Use of Oxygen Concentrators in Veterinary Anesthesia

Abstract

This white paper sets forth to educate readers about oxygen concentrators, how they were developed and how they can now be used for veterinary medicine. It also seeks to explain the cost advantages (ROI) of using oxygen concentrators for veterinary medicine while simultaneously addressing safety concerns for both patients and the veterinarians.

Introduction

The goal of an oxygen concentrator is simple. Once an oxygen concentrator unit is turned on, it will produce medical grade oxygen (USP 93%) and deliver it on demand. This oxygen, extracted from the ambient air, is pure enough to use in the delivery of home or personal oxygen, as well as in both medical and veterinary anesthesia applications.

Utilized all over the world, from veterinary hospitals to medical hospitals and third-world medical outposts, oxygen concentrators have proven to be safe, reliable, and cost-effective. In addition to providing a safer, more readily available alternative to traditional compressed oxygen cylinders, oxygen concentrators have saved thousands of dollars and untold numbers of lives in situations where access to compressed oxygen cylinders was limited or in short supply. First used in remote field hospitals with little or no access to compressed oxygen cylinders, the oxygen concentrators not only provided patients with much-needed oxygen, but also increased the cylinder/patient efficiency of the units in question by more than 1200%.[1] Today, oxygen concentrators have been introduced as primary sources of oxygen in state-of-the-art medical hospitals and veterinary hospitals alike.

By using a chemical filter known as a "molecular sieve", oxygen concentrators can take in normal atmospheric air, filter out nitrogen and other components, and deliver a supply of USP 93% pure oxygen at a rate consistent enough to reliably drive any existing anesthetic unit.[2, 3]

How an Oxygen Concentrator Works

Oxygen concentrators leverage common technology to pull oxygen from the air and deliver it on demand. The selective adsorption of the components of air by naturally occurring zeolites has been common knowledge in the scientific community for over 40 years.[2] Adsorption—not to be mistaken with "absorption"—is the binding of molecules to a surface, rather than the filling of pores in a solid. And unlike absorption, the binding to the surface through adsorption is usually weak and reversible.[4, 5] It is the adsorption of zeolite structures that provides the foundation for the oxygen molecular sieves used in oxygen concentrators.[2] Although many types of zeolites occur naturally, industrial research has paved the way for production of synthetic zeolite structures that are more rigid and provide uniformity in consistency and performance.[2]

To produce oxygen, concentrators draw room air into the machine via a compressor and through a series of filters to remove dust and bacteria.[6] The compressed air is then passed into a column which contains a zeolite molecular sieve composed of aluminum silicate.

Nitrogen from the air binds itself to the zeolite through adsorption, while oxygen passes through the sieve. Just before the zeolite fully saturates with nitrogen, the flow of room air is switched to a second column and the first column is vented and back flushed with a small flow of oxygen from the alternate column. The two columns alternate to avoid saturation of the molecular sieve and produce a consistent flow of USP 93% oxygen, which passes through a small reservoir, and a flow control system to be delivered to the patient or anesthesia delivery system.[7, 8]

Oxygen Concentrators: Then and Now

First available commercially in the late 1960s, oxygen concentrators were developed initially for military and domestic use. The earliest concentrators were large and worked using a supply of compressed air.[3] They also required regular maintenance about every 5,000 hours of use, or about every six months, and had a life span of about 10 years of use.[6] In the 1970s, portable versions of these concentrators were developed as a safer alternative to large compressed oxygen cylinders used in the homes of patients with respiratory issues.[2]

Thanks to ongoing development, oxygen concentrators have proven themselves reliable in a variety of settings, including the delivery of personal oxygen and anesthesia,[3] as well as different environments, some of which include third-world medical units, large medical installations, and high-altitude field hospitals.

Modern oxygen concentrators are available in many different sizes ranging from portable domestic models to large installations with the capacity to supply the oxygen requirements of an entire hospital.[3]

The Challenges of Compressed Oxygen Cylinders

The greatest challenge

On the surface it may seem that the use of compressed cylinders is the simplest and cheapest option. Oxygen cylinders are, however, more complicated to operate than is apparent at first glance due to the necessity for an extensive and costly infrastructure to effectively deliver oxygen to the patient. Among other things, this infrastructure includes:

- Methods of regulating and controlling flow of oxygen
- Methods for handling and delivering cylinders to the practice itself[10]
- Training on how to deliver oxygen from the cylinder to the patient
- Physical methods of delivering oxygen to the patient

Although each of these factors can be costly, the cost is even greater if a practice using compressed cylinders is missing any one of these components, as the process quickly becomes wasteful, or even dangerous.[10] Combined with the increasing costs of renting, storing, and refilling cylinders, this necessary infrastructure can translate into a significant fixed cost for hospitals who use compressed oxygen as a primary source of delivering oxygen to the patient.

