Oxygen Contamination of the Nitrous Oxide Pipeline Supply

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SUMMARY

Midogas® (CIG Australia) nitrous oxide/oxygen blenders are commonly used in delivery wards in Australia. In this case report we describe an incident where a small hole in the diaphragm of the oxygen failure alarm in a Midogas nitrous oxide/oxygen blender led to retrograde flow of oxygen contaminating the nitrous oxide pipeline supply to the operating theatres and the delivery ward. This caused a reduced level of nitrous oxide to the patient in theatre, but there was no adverse outcome. However, if the oxygen pipeline pressure had been lower than the nitrous oxide pipeline pressure, the contamination would have been reversed, potentially resulting in a hypoxic mixture being delivered to many patients. Suggestions are made as to a method of prevention of this problem.

Key Words: EQUIPMENT, FAILURE: nitrous oxide/oxygen blender, Midogas, oxygen alarm

CASE REPORT

After a routine preoperative check of the anaesthetic machine by the anaesthetist, a patient was anaesthetized for vaginal hysterectomy and repair. Towards the end of the operation, it was noted that the oxygen analyser (Teledyne Electronic Devices 200T) was reading 49% despite the rotameter flows of oxygen 1 litre/minute and nitrous oxide 2 l/min (calculated O₂ concentration of 33%). The oxygen analyser was recalibrated, with no change in the readings. A new oxygen analyser was installed in the inspiratory limb of the circle circuit, but the inspired oxygen concentration remained unchanged. As it was the end of the operation no further action was taken. The patient was transferred to the recovery area with no adverse effects.

The following case on the list was performed in a larger theatre in the same block (King George V operating theatres) because of the nature of the surgery. The anaesthetic machine in this theatre was checked and the oxygen analyser calibrated to air (21% O₂) and 100% O₂. The O₂ and N₂O bulk supply line pressures were within normal limits. Shortly after the case had commenced it became apparent that the same problem was occurring in this theatre. At rotameter flows of O₂ 1 litre/min and N₂O 2 l/min the oxygen analyser read 50% and the N₂O analyser (Nellcor N-1000 monitor) read 50%. The rotameter flows of O₂ and N₂O were then changed and although the O₂ analyser and N₂O analyser readings altered, the N₂O readings were less and O₂ readings greater than calculated.

There were three theatres in this particular theatre block and a check in the other theatre being used revealed the same problem. The machine was then disconnected from the wall pipeline supply of oxygen and nitrous oxide. Using cylinder supplies, the O₂ analyser and N₂O analyser showed correct readings. The same result occurred when this was done in the other two theatres. It was then concluded that the wall pipeline supply of nitrous oxide was contaminated with oxygen.

Inquiries were made to the three other theatre blocks within the hospital (Figure 1). No problems were noted in these areas. It seemed that the problem was confined to this theatre block in the obstetrics and gynaecology building. The head of the medical gas department was notified and the bulk gas supply area checked. The pressure gauges on the nitrous oxide manifold system did not show any abnormalities. As a precautionary measure the nitrous oxide supply was switched over to the other bank of cylinders with no change to the abnormal readings in the theatre.

The only other area where nitrous oxide was used in this building was the delivery ward. Using an O₂ analyser we tested the gases from the wall pipeline supply there. The oxygen supply was appropriate, however the nitrous oxide supply showed approximately 11 to 13% oxygen. In the delivery ward, each room had a CIG Midogas nitrous oxide/oxygen...
blender (on-to-wall model) which was used for analgesia. Each Midogas machine was disconnected and the wall outlets checked. When the faulty Midogas machine was disconnected from the N₂O pipeline outlet, there was retrograde gas flow out of the N₂O hose from the machine. At the wall pipeline N₂O outlet the oxygen analyser showed the gas to be 100% O₂. As the gas was bled out the analyser reading gradually fell to zero, indicating that as the gas bled out it was initially 100% O₂, then a mixture of N₂O contaminated by O₂, and finally 100% N₂O. After the faulty Midogas machine was disconnected, the analyser readings we obtained in theatre and in the delivery ward returned to normal.

