Developing TCCC Guidelines for Unmanned Aerial Vehicle Casualty Evacuation

Paul J. Parker, RAMC, MB BCh, BAO, DipIMC, FRCSEd, FRCSOrth, FIMC

> *". . . Would a means to fly in and extract isolated personnel without putting additional personnel in harm's way be of value? The answer to that question is an obvious—Yes!"*
>
> —CWO4 Michael Durrant, USA (Ret), Pilot Super Six-Four, 160th SOAR, Battle of Mogadishu, Operation Gothic Serpent, 1993

The first ever successful drone strike took place on 27 September 1944. Under Operation "Option," an interstate TDR-1 drone fitted with a nose-cone camera was successfully remote guided onto a Japanese gun emplacement on Bougainville Island in the Pacific and detonated.[1] In Vietnam, North Korea, and China between 1964 and 1974, jet-powered Ryan 147 "Lightning Bug" drones flew 3,345 high- and low-level reconnaissance missions.[2] In Vietnam, under US Navy Project "Midget," Gyrodyne Dash QH-50 anti-submarine rotary drones were secondarily deployed to rescue downed pilots.[3] The first recorded combat retrieval of a Special Forces Soldier from the jungles of Vietnam was reportedly performed by a US Navy Destroyer–launched QH-50 drone.[4]

Unmanned aerial vehicles (UAVs) have an increasing usefulness, in both military and civilian life.[5] In Sweden and the Netherlands, when reporting a cardiac arrest, a UAV carrying a defibrillator can be despatched to your location, using your phone's GPS signal as a guide, within minutes.[6] In Rwanda and Ghana, Zipline (Zipline, Half Moon Bay, CA) drones carrying blood and medicines to treat postpartum hemorrhage are tasked by WhatsApp or text message to remote clinics. To date, 23,404 automated drone deliveries have been made, including more than 13,000 units of blood, plasma and platelets. 70% of remote area blood outside the urban centers in these countries is now delivered via these means.[7] Zipline state that they now have the capacity to undertake 500 such missions a day. Military feasibility studies have confirmed that similar results can be achieved in the field. Using simple UAV technology, "urgent" medical supplies that took 306 minutes to deliver on foot and 61 minutes to deliver by road took only 21 minutes to deliver by drone.[8]

Planners and physicians face the public expectation of rapid casualty evacuation with a high "Western Medicine" level of care (as was the case in Afghanistan, with virtually complete air superiority) in future war. Our reality is one of multiple SOF or training teams working in austere, remote, and isolated areas with elongated timelines and no local coalition air assets or close-by R2/3 medical facilities. There is a clearly a need to develop new capabilities to anticipate these tasks. The dynamics and constraints of future conflict are often unknown. Budgetary issues are often primary concerns.

Current doctrine is still based on (or constrained by) the 10-1-2 concept.[9] Care under fire and tactical field care within 10 minutes, damage control surgery within 1 hour and more definitive surgical care by 2 hours. In a decade where the appetite for risk seems to diminish each month, tactical commanders in the field find themselves increasingly constrained, contained, and militarily fixed by colored maps arbitrarily overlaid with 1-hour CASEVAC rings. Is there a solution?

Unmanned aerial vehicles are becoming increasingly affordable, reliable, and sophisticated. As noted, they are already used for the medical purposes of blood, drug, and AED delivery. Interestingly, the Geneva Convention (1949) under Article 39 is already thought to give guidance on Medical UAVs as it states, "Medical aircraft may not be the object of attack."[10] It does not differentiate between manned and unmanned aircraft. In peer-to-peer conflict, wholly medical, Red Cross–marked drones could therefore use IFF (Identification Friend or Foe) transponders for protection.

The DoD has an "Unmanned Systems Integrated Roadmap 2013-2038."[11] The NATO workgroup publication "RTG-184 / STO-MP-HFM-231: Unmanned Aircraft Systems for Casualty Evacuation: What needs to be done?" states, "The use of UAVs for CASEVAC is ethically, legally, clinically, and operationally permissible, so long as the relative risk to the casualty is not increased. The employment of VTOL UAVs for casualty evacuation will soon be a reality and eventually commonplace in the battle-space. By conducting the research proposed in this paper, NATO members will be ready."[12]

Correspondence to parker_paul@hotmail.com
COL Parker is a consultant orthopaedic surgeon with the Parachute Field Surgical Team, 16 Medical Regiment, Colchester, UK, and senior lecturer in SOF medicine at University College Cork.

