The Journal of Health Design

EDITORIAL

Out-of-sight killers—the ongoing problem with hospital gas lines

Jon Cornwall and Brian Robinson

Graduate School of Nursing, Midwifery and Health, Victoria University of Wellington, New Zealand

To Cite: Cornwall J, Robinson B. Out of sight killers—the ongoing problem with hospital gas lines. JHD 2016;1(2):2–5. https://doi.org/10.21853/JHD.2016.9

Corresponding Author:
Dr Jon Cornwall
Graduate School of Nursing, Midwifery and Health
Victoria University of Wellington
P.O. Box 7625
Newtown, Wellington 6242
New Zealand
jon.cornwall@vuw.ac.nz

SUMMARY
The recent death of one neonate and injury to another due to resuscitation with nitrous oxide and not oxygen highlights the continuing risk associated with the delivery of piped nitrous oxide into hospitals. The cause of this incident was not unique, with many identical deaths and injuries occurring frequently around the world over several decades. While standards and design focus are often directed at the equipment used by clinicians, attention also needs to be directed at developing safety mechanisms throughout an entire gas delivery process to prevent ongoing tragedies associated with gas-delivery errors.

Key Words
Patient safety; nitrous oxide; death; responsibility; standards

INTRODUCTION

The death of a newborn baby in an Australian hospital in July 2016, while another infant at the same hospital was left in critical condition, highlights how easily gas pipeline errors can remain undetected until significant injury or death occurs.[1] The death of one infant, and brain injury to the other, was caused by anoxia (ie, starvation of oxygen) due to a mistake in connecting nitrous oxide to a pipeline that should have contained oxygen. Crossing gas pipes led to the 100% nitrous oxide being delivered through the “oxygen” outlet to resuscitation equipment. This incident was the result of a series of mistakes and breeches of policy directives made out of sight and “behind” the wall by engineers, away from the eyes of medical staff who were unaware of the reasons their young patients were deteriorating. The local government report on the incident identifies broader issues in relation to project planning and risk management,[2] and put forward recommendations including the Ministry of Health promulgate a requirement for (gas) contractors to have a separate installer and tester.

Nitrous oxide (N_2O), commonly known as “laughing gas”, must be mixed with oxygen to be delivered safely to patients. It can be supplied for analgesia (pain relief) in pre-mixed gas cylinders containing, for example, 50% nitrous oxide and 50% oxygen, such as those commonly used in dentistry, emergency departments, or during child birth. This guarantees safe use so that the patient will always receive a minimum guaranteed amount of oxygen. However, when nitrous oxide is supplied through wall pipelines, it is at least 99% pure and is administered to patients through anaesthesia machines or other special devices that precisely mix nitrous oxide with oxygen to ensure patients receive at the very least atmospheric (ie, 21%) oxygen. Networks of pipes have been used to transport nitrous oxide in hospitals since the 1930s.[3] When a pipeline crossover occurs in a wall supply, nitrous oxide can be administered in place of oxygen. When inhaled in situations where patients require oxygen, the unintentional nitrous oxide administration can cause great reductions in the blood oxygen levels, leading to a subsequent decrease in central nervous system activity and permanent brain injury or death.

While news outlets around the world promoted the Sydney story and heralded the fact that this was both an accident and tragedy, there was less recognition that this, unfortunately, is a frequent and preventable event. Several accidents resulting from crossed nitrous oxide and oxygen pipelines have been reported recently, with the deaths of an infant and of an eight-year-old boy in India[4] and at least two deaths reported in Italy in 2007.[5] Yet this is not a problem that has developed in recent times: gas pipeline errors within hospitals are an ongoing problem and have been the subject of many publications over several decades,[6,7] many of which highlight the causes and detail methods for prevention of similar accidents. Between April 2004 and October 2006, six cases of nitrous oxide-related deaths were identified in Germany, Austria, and Switzerland.[8] It is difficult to gauge how many other cases remain unreported.

Why gas outlet accidents continue to occur is unclear as international standards, processes, and procedures have been developed to avoid them. Standardisation has been mandated for indexing the wall gas outlets controlling the connection of gas supply to medical devices in the same manner that the connection of gas cylinders is indexed.[9,10,11] These are forcing functions that are designed to avoid accidental gas line crossover and only appear on the "clinician" side of the wall,[7,8,12] rather than "behind" the wall at the source of all gas where the gas sources are connected. There is no infallible system behind the wall that effectively counters the problem when identical lengths and diameters of copper tubing are braised and soldered together leading to specific gas outlets. Certifying gas outlets involves engineers and health professionals to confirm the specific delivery of oxygen, nitrous oxide, or medical air at each outlet at commissioning,[9] and it appears that it is this process that fails and leads to deaths and injuries. This is therefore a case for designing forcing functions into all steps of gas delivery on either side of the wall.

