

Prospective use of unmanned aerial vehicles for military medical evacuation in future conflicts

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ABSTRACT

In order to continue to deliver outstanding medical care on the battlefield, the UK Defence Medical Services must continue to adapt, overcome and actively embrace change. One potential area is the rapid proliferation and sophistication of automated and remote systems such as unmanned aerial vehicles (UAVs). UAVs are already used to deliver blood to remote military locations in Afghanistan and defibrillators to those that need them in the USA and Sweden. An area of future opportunity would be to facilitate rapid evacuation of wounded personnel from high intensity, high threat, remote and austere areas directly to specialist care. Such a capability would reduce threat to human life while allowing rapid extraction of casualties from high risk or inaccessible environments straight back to Role 3 care, all of which in these situations is either not possible or carries too much risk using conventional aerial assets. The article aims to highlight a potential future capability, stimulate debate and reflection, all of which is essential for innovation and future organisational development. The potential uses and benefits of UAVs are highlighted including both the challenges and rewards of utilising UAVs for casualty evacuation. Key benefits are reduced risk to human life, cost, ability to insert into areas conventional aircraft cannot and the rapidity of transfer. Challenges are likely to be airspace management, decisions on appropriate level of care to deliver during transit and ultimately user acceptability. The article also highlights that in order to maximise our ability to exploit new technologies, all arms and trades within the military must be involved in collective research and development. Furthermore, sensible corroboration with private companies will further enhance our ability to acquire products that best serve our needs.

INTRODUCTION

As the capability of unmanned aerial vehicles (UAVs) increases, their use will proliferate and medical utility is no

exception. This has resulted in the US military and large defence contractors directly investing and exploring this area of opportunity. One potential use is the rapid evacuation of battlefield casualties directly from the front line to a higher level of care. This would mitigate the risk of sending manned assets and reduce the reliance on and risks to current conventional limited aerial assets. This article aims to explore potential capability and discuss both the advantages and challenges associated with UAV use. By doing this, a potential future capability is highlighted which will stimulate debate and discussion while challenging current beliefs, all of which is essential for the ongoing innovation of our organisation.

THE FUTURE OPERATING ENVIRONMENT

Currently, the British Army is committed to multiple small-scale operations, as well as defence engagement and capacity building. The result is small isolated teams operating in austere environments. Unlike operations in Afghanistan and Iraq, these teams may not have airframes available for medical evacuation or a medical emergency response team (MERT) within their area of operations. This can result in challenging and often ad hoc casevac plans. These teams are then reliant on self-evacuation or the variable capability of partner nations. With the introduction of the new Specialised Infantry Battalions, it is clear these engagements will continue for many years. Automated systems placed at key strategic locations would aid casualty evacuation in such operating environments.

Looking further forward, the military is likely to continue to be busy in an increasingly complex world and future significant conflict cannot be ruled out. Over recent years, the decline in appetite for military risk with a relative increase in the value placed on human life, compared with conflicts such as the Great War, is likely to endure. We therefore predict that the use of remote and automated systems will become commonplace to mitigate risk to human life.¹

HOW UAVS MAY CONTRIBUTE TO CASUALTY EXTRACTION

UAVs may have two uses in the evacuation of injured personnel. In the case of minor casualties, multiple injured personnel could be placed in the UAV and transported back to an appropriate level of care. In the case of more serious casualties, such as traumatic amputations, medical personnel would assess at the point of injury or at the Role 1 level. Lifesaving initial interventions such as peripheral and junctional tourniquet application with pelvic binder placement will then take place. A UAV will come to the casualty, even if troops are in contact (figure 1). The casualty will then be loaded onto the UAV, monitoring rapidly placed on the patient that feeds directly back to the receiving hospital. The UAV will then rapidly extract from the battlefield direct to the receiving treatment facility that will be able to observe the physiological monitoring and start to build a picture of the casualty before admission to their unit.

BENEFITS OF UAVS

Cost

When comparing UAVs to manned aerial vehicles (MAVs), there is a clear cost benefit.^{2,3} Furthermore, as these systems proliferate, become easier to produce and technology advances, the cost benefit is likely to grow further.¹

Expendability

Compared with MAVs, there is no risk to life when UAVs are used. A higher tolerance for insertion into kinetic areas or during adverse weather conditions is likely. However, in comparison to UAVs used for logistical resupply or delivery of fresh whole blood, drugs, water and ammunition to forward bases, surveillance or strike missions, we must still keep in mind that there will be a human life on board, although at risk, when they exit the area to return to a medical treatment facility (MTF). Consequently, there will still always need to be a risk versus benefit decision for the evacuation of wounded service personnel.

