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Abstract
The unprecedented for modern medicine pandemic caused by the SARS-COV-2 virus ("coronavirus", Covid-19) creates in turn new data on the survival of cardiac arrest victims, but mainly on the safety of Cardiopulmonary Resuscitation (CPR) providers. The covid19 pandemic resulted in losses in thousands of lives, and many more people were hospitalized in simple beds or in intensive care units both globally and in Greece. More specifically, in victims of cardiac arrest, both in and out of hospital, the increased mortality and high contagiousness of the SARS-CoV-2 virus put the CPR rescuers in front of new questions of both medical and moral nature. What we all know in Resuscitation, is that we cannot harm the victim and therefore do the most/best we can, it is no longer the full reality. What we need to know and incorporate into decision-making in the resuscitation process is the distribution of limited human and material resources, the potentially very poor outcome of patients with covid-19 and cardiac arrest, and especially that a potential infection of health professionals can lead in the absence of health professionals in the near future. This review tries to incorporate the added skills and precautions for CPR providers in terms of both in hospital and out hospital CPR.

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Coronaviruses are a group of viruses that usually cause respiratory infections of varying severity in humans and animals. Initially in Wuhan (China), at the end of 2019 and in the beginning of 2020 there was a series of pneumonia cases for which, on January 9 2020, the Chinese health authorities announced that it was due to a new coronavirus strain (2019-nCoV, later SARS-CoV-2). During the following months, the transmission of the virus around the world led to a pandemic, with main characteristics being its high contagiousness, even in pre- or asymptomatic stages, and a high mortality, especially between the elderly or patients with comorbidities.

The unprecedented for modern medicine pandemic caused by the SARS-COV-2 virus ("coronavirus", Covid-19) creates in turn new data on the survival of cardiac arrest victims, but mainly on the safety of Cardiopulmonary Resuscitation (CPR) providers. It is of particular importance, especially during CPR, the mode of virus transmission, aerogenously, with droplets exhaled through the patient’s mouth and nose to the rescuer’s mucosa, from the resulting aerosol that suspends for a long time in closed spaces or even from surfaces. Health professionals during Advanced Life Support (ALS), as well as non-health professionals that provide Basic Life Support (BLS) can be exposed during CPR to this new virus characterized by high contagiousness. As a result, they need to take protective measures and adjust their actions based on the new data, especially as long as there is a lack of effective weapons for its prevention and treatment (vaccines, anti-viral drugs, immunotherapy)\textsuperscript{1-3}.

During the pandemic, there was a dramatic increase in deaths around the world in the affected countries. In countries with a proven increase in deaths, this was accompanied by a simultaneous increase in out-of-hospital cardiac arrests (OHCA), both in time and in geographical coincidence. For example, in Italy, this increase in
OHCA was 58% compared to corresponding period last year while in New York district (USA) calls to Emergency Medical Services (EMS) quadrupled (ie increased by 400% www.nbcnewyork.com/news/..../2368678/) 1, 2.

The above show the increased need for extensive CPR performance in the community by health professionals and by educated citizens. In addition, there is need for early and clear adjustment of the guidelines for the CPR performance both in national (Hellenic Society of Cardiology, National Public Health Organization) and in global level (European Resuscitation Council, American Heart Association) in order to reassure the efficacy and safety of rescuers. With reservation for the scientific data available so far and in line with global recommendations, we need to re-examine the safe way to perform CPR in victims of both out-of-hospital and in-hospital arrest3, 4.

A. Recommendations for performing CPR and/or defibrillation in an out-of-hospital environment

Every time CPR is performed, especially to an unknown victim, there is a risk of cross-infection, which is particularly related to rescue breathings. Normally, this risk is very low and is considered negligible compared to the fact that the victim of cardiac arrest will die if no effective help is given. In any case, based on the existing guidelines, the first thing to do is call for help and call the Emergency Medical Services immediately at 112/166, informing that there is a victim of sudden cardiac arrest (SCA) ("he is dead", "he is not breathing", etc). The bystanders and the first ones to respond to a SCA (eg specialized staff at the workplace, trainers, etc), who are required to provide initial care, which may include CPR, should have already specific orders from their employers, special for each workplace. It is already foreseen (European Resuscitation Council-ERC Guidelines 2015) that if you are untrained or
unable to provide rescue breathings, give CPR only by chest compressions (ie continuous chest compressions at a rate of at least 100-120 per minute). In times of a pandemic outbreak and depending on the local and national epidemiological data concerning the probability that the victim has Covid-19, it is suggested that some modifications should be considered such as the recognition of SCA by searching for the absence of signs of life and the absence of normal breathing. However, its better to completely avoid listening to or feeling breath sounds by placing your ear and cheek near the victim's mouth. Immediately afterwards, cover the victim's face (mouth and nose) with a cloth of his own or even yours. If you have doubts about the confirmation of cardiac arrest, start chest compressions until help arrives (or obviously until the patient shows signs of life such as a reaction with movements). Make sure an ambulance is on its way. If you suspect Covid-19, inform the Emergency Medical Services center from the beginning when you call 112/166. As it is well known, we perform CPR continuously only with chest compressions (ie continuous chest compressions at a rate of at least 100-120 per minute). Special emphasis is needed on the existence of AED (automated external defibrillator). Early and correct use of AED by an adequately trained person, significantly increases the chances of survival of the victim while does not increase the risk of infection of the rescuer. If the rescuer has access to personal protective equipment (eg protective mask, disposable gloves, eye protection), it must be worn before CPR initiation. Even the use of a mask (medical or not) reduces the chances of inhaling respiratory droplets.