TR-HFM-184 also sets out "Safe Ride Standards for Casualty Evacuation using Unmanned Aerial Vehicles" and notes clearly, "The use of UAVs for CASEVAC will take place as soon as cargo UAVs or optionally-piloted conventional aircraft are available on the battlefield, it is up to NATO and the nations to be ready." These safe ride standards include restraint and safety issues, maximum G loading (2G), maximum rate of application of G (0.25G/sec), and acceptable noise, vibration, and egress levels.[13]

Such drones already exist. The US Dragonfly DP 14 Hawk is a twin-rotor drone with VTOL self-launch/recover capability and a 5-minute "hot-on-pad" launch time. It has a top speed of 105 knots (Cruise 72Kt) and is nap of the earth flight capable with non–line of sight navigation if no GPS. All terrain landing (<15°) and a 2.4-hour endurance capability are standard. It also has 4.5Kw on-board generator. This UAV can carry with ease a lone patient but no attendant.[14]The ducted-fan Israeli Tactical Robotics Cormorant UAV can carry two patients and already meets IDF and NATO RTG-184 MEDEVAC and CASEVAC standards. It cruises between 100 and 120 knots and has a 5-hour loiter time. It has two laser altimeters, a Doppler altimeter for use in dust/brown-out situations, GPS, and inertial/electro-optical navigation sensors.[15]

The Bell 247 Vigilant drone, based on Bell 280 Valor technology, has a 13,000-lb payload and can cruise at 250 knots.[16] It has a 1,400–nautical mile range, a 11- to 15-hour loiter time, and an in-flight refueling capability. Two fit easily in a C-17. The V280 is the replacement for the MV/CV-22 Osprey as part of the US Army Future Vertical Lift Program. Its top speed is over 300 knots. As with the UK Medical Emergency Response Team (MERT) and In-Flight Surgery (IFS) program in CH-47s and CV-22s, this would clearly allow for physician-led en route team care on the V-280 and perhaps the V-247.[17]

Military UAV concepts of operation generally include; autonomous transit from start-point, to pick up point, to medical unit. Collision avoidance, avoidance of no-fly zones, and meteorological data, are all remotely and ready-factored in. This should allow us to completely change our standard doctrinal 10-1-2 approach. Tactical field care would be immediately followed by transport to surgery. Given that larger drones can fly at close to 300 knots, this means that the receiving R2 could be in a different country yet only 30 minutes away. In-flight TCCC or critical care could be automatically delivered, and for us, this is the key. Autonomous en route care was examined previously, well over a decade ago. The DARPA Trauma Pod project was funded at $12 million in 2005. It turned out to be more useful for on-site minimally invasive prostatic surgery (MIS), than remotely performed surgery on the battlefield.[18] We should perhaps look again.

What levels of care can be delivered? For the purposes of discussion, it may be reasonable to divide levels of UAV care into the following:

- Level 0: lone patient
- Level 1: en route TCCC provider
- Level 2: en route interventional care
- Level 3: en route surgical care

Level 0 transport is the most likely in the near future. A large cargo drone in 2020 will have brought ammunition and water forward to an FOB where a wounded soldier is extremity injured, without a clear CASEVAC timing or plan, and without the benefit of the air superiority of previous campaigns. The tactical commander makes the decision to place the Soldier into the drone to fly back to the base area. He asks the TCCC provider or qualified medic (18-D) to prepare the patient for transport. What are the medical considerations? C-A-Ts 1 or 2? Junctional tourniquet or pneumatic tourniquet applied with altitude considered losses and gains? Antibiotics given; TXA autoinjector ready, warmed blood (premixed cells and plasma) in a single robust bag securely hung and ready for a flight of up to 2G with maximal 0.25G/sec application. A remote monitor connected to the on-board generator and encrypted data transmitter, the physiology-driven remote syringe driver filled with enough analgesia for the journey? Oxygen delivery system primed, in-drone overhead camera monitor on and compartment warming engaged?

For truncal or head-injured patients, balancing the risk of death of remaining at the Field Medic/R1 level for 24–36 hours versus rapid drone CASEVAC will be problematic. Telemedicine may be of use, but a physiological scoring system allied to mechanism of injury on the other side of the checklist might be of more use. Junctional tourniquets such as the AAJT are already known to be as effective as Zone 3 REBOA and are much more easily applied.[19] Intra-abdominal hemostatic foams continue to be developed. The far future may allow for remote ventilation and in-transit cooling.

Level 1 UAVs where there is the physical space for en route care with a TCCC provider is the next step. I-Gel airway management, peripheral nerve catheter placement and active wound care are now all possible. However, it is obvious to field commanders that their troops will need to be as comfortable psychologically climbing into this drone as into a CH-47.

Level 2 will equate to UK MERT care with physician led en route interventions. This team can now deliver endotracheal intubation, mechanical ventilation, and advanced resuscitation skills, including thoracostomy, fibrinogen, and calcium administration and ISTAT sampling. The on-board physician can also make the clinical decision to overfly a R2 and transit to a CT-equipped R3 with a head-injured patient by interfacing directly with the on-board drone control system.