Reliability and removal of human error

Analyses of aviation incidents cite human factors to be the predominant cause.^{4,5} As UAVs become increasingly automated, human factors will be mitigated suggesting a future increase in safety profile. Very early UAVs had high attrition rates compared with manned flights; however, this has now reduced

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Figure 1 A UAV lands in an austere location to remotely extract a casualty. Aerial reconfigurable embedded system (ARES) medical evacuation module artistic impression by Lockheed Martin. Reproduced with permission from Lockheed Martin.

and as features such as automated landing become commonplace, this is likely to lower even further.⁶

Long hover time

MAVs are limited by fuel and human flying hours in their ability to hover over the battlefield. UAVs can enter autonomous holding cycles that allows them to linger over the threat area or battlefield and rapidly drop to the casualty when required. Teams of pilots and aircrew 'on standby' will no longer be required. UAVs could also be prepositioned in larger bases or on a safe-house roof, ready for load-up, push-button, fly-home-now iterations. This would rapidly remove the casualty from the care of the team on the ground allowing them to refocus purely on their mission and task and not be fixed by having to manage a casualty that may well be detrimental to the teams safety and/or likely success of the mission.

Landing ability

UAVs have the ability to undertake automated landing and take-off. This means that due to their design, smaller footprint and complex sensor systems, they can land in unprepared and challenging terrain such as small clearings, fallow fields and

icy roads^{7 8} which conventional MAVs cannot.

Direct to a Role 3 medical treatment facility

Doctrinally, we plan for casualties to pass up through echelons of care and therefore plan our evacuation pathway to accommodate this. There is growing evidence that outcomes are improved if casualties go directly to a Role 3 MTF and not a Role 2 MTF. There is an argument that this benefit continues even if total prehospital transport time is increased.⁹ UAVs could therefore be used to rapidly transport casualties from point of injury directly to a Role 3 MTF.

CHALLENGES OF UAVS

Despite the benefits discussed above, there are challenges associated with UAVs.

Battle-space management and congested airspace

A significant challenge to increased UAV usage is management of the airspace. This involves not only flight path deconfliction but also the parabolic pathway of fired munitions. To further complicate the situation, UAVs may hover over the battlespace in order to be rapidly available for casualty extraction. This could result in a swarm of UAVs lingering in the airspace. Complex and reliable control measures must be in

place to prevent potentially disastrous aerial incidents.

Cyberattack and security

If the UAVs are being used exclusively for medical tasks, they will be offered protection via the Geneva Convention and thus should not be the target of cyber or conventional attack.^{10 11} However, future adversaries may not respect this protection. The UAVs need to be secure and have protection from cyberattack. In future conflicts, enemy electronic and cyberattack capability will increase.¹ An unintended outcome of an attack against our forces may be widespread cyber/electromagnetic disruption essentially preventing the operation of UAVs which would be detrimental to casualty extraction.

Level of care delivered

Casualty evacuation also known as CASEVAC or by the callsign Dustoff in US sources is a military term for the emergency patient evacuation of casualties from a combat zone. CASEVAC can be done by both ground and air. Medical evacuation, often shortened to MEDEVAC, is the timely and efficient movement and en route care provided by medical personnel to wounded being evacuated from a battlefield. Put simply, CASEVAC delivers no treatment or care, while MEDEVAC offers a variable degree of medical care. As it stands, this article has essentially described a CASEVAC capability using monitoring, with the justification for CASEVAC being rapidity of transfer back to a higher level of care outweighing the reduction in care during transit; inevitably, this requires a risk benefit balance analysis.

In order to deliver a MEDEVAC capability, one could place a medical asset in the UAV; this could be a Combat Medical Technician, Medical Officer or depending on platform size, a MERT. When more personnel are placed on the platform, the risk tolerance for use of the UAV will reduce, as more lives will be at stake and also the ability for prolonged hovering above the battlefield will decline. A way round this would be to have different UAVs capable of delivering variable levels of care across the spectrum from CASEVAC to MERT. A specific UAV would then be dispatched depending on the needs of the casualty and also the situation on the ground.

