruses would probably have been used". The genetic data show irrefutably that SARS-CoV-2 is not derived from any previously used virus skeleton.

On the other hand, the first cases identified in Wuhan, China, are known to be linked to an animal market, so it is possible that there was an animal source there. There is some similarity between SARS-CoV-2 and SARS-CoV-like coronaviruses, with bats likely to serve as reservoirs for their parent. However, although the bat RaTG13 virus Rhinolophus affinis is 96% identical to SARS-CoV-2, its peak diverges at RBD, "suggesting that it may not bind efficiently to human ACE2," Kristian again explains in his study. Malaysian pangolins illegally imported into Guangdong province contain SARS-CoV-2-like coronaviruses. Although RaTG13 remains the closest virus to SARS-CoV-2 in the entire genome, some pangolin coronaviruses exhibit strong similarity to SARS-CoV-2 in RBD. "This clearly shows that the peak protein (S) of SARS-
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CoV-2 optimized to bind human ACE2 is the result of natural selection,” the group's researchers conclude.

So far, no animal coronavirus has been identified that is similar enough to have served as a direct progenitor of SARS-CoV-2, but, as Kristian G. Andersen's study points out, the diversity of coronaviruses in bats and other species is "massively" underestimated.

As time goes on, and as the pandemic continues to advance around the world, more scientific studies are trying to find out more about this microorganism and its effects on human health.

Environmental damage may also influence the emergence of emerging viruses. The destruction of natural ecosystems can favour the transmission of viruses from animals to humans. A paper published in the journal Proceedings of the Royal Society analyses the 142 pathogens that have managed to jump the barrier between species to infect humans. The study concludes that the smaller the distance between humans and wild species, the greater the risk of contagion of possible diseases.

The SARS-CoV-2 pandemic has had a particular impact on the older population, and research is being rushed to determine what factors may be responsible. The virus infection affects very slightly the younger population, which at first sight seems quite disconcerting for scientists.

It seems that the study of wastewater could be an alternative to have a first approximation of the number of people affected by the pandemic, this solution is suggested in an article published in the journal 'Nature'.

Ionising radiation appears, as the authors of this article propose, to help the population, in the midst of this whole crisis of hypotheses and scientific studies. It has been proven that this type of radiation is an excellent method for combating the high microbial load of health care equipment (gowns, bandages, masks, tests, etc.) and auxiliary materials (23-27).

Although China is the country that is leading the way in terms of returning to normal life after the pandemic, the truth is that it has been slow in implementing its isolation protocols. This has allowed the virus to spread rapidly throughout the country.

The strategy followed by South Korea is different from that of China and has been based on information, medicine and technology. The country's Ministry of Health created a site through which any citizen with symptoms enters his or her personal information and receives an appointment to be examined by medical specialists. These tests are carried out in purpose-built locations, which has avoided overcrowding in hospitals. A system that has made it possible to avoid matching possible new infections and to prepare health professionals. This mechanism has
enabled South Korea to identify a high percentage of infected people from the outset (more than 200,000 people have passed through this system), so that the Government has had accurate information about the population. In addition to this process, geolocation technology has been used to ensure that those infected are properly quarantined and isolated. A system that has avoided decreeing widespread closures throughout the country with the consequent economic and productive repercussions.

However, some important questions arise, did the governments of China and South Korea use ionizing radiation as a technology to fight the pandemic? And if they did, on what scale did they use it, why haven't they said anything?

Chinese companies are known to have improved the sterilization method to speed up the production of medical protective clothing for the country's fight against the new outbreak of coronavirus (COVID-19). A subsidiary of the China National Nuclear Corporation (CNNC) has begun to adopt irradiation sterilization, a key step in increasing the efficiency of protective clothing production. CNNC has nine irradiation devices in several cities, including Beijing and the city of Suzhou in eastern China. The device in Suzhou has the capacity to sterilize 100,000 sets of protective clothing per day.

On 8 February, the State Council reportedly issued an interim document to allow companies to use irradiation sterilization on medical protective clothing by putting special marks on the packages that were irradiated. These sterilization methods have an equivalent effect to the traditional method and can be completed in one day. The call is made for the governments of the industrialized countries of the world to be able to use or retrofit this technology to fight such a pandemic, regardless of the absolute cost of the operation. Humanity is at stake; exceptional situations require exceptional measures.

**Discussion**

In the modern manufacture of medical equipment, as well as biological tissues whose demand is increasing in sterile clinical use within reconstructive surgery, the application of radio-sterilization is considered the most effective and safe technique from the point of view of health and product quality.

Adequate sterilization doses do not cause any significant increase in temperature. Being a 'cold' process, heat-sensitive materials such as plastics can be sterilized. The sterilizing effect of the radiation is instantaneous and is done simultaneously on all products, without producing problems of heat convection or gas diffusion as occurs with other techniques.
In radio-sterilization, unlike other methods and techniques, it is presented as a continuous and automated process where the most important thing is to control a single parameter such as the time of exposure of the product to irradiation.

Gamma radiation reaches easily all parts of the products due to its high penetrating power, this adds as an advantage that these products can be packed in totally hermetic containers to avoid any kind of contamination of them.

A possible range of irradiation is observed between 25 and 40 KGY where it is expected that the Covid-19 can be found (range from 1 to 40 KGY) and be able to finish with this type of virus, beyond this range the sanitary products could be altered and it is not recommended to use it.

Sterilization by irradiation is safer, more environmentally friendly and more effective. No waste water or chemicals are discharged throughout the sterilization process.

Sterilization by irradiation can also be performed without damaging the product packaging, which does not produce secondary microbial contamination.

The industrialized countries, apart from political and social opinion, in extreme emergency situations, should fight against this type of pandemic that threatens us today with all its force (using ionizing radiation). First it must be the survival of humanity, whatever the cost, and then other types of speculation at other levels.

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