



Out-of-Hospital Cardiac Arrest Treated with a Drone-Delivered Defibrillator Before Ambulance Arrival: A Narrative Review of Bystander Response Systems

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Abstract

Survival after cardiac arrest outside hospital falls by roughly a tenth for every minute without treatment, and the ambulance takes about eleven. Flying a defibrillator to the scene is an obvious idea that has now been tested in real emergencies, with results that are genuinely encouraging and much smaller than the coverage suggests.

Objectives: To review the published evidence on drone-delivered automated external defibrillators: whether delivery is feasible, how much time is saved, how often a delivered device is actually used on a patient, and where this sits against the rest of the bystander response system.

Material and Methods: Narrative review of prospective clinical studies, observational series, simulation studies, geographical modelling and resuscitation guidance indexed in PubMed and the major cardiology and resuscitation journals. No new patient data were generated; every estimate quoted is one published by the original investigators.

Results: In the first prospective clinical study, 14 of 53 alerts were eligible, drones took off in 12, and delivery succeeded in 11 (92 per cent). The drone arrived before the ambulance in 64 per cent of successful deliveries, with a median time benefit of 1 minute 52 seconds. In a larger subsequent series with both arrival times available in 55 cases, the drone arrived first in 37 (67 per cent) with a median benefit of 3 minutes 14 seconds; 18 were true arrests, a delivered device was attached in 6, two were defibrillated before ambulance arrival, and one survived to 30 days.

Conclusion: Delivery works and saves clinically meaningful time. The attrition between a device landing and a shock being delivered is severe, and it is not a technical problem: it depends on a bystander willing to collect the device and apply it. That, rather than the aircraft, is where the remaining gain lies.

Abbreviations: AED – Automated External Defibrillator, CPR – Cardiopulmonary Resuscitation, EMS – Emergency Medical Services, IQR – Interquartile Range, OHCA – Out-of-Hospital Cardiac Arrest, ROSC – Return of Spontaneous Circulation.

Keywords: Out-of-Hospital Cardiac Arrest; Automated External Defibrillator; Drone Delivery; Bystander Response; Time to Defibrillation

Introduction

Out-of-hospital cardiac arrest kills the great majority of those it affects, and survival depends on a sequence that begins before any professional arrives: recognition, bystander cardiopulmonary resuscitation, and early defibrillation [1,2,3]. Where all three occur promptly, survival can reach 50 to 70 per cent; where they do not, it is a small fraction of that [4,5].

The constraint is time. Each minute without treatment reduces the probability of survival by roughly 10 per cent, and in Sweden the median ambulance response interval for cardiac arrest was 11 minutes in 2019 [4,6], and shortening that interval increases survival [35]. Public access defibrillators exist but are unevenly distributed, frequently inaccessible out of hours, and most arrests occur at home where no device is nearby [7,8,9].

Delivering a defibrillator by unmanned aircraft addresses that geography directly. Modelling and simulation work suggested substantial theoretical time savings [10,11,12,26], and scoping reviews have catalogued the field [33], and the approach has since been tested in real emergencies. This review examines what those tests showed.

Material and Methods

Search strategy: PubMed and the archives of the major cardiology, resuscitation and emergency medicine journals were searched for studies of drone-delivered defibrillation. Search terms combined out-of-hospital cardiac arrest and automated external defibrillator with drone, unmanned aerial vehicle, delivery, time to defibrillation and bystander. Reference lists of resuscitation guidance [3,13] were screened by hand for primary sources.

Eligibility: Studies were included if they reported drone delivery of defibrillators in real or simulated emergencies, modelled the coverage or time saving achievable, or characterised the bystander response on which any delivered device depends. Studies of dispatcher-assisted resuscitation and volunteer responder systems are cited as the comparator and identified as such.

Data extraction and handling: Design, setting, number of dispatches, delivery success, comparative arrival times and downstream clinical outcomes were extracted as published. The denominator is reported alongside every proportion, because the percentages in this literature are calculated on successively smaller subsets and quoting them without denominators is the commonest way the results are overstated. No pooling or re-analysis was performed. Figures 1 to 4 and Tables 1 and 2 reproduce published values only. This is a narrative synthesis and was not registered as a systematic review.

