

# Maritime Anaesthesia

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## Introduction

Anaesthesia (other than local infiltration) at sea, in the 21<sup>st</sup> century, is a relatively unusual occurrence. It can only be provided in ships carrying a Role 2 (damage control resuscitation) or Role 3 (hospital) medical capability. RFA ARGUS is the Royal Navy's sole maritime Role 3 facility (Figure 1). She carries a bespoke hospital facility, of up to 100 beds, with a wide range of specialist capabilities and has the ability to hold patients at all levels of dependency, until further evacuation can be effected.



*Figure 1 Main theatre complex on board RFA Argus*

The maritime Role 2 capability is not linked to any specific platform. In the early 1990s, the aircraft carriers had a permanent complement of two medical officers as a Principal Medical Officer (PMO) and Deputy PMO. One of these two medical officers was an anaesthetist and the other a surgeon and whilst one was usually an accredited consultant, the other was frequently a trainee. They provided an organic Role 2 capability for any task group with whom they deployed (Figure 2). However, the limited numbers of theatre operations performed meant that core specialist medical skills were difficult to maintain. Following the Calman review and subsequent changes in training, and with the emergence of clinical governance, it was deemed inappropriate to have Secondary Care trainees working unsupervised. The surgical team was therefore removed from the permanent ship's complement and replaced by an accredited General Practitioner.

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*Figure 2 Administration of a general anaesthetic on board HMS Ark Royal in 2007*

When the ship deployed to an area of perceived risk (e.g. East of Suez), the medical department was augmented by a Role 2 surgical team, consisting of a surgeon and anaesthetist (both consultants at OF4) and an Operating Department Practitioner. However, after several deployments in this configuration, it became apparent that resources for damage control surgery were still inadequate.

From the early 2000's, Fleet has scrutinised deployments requiring Role 2 support to ascertain which vessel is most suited to host this facility. Maritime Role 2 can therefore be expected to configure differently, due to differing platforms and medical schemes of complement, on each occasion it is utilised. At the same time, advances in Role 2 care have developed based on the experience gained in both Iraq and Afghanistan. This has also necessitated changes in the composition of the maritime Role 2 team deployed. The current configuration encompasses casualty retrieval, emergency medicine, surgery and anaesthesia, critical care and onward transfer. The anaesthetist has the potential to play a part throughout this care pathway.

In both the Role 3 platform and whichever vessel is selected for Role 2, certain constraints, unique to the maritime environment, influence the delivery of anaesthetic (and indeed all clinical) care. All ships are fighting platforms and although clinical care would be expected to continue during contact, no surgery and anaesthesia would be envisaged. The priority under these circumstances is the engagement and the survival of the ship. All embarked personnel, irrespective of speciality, are therefore required to support this aim and can be required to fight fires or undertake damage control as well as provide first aid medical care. These skills, plus sea survival in the event of ship loss, are a mandatory part of maritime pre-deployment training.

## Pre-Operative

The anaesthetist is likely to be involved with any serious casualty, often at, or close to, the point of wounding or accident. The Royal Navy has now formed and tested a Maritime Medical Emergency Response Team which variably includes an Emergency Nurse (Practitioner), a Medical Assistant and an anaesthetist (Figure 3). The process of reaching the casualty and then extracting him to the medical facility can often be time-consuming and convoluted. This process may involve a helicopter or sea boat.



**Figure 3** Preparation for deployment as MERT from RFA Fort Victoria

Utilising a helicopter for a patient transfer creates many difficulties. Of course, the issues with helicopters and casualties are applicable to any environment such as the limited space, vibration, poor lighting and noise. All of this would be complicated in a contact situation where the helicopter may have to perform evasive manoeuvres. A specific problem in the maritime environment is lifting the casualty from the deck of a vessel into the helicopter. The sea state could be such that it is taxing for the pilot to maintain a hover over the deck and the winch is only designed for the winchman, the casualty and the lightweight stretcher. It takes careful planning to manage an intubated casualty needing ventilation during winching. One potential solution is to have one medic in the helicopter ready to receive and take over ventilation and one medic with the lightweight stretcher on the deck. Once all parties are ready, ventilation is stopped and there is a period of apnoea whilst the winching occurs.