However, it should be mentioned that in terms of OHCA in suspected Covid-19 victims in nursing homes (which has increased incidence during the pandemic in some countries), the first responders who are called to provide CPR to these victims
have already long been in contact with them, with the relative risk of transmission preceding the arrest. Therefore in these cases, the delay in CPR initiation so that the rescuer who has already been in contact (and possibly contaminated) can put his personal protective equipment (PPE), can be fatal and probably doesn’t further protect the airborne contamination of the responder. Although there are no official guidelines about this topic it seems reasonable that this can be discussed in extent in each institution.

After performing CPR only with chest compressions, all rescuers must wash their hands thoroughly with soap and water. Alcohol-based hand sanitizer gels are a convenient alternative\(^1\). They should also seek further advice from the Counseling Service for coronavirus of the National Public Health Organization (EODY-https://eody.gov.gr/neos-koronaios-covid-19/). The above instructions for first lay responders have been visualized both abroad and in Greece, by the Hellenic Society of Cardiology: in video (https://youtu.be/ooAlPXRimfc), as well as in poster format (Figure 1).

**B. CPR from health professionals in a hospital setting and other organized health structures (eg Emergency Medical Services means of transfer).**

The coronavirus is thought to spread mainly in a manner similar to influenza, from person to person through close contact and droplets. The basic principles of infection control and protection from droplets are the main control strategies and should be strictly followed. Aerosol transmission may also occur. Attention to hand hygiene and to the retention of respiratory secretions produced by coughing and sneezing are the cornerstones of effective infection control. Deteriorating patients with possible or
suspected Covid-19 infection should be preferentially transferred to negative-pressure rooms to minimize risk of exposure to providers during CPR\textsuperscript{6}.

All people suspected or confirmed for Covid-19 infection should follow the instructions for infection control and the use of PPE (see National Public Health Organization, EODY instructions). All those involved should keep in mind that during CPR, there is always the possibility that rescuers may be exposed to body fluids. Also procedures (such as tracheal intubation or ventilation) are likely to create infectious aerosol. The use or not of PPE for victims, depending on the degree to which they are suspected, is decided in advance. Interventional procedures on the airway should be performed by experienced individuals (eg introduction of supraglottic airway devices or tracheal intubation). These individuals should only practice the skills for airway management (eg bag-mask ventilation) for which they have been trained. Tracheal intubation or the insertion of a supraglottic airway device should only be performed by people who are experienced and capable in this procedure. In any case, airway management and ventilation, whether non-invasive or invasive (eg tracheal intubation by an anesthesiologist) are procedures of high-risk for dispersion of droplets and / or aerosol from the victim and therefore protection measures that are taken should be of the highest level of security. Several national societies of Anesthesiology worldwide, have issued in time clear and detailed instructions on the matter\textsuperscript{7, 8}.

However, any case of difficult airway management is accompanied by widespread dispersal of infected aerosol throughout the surrounding area and therefore this should be taken into account and other attendees should be adequately protected.
Participants in CPR (ideally members of the resuscitation team) should be trained in safe but rapid placement / removal of PPE and avoidance of infection. Recommendations for CPR in healthcare facilities in patients a) with diseases similar to covid-19 infection or b) with confirmed Covid-19.

Patients with Covid-19 infection or Covid19-like disease (pending laboratory documentation) who are at risk for acute deterioration or cardiac arrest should be identified early. Appropriate measures must be taken in time to prevent SCA and avoid unprotected/uncovered CPR. The use of monitoring systems and early activation on clinical deterioration will allow the early detection of such patients. The best way to deal with cardiac arrest is to prevent it, since in 50-80% of the cases there are clear clinical signs of deterioration, such as hypoxia and hypotension.

Although, in Greece, there is no relevant legislation on the decision of no resuscitation (DNR - do not resuscitate), CPR performance in China in 136 hospitalized patients with covid19 pneumonia who presented cardiac arrest (with the relative risks of transmission to staff) led to a survival of only four $^9$. The level of PPE to be used in order to evaluate a patient, to initiate chest compressions and to assess heart rhythm in the regular intervals of two minutes is determined by the National Guidelines. In any case, as few as possible, absolutely necessary, healthcare professionals should participate in the ALS while ideally; it should take place in a special, negative pressure isolation room.

