Health Services Safety Investigations Body

Interim bulletin 1

Oxygen issues during the COVID-19 pandemic

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Theme:
Medical devices,Coronavirus (COVID-19)

Contents

Notification of event and decision to investigate

COVID-19 can cause severe inflammation of the lungs affecting a patient's ability to breathe. As a result, an increased number of patients have required oxygen therapy within hospitals which has placed increased demand on medical gas pipeline systems (MGPS). Insufficient oxygen supply to seriously ill patients can have very severe consequences, including death.

HSIB identified a reference event where an acute hospital trust (the Trust) declared a major incident when demands on its MGPS led to patients being diverted to different hospitals, elective surgery being cancelled, and a need to reconfigure ward environments. The Trust had sufficient supplies of liquid oxygen but its MGPS was unable to deliver the volume of oxygen gas required to meet all patient needs.

The reference event highlighted a national safety risk where MGPS may be unable to meet the anticipated output due to factors related to the COVID-19 pandemic. Following a preliminary investigation, the Chief Investigator authorised a full investigation as the risk met the following criteria:

Outcome impact – What was, or is, the impact of the safety issue on people and services across the healthcare system?

An inability to provide appropriate volumes of oxygen to patients poses significant risks to patient health and wellbeing. Where an insufficient volume of oxygen is available it may be necessary for clinicians to manage decisions about how available oxygen supply should be used. This may require patients to be prioritised for care or for target oxygen saturation levels (the percentage of oxygen in the blood) to be lowered to maximise the available oxygen supply.

The need to manage oxygen supply can also lead to hospitals being unable to use their full capacity to care for patients. This creates additional challenges for the healthcare system as patients requiring care may need to be diverted or transported to other healthcare facilities to receive sufficient oxygen therapy. In addition, planned elective procedures may need to be cancelled to reduce demand on oxygen.

Systemic risk – How widespread and how common a safety issue is this across the healthcare system?

Oxygen is widely used in healthcare settings and is one of the commonest drugs used in the care of patients who present with medical emergencies. Incidents reported to the NHS strategic executive information system (StEIS) and national

news articles have drawn attention to challenges hospitals have faced in providing sufficient oxygen to patients due to the demand on MGPS. The hospitals reporting pressures on MGPS varied in size, age of hospital estate and geographical spread across England.

In each reported instance that HSIB is aware of sufficient liquid oxygen supplies have been available to trusts. However, there have been limitations in the ability for MGPS to meet the volume of oxygen gas required to treat all patients that may require oxygen therapy in the preferred clinical area of the trust.

Learning potential – What is the potential for an HSIB investigation to lead to positive changes and improvements to patient safety across the healthcare system?

Local action has been taken by a number of trusts that have encountered oxygen supply issues. In addition, estates and facilities safety notifications, in-depth guidance and support has been made available by NHS England and NHS Improvement (NHSEI, 2020 a,b,c,d) and the NHS Specialist Pharmacy Service (NHS SPS, 2021) to address and mitigate potential issues with MGPS. Despite these measures, issues with oxygen provided via MGPS continue to be reported.

A HSIB national investigation can consider the systemic safety issues relating to the provision of oxygen via MGPS and examine why existing measures aimed at addressing the risk to MGPS may not have been fully effective; this may also include safety recommendations if appropriate.

History of the event

Early on a Saturday morning, the Trust found that two patients being provided with oxygen therapy on the high dependency unit (HDU) had desaturated (lost the required levels of oxygen from their blood). It was unclear why these patients had desaturated and the Trust considered whether there had been a failure in the MGPS within HDU. As a precaution, the Trust moved these patients from its HDU to its theatres where sufficient oxygen supply was available.

The Trust initially diverted incoming patients to another of its hospital sites and cancelled all elective surgical work whilst further investigation took place. However, capacity levels at its other sites also began to cause concern and so the Trust declared a major incident and requested all incoming patients be diverted to other hospital trusts. The Trust began planning further patient moves and identified mitigating measures that would allow it to carry out a test on the MGPS in the HDU.

The Trust carried out a pressure test on the MGPS to identify any failures. These tests identified no immediate causes for the potential issues in HDU. However, a full pressure test was recommended across the MGPS at all Trust sites to confirm pressure and flow calculations that the Trust had used on which to base its care for COVID-19 patients requiring oxygen therapy.

The results of the pressure tests identified a number of areas where there was a reduced capacity in the MGPS. The Trust initially understood that the HDU should have been capable of providing a specified volume of oxygen per minute and had used this to calculate the number of patients that could be treated, and type of oxygen therapy that could be used. However, the pressure test revealed that the expected oxygen capacity was not achievable and it was only possible to provide a lower volume of oxygen to the HDU. The reduction in the maximum volume of oxygen available reduced the number of patients that could be treated and type of oxygen therapy that could be used.

