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Medical drones: Disruptive technology makes the future happen

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Abstract

Trauma surgery has always been driven forward by innovative technological advancements. The recent appearance of “advanced air mobility” (AAM) represents one of the next steps in these technological developments. These innovative flying systems have major implications for all of the various healthcare stages in trauma surgery: Unmanned aircraft systems, or drones, can deliver critical supplies on demand, just in time, without physical contact, within the “last mile delivery” concept, such as AEDs, critical medication, blood for transfusion etc. Electric vertical take-off and landing (eVTOL) devices add new horizons for healthcare thanks to the smallest take-off and landing areas. These eVTOLs are not only new aircraft but, thanks to the autonomous flying options, they are flying computers with novel technological opportunities on board. With these new, flying operation systems, the whole rescue chain will be completely revolutionized by much faster response intervals, patient transportation times, telemedical applications, optimized emergency medical services, laboratory transportation etc. Hence, this article aims to provide a tentative overview of these new exciting technological developments in the field of trauma surgery for the benefit of our patients.

Keywords

Aircraft · Transportation · Emergency treatment · Technological innovations · Unmanned aerial devices

The history of orthopedic and trauma surgery is a history of successfully implemented innovative technology into the process of medical caregiving. In this respect, we live in a time where a completely new, similarly disruptive technology is appearing on the horizon of our technological world. Since this innovative technology comprises much more than only drones, it was described recently as “advanced air mobility” (AAM).

The successful use of advanced aircraft has major implications for healthcare. In densely populated cities, AAM can be used to provide hospitals and laboratories with fast and predictable transportation methods that avoid urban congestion. In remote areas not easily accessed by roads, AAM technology can be used to solve major challenges in healthcare delivery, saving

people who would have otherwise lost their lives through childbirth, snake bites, accidents, and other life-threatening emergencies.

Unmanned aircraft systems

The global impact of COVID-19 has strained the world’s supply chain like never before. There is now an accelerated need for rapid advancements in logistics technology, especially in healthcare. Drone delivery is one solution to getting critical supplies where they are needed, when they are needed most.

Since the shortest distance between two points is a straight line, medical drones can significantly shorten delivery times between hospitals and clinical laboratories while lowering transportation costs and



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improving the effectiveness of caregiving. As a result, the global medical drone market is projected to grow from \$255M in 2021 to \$1.4B in 2028, according to a recent report by *Fortune Business Insights* [1]. This includes applications such as delivering blood, medicines, or small medical devices to surrounding areas. Key advantages that are enabled by this technology include on-demand and just-in-time delivery, minimal physical contact, last-mile delivery to remote locations with an extended logistical network, and low viral or pathological transmission risk.

Urban air mobility

Forecasted to provide 90,000 new jobs in the European community by 2030, urban air mobility (UAM) is a new technology comprising several different airborne vehicles with novel designs and various configurations including conventional fixed-wing, rotary-wing, and hybrid (i.e., separate lift and cruise, tiltrotor, tilt-wing, etc.). Most of these new aircraft are all-electric vertical takeoff and landing drones (eVTOLs), powered by either lithium-ion batteries or hydrogen fuel cells with zero carbon emissions.

Each year in the United States, roughly 350,000 cardiac arrests occur outside of hospitals (OHCA), and only 12% of the victims survive. One reason the survival rate is so low is that ambulances take 11 min on average to arrive on the scene. According to research from ARK Invest, eVTOLs could be the answer to shorter ambulance response times, creating a \$20B addressable market for manufacturers of such aircraft [2]. An eVTOL could reduce the ambulance response time to 5 min, saving an additional 20,000 and increasing the OHCA survival rate from 12 to 18%.

In general, UAM is likely to provide safer mobility networks since the probability of a fatal accident in an air taxi is much lower relative to road transport. Further, advanced aircraft such as eVTOLs will enable faster mobility, with a predicted reduction of transportation time from 40 min to only 15 min on an average standard city travel trip and, critically, 70% time-savings for emergency or medical delivery.

Exemplary AAM projects

Zipline

A California-based drone start-up that delivers critical medical supplies, Zipline started couriating blood and drugs in Rwanda in 2016 [3]. Since then, the company expanded its operations to Ghana in 2019, the United States in 2020, and Nigeria in 2021 [4–6]. Zipline's on-demand logistics enables service providers to decentralize patient therapy by, as an example, transporting chemotherapy medication to tumor patients who can stay in the comfort of their own home. The company promises an average reduction of \$169 for patient costs by telehealth visits, an 18% increase in medication adherence as a result of on-demand delivery, and a 28% reduction in transportation costs on average compared to ground-based technology. Most recently, Ghana's government selected Zipline to deliver the first vaccines supplied to Africa by the COVAX initiative, a project launched with the help of the World Health Organization to ensure that developing countries have access to COVID-19 vaccines [7].

Kitty Hawk

Emergency response and healthcare company Falck, as part of its Vertical initiative, which aims to assess the potential of drone technology in the prehospital and ambulance services of the future, is partnering with Silicon Valley's Kitty Hawk to explore the use of eVTOL aircraft in emergency medical services (EMS) operations [8].

