

# Emerging and Future Technologies in Out-of-Hospital Cardiac Arrest Care



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## KEYWORDS

- Emergency medical services • Out-of-hospital cardiac arrest
- Extracorporeal membrane oxygenation • Ultrasound • Mobile applications • Aircraft • Defibrillators
- Crowdsourcing

## KEY POINTS

- The management of victims of out-of-hospital cardiac arrest is rapidly evolving and new and emerging technologies will play a role in improving survival.
- The progression of extracorporeal life support and point-of-care ultrasound technologies both in-hospital and out-of-hospital may improve out-of-hospital cardiac arrest survival for certain subsets of patients.
- Unmanned aerial vehicles capable of delivering automated external defibrillators to the scene of a cardiac arrest may augment the availability of early defibrillation by bystanders in some systems.
- Digital and mobile technologies to leverage bystander response could result in the next great leap in survival for victims of out-of-hospital cardiac arrest.

## INTRODUCTION

Throughout history, the care for victims of out-of-hospital cardiac arrest (OHCA) has progressed through long periods of little advancement in knowledge separated by relatively brief periods of rapid advancements in the science. Modern human interests in resuscitating victims of sudden cardiac death began in the enlightenment era and slowly grew throughout the 18th and 19th centuries, principally in the port cities of Western Europe in response to the large number of victims of drowning and submersion injury.<sup>1</sup> These interests progressed to the creation of organizations interested in the care and resuscitation of victims of sudden death, namely the Amsterdam Rescue

Society in the Netherlands and the Royal London Humane Society in 1767 and 1774, respectively (Fig. 1). The creation of these societies arguably represents the first great step in the advancement of cardiac arrest science.

OHCA care again progressed rapidly and dramatically over the last half of the 20th century with the advent of closed chest cardiac massage and external cardiac defibrillation. The first case of successful closed chest cardiac massage was described in 1960<sup>2</sup> and was rapidly combined with mouth-to-mouth ventilation into modern day cardiopulmonary resuscitation (CPR), which was endorsed by the American Heart Association in 1963.<sup>3</sup> The first use of a portable external cardiac defibrillator was reported in 1967,<sup>4</sup> allowing for

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**Fig. 1.** The emblem of the Royal London Humane Society, founded in 1774. This token was given to those who were credited for assisting a person in distress. The front reads, "Lateat scintillula forsan" (A small spark may perhaps lie hid) and the back reads, "Hoc pretium cive servato tulit" (He has obtained this reward for having saved the life of a citizen). (From The Royal Humane Society. In: Newnes G, editor. The project Gutenberg ebook of the strand magazine, vol. V, Issue 28, 1893. Project Gutenberg; 2007. Available at: <http://www.gutenberg.org/ebooks/20798>. Accessed November 8, 2017.)

mobile treatments for victims of OHCA. Since that time, an array of technologies have been introduced that have improved the care of patients in OHCA, including portable and public access automatic external defibrillator (AED) technology, advanced computerized mathematical analysis of cardiac waveforms, mechanical CPR devices, and digital strategies to leverage bystander response. To this day, however, victims of OHCA have a relatively poor prognosis, even in the best of systems.<sup>5</sup>

There are a number of emerging therapeutics and technologies for the treatment of patients suffering from OHCA that may play an important role in the future of OHCA management, ranging from prehospital extracorporeal membranous oxygenation (ECMO), prehospital ultrasound imaging to improve the quality of CPR, automated flying drones to deliver AEDs directly to the scene of an OHCA, to digital and portable technologies for lay people that can detect cardiac arrest and notify good Samaritan bystanders as well as emergency medical services (EMS). One or several of these advances in combination may represent the next great leap in improving survival for patients of OHCA. In this article, we discuss some of these emerging and future technologies.

### **EXTRACORPOREAL MEMBRANOUS OXYGENATION AND APPLICATIONS FOR VICTIMS OF OUT-OF-HOSPITAL CARDIAC ARREST**

There are roughly 365,000 OHCA events annually in the United States with an estimated survival rate of approximately 9%. This survival rate is

highly variable from system to system, with reports ranging between 3% and 22%<sup>5,6</sup> of all prehospital treated cardiac arrests. Most patients that are successfully resuscitated with meaningful neurologic outcomes regain pulses by roughly minute 15 or by the third defibrillation attempt if the patient is in a shockable rhythm.<sup>7</sup> There are very few survivors of OHCA with favorable neurologic outcome receiving chest compressions for more than 45 minutes.<sup>8</sup>

It is challenging for prehospital providers to perform high-quality CPR during patient movement and transport,<sup>9</sup> and consistent high-quality closed chest CPR is correlated with survival.<sup>10-13</sup> Given these data, and in light of provider safety issues, many prehospital agencies in the United States have protocols that stress remaining on scene to complete the initial and critical resuscitation attempts for most patients suffering OHCA. Despite no current evidence demonstrating that mechanical CPR devices are more efficacious than manual CPR,<sup>14-17</sup> these devices may have a role in transporting certain cases of refractory cardiac arrest to the hospital.<sup>18</sup> There could be a subset of patients suffering from refractory cardiac arrest that may be successfully resuscitated if the underlying cause of the arrest, such as an occluded coronary artery, can be effectively addressed with advanced diagnostics and therapeutics only available in the hospital. Identifying this cohort, however, is challenging. Most hospitals currently do not have these therapies to offer a victim of refractory OHCA actively undergoing CPR.

An obstructed coronary artery is felt to be the cause of refractory cardiac arrest in as many as 80% of patients with an initial shockable rhythm

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