The Trust reported that the overall demand on the MGPS never exceeded more than 56% of its total capacity. Given this, the Trust identified that any possible lack of oxygen flow available to the HDU was due to the distribution of patients and types of oxygen therapy required in other parts of the hospital.

During the first wave of the COVID-19 pandemic, the Trust had identified where patients requiring oxygen therapy could be cared for within the hospital to ensure demand on the MGPS was evenly distributed. The plan had accounted for anticipated demand on oxygen supplies and the type of oxygen therapy expected to be provided at that time. However, the Trust considered that the plan had not been effective due to a range of factors, including:

- a lack of COVID-19 patient demand during the first wave of the pandemic
- the need to clinically cohort patients creating uneven demand on the system
- the baseline figures for anticipated oxygen consumption used to calculate potential demand being too low
- variation in the volume of oxygen consumed by different equipment capable of delivering oxygen therapy
- existing MGPS pipework infrastructure
- general demand for bed spaces caused by the number of patients requiring treatment for COVID-19.

The Trust carried out work to revise its plans and understand how this impacted on where patients requiring oxygen therapy could be cared for within the hospital to maintain sufficient pressure across the system. This work enabled the Trust to redistribute patients across the hospital to provide a more equal spread of oxygen demand and allowed one of its hospital sites to readmit patients.

Following this work, and a decrease in the number of patients being treated at both hospital sites due to the impact of the ambulance divert, the Trust was able to stand down from the major incident and recommence admitting patients to both hospital sites seven days after the major incident was declared. The two HDU patients that had become desaturated recovered their oxygen saturation levels without any adverse effects. It remains unclear whether their desaturation was associated with any pressure loss or reduction in oxygen flow within the HDU.

National context

In hospital, oxygen is normally provided to patients by piped oxygen supplies which are built into the hospital estate or portable oxygen supplies that use oxygen cylinders. The HSIB investigation will focus on piped oxygen supplies. HSIB has previously investigated safety issues arising from the use of portable oxygen systems Design and safe use of portable oxygen systems - Healthcare Safety Investigation Branch.

Oxygen therapy can be provided via a number of devices (such as: ventilators, continuous positive airway pressure, high flow nasal oxygen) which require/supply oxygen to be provided at a varying range from one litre per minute to 120 litres per minute.

Guidance on the installation and management of MGPS is available via a health technical memoranda that was issued by the Department of Health and Social Care (DHSC, 2006 a,b). This specified that trusts should convene a Medical Gases Committee to oversee the MGPS and appoint designated nursing and medical officers to provide a focal point for interactions with clinical staff about the MGPS. The main components of an oxygen MGPS are:

