Descriptive record of the activity of military critical care transfer teams deployed to London in April 2020 to undertake transfer of patients with COVID-19

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ABSTRACT

In the face of the COVID-19 outbreak, military healthcare teams were deployed to London to assist the London Ambulance Service t transfer ventilated patients between medical facilities. This paper describes the preparation and activity of these military teams, records the lessons identified (LI) and reviews the complications encountered'. The teams each had two members. A consultant or registrar in emergency medicine (EM) and pre-hospitalemergency medicine (PHEM)E or anaesthesia and an emergency nurse or paramedic. Following a period of training, the teams undertook 52 transfers over a 14-day period. LI centred around minimising both interruption to ventilation and risk of aerosolisation of infectious particles and thus the risk of transmission of COVID-19 to the treating clinicians. Three patient-related complications (6% of all transfers) were identified. This was the first occasion on which the Defence Medical Services (DMS) were the main focus of a large-scale clinical military aid to the civil authorities. It demonstrated that DMS personnel have the flexibility to deliver a novel effect and the ability to seamlessly and rapidly integrate with a civilian organisation. It highlighted some clinical lessons that may be useful for future prehospital emergency care taskings where patients may have a transmissible respiratory pathogen. It also showed that clinicians from different backgrounds are able to safely undertake secondary transfer of ventilated patients. This approacmay enhance flexibility in future operational patient care pathways.

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Key messages

- In the face of the COVID-19 outbreak, military personnel were deployed to London to assist the London Ambulance Service i transferin ventilated patients between medical facilities.
- This paper describes the preparation and activity of the military teams who deployed to London and records the lessons identified.
- Fifty-two transfers were undertaken; over a 13-day period, only three significant patient-related complications occurred.
- This was the first occasion when the Defence Medical Services were the focus of a large-scale military aid to the civil authorities activity.
- Lessons related to the transfer of patients with a transmissible respiratory pathogen were identified.
- Clinicians from different backgrounds were able to safely undertake these transfers.

INTRODUCTION

After World War I, Spanish Influenza swept across the world. This was the first and, until recently, the only truly global pandemic of the modern age.[1] The COVID-19 pandemic is the second. It has tested health services, across the world, in a way not seen in the last hundred years. At the time of writing, there have been almost 4.7 million cases of COVID-19 worldwide and nearly 315 000 deaths.[2] In the UK, there have been over 250 000 cases and 34 636 confirmed deaths.[2]

The distribution of cases in the UK has not been uniform. London had approximately 25% of all UK incidences of the disease.[3] The burden of patients in the intensive care unit in some London hospitals meant that they were in danger of moving from a state of 'surge' to 'super surge', that is, moving from a situation where exceptional measures within the trust could manage to a situation where effective critical care could only continue to be provided with resources from outside that trust.[4]

The London Ambulance Service (LAS) were tasked with transferring patients to prevent super surge occurring. In common with most UK ambulance services, LAS had little inherent capability to transfer ventilated patients. Therefore, among other strategies, a military aid to the civilian authorities (MACA) request was submitted, asking for personnel to undertake these moves. Military teams, known as critical care transfer teams (CCTTs), were deployed to meet this need. This paper describes the deployment of CCTT to London and describes how they prepared and operated. It also records the clinical lessons identified (LIs) and reviews the incidences of complications reported by CCTT.

TEAM COMPOSITION AND ACTIVITY

Team composition is described by career employment group, service and the specialty of the physician (see Table 1). This is consistent with military practice of defining a team's capability by the level of the senior clinician.[5] The patient demographics, referring and receiving hospitals, crew allocation and additional notes were recorded and stored in the dispatch and allocation program Meridian (3tc Software, Leicester, UK). This information was made available to the authors. The activities undertaken by the team to reach full operational capability were recorded contemporaneously. The clinical LIs were retrospectively collated by the authors.

Ten CCTTs were deployed to London. Each team consisted of a consultant or registrar in emergency medicine (EM) and prehospital emergency medicine (PHEM) or anaesthesia. They were paired with an emergency nurse or paramedic, all of whom were level 5 practitioners.[5] Each CCTT was equipped with a Tempus Pro monitor (Remote Diagnostics Technologies, Basingstoke, UK), EVE-TR ventilator (Fritz Stephan GmbH, Gackenbach, Germany) and Perfusor Space infusion pumps (Braun, Kronberg, Germany) from military stores. They were also provided with a STP9000 Terrestrial Trunked Radio Airwave Handportable (Sepura, Cambridge, UK) by LAS. The ambulances used for transfers were modified to prevent airflow between the rear (patient-containing) and front (driver) compartment. They contained the usual equipment