Wingcopter

Regional Medical Center (Hutchinson, KS) is working with German drone manufacturer Wingcopter and Denver-based air medical service provider Air Methods to pilot a drone-powered delivery network for delivering healthcare resources, such as medicine, laboratory samples, and vaccines [9]. Wingcopter was also selected as one of the World Economic Forum's latest "Technology Pioneers" for its pioneering work in the South Pacific Island state of Vanuatu, Tanzania, Malawi, and Scotland [10].

Volansi

Merck, Vidant Health (Greenville, NC), and drone delivery start-up Volansi are collaborating to deliver cold-chain medicines, such as aerosol sprays for asthma, eye drops for glaucoma, diabetes medications, and COVID-19 vaccines [11].

Matternet

Atrium Health Wake Forest Baptist (Winston-Salem, NC) partnered with UPS Flight Forward and drone delivery startup Matternet to deliver COVID-19 vaccines from its main medical center to family practices within its network [12]. California-based Matternet has now launched medical drone delivery networks in the United States, Switzerland, Japan, and Germany [13–15].

DroneUp

The State University of New York (SUNY) Upstate Medical University (Syracuse, NY) teamed up with drone services company DroneUp and the Northeast UAS Airspace Integration Research (NUAIR) Alliance, a nonprofit organization that tests unmanned aircraft systems, to conduct a 12-month project testing the use of drones for medical deliveries of items such as unused COVID-19 tests and patient tissue samples [16].

Summary

Although public approval of advanced air mobility technology remains a substantial question mark, the information presented here clearly demonstrates that medical applications have an almost unrestricted acceptance. And while public perception of new technology often improves with familiarity, findings from a recent study by Virginia Tech University are particularly significant for drone delivery [17]. In early 2021 researchers conducted a survey among residents of Christiansburg, Virginia; a community of just over 20,000 where Alphabet's Wing has operated a residential drone delivery service since October 2019. According to Virginia Tech's survey of over 800 residents, 87% of respondents have positive sentiments about drone delivery;

89% report that they would likely use the service if it were available; and 87% say they view drone delivery equally or more favorably than other drone applications.

Since logistics is one of the critical columns for taking care of trauma patients, any technology that improves transportation will have a substantial effect on the treatment of patients; this was seen in the strong effect of helicopter transportation. Hence the conclusion is that these innovative transportation devices might be implemented into daily life within medical transport. Due to the much lower cost of operating and maintaining drones and eVTOL aircraft, not only patient transport but all the issues in the entire chain of the caregiving process will be strongly influenced by these flying devices.

Although this is a very optimistic view into the future and no scientific data are available to prove this prophecy, we are convinced that these innovative transportation devices will revolutionize the whole process of medical caregiving. And it stands to reason that the more this process depends on time and effectiveness, the stronger this effect will be. Hence, we are more than happy that Springer allows us to present this very innovative technology to a broad audience of trauma surgeons, who may want to keep tabs on the expansion of such advancements as there may be meaningful opportunities to improve clinical outcomes and patient satisfaction in the near future.

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Declarations

Conflict of interest. C. Sigari and P. Biberthaler declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies performed were in accordance with the ethical standards indicated in each case.

Medizinische Drohnen: innovative Technologie eröffnet neue Horizonte der Unfallchirurgie

Die Unfallchirurgie wurde schon immer ganz entscheidend durch technologische Entwicklungen vorangetrieben. In der jüngsten Vergangenheit wurde nun durch die Neuentwicklung der „advanced air mobility“ (AAM) eine ganze Reihe von neuen technischen Entwicklungen angestoßen, die disruptive Änderungen im Bereich der Notfallmedizin allgemein und Unfallchirurgie im Besonderen haben wird. Diese neuartigen AAM können beispielsweise medizinisches Gerät (z. B. automatisierte externe Defibrillatoren [AED], Ulmer Trauma-Box usw.), Medikamente, Blut u. Ä. ohne physischen Kontakt zu Menschen und damit ohne Infektionsrisiko in wesentliche kürzerer Zeit im Vergleich zu bodengebundenen Systemen transportieren. Die elektrisch betriebenen Senkrechtstartersysteme („electric vertical take-off and landing“, eVTOL) werden das gesamte Feld der Notfallversorgung sowohl auf dem Land als auch in der Stadt revolutionieren. Durch die technischen Optionen des autonomen Betriebs stellen diese Geräte eine ganz neuartige Klasse von fliegenden Betriebssystemen dar, mit denen die gesamte Rettungskette signifikant verbessert werden wird durch drastisch verkürzte Response-Intervalle, Patiententransportzeiten, optimierte Logistik, telemedizinische Applikationen usw. Daher versucht dieser Artikel einen vorsichtigen Ausblick in diese neuartige Technologie für das Wohl unserer Patienten zu geben.

Schlüsselwörter

Luftfahrzeug · Transport · Notfallversorgung · Technologische Innovationen · Unbemannte Flugsysteme

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