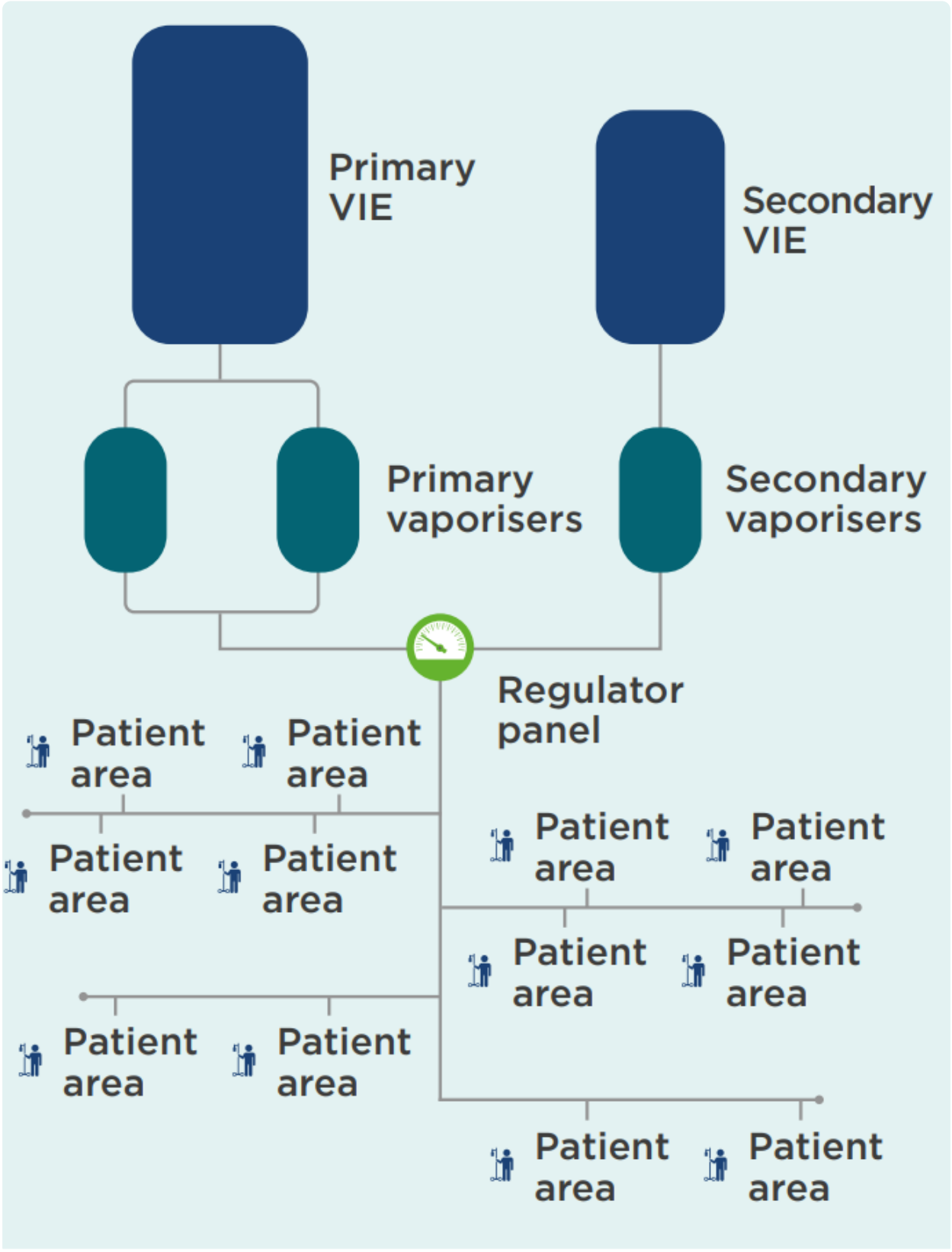
- Vacuum Insulated Evaporator (VIE): a pressurised vessel that stores liquid oxygen.
- Vaporisers: convert liquid oxygen into oxygen gas.

- Regulator control panel: regulates the flow of oxygen gas from the VIE into the hospital building (the VIE, vaporisers and regulator control panel may be locally referred to together as ‘the VIE’ and not as separate components).
- Master and local alarm panels: warn of potential issues with the supply of oxygen gas.
- Associated pipework that transports the oxygen gas around the hospital.

These components work together to deliver oxygen gas safely into the hospital environment. Each MGPS provides a specified volume of oxygen gas to a hospital (commonly measured in litres available per minute). The expected volume of oxygen gas is only able to be delivered if the pressure is maintained. The delivery pressure should remain within expected ranges for the anticipated volume of oxygen to be supplied.