Table 1 Team composition

	Physician details		Allied health professional details	
Team number	**Specialty and grade**	**Service**	**Professional background**	**Service**
1	Anaesthetic/PHEM consultant	Army	EM nurse	RAF
2	Anaesthetic StR	RN	EM nurse	RAF
3	Anaesthetic StR	RN	EM nurse	RAF
4	Anaesthetic consultant	Army	EM nurse	RAF
5	Anaesthetic StR	RAF	EM nurse	RAF
6	EM/PHEM consultant	Army	EM nurse	RAF
7	EM/PHEM consultant	RAF	EM nurse	Army
8	EM/PHEM consultant	Army	EM nurse	RN
9	EM/PHEM consultant	Army	Paramedic	RAF
10	EM/PHEM consultant	Army	EM nurse	RAF

EM, emergency medicine; PHEM, prehospital emergency medicine; RAF, Royal Air Force; RN, Royal Navy; StR, Specialty Registrar.

and drugs that would be carried by an LAS paramedic crew. All additional drugs (eg, hypnotics and vasoactive drugs) were provided by the sending hospital.

Personal protective equipment (PPE) was provided by LAS. Two levels of PPE were worn: for clinical contact, CCTT personnel wore level 3 (L3) PPE, consisting of a visor, hooded Tyvek suit, FFP3 mask (for which military personnel had been fit tested by LAS), two pairs of nitrile gloves and shoe covers. Two spare sets of L3 PPE were carried in case of damage or retasking. The LAS driver wore level 2 PPE, a fluid-resistant surgical mask, nitrile gloves and a plastic apron when they were required to be near a patient. This was also worn by CCTT personnel to decontaminate equipment and the vehicle after a transfer.

The first 2 days of the deployment were used for kit familiarisation and training. This was provided by personnel from within the CCTT and by members of the Tactical Medical Wing, the RAF's operational medical hub. There was a specific focus on the use of the EVE-TR ventilator; this was its first use by the Defence Medical Services (DMS). FOC was achieved on day 3 of the deployment. From then, at least eight military teams were available for tasking. On one occasion, additional military personnel formed a ninth team and undertook a transfer. This move has been included in the overall statistics. During the deployment, no one was unfit for duty due to actual or suspected COVID-19.

The CCTTs were based at the LAS Nightingale Ambulance Station, situated outside the NHS Nightingale Hospital London (NNHL). Dispatch and coordination were carried out by LAS control staff. Three consultants (two EM/PHEM one anaesthesia/PHEM), from within the deployed team, provided remote clinical advice. The LAS Deputy Clinical Lead for the Critical Care Transfer Service was also contactable by mobile phone to discuss logistical issues.

Table 2 summarises the activity undertaken by the military teams; Figure 1 shows activity by day and team. Fifty-two transfers were completed. It is not possible to attribute two transfers to a team; descriptive statistical analysis has been performed on the 50 transfers with complete data. Some allocated transfers were not completed. This was either because the patients were too unstable for transfer or because they did not meet the admission criteria for the receiving hospital.

Variation in numbers of transfers undertaken by each team is random. Teams were allocated transfers in a predetermined order; there was no attempt to allocate more complex transfers to a particular team. Twenty-nine transfers were to the NNHL. Five transfers were moves out of the NNHL. The remaining transfers were between pre-existing hospitals, usually from peripheral, smaller hospitals to larger, central hospitals. Interhospital transfers occurred for two main reasons: either to ease crowding or to move a patient to a facility that could better meet their clinical needs. Usually, as reported elsewhere,[6] this was due to a shortage of renal replacement therapy.

COMPLICATIONS

In order to appropriately classify complications, we reviewed the critical care transfer literature. Complications are typically categorised as 'patient'—encompassing physiological deterioration, 'technical'—related to difficulties with equipment, and 'logistical'—covering issue with access to hospitals or associated with the transport itself.[7] Incidents are also divided into minor or major adverse events (AEs).[8] Major patient AEs may cause morbidity or mortality. Thus, evaluation of when AEs should be classified as 'major' is prudent. In the literature, there was no agreed definition of when a patient complication should be categorised as major. While hypotension and hypoxia are both listed as AEs, there was no numerical value defining when these events should be considered a major AE. Fanara *et al* describe a major AE as a greater than 20% deterioration from baseline.[8] In a typical patient with COVID-19, this would allow a fall in saturation of around 18%, that is, a fall in saturation from 90% to 72% without this deterioration being classified

Table 2 Deployed military team activity

Criterion	Value (n (%), unless otherwise stated)
Total transfers, n (%)	50 (100)
Transfers per team, median (IQR)	5 (3–6)
Ventilated transfers, n (%)	49 (98)
Transfers to NNHL, n (%)	29 (58)
Transfers out of NNHL, n (%)	5 (10)
Transfers undertaken by a consultant, n (%)	36 (72)
Transfers undertaken by a team where the doctor's base specialty is EM/PHEM, n (%)	24 (48)
Transfers where a patient's major AE was recorded, n (%)	3 (6)

AE, adverse event; NNHL, NHS Nightingale Hospital London.

