CORRESPONDENCE

# Use of a Drone-Delivered Automated External Defibrillator in an Out-of-Hospital Cardiac Arrest

**TO THE EDITOR:** Out-of-hospital cardiac arrest affects approximately 600,000 persons in the United States and Europe annually, and although survival averages 10%, it can be increased if an automated external defibrillator (AED) is used within minutes after onset.[1] Given that most cardiac arrests occur at home, where AEDs are typically unavailable, new methods for the faster delivery and use of AEDs are warranted.[2,3] A recent feasibility study in Sweden showed that drones can be used to deliver AEDs in cases of suspected out-of-hospital cardiac arrest.[4]

In an ongoing, prospective, follow-up study that was initiated on April 21, 2021, we aimed to evaluate whether AED-equipped drones could arrive before emergency medical services (EMS) with clinically significant time benefits (ClinicalTrials.gov number, NCT04723368). Five drones with a 6-km–radius range were situated within the controlled airspace of two airports, which covers approximately 200,000 inhabitants during the daytime in Sweden. The drones were adapted with a winch system for the delivery of an AED. (Details of the AED, the drone, and the drone operator are provided in the Supplementary Appendix, available with the full text of this letter at NEJM.org.) To deliver the AED, the drone pilot requests permission from air traffic control for the drone to take off, remotely surveils the autonomous flight, and chooses an appropriate spot to winch down the AED from a 30-m height.[4]

On December 9, 2021, a 71-year-old man with a history of myocardial infarction, heart failure, and atrial fibrillation had a cardiac arrest while he was shoveling snow outside his home. He was found by his wife, and chest-compression-only resuscitation was initiated by an emergency physician who happened to pass by. The dispatch center alerted EMS (ambulance and fire department personnel), and a smartphone was used to dispatch volunteer lay responders (citizens with training in cardiopulmonary resuscitation) and an AED-equipped drone to the scene. The responding ambulance crew consisted of two registered nurses with advanced life-support competence, including AED capability. The drone flew autonomously out of sight for 673 m and, at 3 minutes 19 seconds after dispatch, safely delivered an AED in the snow 10 m from the patient before EMS had arrived (Table 1). A camera onboard the drone showed the delivery and retrieval of the AED by a second bystander (a neighbor) (see the video, available at NEJM.org).

*A video showing drone delivery of the AED is available at NEJM.org*

The AED was immediately attached to the patient by the emergency physician and was used to defibrillate ventricular fibrillation; the electrocardiographic report is provided in the Supplementary Appendix. The first shock was delivered

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**Table 1. Characteristics of Emergency Response and Treatment in the Case of a Patient with Out-of-Hospital Cardiac Arrest.***

| Variable | Data |
|---|---|
| Time of day | |
| Dispatch center answer of emergency telephone call | 10:04:43 |
| Dispatch of drone | 10:05:28 |
| Dispatch of EMS | 10:05:39 |
| Drone takeoff | 10:06:51 |
| Drone delivery of AED | 10:08:46 |
| First arrival of ambulance personnel† | 10:09:53 |
| AED attached to patient and started | 10:10:18 |
| First shock administered | 10:10:58 |
| First arrival of ambulance personnel at patient's side† | 10:11:42 |
| First arrival of fire department personnel | 10:13:09 |
| Inpatient hospital care until discharge | 7 days |
| Delay times | |
| Time to recognition of out-of-hospital cardiac arrest at dispatch center | 0 min 0 sec‡ |
| Time from dispatch of drone to approval by air traffic control | 0 min 20 sec |
| Time from dispatch of drone to drone delivery of AED | 3 min 19 sec |
| Time from dispatch of EMS to arrival of first ambulance | 4 min 14 sec |
| Time from dispatch of drone to attachment of AED to patient | 4 min 50 sec |
| Time from dispatch of drone to first AED shock | 5 min 30 sec |
| Time from dispatch of EMS to arrival of fire department personnel | 7 min 1 sec |
| Weather and flight data | |
| Temperature and sky cover | 0°C, cloudy |
| Wind speed | 18 km/hr |
| Distance from hangar to patient | 580 m§ |
| Total flight time | 4 min 19 sec |
| Drone battery level (%) | |
| At takeoff | 97 |
| At return landing in the hangar | 81 |

* Data regarding drone-delay times and weather and flight data were retrieved from the drone operator (Everdrone). AED denotes automated external defibrillator, and EMS emergency medical services.
† On ambulance arrival, personnel put on personal protective equipment and retrieved emergency equipment, actions that prolonged the time from arrival at the address to arrival at the patient's side by 1 minute 49 seconds.
‡ Cardiopulmonary resuscitation was ongoing when the telephone call was made.
§ The actual flight route was 673 m.

by the emergency physician just before the arrival of ambulance personnel at the patient's side. After the arrival of ambulance personnel, a LUCAS (Lund University Cardiopulmonary Assist System) chest-compression device for the delivery of consistent and uninterrupted automatic chest compressions was attached to the patient, and advanced life support, including epinephrine and amiodarone, was administered. The patient woke up en route to the hospital after another three defibrillations. At the hospital, he underwent insertion of an implantable cardioverter–defibrillator; he was discharged after 7 days. Although the patient had residual chest pains from the chest compressions, he had a full neurologic recovery, with a Cerebral Performance Category value of 1 (on a scale from 1 [good cerebral performance] to 5 [death or brain death]) 30 days after the cardiac arrest.

It is uncertain whether the earlier delivery of the AED by the drone (rather than waiting for the arrival of EMS) affected the patient's outcome. Moreover, it is likely that the prompt delivery of effective chest-compression-only resuscitation by the emergency physician was important for the good outcome.

This case report describes a patient who had an out-of-hospital cardiac arrest and underwent defibrillation by a drone-delivered AED. The drone delivery made it possible to perform defibrillation shortly before EMS arrived (even though the EMS response time was short), which shows feasibility and also shows that the use of drones to deliver AEDs has the potential to be a relevant and important part in the chain of survival in the future.

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