Yet deaths and injuries continue despite publication about the safety issues associated with gas exchange and using nitrous oxide.[12] Simulation has explored the performance and training strategies of anaesthetists for the management of equipment failure and contaminated gas supply, however, implementation of such training is not common. This means there is a lack of standardised operating procedures to assist in the management of gas pipelines, indicating a potential lack of will to make skilled management a competency required for clinical practice.[13,14]

What is holding back progress in the development and adoption of failsafe devices in this area of patient safety? The more cynical among us could suggest that there is little potential for successful litigation by affected families that could lead to enormous compensation pay-outs, or only a remote possibility a corporation would take responsibility for acknowledging failure to ensure patient safety when it adversely affects the success of their business. Contrast this to the corporate impact of "accidental" deaths by the erroneous application of nitrous oxide with those faced by large businesses. If aircraft faults are identified, inspection of all aircraft that could be affected by that same fault generally follows worldwide, often occurring with litigation or compensation. When the engine of Qantas flight QF32 failed en route to Australia from Singapore, fleets of the same plane were grounded worldwide and significant amounts of money were transferred as compensation; we do not "ground" or close hospitals when a failure occurs in one, however, similar attitudes to safety should perhaps be considered.

While such a comparison of risk management cultures may seem spurious, it does highlight how corporate interest, revenue streams, threat of litigation, and public perception are strong motivators for industry action and change. It seems that action comes directly from large catastrophes that can potentially cost a significant amount of money, yet the death or injury of individuals in hospital from a gas exchange error is no less of a catastrophe than other accidents that lead to the loss of human lives. Perhaps it is because it is problematic for "blame" to be attached for individual deaths that this issue has not been consigned to the annals of "problems that we used to have". Retention of the non-litigious (punitive) status quo in managing accidental deaths in this area may be more beneficial in the longer term, as a continual threat of litigation may have adverse downstream effects in regard to insurance premiums, healthcare costs, and contractual obligations for employees and contractors alike. The extremes of both positions still require exploration during the search for an effective solution, in order to find the "best fit" for the healthcare community and wider society.

The anaesthetic community continues to debate whether nitrous oxide should be removed from the WHO list of essential medicines.[13] It is important to recognise that this gas is ingrained internationally within anaesthesia practice despite many other recognised complications ranging from nausea to myocardial infarction, stroke, and pulmonary embolism in addition to its contribution to ozone depletion.[15] While the demand for nitrous oxide continues, it will be piped through the walls of hospitals and the risk of accidental death through delivery error will likely continue. Initiatives to record these incidents in a central repository (perhaps similar to the National Patient Safety Authority in the United Kingdom) could provide the platform for incident analysis and the development of appropriate safety strategies. However, implementing such a system on an international basis would require substantial effort on the part of safety agencies, necessitating significant coordination and infrastructure to manage effectively.

Decades of death and injury have occurred from errors "behind the wall", and while some preventative measures aimed at preventing such incidents may have been implemented, it is clearly not adequate. What is required is the prioritisation of design, development, and incorporation of safety systems with common or historical issues, such as this very problem. When the focus turns to addressing or solving common problems such as this, one possible consequence is a health system that provides failsafe design throughout the entire system. This includes those systems "behind" the wall, not just on the "clinical" side of the wall where clinicians may be held responsible for equipment use. Perhaps it is time to remind ourselves that system design for safety mechanisms must go beyond just clinical spaces; the risk with not doing so is continued loss of lives and the potential for future accidents and tragedy. Not to do so may see future errors and accidents find their way more frequently into court action and litigation—with the risk that lawsuits become the motivating factor for innovation, rather than necessity and duty of care.

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ACKNOWLEDGEMENTS

None.

PEER REVIEW

Not commissioned. Externally peer reviewed.

CONFLICTS OF INTEREST

Dr Jon Cornwall is a member of The JHD editorial board.

FUNDING

None.

ETHICS COMMITTEE APPROVAL

None.