Results

The first prospective study: Three defibrillator-equipped drones were placed within controlled airspace in Sweden,

covering approximately 80,000 inhabitants across 125 square kilometres, and integrated with the emergency medical dispatch system for automated beyond-visual-line-of-sight deployment. Of 53 alerts during the study period, 39 (74 per cent) fell outside the service area or met exclusion criteria. Fourteen were eligible; drones took off in 12 (86 per cent) and delivery succeeded in 11 (92 per cent of take-offs) (Figure 1). Median distance flown was 3.1 km (IQR 2.8 to 3.4), and the device was delivered within 9 metres of the location (IQR 7.5 to 10.5) [14].

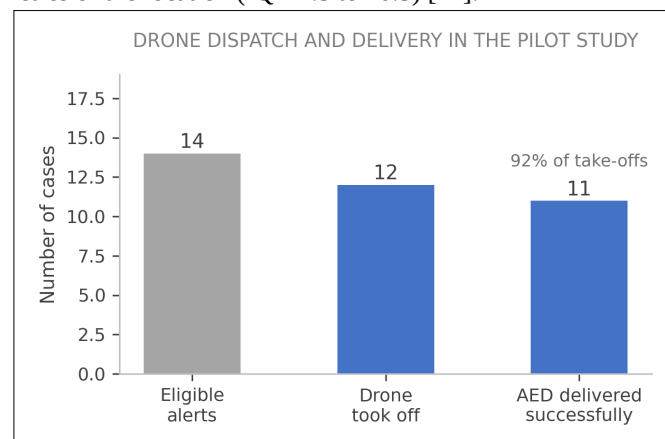


Figure 1: Dispatch and delivery in the first prospective clinical study of drone-delivered defibrillators [14]

Did it beat the ambulance: In 7 of the 11 successful deliveries (64 per cent) the drone arrived first, with a median time benefit of 1 minute 52 seconds (IQR 1:35 to 4:54); averaged across all cases the benefit was 49 seconds [14,15]. A larger subsequent series reported both arrival times in 55 cases, with the drone arriving first in 37 (67 per cent) and a median benefit of 3 minutes 14 seconds (Figures 2 and 3) [16]. Against a median ambulance response of about 11 minutes, three minutes is a meaningful fraction of the interval that determines survival [6].

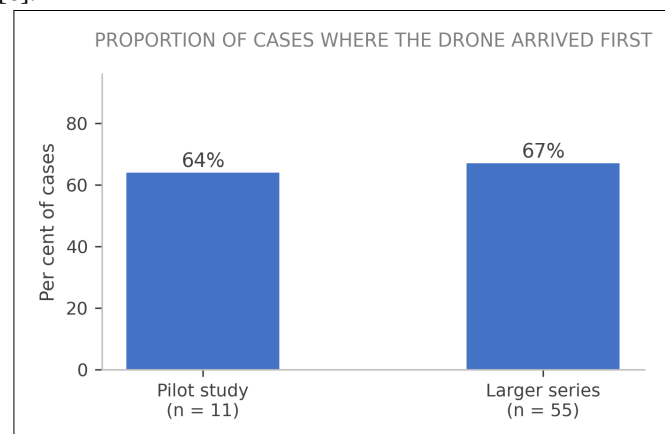


Figure 2: Proportion of cases in which the drone arrived before the ambulance [14,16]

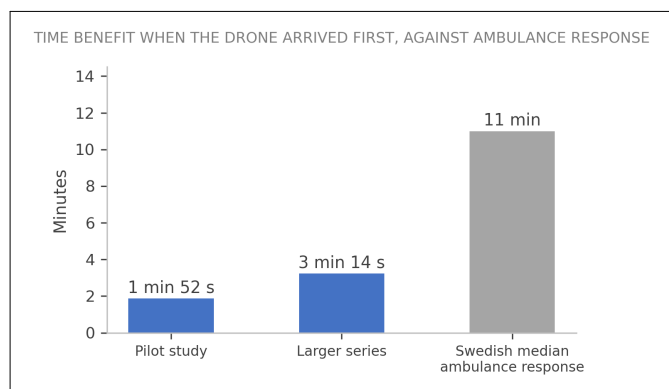


Figure 3: Median time benefit when the drone arrived first, against median ambulance response interval [6,14,16]