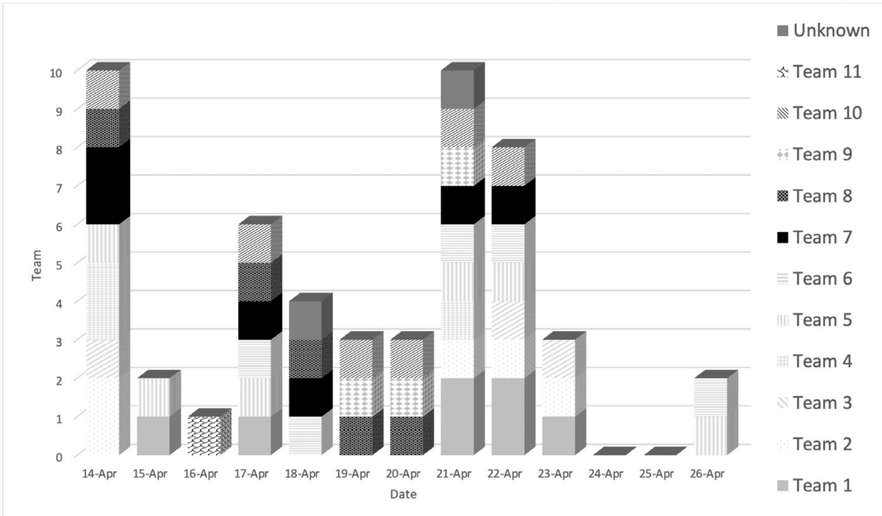

Figure 1 CCTT activity by day and team. CCT, critical care transfer team.

as major, this does not make pathophysiological sense. Parmentier-Decrucq *et al* classify a major AE as 'one that leads to a change in therapy during (interhospital transfer) IHT'.[7] This is more relevant to this clinical setting and was therefore the basis of our definition of a major AE.

For the duration of the MACA, physiological data were live streamed from patient monitors, equipped with SIM cards and stored in the Corsium suite, a secure, Ministry of Defence D-accredited, UK-based server which enables remote reach-back and patient record archiving. The authors had secure access to these data. Retrospectively, it was not possible to tell whether changes in physiology had triggered a response from the team managing the patient. Therefore, for the purposes of this paper, a major AE will be defined as a change in physiology for more than 1 min, which should prompt a change in management. The authors were blinded to the identity of the team managing the patient when reviewing these data.

Four potential major AEs were identified following review of our data. One of these, a profound tachycardia, was accompanied by a clinical note stating that this reading was erroneous and did not or relate with the clinical findings nor the arterial line trace. Therefore, this has not been considered an AE. Two events were related to a decrease in patient oxygen saturations, one for 5 min, at which point the saturations returned to normal and one lasted until the patient was removed from CCTT monitoring. No further explanation was available for these events. The final major AE was a period of hypertension and tachycardia. The hypertension and tachycardia occurred following flushing of a central line. We believe that some norepinephrine remained in this line, which led to the physiological derangement. A decision was made not to transfer this patient at that time due to their deterioration. They were later transferred by a military CCTT.

The small number of major AEs makes iterative statistical analysis inappropriate. Teams with clinicians of all grades and from all base specialties experienced major AEs. However, most transfers (94%) were completed without any patient major AE.

In addition to the patient AEs, there were some technical complications:

- Non-standard Schrader valves, identified prior to any team going live, meant that the ventilators could not be plugged into the oxygen cylinders carried in the ambulances. This was rapidly resolved by the supply of new oxygen hosing for the affected ventilators.
- The EVE-TR ventilator battery seemed to discharge quickly, and we suspected it would not meet its advertised life. This was mitigated by plugging it into an inverter in the ambulance. This meant that it only needed to run on battery power when the patient was not in the ambulance.
- On one occasion, the EVE-TR stopped ventilating a patient. The touchscreen interface also became non-functional. A hard reset was performed on the ventilator and normal functioning resumed. After appropriate reporting and investigation, this fault was found to be due to a manufacturing problem.

None of the technical complications described resulted in a patient major AE.