The faulty Midogas machine was sent to the company which services them. It was more than ten years old and had been serviced regularly at three-monthly intervals. On bench testing the machine was connected to 400 kPa oxygen. A gas leak was heard and felt through the nitrous oxide hose. The leak was measured at 250 ml/min. The oxygen was then disconnected and the same test carried out with the nitrous oxide supply at 400 kPa. A similar leak rate of nitrous oxide was found through the oxygen hose. On dismantling the apparatus the problem was found to be a 2 mm slit-like hole in the whistle diaphragm from the oxygen failure alarm (Figures 2 and 3).

**DISCUSSION**

Problems with the nitrous oxide supply have been described in the literature. They include cross connections of oxygen and nitrous oxide pipelines, replacement of a nitrous oxide cylinder instead of an Entonox (nitrous oxide 50%, oxygen 50%) cylinder whilst using an Entonox device, malfunctions with rotameters and proportioning devices resulting in hypoxic mixtures to the patient, failure of nitrous oxide supply due to maintenance work on the pipeline. Pipeline contamination has been reported from blenders in intensive care involving air and oxygen. A Medline search from 1983 found that no such problems with the Midogas nitrous oxide/oxygen blender have been reported. However there have been two cases of oxygen contaminating the nitrous oxide line due to defects in the O₂ fail-safe device in blenders.
The Midogas nitrous oxide/oxygen blender is designed to provide a mixture of nitrous oxide and oxygen to the patient such that the minimum oxygen concentration is 25% (maximum nitrous oxide concentration is 75%). There are three models available in Australia: on-to-wall, in-to-wall, and pedestal mounted. Essentially they are the same blender differing only in the positions where they are mounted.

The safety features of the apparatus are:
- an oxygen failure alarm. At a pressure of less than 240 kPa in the pipeline oxygen, a diaphragm valve opens a nitrous oxide powered whistle alarm and an air inlet valve, allowing the patient to breathe a mixture of air and nitrous oxide.
- an emergency oxygen button which delivers 30 l/min of oxygen to the circuit.

The problem identified with the Midogas nitrous oxide/oxygen blender in this case report is significant. There is no mechanism to prevent opposing gas contamination and the pipeline with the lower pressure will be contaminated by the gas with the higher pressure. Contamination is not limited to that one machine or room or operating theatre. It extends back through the wall outlet into the pipeline supply therefore affecting many areas and patients.

In our hospital bulk supply, oxygen pressure is regulated at 440 kPa (the maximum pressure allowed by Australian Standard). Because of the high level of oxygen usage, the oxygen pipeline pressure fluctuates from 440 kPa at times of low usage down to 410 kPa at times of extremely high usage. The usual pressure is about 420 kPa. The nitrous oxide pipeline pressure is reasonably constant at 415 kPa, as it is used only in the theatres and delivery ward. The corollary of this is that a hypoxic mixture could have been delivered to the patients if the oxygen pressure was lower than the nitrous oxide pressure, which does occur at periods of extremely high oxygen usage. In the operating theatres with our standard monitoring devices of oxygen analyser and pulse oximetry, a hypoxic mixture should be recognized. However in the delivery ward these monitoring devices are not standard and a hypoxic mixture would not be detected, with potential harm to both the mother and the unborn baby.

We suggest several changes that may prevent this problem from causing morbidity.

1. The Australian Standard be changed such that the pipeline pressure for oxygen is higher than for other medical gases. Although it would be technically difficult to maintain a set pressure differential, each individual hospital should ensure that at periods of maximal oxygen demand the oxygen pipeline pressure does not drop below the nitrous oxide pipeline pressure. This would mean that at periods of low oxygen demand, the pressure differential would be greater.

2. An oxygen analyser with alarm be incorporated at the gas outlet of the Midogas nitrous oxide/oxygen blender (before the breathing circuit), so that it would continuously monitor the oxygen content of the gas mixture when the blender is switched on.

3. Nonreturn valves be incorporated ideally at the O₂ and N₂O inlets of the Midogas machine, and/or at least at each wall pipeline outlet, so as to prevent retrograde flow of contaminated gas into the pipeline supply.

4. Increased awareness of this problem when servicing the device regularly.

REFERENCES