What happened to the patients: The larger series followed the chain further, and this is where the numbers become sobering. Of the 37 cases in which the drone arrived first, 18 (49 per cent) proved to be true cardiac arrests. A drone-delivered device was attached to the patient in 6 of those 18 (33 per cent). Two of the six had a shockable initial rhythm and were defibrillated by the delivered device before the ambulance arrived, and one of those two survived to 30 days (Figure 4). No adverse events occurred, and delivery was made within 15 metres of the patient or building in 91 per cent of cases [16]. In the earlier pilot, no delivered device was attached to a patient at all [14,17].

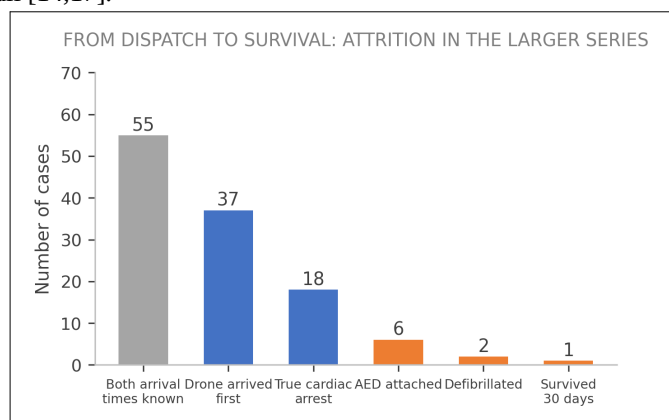


Figure 4: Attrition from dispatch to 30-day survival in the larger observational series [16]

Study	Design and cohort	Principal reported finding
Schierbeck et al. 2022 [14]	Prospective clinical study, 12 take-offs	Delivery successful in 92%; drone first in 64%; benefit 1:52
Schierbeck et al. 2023 [16]	Observational series, 55 paired arrival times	Drone first in 67%; benefit 3:14; one 30-day survivor
Schierbeck et al. 2022 [17]	Case report	First reported survival after drone-delivered defibrillation
Claesson et al. 2017 [10]	Simulation and modelling	Predicted substantial time savings, particularly rural
Baumgarten et al. 2022 [11]	Simulation study, rural Germany	Integration into the chain of survival modelled
Smith et al. 2025 [18]	Simulation-based feasibility, United Kingdom	Drone arrived before ambulance in 7 of 12 flights
Hansen et al. 2017 [8]	Registry, bystander defibrillation	Public versus residential location determines device access

Table 1: Principal studies reviewed, with the finding as reported by the original investigators

Coverage and dispatch rate: The dispatch rate is the least discussed and most consequential figure. In the pilot, 74 per cent of alerts were outside the service area or excluded [14]. Drones cannot fly in all weather, require airspace authorisation, and operate within a defined radius; geographical modelling of national coverage indicates how many units would be needed for meaningful population reach [19,20]. A system that delivers rapidly to a quarter of arrests is not equivalent to one that delivers to all of them, and modelled national benefit depends on assumptions about density that pilot studies do not test [30,31]. Rural and remote delivery has been examined separately [20,29].

The rest of the chain: Delivered hardware is worth nothing without a person to use it. Bystander cardiopulmonary resuscitation rates, dispatcher-assisted instruction and volunteer responder systems determine whether anyone is available to collect the device and apply it [21,22,23]. Randomised evidence supports smartphone-based activation of nearby trained volunteers, which increases bystander resuscitation rates [23,24]. Where such systems exist, a drone delivers to someone able to act; where they do not, it delivers to a bystander who may not know what to do with it. Simulation work on how bystanders actually interact with a delivered device reaches the same conclusion [27,28].