Arguably as the UAVs will be loitering above the battlefield and rapidly descend to the casualty, immediately following basic trauma care, the casualty will be transported onto the UAV and rapidly

delivered to specialist care. The rapidity of this pathway may well counteract the reduced care during transit. This could be especially useful in cases with non-compressible internal haemorrhage or closed head injuries which need surgery as a matter of urgency. Some may argue, however, that if transit time increases in future operations, the need for high level prehospital care increases with cessation of bleeding, blood resuscitation and securing the airway being key priorities; all of which has been expertly delivered by MERT in previous conflicts most notably Op HERRICK. Some of this is currently beyond the capability one imagines in a traditional Role 1 MTF environment. However, capabilities are rapidly evolving and in the future, Role 1 MTF capability will continue to evolve. Emergency Whole Blood 'Buddy to Buddy' transfusion is a now well-established capability for deployed, isolated and remote teams. Equally, those teams in fixed locations, with a reliable power supply, are deploying with blood fridges; therefore, the ability to resuscitate, albeit with limited quantity, with blood is achievable.

Peripheral bleeding can be controlled with both peripheral tourniquets and junctional tourniquets, such as the SAM Junctional Tourniquet, which although currently not part of standard medical modules are a potential lifesaver. The Abdominal Aortic and Junctional Tourniquet (AAJT) is another simple to use device that can be used for both lower and upper junctional bleeding, or when applied over the mid-abdominal region occludes the aorta around the level of the bifurcation thus having an effect on complex pelvic injuries. As in the case of the SAM Junctional Tourniquet, the AAJT's simplicity makes it easy to imagine as a future addition to prehospital medical modules as evidence grows.

Looking further forward, as evidence grows for novel interventions such as Resuscitative Endovascular Balloon Occlusion of the Aorta or intra-abdominal foam for non-compressible haemorrhage, these could well be initiated in the Role 1 MTF environment providing stability for unmanned evacuation of significant casualties. Obtaining a definitive airway can be challenging; however, as technology advances one could foresee UAVs having in-built ventilators and drug delivery systems; therefore, if intubation was obtained in the Role 1 MTF environment, the remote monitoring would allow a trained clinician to remotely control an

inbuilt ventilator and pharmacologically control a patient's physiological parameters. If this did become a capability, it would of course involve training some Role 1 MTF providers to a higher level of prehospital emergency medicine competency.

The authors of this paper accept that UAVs could theoretically be used in current times; yet, there would need to be detailed and well-considered thought behind their use in regard to the level of care delivered in transit against time to higher level of care prior to widespread adoption. However, their potential is undeniably exciting and with continued advances among other remote technologies and prehospital capabilities, they could in the future allow rapid extraction and delivery to a higher level of care with continued stabilisation throughout transit resulting in increased survival.

User acceptability

Civilian evidence suggests that whether it is aerial or ground vehicles, there is a negative attitude or distrust towards autonomous or radio-controlled capability.^{12 13} This is likely to be further confounded when the idea of casualties is introduced. If injured and then alone in a confined automated device, one can deduce that stress levels would rise and potentially psychological injury occurs. User acceptability is likely to be a significant challenge to implementation and the potential impact on the patient would need to be explored further. However, once troops realise that it is probably better to be in-flight for 30 minutes to a Role 3 MTF than stuck in a Forward Operating Base or 'Safe-House' for 3 days slowly dying, attitudes will surely change.

OTHER MEDICAL USES OF UAVS

In Africa, a civilian company has demonstrated success in using UAVs to deliver blood products, medication and other items to rural and isolated locations.¹⁴ The capability to deliver products rapidly, into austere challenging and dangerous environments with no risk to human life will be of significant benefit during conflicts, disaster relief operations and to small isolated austere teams. It is foreseeable that as warehouses become increasingly automated, one could even imagine a system where on requesting a hard item every step will be completed autonomously allowing 24 hours service all year round with no reliance on human work power.

We must also ensure that future research and development is carried out hand in hand with the end user, the soldiers and medics on the ground. The Specialised Infantry Battalions are a novel concept for the UK Military who will operate in challenging, austere and isolated environments. Partnering our Medical Research Capacity and Development team with this group could lead to exciting and pioneering new developments.

SUMMARY

As with all new technologies, there will be challenges and for the near future when available and feasible MERT will likely remain the preferred evacuation method. For UAVs in the context discussed, challenges will likely be airspace management, decisions on appropriate level of care to deliver during transit and ultimately user acceptability.

UAVs whether fully autonomous or radio controlled do offer the potential to improve casualty evacuation and patient outcome in conflict zones, isolated austere deployments and disaster relief operations. This is likely to become increasingly the case as additional novel therapies and tools are introduced into the prehospital care environment strengthening the usefulness of UAVs.

As an organisation, we must embrace and mould future capabilities to best serve our needs. This requires forward thinking, early engagement in research and development and importantly collaboration with civilian companies who will then deliver a product which suits the needs of our organisation.

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