For example, in an average small animal hospital that makes use of E tanks to provide oxygen to its patients using roughly 124,800 liters of oxygen per year would go through approximately 184 E tanks per year, at a volume of 680 liters of oxygen per tank. Given a $20.00 charge per tank refill, and a total yearly delivery cost of $1040, the total cost comes to $4,720.00 per year.[9]

For a same size practice making use of H tanks, the yearly costs are less expensive. Again, assuming a yearly oxygen usage of 124,800 liters, and 18 H tanks used, each with a volume of 7,051 liters. At $80 per refill and delivery per tank, and a yearly tank rental of $110.50, the total cost comes to $1,550.50 per year.[9]

Other challenges

In addition to the cost of oxygen cylinders, there are several challenges associated with using compressed oxygen. These include the dangers of oxygen enrichment, the constant need for regular maintenance and upkeep, issues with handling and using oxygen, and the risk of tank rupture or explosion.[8/5]

The greatest danger in using oxygen is the occurrence of oxygen enrichment, which makes for a fire hazard when the ambient oxygen levels rise by as little as 3%.[12]

Among other things, oxygen enrichment is often caused by:

- damaged or poorly maintained hoses, pipes, and valves
- leaks from poor connections
- using an excess of oxygen

These risks are only increased when using compressed oxygen, due to the very nature of oxygen cylinders themselves. Hoses, pipes, and valves wear out; connections must be carefully monitored for leakage; and valves are easily left open. This is especially true when best practices require disconnecting hoses that deliver oxygen from the tank itself when not in use.[12]

And while regular maintenance of the compressed oxygen delivery system is vital to ensuring the safety of a practice, it is just as important to use only approved materials when performing maintenance, as some materials react explosively if they come into contact with oxygen at high pressure. O-rings, gaskets, regulators, hoses, and lubricants must be specially approved by the equipment supplier before use.[12]

Handling tanks can also prove to be problematic. Requiring careful handling and a purpose-built trolley, oxygen cylinders must be clamped or chained to prevent them from falling over, and while a sophisticated or professionally developed piping system can help alleviate the danger, many oxygen delivery systems require a dedicated, well-ventilated storage space to minimize the risk of fire or damage to the cylinders themselves.[12]

These tanks are difficult to operate and hard for an individual to handle with one hand, often proving cumbersome in situations where an individual is performing surgery while also using oxygen.

Finally, oxygen cylinders are a limited resource, the use of compressed oxygen often leads to shortages or interruptions in supply, which must be consistently monitored to prevent issues during surgery or during the use of anesthesia.

Oxygen Concentrators: A Cost-Effective Solution

While the necessity for oxygen in veterinary anesthesia promises to be a consistent one, the delivery is not limited to the use of large, bulky, and expensive oxygen tanks. Used in both human and veterinary anesthesia for over 40 years, oxygen concentrators have proven themselves to be a safe, efficient, reliable, cost-effective, portable, and more flexible alternative to traditional compressed oxygen cylinders.

Savings and efficiency

In a 1991 study, Kingsley and Baumgarten concluded that oxygen concentrators were simpler and safer to operate than pressurized cylinders, while offering a less-expensive, always-ready source of oxygen.[8] Given the ongoing costs of traditional cylinders, as well as the oxygen concentrator's capacity to operate without an extensive infrastructure, an oxygen concentrator can both pay for itself in as little as one year while greatly reducing maintenance and logistics issues for years to come.

Safety

Because concentrators only store a few liters of oxygen while the machine is running (the remainder of which drains out when turned off), they can provide the same medically-beneficial USP 93% oxygen as high-pressure tanks with a drastically reduced risk of fire. This helps solve fire code issues in buildings that are not built to store or deliver oxygen from compressed cylinders.

Additionally, due their small size, compact design, and ease of use, oxygen concentrators can be handled and operated much more safely than oxygen tanks. By using an oxygen concentrator the infrastructure necessary to deliver oxygen to a patient is greatly reduced, making oxygen concentrators safer and easier to operate than traditional oxygen delivery equipment.

Use of Oxygen Concentrators as a Primary Oxygen Source

Oxygen concentrators have been proven safe and reliable for use with anesthetic delivery systems in human medicine for many years.[6] While in the late 1980s concentrators were already considered a safe and independent backup to compressed gas in underdeveloped nations,[8] modern concentrators are fully capable of serving as the primary source of oxygen altogether, with a compressed cylinder serving as the backup oxygen in case of emergency.