Cost and comparison: No randomised comparison of drone delivery against any alternative has been conducted, and no economic evaluation with real-world dispatch rates has been published. The competing uses of the same funds are fixed public access defibrillators in residential areas, volunteer responder networks, and dispatcher training, each of which has supporting evidence [7,21,23,25]. Long-term survival after arrest depends on the whole system rather than any one component [32,34]. Comparative cost-effectiveness is unknown.

Link in the chain	What the drone evidence shows	What determines it
Dispatch	74% of alerts outside area or excluded	Coverage radius, airspace, weather [14,19]
Delivery	92% of take-offs successful	Technically solved in these studies [14,16]
Time saved	1:52 to 3:14 when drone arrives first	Distance and ambulance interval [14,16]
Device attached	6 of 18 true arrests	A bystander willing and able to act [16]
Shock delivered	2 of 6 attached	Presenting rhythm; not modifiable [16]
Survival	1 of 2 defibrillated survived 30 days	Whole-system quality, not the aircraft [16]

Table 2: The chain from dispatch to survival and what governs each step

Discussion

The engineering question has been answered. Drones can be integrated with a dispatch centre, fly beyond visual line of sight to a residential address, and place a defibrillator within metres of the location, succeeding in over nine tenths of take-offs and without adverse events [14,16]. That was not obvious in advance and it is a real achievement.

The time saving is also real and is the strongest part of the case. Three minutes against an eleven-minute median ambulance interval is a substantial proportion of the window in which defibrillation determines survival [6,16]. If the shock is what matters, arriving three minutes earlier with the device that delivers it is worth having.

The difficulty is everything after landing. In the larger series, 55 cases with paired arrival times yielded 37 in which the drone arrived first, 18 true arrests, 6 devices attached, 2 shocks delivered and 1 survivor at 30 days [16]. In the earlier pilot, not one delivered device was attached to a patient [14,17]. Read carelessly, this literature supports the claim that drones save lives; read carefully, it shows that a device on the ground is roughly a third of the way to a device on a patient, and that the remaining distance is covered by a frightened bystander, not by an aircraft.

That reframing determines what should be built next. The rate-limiting step is human and it already has its own evidence base: dispatcher-assisted resuscitation and smartphone activation of nearby trained volunteers both increase bystander action, and the latter has randomised support [21,23,24]. A drone dispatched into a system with trained responders on the way delivers to someone who will use it. Dispatched into one without, it delivers a device to a doorstep. Deploying the aircraft first, in the absence of the responder network, gets the order wrong.

Study limitations

The limitations belong to the underlying literature. The clinical evidence comprises one prospective feasibility study of 12 take-offs and one larger observational series, both from the

same Swedish group in the same regulatory environment [14,16]. There is no randomised comparison against any alternative and no control group. Downstream outcomes rest on single-figure counts, so the 30-day survivor is a case report embedded in a series rather than an effect estimate. Denominators shift between reported proportions, and the dispatch rate excludes most alerts [14]. Weather, airspace and daylight constraints are inconsistently reported. Simulation and modelling studies assume dispatch and flight conditions that real operations do not achieve [10,11,18]. No economic evaluation using observed dispatch rates has been published. And the findings come from a country with unusually high bystander resuscitation rates, which flatters the downstream steps rather than the aircraft [5,21].

Conclusion

A defibrillator delivered by drone can reach a cardiac arrest around three minutes before the ambulance, in a system where nine in ten dispatched flights place the device within metres of the patient. That is a genuine advance against a clock that costs roughly ten per cent of survival per minute. What the same studies show is that of eighteen true arrests reached first by a drone, six devices were attached, two shocks were given and one person was alive at thirty days. The aircraft is not the limiting factor. The person standing over the patient is, and any system investing in drones before investing in the responders who will use them has bought the wrong half of the solution.

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Conflict of Interest

The authors declare no competing interests.

Ethics Statement

This article reviews previously published studies only. No new patient data were collected and no participants were recruited, so ethical approval was not required.

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