LESSONS IDENTIFIED

These relate to the transfer of patients with substantial requirement for ventilatory support and a transmissible respiratory pathogen:

- All connections in the ventilator circuit, proximal to the heat and moisture exchange filter, should be taped. This minimises the chance of inadvertent disconnection and thus leads to a reduced risk of interruption to the patient's ventilation, which in this patient group may have led to significant deterioration in physiology and a reduced chance of disease transmission to the clinicians.
- Immediately prior to changing the ventilator circuit, an inspiratory hold manoeuvre should be performed and the endotracheal tube clamped. This again lessened the risk of transmission of disease and ensured maintenance of positive end expiratory pressure (PEEP). There is some debate around the PEEP requirements for patients with COVID-19. Two pathophysiological subtypes have been identified, both with different PEEP requirements dependent on lung compliance.[9] For those identified as requiring PEEP, it is important that this is maintained to prevent alveolar collapse. Discussions among CCTT personnel and other clinicians familiar with caring for patients with COVID-19 revealed that, for those patients who showed a benefit from PEEP, a brief interruption to PEEP could result in desaturation and the requirement for up to an hour of reoptimisation before the patient's oxygenation returned to baseline.

DISCUSSION

This was the first large-scale MACA tasking with medical as the primary focus. The successful completion of this mission has demonstrated that the DMS is capable of carrying out taskings in support of the NHS, fulfilling a requirement identified by Connolly.[10] Due to the relative sizes of the DMS and NHS, we feel that future medical MACAs are, as in this case, likely to feature the provision of specialist capabilities.

One of the most notable features of this MACA was the close and effective integration between the CCTT and LAS. This was facilitated by an understanding by both organisations of where responsibilities lay. It should serve as a paradigm for future MACAs.

The requirement for the military to assist in this tasking highlights the lack of dedicated adult critical care transfer services in England. This contrasts to the situation in the devolved nations and also for paediatric patients within England. A consequence of this epidemic has been a renewed interest in establishing a pan-London critical care transfer capability (T Lightfoot, personal vommunication, 2020). Air ambulances (AAs) across England have undertaken transfers of ventilated patients with COVID-19. Once established, this secondary transfer capability is unlikely to be lost. As such, the breadth of services offered by AA in the future may increase.

Future military prehospital emergency care (PHEC) taskings are likely to feature prolonged evacuation timelines, certainly compared with those seen in operations in the early part of the 21st century. It is also likely that the DMS will be required to treat a wider range of patients than it has traditionally.[10 11] This range of patients will require a more varied clinical skillset from military PHEC practitioners than has been the case in recent operations. This MACA has shown that the DMS is able to undertake this extended range of clinical care.

The clinical LIs during this MACA are also of relevance to future operations. We face the prospect of operating in a world where COVID-19, or another equally concerning disease that comes to light in the future, continues to be a potential cause of illness to patients and a hazard to clinical staff.

The AE encountered by the CCTT follows the pattern of AE described in the existing literature. Parmentier-Decruq *et al* examined 262 mechanically ventilated patients undergoing IHT. Equipment-related incidents accounted for the largest subgroup of AEs with incidents involving airway equipment accounting for 17.2%.[7] Similarly, Venkategowda *et al* reported on 254 patients undergoing transfer and found that 64% of adverse incidents were related to equipment failure.[12] In Grier *et al*'s recent work, equipment-related issues were again the predominant problem with battery failure a particular issue.[13 14]

Historically, secondary transfer has been a task undertaken by anaesthetists. However, in the last decade PHEM has emerged as a subspecialty. This has resulted in a cadre of clinicians specifically trained to manage critically ill and injured patients in the prehospital environment. Secondary transfer is an important part of PHEM training. Theme 5 of the Intercollegiate Board for Training in Pre-hospital Emergency Medicine curriculum is about "Supporting Safe Patient Transfer" and the underpinning knowledge, technical and non-technical skills required to safely undertake secondary transfer are tested as part of the Fellowship in immediate medical care examination, the exit exam from PHEM training.[15 16]

Our small study suggests that military teams, led by PHEM doctors, are able to undertake safe, secondary transfer of critically unwell, complex, ventilated patients. Our data indicate that this is the case irrespective of the base specialty of that doctor. In the context of likely extended transfer timelines in future conflicts, this study should reassure military medical planners that level 7 and 8 PHEM doctors are able to be used to undertake complex patient moves over long distances.

CONCLUSION

The tasking described in this paper was unlike any previously required of the DMS. The successful completion of this unprecedented mission has demonstrated the ability of the organisation to adapt. This should give commanders the confidence to use the DMS in new ways in order to deliver novel effects. Useful clinical lessons pertaining to the transfer of ventilated patients with a transmissible respiratory disease were learnt and should be absorbed into the corporate knowledge of the DMS. The ability of PHEM doctors to safely undertake secondary transfer of ventilated patients gives defence greater flexibility in designing future operational patient care pathways.

Correction notice This article has been corrected since it appeared Online First. Main title has been changed from '20 April' to 'April 2020' for clarity.

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