Indeed, due to rising costs of compressed oxygen, oxygen concentrators were winning themselves a spot as a primary source of oxygen in Canada as early as 1987. In 1992, 22 Canadian hospitals reported their experience using oxygen concentrators as a primary oxygen source in the Canadian Journal of Anesthesia. In a 1999 study on the use of oxygen concentrators as a primary oxygen supply source, Friesen and his colleagues identified 52 Canadian hospitals using oxygen concentrators as a primary source of oxygen.[13] Friesen also concluded that "when considering a primary oxygen supply, [oxygen concentrators] should be ranked equal to other bulk oxygen supply systems," noting that oxygen concentrators offer "distinct advantages regarding cost and availability of supply."

This position is substantiated by Dobson, who in a 1999 paper concluded that "use of concentrators can bring both a substantial improvement in the availability of treatment and cost savings for the hospital." And while he cautioned that any hospital installing oxygen concentrators as a primary oxygen supply source keep a back supply of reserve cylinders, he also cited a 1999 case in which a Nepal hospital had yet to open the three large reserve compressed cylinders a full 12 years after it installed oxygen concentrators in its operating theaters.[7]

Now, more than 14 years after Dobson completed his study, improvements in oxygen concentrator technology have made it even safer, more reliable, and more affordable than ever before. This technology has been used to deliver safe, reliable oxygen on-demand for use in both human and veterinary anesthesia in Europe, Canada, and developing countries for over 40 years.

> *"The analogy is more like getting water from a new source. You know it's water and how water works, it's just a different way of getting it."*
>
> *~Brian Lawson, President and CEO of Supera Anesthesia Innovations*

The Pureline® Solution

Led by President and CEO Brian Lawson, Supera Anesthesia Innovations (formerly LEI Medical) has firmly planted itself at the forefront of innovation with the introduction of the Pureline series of oxygen concentrators. With the Pureline brand, Supera has perfected the oxygen concentrator technology, offering seamless integration with current equipment, the highest-quality components, added safety features, and a return on investment (ROI) as low as one year. Supera offers an industry best 3 year warranty on its Pureline oxygen concentrators and a full 10 year warranty on their anesthesia machines.

While many oxygen concentrators intended for veterinary use are merely a "oxygen therapy" version of concentrators designed for use with human patients, Pureline concentrators are purpose-built for use with pressurized veterinary anesthesia equipment, which allows you to provide the best and most reliable care possible to your patients.

Integration

Although the average oxygen concentrator may require special adaptation for use with anesthesia equipment, the Pureline oxygen concentrators are specifically designed to integrate with veterinary anesthesia equipment. These concentrators work with all industry-standard anesthesia equipment currently used to deliver pure oxygen to a patient, so there's no need to replace any existing equipment when switching from compressed oxygen to a Pureline concentrator.

This seamless integration didn't happen by accident. It is, in fact, the result of years of research and testing conducted by Lawson and his team at Supera. Lawson, seeing the adoption of oxygen concentrators for use in veterinary anesthesia in Europe, worked to perfect the safest integration engineering between oxygen concentrators and anesthesia machines for a full seven years before bringing it to market in the form of the Pureline oxygen concentrator.

Savings and efficiency

By eliminating the cost of oxygen tank rental or purchase, refills, delivery, management and maintenance, a Pureline oxygen concentrator can pay for itself very quickly. Supera has calculated these sample yearly savings based on an average small animal hospital, using anesthesia four hours a day at an average flow rate of 2 LPM, five days a week (see calculations on page 2).[9]

In addition to an excellent ROI, all Pureline oxygen concentrators have a small floor footprint designed to save valuable floor space, run quietly at only 40-dBA, and are energy efficient, costing on average 12 cents per day to operate.

Safety

Pureline oxygen concentrators were designed with safety in mind and produce medical-grade oxygen (USP 93%) from the air and deliver it on demand. Approved by the FDA and UL tested, Pureline oxygen concentrators include purity and flow safety alarms to immediately notify the veterinarian of any malfunction.

Additionally, just so that you're prepared in the event of a power outage, some Pureline systems have a standard high pressure “E” tank for backup in case of a power failure and also for additional oxygen flush flow. The built-in “E” tank manifold on the Pureline M6000, OC6000 and OC6200 models also allows for mobile use of the machine.

Reliability

Supera strives to make oxygen concentrators as easy to use and maintenance free as possible. The controls of each machine are large and easily accessible, and each machine is built with a low center of gravity for extreme stability. When you use a Pureline oxygen concentrator, you don't have to worry about buying, storing or replacing tanks, hoses or regulators. Pureline concentrators supply oxygen “on demand”, which means you'll never run out of oxygen.

Supera is confident that their concentrators are the best available, and backs that confidence with an industry-best 3-year warranty. Pureline oxygen concentrators are absolutely safe to place in any veterinary practice requiring an oxygen supply and guaranteed to work both properly and safely for many years.

For more information on Pureline Oxygen Concentrators or Supera Anesthesia Innovations, please call 877-620-1500 or visit http://www.superavet.com.

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