Critical incident is a possibility with water in flowmeter

INTRODUCTION

The compressed medical air facility and pipeline distribution system are generally installed by mechanical contractors and maintained by the maintenance department of the hospital.[1] These systems are situated out of sight and do not attract attention until a problem occurs. The anaesthesia personnel may not be well versed with the working of these systems as they may not be involved in its designing and functioning. Despite the presence of safety features in modern anaesthesia workstations, catastrophic events are still a possibility due to flaws occurring in the medical gas distribution system.[2]

We report a critical incident wherein faulty medical air supply system resulted in water influx to the air flowmeter which was recognised immediately, averting dangerous consequences to the patient.

CASE REPORT

A 30-year-old male patient with suspected bowel ischaemia presented for emergency laparotomy. Routine preoperative evaluation and monitoring were followed. Anaesthesia workstation (Datex Ohmeda Aestiva/5®; GE Healthcare, Finland), after following recommended preoperative checklist, was used to administer general anaesthesia. Patient was preoxygenated with 100% oxygen, and rapid sequence induction was performed using thiopentone sodium 5 mg/kg and suxamethonium 1.5 mg/kg. Airway was secured with 8.5 mm endotracheal tube. Anaesthetic plan for maintenance included air-oxygen mixture, isoflurane, intermittent doses of atracurium and fentanyl.

On opening the flow control knob of air flowmeter, sudden influx of water was noticed with the liquid column in air flowmeter [Figure 1] rising rapidly. The patient was disconnected immediately from the workstation and was ventilated with a manual resuscitator until the standby Boyle's machine (BOC India limited) was ready for use. Anaesthesia was continued as planned, with nitrous oxide replacing air. To delineate the vital bowel, 100% oxygen was used intermittently. At the end of 3 h of surgery, patient was extubated with an uneventful recovery.

DISCUSSION

Medical air is used in anaesthesia gas mixers, ventilators, to power humidifiers and in drug nebulisers.[3] The central supply of medical air can be from manifold, compressor or a proportionating (synthetic air) system and includes emergency reserve manifold.[1,3]

Air compressor is the most common source of medical air in hospitals.[4] Air drawn into the compressor intake has 2.5 g/m^3–40 g/m^3 of water vapour depending on climatic conditions.[4] The aftercooler and receiver remove some of this but about 20 g/m^3 is likely to remain in the compressed air until removed by dryers.[1,4] Aftercooler is installed downstream of the compressor in which air is cooled, and the condensed moisture is removed. Further, water may condense at receiver and is removed by manual/automatic drains. Residual water is removed by running through a dryer.[1] Water content not exceeding 67 volume parts per million equivalent to the dew point (−46°C at atmosphere) is specified for medical air pipeline system which is achieved only by desiccant dryer.[4] Regeneration of desiccant dryer should be ensured in proportion to the compressed air usage. Water content of the air is measured by placing electronic dew point hygrometer upstream the pipeline distribution system.[4]

Contamination of medical air with water/moisture may occur at source (compressors), distribution system or outlet assembly.[5] This water contamination can damage equipment, can be a source of bacteria, can freeze and occlude pipeline. Malfunctioning of ventilator can occur if air is the driving gas. Water condensation can pose problems in the mechanical,

Figure 1: Arrow showing influx of water in air flowmeter

electrical and electronic components of the newer anaesthesia workstation.[6] Influx of water in a flowmeter when the anaesthesia workstation is in use can jeopardise patient safety, leading to critical incidents. The accumulated water can cause erratic or no movement of the bobbin in the flowmeter, resulting in inaccurate flow of anaesthetic gases.[7] It can eventually spill over to other flowmeters with possibility of hypoxic mixture being delivered to the patient.[8,9] This requires constant vigilance to prevent any catastrophe. It is important to note that routine preoperative apparatus checklist may not prevent such critical incidents as water can enter at any point of time during use.[10,11]

In our case, fortunately, water was noticed in the flowmeter immediately, and safety measures were followed, preventing any harm to the patient. Examination of the affected workstation later by the biomedical personnel revealed presence of water in air tubings and flowmeter. Air pipeline outlets at several locations in the hospital also tested positive for water.

On further probing into the incident, it was found that around the same time, an Avance Workstation (GE Healthcare, Finland) with electronic gas mixer was reported malfunctioning with no fresh gas flow detected, requiring replacement of the expensive electronic gas mixer. Reports of ventilator malfunctions (where compressed air was used as driving gas) were noted from the neonatal and medical intensive care units. One of the probable causes attributed by service engineers in all these instances was contamination of medical air with water.

Figure 2: Air dryer bypass valve removed (A) and installation of air stopper valve assembly (B)

Medical air is used in our institution for several decades without any adverse events being noticed or reported in the past. An investigation initiated by our department in co-ordination with biomedical department revealed several probable causes for contamination of medical air with water [Table 1].

Inbuilt sintered metal filters that are present at the workstation inlets have pore size of 100 microns or less, prevent only particulate matter (and not water) from entering the workstation.[12] Anand *et al*. have reported using water traps upstream of the anaesthesia workstation to prevent contaminants from entering it.[2] These traps can get clogged and need frequent checks and draining for proper functioning. Procurement and maintenance of such traps was considered uneconomical and impractical in view of larger requirement in our institution. Moreover, they cannot substitute for supply of safe medical air.

Hence, all the flaws identified in the medical air supply system in our institution were addressed appropriately with corrective measures [Figures 2, 3 and Table 1] by the biomedical department in co-ordination with end user departments. Periodic checking with validation and certification of air quality was made mandatory to ensure patient safety.

CONCLUSION

The involvement of anaesthesia personnel in planning and designing the pipeline system can improve patient safety. Close communication is necessary between anaesthesia providers and maintenance personnel of medical air supply system. Periodic testing, validation and certification of medical air are recommended.

Figure 3: Installation of dryers, filters, electronically operated drains

Table 1: Probable factors found responsible for water contamination of medical air and corrective measures taken

Pre-existing factors
Presence of refrigeration air dryer bypass valve (Figure 2)
Manual water drain operated at longer time interval (with resultant spillage)
Absence of air stopper valve assembly to prevent hot air flow during power failure (Figure 2)
Absence of desiccant air dryer
Absence of alarms for water level
Recent factors
Outsourcing of maintenance work including pressure leak tests
Changes that greatly increased the demand on medical air usage in our institute, resulting in excess burden on existing dryer and filter system making them insufficient
Facility of surgical air supply (under higher pressure) from same source of compressed medical air
Changeover from inbuilt compressor driven ventilators to pipeline air driven ventilators (35 in numbers) in intensive care units
Increased practice of using air, replacing nitrous oxide in the operation theatre
Corrective measures undertaken
Air dryer bypass valve removed
Installation of
Air stopper valve assembly
Automatic water drain
Desiccant air dryers (activated alumina, ensuring regeneration)
Alarm for water level

Eternal vigilance remains a mandatory requirement for a safe conduct of anaesthesia.

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M Manjuladevi, KS Vasudeva Upadhyaya, PS Sathyanarayana, Rashmi Rani, Viraj Shah

Department of Anaesthesia and Critical Care, St. John's Medical College and Hospital, John Nagar, Bengaluru, Karnataka, India

Address for correspondence:
Dr. M Manjuladevi,
Department of Anaesthesia and Critical Care, St. John's Medical College and Hospital, John Nagar, Bengaluru - 560 034, Karnataka, India.
E-mail: drmanjula95@yahoo.com

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