Human factors in contingency operations

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ABSTRACT
The UK Defence Medical Services are currently supporting contingency operations following a period of intensive activity in relatively mature trauma systems in Iraq and Afghanistan. Among the key lessons identified, human factors or non-technical skills played an important role in the improvement of patient care. This article describes the importance of human factors on Role 2 Afloat, one of the Royal Navy’s maritime contingency capabilities, and illustrates how they are vital to ensuring that correct decisions are made for patient care. This article focuses on the importance of human factors on a Role 2 Afloat (R2A) platform, as the authors have considerable recent experience in this environment, but the concepts are readily transferable to other small teams deployed either on military contingency operations or on civilian disaster relief settings.

ROLE 2 AFLOAT
The modern configuration of R2A has already been described19 and the composition of the team is noted in Box 1. The anaesthetic20 and surgical21 aspects of the R2A have also been described in detail but essentially the available personnel allow damage control resuscitation22 to be conducted within the confines of their scaled equipment and drugs (referred to as ‘the 370 module’ which is adapted for the maritime environment). It includes sufficient team members to enable consultant-delivered care to be achieved for two seriously injured casualties arriving at the same time with one surgical operating table and two critical care beds; this is denoted by the configuration 2-1-2 (two emergency department bays, one operating table, two critical care beds). It is key that the deployed team support the emergency
medicine consultant who is the nominated team leader with impeccable followship defined as ‘the ability to effectively follow the directives and support the efforts of a leader to maximize a structured organization’.24

WHAT ARE THE DIFFERENCES IN WORKING ON ROLE 2 AFLOAT? Clinical

The well-resourced complex trauma team described in Camp Bastion Trauma Hospital has been reduced in numbers and thus team members are required to undertake less familiar roles (eg, general and orthopaedic surgeons are required to perform a primary survey) and have reduced rest periods when it is busy. There is also the risk of clinicians becoming isolated if they are the only person in their particular field of expertise. Personnel may not have deployed in this environment before and may need to prepare for short notice deployments, perhaps without a predetermined end date and with individuals they have not worked with before.

In a resource-limited environment (equipment, blood products, personnel, space), there will be capacity, resilience and ethical implications attached to clinical decisions that were previously not encountered. Early decision making on where and how the patient will be evacuated is important to ensure that they receive their ongoing and enhanced treatment in a timely manner and that the R2A facility is ready to receive more casualties if required. All clinicians have difficult decisions to make as offensive operations may be compromised if the medical facility cannot receive casualties. The emergency physician has to decide if and when to activate massive transfusion protocols, how to manage more than two casualties and be capable of leading multiple trauma resuscitations in different locations within the medical complex. The anaesthetists need to decide whether a rapid sequence induction (RSI) of anaesthesia is required as, if undertaken, that casualty will be a much greater burden upon limited resources and will reduce the number of personnel available for other activities. The surgeons need to decide if an operation is required and when it is required: with limited surgical sets, there must be an emphasis on life, limb and sight-threatening injuries only. In the event of multiple casualties requiring surgery, then a decision will need to be made as to which patient to operate on first. This may mandate the use of the T4 (expectant) triage category in the UK or friendly forces, which will be both a novel and an emotionally challenging process.

Equipment

The equipment on R2A is made up of those items present in the 370 Afloat module and thus there is no CT scanner or near-point testing of coagulation (eg, RoTEM). This may require a change in clinical practice, as investigations from both of these were previously integral to the DCR-DCS sequencing.5 Appreciation of the limited available resources is important: there is a limited stock of blood products with an uncertain resupply chain and surgical sets are also limited, although sterilisable. The resource constraint will require careful communication within the team facilitated by the clinical director to ensure that ‘everyone is on the same page’ and has equal situational awareness in terms of clinical delivery and that those choices that are made represent the best use of available resources.

Patient pathway

Key human factors are present at almost every stage of the patient pathway24 and those pertinent to R2A are depicted in Figure 1. Working in a maritime platform adds its own integral problems such as a moving ship, limited space, noise and also the ship’s own power supply, which need to be taken into account when high voltage equipment such as the Dragon (Xography, UK) X-ray machine. DMS personnel must also be well versed in emergency actions onboard such as fire fighting and damage control.

