

# Epstein-Macintosh-Oxford Inhaler (EMO anaesthetic apparatus)

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In a previous article in this section in 2014, I discussed the use of the Schimmelbusch mask in administering volatile anaesthetics, including ether.<sup>1</sup> Another piece of anaesthetic apparatus in relation to ether anaesthesia that can be found in the Hong Kong Museum of Medical Sciences is the Epstein-Macintosh-Oxford inhaler (also known as the EMO anaesthetic apparatus or simply as EMO) [Fig 1]. It was donated by Queen Mary Hospital to the Museum in 1998.

Ether was a popular anaesthetic agent both before and after the Second World War of 1939 to 1946. After ether was introduced to anaesthetic practice in 1846, various pieces of apparatus were designed for vaporising ether to be administered to patients. One reason that this agent was popular was its volatility, which allowed a wide range of clinical concentrations to be achieved easily.

Early devices for the administration of volatile anaesthetics, such as the Schimmelbusch mask, were challenging to use and required experience and skill of the anaesthetist. This was mainly due to the difficulty in controlling the concentration of the vapour being administered. In the case of ether, it was exacerbated by the cooling of the liquid ether on vaporisation, changing its volatility and hence the concentration delivered to the patient.



FIG 1. EMO anaesthetic apparatus

Professor Sir Robert R Macintosh (1897-1989) was born in New Zealand and fought in the First World War. He completed his medical studies and eventually became the founding professor of the Nuffield Department of Anaesthesia at Oxford University in the United Kingdom. Macintosh, together with Dr HG Epstein, designed a drawover anaesthetic vaporiser to deliver volatile anaesthesia, the Oxford Vaporiser (1941).<sup>2</sup> This was the first generation of a variable bypass drawover (low flow resistance) vaporiser for volatile anaesthetics with reasonable control over the delivered vapour concentration, using a crystalline jacket to utilise the heat of crystallisation to keep the anaesthetic warm during use. A redesigned miniature version of the Oxford Vaporiser was subsequently used by the military and others for field anaesthesia. It saw service during the Second World War.

Macintosh and Epstein recruited scientist Dr Kurt Mendelssohn and were assisted by Dr Richard Salt to refine the Oxford Vaporiser in 1952. The new apparatus (vaporiser) was first produced in 1953 by Pentland Scientific Co and named with its designers' initials (Epstein & Macintosh) and Oxford where it was designed.<sup>3</sup> The EMO was introduced in 1956<sup>4</sup> as a refined version of the Oxford Vaporiser, designed to address the problem of variability of the delivered concentration of ether that relates to the change in its temperature during use. It retained the drawover design of the Oxford Vaporiser but has a more sophisticated temperature-sensitive bellows mechanism which works as a "thermostat" to deliver a constant pre-set concentration of ether during clinical use despite ether temperature changes during use. This capability is enhanced by the provision of a water jacket around the anaesthetic reservoir as a heat sink to maintain the temperature of the ether. Hot or cold water (or even ice) could be added to this jacket to allow the apparatus to be used within its operational temperature range despite adverse ambient temperatures or prolonged use. These design features together with its relative portability make it a very convenient all-in-one anaesthetic apparatus that can be deployed not only in hospitals, but also for providing anaesthesia in unsophisticated environments and in environments where facilities are limited. The EMO can also be used as an

add-on to other compatible anaesthetic systems. It was extensively used all over the world since its production and introduction. However, it should be noted that the performance characteristic of the EMO is not suitable for use in paediatric anaesthesia where gas flows are lower than in the adult. Pentland was renamed Penlon in 1962. The specimen held by the Hong Kong Museum of Medical Sciences bears the trademark of Penlon and thus would have been produced after 1962.

The EMO is usually used together with the Oxford Bellows (Fig 2) to provide artificial ventilation during ether anaesthesia. It has a set of two one-way valves to ensure that the gas flow goes towards the patient when the bellows are operated during artificial ventilation and prevents rebreathing of expired gases. A magnet provided with the Bellows allows one of the valves to be disengaged to reduce flow resistance during spontaneous breathing anaesthesia. The bellows in artificial ventilation mode is operated by hand by the anaesthetist or an assistant. Thus, the EMO/Oxford Bellows combination (Fig 3) is not dependent on power supply and has full operational flexibility in either spontaneously breathing patients or artificially ventilated patients. This made it very popular, especially where available facilities were primitive and ether could be easily obtained. A one-way valve at the patient end of the breathing circuit, such as the Ruben Valve or Ambu Valve,<sup>5</sup> may be used without the Oxford Bellows to enhance effectiveness and efficiency in spontaneous breathing anaesthetic techniques. In more recent times, a self-reinflating resuscitator bag that can have the EMO connected at its fresh gas inlet can be used for anaesthesia with the EMO instead of the Oxford Bellows.<sup>6</sup>

The use of ether in hospital practice has declined since the 1960s because of the introduction of newer anaesthetic agents and anaesthetic techniques. Nevertheless, the EMO did not disappear in less developed countries until the 1970s or, in some countries, well into the 1980s. Often, the EMO was retained as a backup to modern anaesthetic facilities in case of power failure or disasters. Hong Kong public hospitals kept operational EMO units until they were decommissioned in the early 1980s. Professor



FIG 2. Oxford Bellows



FIG 3. EMO/Oxford Bellows combination

Macintosh, who was knighted in 1955, visited Hong Kong in the mid-1970s and gave a lecture at the invitation of the Society of Anaesthetists of Hong Kong. The writer still remembers giving his last ether anaesthetic with the EMO in 1982 at Princess Margaret Hospital, Hong Kong, before the apparatus was decommissioned.

## References

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