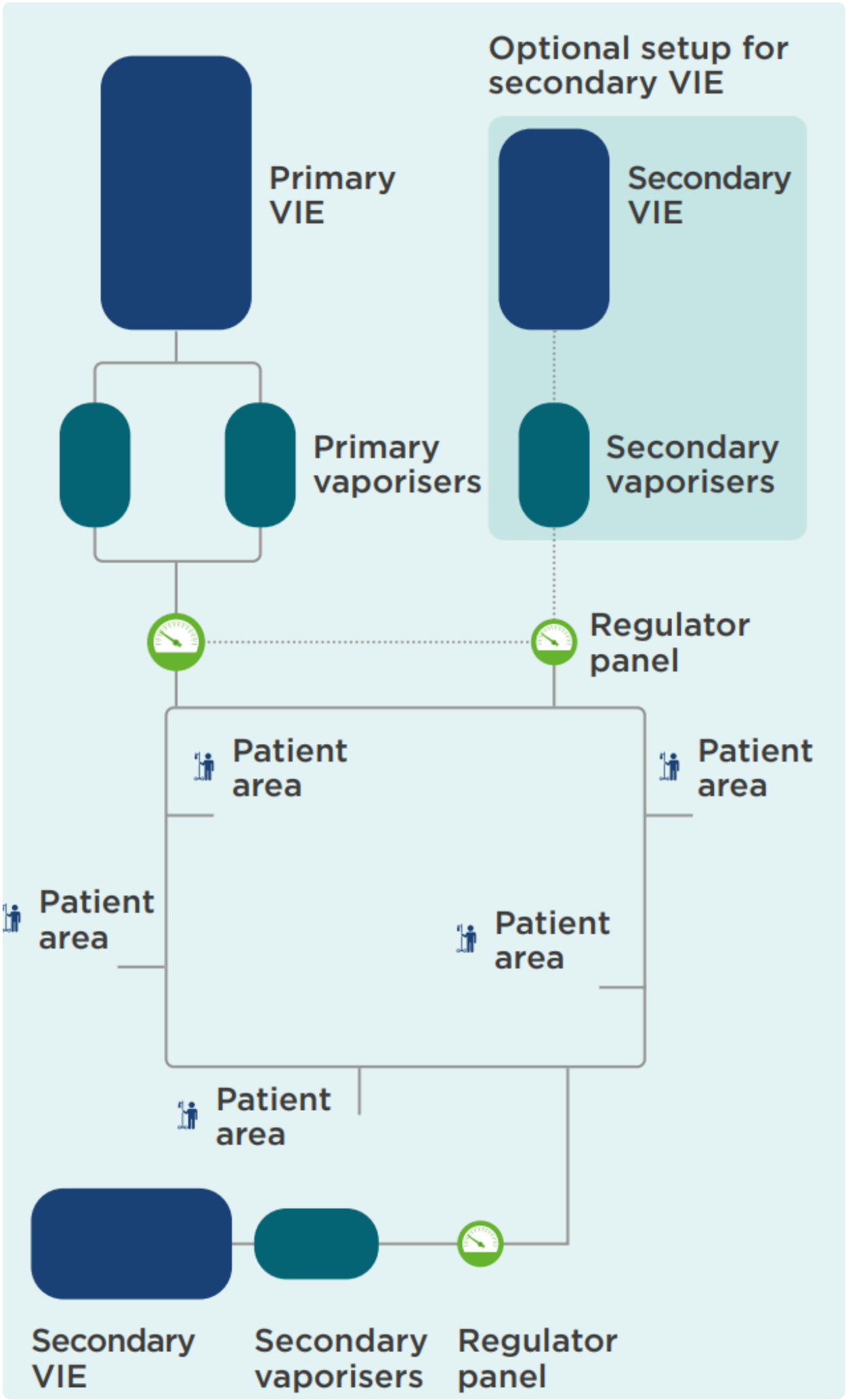
Typically, these systems are arranged as either:

Figure 1: Example radial system



A radial system (Figure 1): a pipeline system which begins at the piped oxygen source and ends at another point so that every outlet has only one possible route of oxygen supply.

Figure 2: Example ring main system


Optional setup for secondary VIE
Primary VIE
Secondary VIE
Primary vaporisers
Secondary vaporisers
Regulator panel
Patient area
Patient area
Patient area
Patient area
Patient area
Secondary VIE
Secondary vaporisers
Regulator panel

A ring main (Figure 2): a pipeline system which begins and ends at the piped oxygen source so that every outlet has two possible routes of oxygen supply.

The HSIB understands that many NHS hospitals operate on radial systems. In radial systems, oxygen that is drawn off the system earlier in its progress through the hospital reduces the potential pressure to oxygen outlets later in the system. The loading of patients requiring oxygen therapy across the MGPS needs to be carefully planned to avoid unequal pressure on the MGPS and unanticipated reductions in oxygen supply at other points in the system.

Identified safety issues

The HSIB has identified the following considerations that may require urgent attention by NHS trusts. These should be considered in conjunction with the existing alerts, guidance and support available:

- VIE capacity (or a subcomponent within the VIE) is not necessarily the limiting factor in delivering required levels of oxygen into hospital via MGPS.
- Demand issues can occur even where VIE capacity is well within expected parameters. Existing pipework infrastructure, where patients on oxygen therapy are placed within the hospital estate, and the variable amounts of oxygen used by different equipment can limit the available volume of oxygen gas in different clinical areas.
- Real time monitoring of oxygen flow and suitable pressure alarms in individual clinical areas may support efficient management of MGPS loading.
- Cohesive senior clinical, operational, estates and pharmaceutical leadership is required to ensure there is a shared understanding about the limitations in the local MGPS across all clinical areas and how these may directly impact on clinical decision-making and patient safety.
- Executive boards should take urgent action to ensure that trusts have fully understood and complied with alerts and guidance from NHS England and NHS Improvement, and the NHS Specialist Pharmacy Service, on how to manage demands on MGPS.

The national investigation will explore the following areas:

- The current scope and effectiveness of national and professional guidance related to MGPS.
- Limitations in existing infrastructure for MGPS in hospitals.

- Multidisciplinary decision-making and understanding of the capabilities of MGPS in light of the COVID-19 pandemic.
- The role of the Medical Gases Committee and designated people within NHS trusts.

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