Ships' sea boats create their own difficulties when used for casualty transfer. Firstly, the sea state can result in extreme movements of the boat when either stationary or under way. Attempting to treat or even handle a casualty in this situation is difficult. Many of the sea boats used are Rigid Inflatable Boats and have very limited space, especially if the patient is on a spinal board. Once the boat is back alongside the ship, it has to be winched up to deck level (providing the hoist is man-rated for lifting) with further casualty handling required to bring the casualty inboard.

The transfer of casualties through the ship to the medical facility requires teams of personnel and frequent practice. Army field pattern stretchers are not conducive to being carried up and down ladders and through narrow hatches. Certain platforms allow the use of lifts (e.g. aircraft lifts or bomb lifts) to facilitate movement between decks. The alternative is to use either a spinal board, a Neil-Robertson stretcher or a hose lift technique to hoist the casualty between decks.

## Per-Operative

The layout of the hospital is very variable depending on the platform. On the warships it is fixed, whereas the RFA platforms have a greater amount of space which can be utilised as a hospital. Modern anaesthesia providing damage control resuscitation requires laboratory support and preferably radiography, which in turn need further dedicated space for equipment.

An operating theatre, triage bay and critical care bed all require significant amounts of equipment to carry out their respective functions. Most ships have their core power supply running on 115V although further circuits of 230V have been overlaid for standard UK 3 pin plugs. There may be insufficient 230V plug sockets in the hospital area and even if extra sockets are added, the system may not be rated to support the power required.

The ship is a closed environment holding everything from fuel to armament in relative close proximity. Therefore, explosive gases such as oxygen and nitrous oxide, need to be carefully stored in a secure area that can be flooded to prevent explosions in the event of a ship fire.

Overall, medical stores become an issue due to the limited storage space on board and the potential difficulty of resupply at sea. All stores whether in a hold or in the hospital need to be fully secured for sea when not in direct use, due to motion from sea states. It is very easy for an anaesthetic machine on wheels, stacked with kit and a monitor on top to roll and have equipment fall off and break (Figure 4).



**Figure 4** The anaesthetic machine set up on board RFA Fort Victoria

Anaesthesia at sea is similar to that on land in a Role 3 facility. It is based on an anaesthetic machine (currently the Smiths Lamtec 330) which has pipeline input for oxygen, air and nitrous oxide and cylinder input for oxygen and nitrous oxide only. There is one vaporiser mount taking either isoflurane or sevoflurane. A circle system is used with ventilator support from the field Compac 220. Monitors are the Datex S5 with full invasive capability. There is equipment to perform regional or neuraxial blocks, intravenous warming, rapid infusion and patient warming.

The space of the operating theatres is minimal and usually the size of a standard anaesthetic room in UK hospitals. This makes teamwork and communication absolutely essential between all members of the theatre team, as sterility and free movement become problematic (Figure 5).



**Figure 5** The narrow operating theatre on board RFA Fort Victoria

Room ventilation in theatre is often on a shared, partially closed circuit with other compartments of the ship. It is unlikely to meet the standards of a modern orthopaedic theatre. Scavenging of vapours can be done using a Cardiff Aldasorber, although with the current scale of equipment it is impossible to scavenge and utilise PEEP at the same time. If nitrous oxide is used, the quantities which could build-up in theatre are unknown. Total intravenous anaesthesia could be used but the pumps on scale do not have target-controlled infusion capability.

Re-sterilisation of anaesthetic and surgical instruments is an essential component of afloat anaesthesia and surgery. The steriliser used on board all ships is the Portoclave Field Steriliser which has now become obsolete. Future sterilisation should be delivered on board as a separate module covering all equipment needed for decontamination, disinfection and sterilisation.

### Post-Operative

Post-operative care is delivered within the same constraints as pre- and peri-operative care. Low dependency patients are likely to be nursed in the bottom bunks of standard mess deck accommodation, appropriated as a ward area. Such bunks are fixed and accessible from only one side. They have limited (or no 230V) power sockets and securing ancillary equipment (monitors, infusion pumps, oxygen cylinders or concentrators and even drips) is challenging. As standard sea-going berths they do provide lee-cloths and straps to secure the occupant in the event of heavy weather. Access to toilet, sluice and washing facilities may also be less than optimal, raising issues of infection control.