Usually, notification of a casualty will be via a signal to the ship and a decision will be made as to how the casualty will be brought onboard. This will typically be via a helicopter to the flight deck but could also be via a boat transfer or even from within the ship in the case of an onboard incident. The whole R2A team will be activated at this point and be briefed by the team leader. Communication with the biomedical scientist will occur at this point regarding the potential issue of a ‘shock pack’: locally, this will be two units of universal donor packed red cells and two units of universal donor fresh frozen plasma (FFP) but a further issue can be made including cryoprecipitate, if carried and required.

Following sanitisation of the patient (removal of weapons by an onboard reception team), the R2A team must carefully transfer the patient to the hospital facility. In the emergency department, immediate checks for signs of life, catastrophic haemorrhage and airway compromise are quickly completed before the patient is handed over by the prehospital team. Once complete, the primary survey are undertaken by the team in their designated roles in a ABC format (catastrophic haemorrhage, airway, breathing, circulation)25 coordinated by the team leader who is responsible for maintaining and updating the team’s situational awareness (‘the perception of the elements in the

Figure 1 Human factors involved in the patient pathway on a R2A unit. Casualty movements are shown in red and lines of communication in black. AT-MIST, Age, Time of Injury, Mechanism of Injury, Injuries Sustained, Signs and Symptoms and Treatment Given.
environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future©). In situations where more than one casualty requires surgery, emergency department personnel must be prepared to have a role in optimising their condition with support from the intensive care team as required. The resuscitation bay and trauma team working is outlined in Figure 2.

In order to optimise communication in complex trauma, the ‘Trauma WHO’© (Table 1) was developed. Once the primary and secondary surveys are complete and initial investigations are taken, the ‘Command Huddle’ will take place. Because of the limited space in the trauma bay, all personnel will be able to hear this important conversation where effectively the lead clinicians plan the casualties’ ongoing treatment. This might entail a primary transfer to intensive care to await further transfer or if a surgical procedure is required, then the patient will need to be transferred into the operating theatre and positioned on the operating table. Prior to any further activity, the second part of the Trauma WHO is undertaken where the patient’s identity is confirmed, the mechanism of injury, injuries sustained and relevant investigations repeated and then the surgical and anaesthetic plans stated. It is helpful to write down the surgical plan on the white board in theatre and the triggers to move from plan A to plan B and plan C if this is appropriate. Once surgery is underway, then regular ‘SIT-REPS’ are required. When this was tested in a clinical operational environment,14 it was felt that these should only be undertaken when there was new information to share with the group and might be at a frequency of every 10–30 min. Recently, the mnemonic for the sit-rep has been changed to STACK (Lt Col Harry Pugh, Personnel communication) (Table 2), as this is relatively easy to remember. Following handover to critical care, a debrief of the team will occur.

Once the patient has left the emergency department, the emergency physician must liaise with the ship or Battlestaff in order to ensure appropriate signal traffic has taken place and that an appropriate Role 3 facility has been identified. Timelines for evacuation must be decided early and an appropriate evacuation asset identified. The evacuation team can then be identified, so they may begin their preparations.

To illustrate the importance of human factors on a deployed R2A unit, two fictional case scenarios are described (Tables 3 and 4).

**DISCUSSION OF CASE 1**

On a deployed R2A platform, equipment is limited: only essential modalities are carried. With this scenario, there is a spectrum of clinical signs and symptoms which largely depend on the exact intra-abdominal injury, the evacuation timeline, critical decision-making timelines and the casualty’s physiological response to the injury.

There is no thromboelastography available to determine the exact nature of any potential coagulopathy and no platelets are carried. Therefore, the clinicians are limited to 1:1 resuscitation (packed red blood cells (PRBC):FFP) with supplementation by cryoprecipitate and recombinant factor VIIa. This is an important factor to consider when dealing with such casualties in a deployed environment as blood products will be limited and the resupply chain may not be immediate. Provision may have been made for an emergency donor panel on the ship and this should be activated as soon as possible.

Once it has been identified that the casualty requires an operation, it is imperative that no delays in care are made. The priority in damage control resuscitation is to use damage control surgery as a haemorrhage-arresting manoeuvre while restoring circulating volume. Constant communication between the anaesthetist and the surgeon is of paramount importance to determine whether:

A. Surgical control of haemorrhage has been achieved, allowing the anaesthetist to volume resuscitate with blood products.

B. Surgical control has been achieved, but the patient is not responding to physiological measures, that is, non-surgical bleeding.

C. Surgical control cannot be achieved and the patient’s physiological parameters are deteriorating, with increasing demand of blood products.

Adherence to the Trauma WHO© is vital and regular ‘sit-reps’ will ensure that all members of the team are aware of the stage of DCR-DCS.