Level 3 UAVs allow for in-flight Damage Control Surgery. Some countries already have this capability onboard their standard manned-pilot airframes. IFS or in-flight surgery is therefore already a reality. Pilot hours are more rigidly controlled than surgeons, but again end-user belief in airframe reliability remains key. A surgical team can hover in a holding pattern close to the troops in contact and land on when called. Laparotomy and vascular control procedures including Zone 1 REBOA, resuscitative thoracotomy and aortic clamping are performed in flight on the way to R3 in a western intensive care level hold.

UAV advantages are therefore; cost, an expendability that obviously alters once a casualty is on board, increased reliability with the removal of all human error, an intrinsic hover time and an ability to place forward, combining stealth with rapid casualty extraction. A UAV has the patience to sit on the roof of a Patrol House for many weeks without boredom supporting a team. There is also the possibility of UAV active/passive self-defense during transfer to Role 2/3 care.

UAV disadvantages are; battlespace space management concerns, parabolic munition avoidance, cyber-attack, user-acceptance, navigation and security issues. However, hardened intelligent navigation systems like those used on Predator drones and Tomahawk cruise missiles (TERCOM [Terrain Contour Matching], DSMAC [Digital Scene Matching Area Correlation and Radar Altimetry]) will help. UAVs are protected by the Geneva Convention but for some opposing forces, this may be a fine distinction. End user acceptability is one for our senior commanders.

In summary, the level of care delivered within the medical UAV will be *our* responsibility. Drones provide both challenges and opportunities for us. UAV CASEVAC is coming. When Skynet became self-aware in Terminator 1, Hunter-Killer drones were the enemy. Now like Terminator 2, they are on our side. We must be ready.

Disclosure

The author has nothing to disclose, and has no declared conflicts of interest.

References

1. https://en.wikipedia.org/wiki/Interstate_TDR. Accessed 5 August 2019.
2. https://en.wikipedia.org/wiki/Ryan_Model_147. Accessed 5 August 2019.
3. https://en.wikipedia.org/wiki/Gyrodyne_QH-50_DASH. Accessed 5 August 2019.
4. https://www.airspacemag.com/military-aviation/dash-goes-to-war-23369442/. Accessed 5 August 2019.
5. **Handford C, Reeves F, Parker PJ.** Prospective use of Unmanned Aerial Vehicles for Military Medical Evacuation in Future Conflicts. J R Army Med Corps 2018;164(4):293–296.
6. https://www.bbc.co.uk/news/av/technology-40360164/the-defibrillator-drone-that-can-beat-ambulance-times. Accessed 5 August 2019.
7. https://en.wikipedia.org/wiki/Zipline_(drone_delivery). Accessed 5 August 2019.
8. **Mesar T, Lessig A, King DR.** Use of Drone Technology for Delivery of Medical Supplies During Prolonged Field Care. J Spec Oper Med. Winter 2018;18(4):34-35.
9. Nato Standard AJP-4.10 Allied Joint Doctrine for Medical Support Edition B Version 1 With UK National Elements. May 2015. DCDC, Ministry of Defence, UK.
10. https://www.icrc.org/en/doc/assets/files/publications/icrc-002-0173.pdf. Accessed 5 August 2019.
11. https://publicintelligence.net/dod-unmanned-systems-2013/. Accessed 5 August 2019.
12. **Lam D, Gilbert G, Beebe M.** *Unmanned Aircraft Systems for Casualty Evacuation: What Needs to Be Done*. Neuilly-Sur-Seine Cedex, France: NATO Science and Technology Organization; December 2012:2.
13. **NATO Science and Technology Organization.** *Safe Ride Standards for Casualty Evacuation Using Unmanned Aerial Vehicles*. Neuilly-Sur-Seine Cedex, France: NATO Science and Technology Organization; December 2012:10-1.
14. http://www.dragonflypictures.com/products/unmanned-vehicles/dp-14-hawk/. Accessed 5 August 2019.
15. https://en.wikipedia.org/wiki/Urban_Aeronautics_AirMule. Accessed 5 August 2019.
16. https://en.wikipedia.org/wiki/Bell_V-247_Vigilant. Accessed 5 August 2019.
17. https://en.wikipedia.org/wiki/Bell_V-280_Valor. Accessed 5 August 2019.
18. https://phys.org/news/2005-03-trauma-pod-robot-soldiers-battlefield.html. Accessed 5 August 2019.
19. **Rall JM, Redman TT, Ross EM, et al.** Comparison of zone 3 resuscitative endovascular balloon occlusion of the aorta and the Abdominal Aortic and Junctional Tourniquet in a model of junctional hemorrhage in swine. *J Surg Res*. 2018;226:31–39.

The Special Operations Medical Association's Official Journal

JSOM

JOURNAL of SPECIAL OPERATIONS MEDICINE™

Spring 2020
Volume 20, Edition 1

THE JOURNAL FOR OPERATIONAL MEDICINE AND TACTICAL CASUALTY CARE

A Peer Reviewed Journal That Brings Together The Global Interests of Special Operations' First Responders