The need for PPE may delay CPR initiation with Covid-19. Reviewing the relevant procedures (including PPE availability in resuscitation carts), along with theoretical training and practice, will minimize these delays. Staff safety is of paramount importance. In cardiac arrest that is likely to be of hypoxemic cause, early ventilation
with oxygen is usually recommended. Passive oxygenation should be provided by a non-rebreathing mask covered by a surgical mask. However, any action or invasive procedure on the airway that is performed without proper protection with PPE will put the rescuer at significant risk of infection. Therefore, in hypothetical hypoxemic arrest, initiation of chest compression-only CPR seems to be safer. The procedure of cardiac arrest recognition includes the search and confirmation of the absence of signs of life and the absence of normal breathing as previously mentioned. If there is doubt about the diagnosis of cardiac arrest, the recommendation is to start chest compressions until more experienced help arrives.

CPR starts only with chest compressions and the patient's underlying heart rhythm should be checked as soon as possible. Use of mechanical compression device (LUCAS device, AutoPulse) should be used as soon as available. Mouth-to-mouth ventilation, including the use of a pocket-mask, is avoided. If oxygen is already administered at the patient with a face mask (Venturi type), the mask remains on the patient's face during chest compressions.

Bystanders, who are not healthcare professionals (already wearing full PPE) may be able to provide support, while chest compressions are ongoing before the resuscitation team arrives. The rest (team members and support staff) must apply a full PPE before taking on the CPR procedure by those who initially responded to the cardiac arrest.

If there is a shockable rhythm, defibrillation should be given quickly-early Return of Spontaneous Circulation (ROSC) can prevent the need for invasive airway management and invasive ventilation. In cases where defibrillation is not performed with self-adhesive defibrillation pads, but with handheld defibrillator paddles, we
emphasize the non-disconnection of the closed breathing circuit in order to reduce the possibility of airborne dispersion from the victim's respiratory secretions. In adjustment of the basic ALS algorithm, at shockable rhythms, we deliver not only 1 but up to 3 shocks in the attempt to restore the rhythm (Figure 2). Patients may present cardiac arrest caused either directly by Covid-19 infection or by a comorbidity. It is important to identify any reversible causes (eg thrombotic events such as acute myocardial infarction or pulmonary embolism) before discussing with members of the group the possibility of discontinuing CPR.

At the end of CPR, the equipment used during CPR is discarded or sterilized, following the recommendations. All work surfaces used for airway management/resuscitation should also be cleaned accordingly. Specifically, make sure that the equipment used in the airway procedures (eg laryngoscopes, face masks) is not left on the patient's pillow, but placed on a tray.

All PPE is safely removed. Hand hygiene plays a very important role in reducing transmission. After performing CPR, even only with chest compressions, all rescuers should wash their hands thoroughly with soap and water. Alcohol-based hand sanitizer gels or even pure alcohol are an alternative solution. The above instructions have been visualized in a video both abroad and in Greece, by the Hellenic Society of Cardiology (https://youtu.be/L98gv0w4iwo).

The Covid-19 pandemic resulted in losses in thousands of lives, and many more people were hospitalized in simple beds or in intensive care units both globally and in Greece. More specifically, in victims of cardiac arrest, both in and out of hospital, the increased mortality and high contagiousness of the SARS-CoV-2 virus put the CPR rescuers in front of new questions of both medical and moral nature.
What we all teach in Resuscitation, is that we cannot harm the victim and therefore do the most/best we can, it is no longer the full reality. While until recently CPR, with simple precautions - skills, was completely harmless to the members of the group, it is no longer valid. What they need to think about now and incorporate into decision-making in the resuscitation process is the distribution of limited human and material resources, the potentially very poor outcome of patients with Covid-19 and cardiac arrest, and especially that a potential infection of health professionals can lead in the absence of health professionals in the near future. This absence can lead to multiple deaths from the one they initially tried to prevent.

Although in Greece, due to successful restriction of the Covid-19 pandemic (sick and hospitalized patients, dead people), this was not perceived, globally, the moral compass in Resuscitation is shifted considerably. The Hippocratic balance of "benefit or do no harm" of the acceptable risks for patients and healthcare professionals (physicians, nurses) has clearly shifted and modern medicine has moved with it.
References:


Figure Legends

Figure 1: Practical instructions for adjusted basic CPR (Basic Life Support) performed by lay early responders during Covid-19 pandemic. Thanks to Mr&Mrs. E. Stamatopoulou, D. Aragianni, E. Sigala.

Figure 2: Adjusted algorithm of advanced in-hospital CPR (ALS) (from Hellenic Society of Cardiology) in Covid-19 pandemic. Key points of change are shown in red: a) do not start ALS CPR without PPE b) fast-immediate rhythm check and up to 3 defibrillation attempts. Special thanks to Dr Andreas Synetos and Dr Marina Kalogridaki.