While surgery is underway, the emergency medicine consultant will liaise with the command of the ship as to how the

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**Table 1** The Trauma WHO

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<td>SIT-REPS</td>
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**Table 2** Sit-rep mnemonic

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<td>K</td>
<td>Kit (including blood products used)</td>
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casualty is best evacuated. This is important for two reasons: the patient will require further treatment in a Role 3 facility and, with a 2-1-2 configuration, casualty throughput is hindered if evacuation is delayed. It is important to decide who will escort the patient as he will undoubtedly remain intubated and ventilated for transfer. A physician-led transfer will reduce the medical staff of the facility by 20% and will therefore have a significant impact on capability.

**DISCUSSION OF CASE 2**

This case illustrates a number of issues when managing patients at Role 2 and also in the maritime environment. Potentially, if there was immediate onward evacuation to a Role 3 facility available with a reasonable transfer time, then this patient may not have required any emergent treatment at R2A and would benefit from direct transfer to Role 3 for definitive treatment. In this situation, there is no immediate transfer available, so treatment is required at R2A. At Role 2, ‘less is often more’ and it is important that the limited resources are not taken up with prolonged surgical procedures which are not required at this echelon of care. In the Command Huddle, the decision is made to take the patient to theatre. The patient initially is clinically stable although during the SNAP Brief it is recognised that there is potential for the patient to deteriorate, in particular the potential for the development of compartment syndrome is recognised. The surgical plan is to use Plaster of Paris to splint the fracture although the team has been warned that external fixation may be required.

It is important that there is constant communication about evacuation plans throughout as the need for a prolonged hold of the patient may influence the surgeons’ decisions in theatre.

The patient is extubated postoperatively as there is no reason to keep the patient intubated for transfer. This also means that there is no need for a physician to accompany the patient during transfer meaning that medical manpower will not be compromised.

**SUMMARY**

The R2A environment provides a unique maritime platform to allow consultant-delivered damage control resuscitation and surgery to be performed followed by transfer to a higher echelon of care. We have described how attention to human factors is vital to ensure that both the correct decision is made for patient care in a timely manner and that the facility remains operational. Such considerations are transferable to any of the small teams in DMS.

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**Table 3** A gunshot wound (GSW) to the abdomen in a UK serviceman

| Background | The R2A is accommodated in RFA MOUNTS BAY in support of an amphibious operation. It is supported by an allied nation Role 3 Hospital that can be reached by a 1-hour flight. It currently has 11 damage control surgery surgical sets, 20 units of packed red blood cells (PRBC), 20 units of fresh frozen plasma and 10 units of cryoprecipitate. Six general damage control sets available which can address damage control laparotomy, thoracotomy, vascular shunt or named vessel repair, stabilise pelvis and fasciotomise a limb with additional supplementary three damage control surgery debridement sets and two damage control surgery neurosurgical sets. |
| Preparation | Radio communication to RFA MOUNTS BAY Ops Room that a UK serviceman has sustained a GSW to the abdomen. The R2A team is activated and assembles in the hospital facility. The team is briefed by the team leader (emergency medicine consultant). In view of the likelihood that damage control resuscitation will be required, an initial ‘shock pack’ is ordered (two PRBC and two FFP). The Belmont Rapid Infuser and other equipment are prepared. |
| Handover of patient | A—25 years T—1700 M—GSW I—wound in right iliac fossa; another wound in right upper back S—HR 110 bpm, BP 90/60 mm Hg T—one large bore cannula into right antecubital fossa, 500 mL crystalloid given, morphine 10 mg intravenously |
| Initial findings and initial actions | Primary survey findings: Airway patient; good bilateral air entry but decreased excursion on the right; generalised abdominal tenderness and peritonism; GCS 15; temperature 35.1°C. CXR—no pneumothorax seen on supine film. Pelvis X-ray—normal. Venous blood gas results—Hb 9.0 g/dL, pH 7.20, lactate 4.5. Administration of cefazolin 1.2 g, tranexamic acid 1 g, ketamine 20 mg. |
| Command Huddle | Decision is made to undertake a trauma laparotomy. Further four PRBC, four FFP and two cryoprecipitate requested. |
| Transfer to theatre SNAP Brief | Patient identification and injuries verified. No identified projectile on X-ray, so tract will likely follow the trajectory between two wounds. Likely colonic injury with possibility of renal, hepatic and diaphragmatic injury. May require large volume resuscitation if extensive solid organ injury. Will require chest drain on right side. Plan A: If colonic injury, irrespective of contamination, given blood loss and acidemia, the bowel will be left in discontinuity with an open abdomen until physiology corrected. Plan B: As per plan A but with limited solid organ injury, requiring <4 units PRBC/FFP, then haemostasis to be achieved and packing performed until physiology corrected. Plan C: If extensive solid organ injury and likelihood of high volumes of PRBC, then revisit at 5 units PRBC transfusion, if ongoing bleeding not amenable to surgical correction, then Command Huddle to discuss likelihood of survival. |
| Ongoing theatre progress | Intubation—fentanyl 70 μg, ketamine 70 mg, rocuronium 70 mg. Surgical findings GSW through ascending colon with gross faecal contamination and a grade 2 renal laceration on superior pole of right kidney. Right hemicolectomy performed and left in discontinuity. Right kidney explored, no intervention required. Open abdomen with ‘Opsite sandwich’. Right-sided chest drain inserted—small amount of blood and air released. Diaphragmatic wound repaired. Emergency medicine consultant liaises regarding evacuation of patient from R2A. |
| Transfer to critical care Packaging for transfer |