Higher dependency patients will require nursing in the critical care area. A limited number of standard hospital beds, with 360° access, are available as part of the Role 2 Afloat. These beds have to be secured to the deck and ideally secondary securing points should be available in the event that the bed has to be moved or re-angled (for example to facilitate access for re-intubation) (Figure 6). The scope and quality of the critical care capability in Role 2 Afloat is limited by the nature of the equipment and stores held and the fragility of the resupply chain.



**Figure 6** Critical care beds in RFA Fort Victoria

The medical mission for any military operation is to contribute to the physical and moral wellbeing of the force deployed, in part through the timely treatment and evacuation of the sick and injured. Currently accepted clinical timelines for treatment are as follows [1]:

- 1 hour from point of wounding to advanced resuscitation
- 2 hours to damage control surgery
- 4 hours to primary surgery

Role 2 is configured to meet the requirement for damage control surgery. Primary surgery requires onward transfer to a Role 3 facility at sea (RFA ARGUS) or ashore (foreign hospital) or to a Role 4 facility in the UK. These doctrinal timelines for casualty treatment may not be met at sea. An incident may occur remotely from the ship and the subsequent transit will delay receipt of Role 2 care. Once on board, there may be an extended timeline to reach the nearest Role 3 facility.

There are many locations where the local hospital will not be able to provide the level of care that can be delivered by the Role 2 Afloat team. Under these circumstances it may be in the patient's best interest to be held for longer at the Role 2 facility, whilst direct liaison takes place with the Critical Care Aeromedical Support Team (CCAST) to arrange transfer directly to UK Role 4. However, the holding capacity and endurance of the Role 2 Afloat is limited by the number of medical and nursing personnel embarked, the number of beds, the space available and the quantity of stores held.

Where an appropriate Role 3 facility has been identified, the successful transfer of a patient can still be delayed due to the sea state, an unserviceable helicopter or the distance of the ship from the facility.

## Patient Transfer

Medical evacuation (medevac) is the process of moving patients between medical facilities. For maritime operations this transfer may be conducted by boat or helicopter. In the latter case it is more properly known as aeromedical evacuation (AE). Transfer to Role 3 or Role 4 facilities will usually be by AE. The Royal Air Force (RAF) is the UK lead service for AE. As a consequence, the Royal Navy has no bespoke maritime AE capability. However, since it is frequently inappropriate to fly the RAF transfer team out to maritime platforms on operations, it is accepted that the Role 2 Afloat will generate its own transfer capability, including transfer ashore of critically ill patients, from within its own organic assets (Figure 7).



*Figure 7 Casualty being prepared for transfer on board RFA Fort Victoria*

Although no RN personnel are currently trained to undertake CCAST, RN anaesthetists, intensivists and intensive care nurses are all experienced in patient transfer. In the absence of a bespoke critical care transfer module, equipment for patient transfer has to be drawn from that available to the Role 2 Afloat which is unlikely to have been tested for aeromedical use in the airframe available. In removing equipment for transfer, the Role 2 capability is potentially reduced. The equipment available is not the most suitable for use in transfer, particularly with regard to portability (weight) and battery life (endurance). It is also unlikely to be directly compatible with that brought out by the CCAST team.

## Conclusion

Anaesthesia in a maritime environment differs in many ways from that on land. The concept of operations has to remain totally flexible. Personnel and equipment may well change with the differing platforms used, the operational area and the task group mission. At maritime Role 2, the anaesthetist will be involved in all aspects of patient care from retrieval and triage, through theatres and critical care to transfer to a Role 3 facility. Specialist knowledge of underwater medicine may also be required and the anaesthetist has to be in date for fire fighting, damage control and sea survival. This makes the job of an anaesthetist at sea a challenging and rewarding one.

## Reference

1. JDP 4-30 2nd Ed Medical Support to Joint Operations