The Portable Glostavent (DPA 01)
Access to Safe Anaesthesia in Remote Areas

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Abstract

Access to medical care, particularly surgical intervention, in remote areas of the world and conflict or disaster situations is often unavailable. One of the reasons for this is the lack of available equipment to provide safe and affordable anaesthesia. This paper provides an explanation of a suitable and cost effective solution.

1 Introduction

In more developed countries the access to appropriate medical treatment is usually an issue of the capacity of the system, with the priority given to emergencies. In less developed countries a number of additional factors have as great an impact, if not more so.

Cost is an obvious factor with some countries able only to provide a few dollars per head of population per annum to the health budget, supplemented by international aid and donation. As a consequence of this financial shortfall facilities are often centralised around major cities.

Transport in many of the developing countries is problematical, with little movement at all at night and journeys being long, difficult and often costly and frequently only undertaken as a last resort. As a result patients with relatively routine or minor ailments may present in a poor condition with additional complicating factors. For example, in the United Kingdom we would expect a fracture to be dealt within a day or two yet in some countries that fracture may be a month old prior to treatment. Further examples include congenital conditions such as cleft lip and pallet or burns, both of which are commonly seen in many developing countries.

As a result there is a strong case for providing low cost simple solutions that can be deployed at a rural level. Providing those solutions are also portable they are ideal for disaster situations, outreach and visiting medical personnel to carry with them to avoid the issue often experienced in that there may not be sufficient facilities on arrival to carry out the planned work.
One such area that would benefit from the approach outlined above is that of anaesthesia. While regional anaesthesia may be one answer, the ability to provide a safe inhalational anaesthetic in remote locations could offer significant improvements and avoid patient's suffering during extended travel and waiting time. This would also reduce the often serious pressures placed on referral hospitals and reduce the numbers of advanced pathologies that present in deteriorating physical condition.

Observation of this situation by the authors and many others working in remote locations was the driving force behind the development of the DPA 01, a complete anaesthesia system in a case suitable to hand carry on a commercial aircraft or deploy in rural locations.

The principle development criteria were that the equipment should be capable of:

Functioning in the absence of compressed gases
Functioning without electrical services
Requiring minimal consumables
Accepting any supplementary oxygen source at any pressure
Providing assisted ventilation for both adults and children
Accepting a range of inhalational agents
Providing a suitable concentration for gas induction
Suitable for local maintenance
Safe operation without complex monitoring

2 The Diamedica DPA 01

The DPA 01 consists of a draw-over breathing circuit, a Diamedica vaporiser, reservoir bag and self-inflating bag. It weighs under 10kg and fits into a polymer container the size of a small suitcase, (42cm x 50cm x 20cm.). The hermetically sealed container is manufactured to a military standard, (Defstan 81/41) and is shock proof, waterproof, dust proof and corrosion proof.

Figure 1: The DPA 01 assembled for use

The DPA 01 case incorporates all the components required to deliver a safe inhalational anaesthetic and includes many of the recent improvements introduced in the Glostavent®. The unit will function equally well as a draw-over system of if an oxygen source is available the unit will operate efficiently as a continuous flow machine allowing gaseous induction of anaesthesia.

The components of the DPA 01 are as follows;

Reservoir

The standard reservoir for draw over anaesthesia is an open ended tube with an oxygen inlet to allow oxygen enriched air to be drawn into the system. In the tri-service apparatus a length of corrugated tubing is used for the reservoir. In the DPA 01 the open ended tube is replaced by a dedicated reservoir unit that increases the effectiveness of the reservoir. The reservoir unit provides for 100% oxygen usage with zero wastage to atmosphere and includes a 2-litre oxygen reservoir bag (Fig.2), a pressure relief valve, set at 5cm H_2O to prevent over distension of the reservoir bag; a non return air inlet valve and a oxygen supplementation tube for connection to an oxygen concentrator or cylinder regulator and flowmeter (also provided).

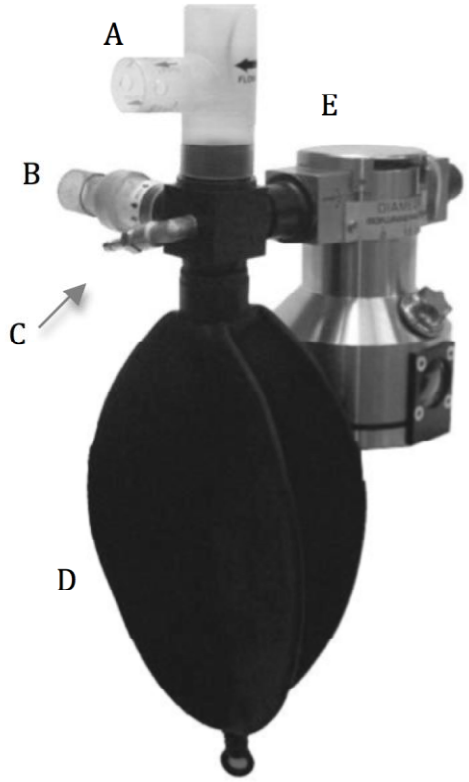

Figure 2 - The vaporiser and reservoir system

A. pressure relief valve (5cmH_2O);
B. non return valve at the air inlet port;
C. connecting piece for the oxygen supply;
D. 2-litre oxygen reservoir bag;
E. entry port of the vaporiser.