**FFP, fresh frozen plasma; RFA, Royal Fleet Auxiliary.**
required to undertake contingency operations. Consideration should be made by medical planners on the individuals present in the team as disruptive personalities could destroy team dynamics.\textsuperscript{15} Teamwork and communication are particularly important to ensure that limited resources such as blood products and other consumables are not wasted and that patients are evacuated to allow the facility the opportunity to accept further casualties. As the team leader, the emergency medicine consultant is responsible for maintaining situational awareness and feeding back information to the whole team in the emergency department. This process is continued in theatre by adoption of the Trauma WHO.\textsuperscript{22}

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**Table 4  Compound fracture to left leg following a fall from a height**

| Background | The R2A is accommodated in RFA MOUTS BAY in support of an amphibious operation. It is supported by an allied nation Role 3 Hospital 1 hour’s flying time away. It currently has six damage control surgery surgical sets, 12 units of packed red blood cells, 12 units of fresh frozen plasma and 6 units of cryoprecipitate. |
| Preparation | Radio communication to RFA MOUTS BAY Ops Room that a UK serviceman has fallen from a height and sustained an open fracture to the left leg. This was bleeding and a combat-application-tourniquet (CAT) has been applied. The R2A team is activated and assembles in the hospital facility. The team is briefed by the team leader (emergency medicine consultant). |
| Handover of patient | A—25 years T—1700 M—fall from 6 feet I—deformity of left lower leg with anterolateral wound S—HR 100 bpm BP 110/80 mm Hg T—CAT applied at 1630 with Sam-Splint |
| Initial findings and initial actions | Primary survey findings CAT released: no neurovascular compromise and no ongoing haemorrhage; therefore, pneumatic tourniquet is applied, but not inflated. Open fracture—wound communicates with fracture site, no gross contamination, no clinical signs of compartment syndrome. CKR—normal. Pelvis X-ray—normal. X-ray left leg—displaced, simple fracture midshaft left tibia and fibula. Venous blood gas results—Hb 11.0 g/dL, pH 7.35, lactate 2.0. Administration of co-amoxiclav 1.2 g, tranexamic acid 1 g, ketamine 20 mg. |
| Command Huddle | Decision is made to undertake an emergency debridement and splintage of open fracture left tibia/fibula. No current need for blood products but patient grouped and saved. |
| Transfer to theatre | SNAP Brief Patient identification and injuries verified. Isolated open fracture left lower leg. No requirement for large volume resuscitation. Plan A: Debridement and washout of open wound with splinting of fracture in above knee Plaster of Paris (POP). Plan B: As per plan A but if fracture very unstable and large soft tissue injury, consider fixation of fracture with external fixator. Plan C: As per plan A but if develops any signs of compartment syndrome, then will require lower leg fasciotomy and fixation of fracture with external fixator. |
| Ongoing theatre progress | Intubation—fentanyl 70 μg, ketamine 70 mg, rocuronium 70 mg. Surgical findings Clean wound with direct communication to fracture site. Limited debridement necessary with healthy muscle and no signs of compartment syndrome. Fracture stable once reduced. Wound dressed with dry gauze and splinted with above knee POP. Foot pulses present at end of procedure. Femoral and sciatic nerve blocks applied and patient extubated at end of procedure. Emergency medicine consultant liaises regarding evacuation of patient from R2A. |
| Transfer to critical care | Packaging for transfer |

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**REFERENCES**


