Use of Unmanned Aerial Vehicles for Medical Product Transport

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Abstract

Advances in technology and decreasing costs have led to an increased use of unmanned aerial vehicles (UAVs) by the military and civilian sectors. The use of UAVs in commerce is restricted by US Federal Aviation Administration (FAA) regulations, but the FAA is drafting new regulations that are expected to expand commercial applications. Currently, the transportation of medical goods in times of critical need is limited to wheeled motor vehicles and manned aircraft, options that can be costly and slow. This article explores the demand for, feasibility of, and risks associated with the use of UAVs to deliver medical products, including blood derivatives and pharmaceuticals, to hospitals, mass casualty scenes, and offshore vessels in times of critical demand.

Introduction

Earlier this year, a brewery in Wisconsin employed drones to deliver beer to ice fishermen on Lake Waconia.[1] This short-lived experiment was curtailed by the US FAA before the efficacy of the delivery method was proved, but the initiative shows a possible alternative to common delivery options for small packages.[2] However, as the FAA re-evaluates the current regulations and restrictions, larger companies, including Amazon, are actively researching the potential feasibility of UAVs for the transport of goods.[3] UAVs may soon be used to transport goods quickly, safely, and inexpensively across both accessible and inaccessible terrain such as to stranded mountain climbers or boats adrift. This presents medical providers with intriguing new possibilities for transportation in times of critical need and in routine circumstances. The possibility of using UAVs for commercial transport, medical transport, and disaster relief has been suggested, but no literature exists on the feasibility and potential applications of UAVs in the medical field.[4-8] Currently, medical supplies in the United States are delivered by ground transport as well as aircraft, both fixed and rotor wing. During emergencies, the availability of blood products and pharmaceuticals is often limited at critical access hospitals, and conventional channels of supply may become disrupted. This article aims to outline the demand, feasibility, and risks regarding the use of small UAVs (Fig. 1) to transport blood and pharmaceutical products to critical access hospitals, mass casualty scenes, and offshore vessels in times of critical demand.

Potential Applications

The prompt use of blood products, including packed red blood cells (PRBCs), plasma, and platelets, has been shown to save lives in bleeding trauma patients.[9-14] Although many critical access hospitals have blood products available, inventory is limited, and supplies of platelets and plasma are typically even more restricted than red cell products. A critical access hospital is defined as a hospital with 25 or fewer beds located at least 35 miles from another hospital via a primary road or 15 miles via a secondary road.[15] Level III trauma centers, although not synonymous with critical access hospitals, are often also located in rural areas and provide critical access to trauma patients in these regions. Since the early 1990s, the number of level III trauma centers in the United States has increased, but they have limited resources, especially centers in rural areas.[16] In addition, 46.7 million Americans still have no access to a level I or II trauma center within an hour from their homes, and an additional 81.4 million Americans would not, without helicopter services, have access to a trauma center within an hour from home.[17] Thus, even with the expansion of trauma centers in the past 2 decades, many Americans still have limited access and could potentially benefit from a higher level of local care.

Although a trauma center must have blood products immediately available, this supply is not unlimited, and large reserves typically are not on hand. Current standards of care recommend transporting patients who require transfusions to larger hospitals when resources, including blood products, are unavailable or limited. This is often a costly process and may delay appropriate initial care. Attempts have been made to alleviate this issue by transporting PRBCs and plasma with advance transport teams. Although innovative, the change does not overcome the significant operating cost of manned aircraft or the risks to flight crews traveling in remote areas. Furthermore, natural disasters and mass casualty incidents may occur in remote locations that require temporary blood

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Figure 1. Artist's rendering of a medical transport drone. (Reprinted with permission from the Mayo Foundation for Medical Education and Research.)

banks, and transportation can be a significant barrier to establishing these forward operating stations.

The ability of critical access hospitals to maintain an inventory of blood products is complicated by numerous factors, including shelf life and cost. Hospitals may have various types of PRBC products and 3 different types of plasma available to prevent delays in emergent transfusions. Although the shelf lives of PRBCs (42 days) and plasma (1 year) are relatively long, other products, such as platelets (5 days) and thawed plasma (5 days), may be wasted when the demand is low.[18] Critical access hospitals stock a restricted supply of blood products compared with large tertiary care hospitals (Table 1). In a patient with severe bleeding, a massive transfusion (> 10 units in 24 hours or 5 units in 60 minutes) may be needed, which can often rapidly deplete a hospital's blood supply.[19] The average trauma patient undergoing massive transfusion requires an average of 22 units of PRBCs and 14 units of platelets, which is more PRBCs than most critical access hospitals stock.[20] Initial massive transfusion resuscitation also includes plasma, and critical access hospitals typically have a limited supply of this product.

Regional blood banks that supply critical access hospitals keep enough frozen blood on hand to meet regular demand. During times of high demand or possibly for only 1 patient with massive bleeding, the blood supply of a critical access hospital may become depleted and require intensive support from the regional blood center.[21,22] An example of this was during an earthquake in Bam, Iran. This event highlighted the inefficiency of the current process by which blood is distributed. Although 108,985 blood units were donated, only 23% of these units were actually distributed to hospitals. Interestingly, only 1.3% of the units were delivered to the disaster site within 4 days.[23] Although many factors can complicate a disaster response, it is clear that distribution, not supply, remains a critical problem.

Studies of similar events in the United States reinforce that a lack of blood products in times of natural disaster or mass casualty is often not the issue; rather, the logistics of distribution are the challenge. One study found that in only 4 cases in the past 25 years have more than 100 units of blood been used in the first 24 to 30 hours after a disaster in the United States.[21,23] In a review of recent disasters in the United States in which mass appeals often resulted in increased blood donations, significant delays were found in the distribution of these time-sensitive donations.[24] It is important to note that, because of screening and laboratory testing, blood is typically not usable on the date donated. Nevertheless, the ability to expeditiously shift blood products between centers to resolve shortages, without involving humans in the transport process, would improve patient care and reduce expenses.

Blood banks have safeguards and backup systems in place to prevent shortages in times of disaster or increased demand. One commonly used method is to keep a small supply of blood products on hand and then request blood, as needed, from regional blood banks or regional hospitals. Although this system helps decrease blood product wastage, reported wastage rates still range from 1% to 26%.[25] When increased demand occurs, blood products are then sent by courier, taxi, ambulance, or police vehicle.[26] The military uses more advanced methods, including refrigerated trucks, helicopters fitted underneath with sling loads, and parachutes, to deploy blood during combat situations. Ground transport is relatively inexpensive, but risks to personnel remain, and transport can be hindered by weather, road conditions, or the austerity of the environment. Conventional air transport by fixed or rotary wing aircraft is expensive and also puts the crew at risk. Although several trauma networks routinely send blood products with helicopter transport crews, this still requires the patient to then be transported to the regional center, putting both the crew and patient at additional risk.