This modification enables the DPA 01 to be used in either continuous flow or draw-over mode without the need for a change of breathing circuit. The mode in use at any given time is determined by the ratio of oxygen flow entering the reservoir and the patient's minute volume leaving the reservoir. The change of mode occurs automatically and requires no intervention by the anaesthetist. Traditional oxygen concentrators generally have outputs from 4 litres.min^{-1} to 8 litres.min^{-1}. If the oxygen inflow exceeds the patient's minute volume, the reservoir bag becomes distended, the pressure rises and the flow to the patient becomes continuous. If the oxygen flow-rate is less than the patient's minute volume, or no oxygen is available, room air enters through the non-return valve and the system operates in draw over mode.

These modifications to the reservoir unit confer further advantages. Firstly, they increase efficient utilization of pressurised oxygen supplies. This is achieved by ensuring that the reservoir bag does not become over distended by excessive flow of oxygen causing escape through the pressure relief valve. Instead, the oxygen flow rate can be titrated to match the rate of utilisation so that over distension does not occur. Secondly, the inspired oxygen concentration is maximised during periods of hyperventilation, for instance during pre-oxygenation.

Diamedica vaporiser

The Diamedica vaporiser is a low resistance vaporiser, it has a 150ml reservoir, and consistency of output and is accurate over a wide range of temperature.

The vaporiser was designed to be used with either halothane and isoflurane, however following requests from a number of locations a version suitable for use with sevoflurane is also now available. The scale for the halothane / isoflurane version is calibrated up to 5%. The sevoflurane version has a scale from 0 – 4% with a setting for induction that provides 8%. The concentration on both versions are such that gaseous induction is readily achievable. The Diamedica vaporiser has a low centre of gravity for stability. (Fig.3).

Figure 3 - The Diamedica vaporiser

Self-inflating bag

A 2 litre self-inflating bag is provided in the standard circuit for controlled or assisted ventilation. It is attached to the inspiratory tubing and separated from the vaporiser by a one way valve. A smaller self-inflating bag is also supplied for use in paediatric patients.

Regulator / flow meter.

A regulator / flow meter with a pin index or bull nose connection is supplied for attachment to an oxygen cylinder. The oxygen flow rate can be set from 0.5 to 15 litres.min^{-1} enabling the breathing system to be rapidly flushed with oxygen in an emergency. A connecting tube is supplied to link the cylinder to the reservoir.

Non re-breathing valve

The function of the valve is to ensure that inspiration is sol from the anaesthetic machine and that expiration is solely to the atmosphere. It is placed as near to the patient as possible in order to minimise the dead space. A Laerdal valve is supplied with the DPA 01 although other makes of non-rebreathing valve, such as the Ambu valve, are also suitable. There is a new circuit available that removes the non re-breathing valve from the vicinity of the patient thereby reducing both bulk and dead space simultaneously.

A Mapleson F (Jackson Rees modification of the Ayres T-piece) is supplied with the DPA 01, which can be attached directly to the outflow port of the vaporiser in place of the draw over breathing system again with a one way valve after the vaporiser. In continuous flow mode this allows for gaseous induction in small children.

The container for the DPA 01 opens like a conventional suitcase. The components are accessible and can be rapidly assembled onto the base of the container. The vaporiser is first removed from its transport position and placed on the left hand side of the base on the rigid wire mesh stand provided. It is fixed into position by means of a screw into the back of the vaporiser. The reservoir unit, including its attachments, is inserted into the entry port of the vaporiser and is rotated so that the metal oxygen inlet port is directed backwards. A one-way valve is then inserted into the exit port of the vaporiser and the self-inflating bag is attached. The corrugated inspiratory tubing is inserted into the other side of the self-inflating bag and anchored to the base of the container to provide stability. The Laerdal valve is connected to the distal length of the inspiratory tubing and the circuit is then ready for use.

Conclusion

The apparatus that is the subject of this paper can be supplied through the many outreach programmes that currently exist. If the equipment is taken as hand luggage with a group working in a remote location it can be used and demonstrated to suitably identified local personnel. With a minimum of training to ensure competency it could be left in place for the benefit of those close to that area. The cost of such a method of deployment would be minimal as there would effectively be zero transport costs involved.

The portable Glostavent® (DPA 01) is especially useful in disaster or conflict situations where no hospital facilities exist and equipment must be carried by the staff. It has proved useful in a variety of situation and is currently deployed in 13 countries. It should be considered as suitable for all anaesthetists who provide anaesthesia in difficult situations.