Small Animal Anesthesia

By Joel Malkoff

An anesthesia system designed to accommodate the physiological characteristics of small animals, including rats and mice, has the potential to provide great practical value to the life science research community.

Small animal surgery requires an investment in equipment and time. The task of anesthetizing research subjects is complicated by the equipment itself, which is designed for use on larger species, such as humans or horses.

Laboratory animal anesthesia is governed by societal concerns to minimize harmful exposure to the research subjects and to the people performing the surgery. Today's economy puts pressure on laboratories to conserve time and resources while maintaining successful research. A miniaturized anesthesia system designed to administer inhalant anesthetics to small animals can address those challenges by providing the following advantages:

- Improved laboratory safety by minimizing exposure to anesthetic gas
- Precision anesthetic dosing resulting in faster, more efficient performance of procedures, and reducing morbidity rates
- Reduction of expense by using less anesthetic, eliminating outside calibration services, improving laboratory space utilization, and increasing successful outcomes

Introduction

Compared to injectable anesthetics, inhalant agents offer an improved level of control over the depth and duration of anesthesia, especially for prolonged procedures. Small animals metabolize and eliminate gaseous anesthetics much faster than injectable agents, enabling rapid recovery. For small animal surgeries, inhaled anesthetic is safer and increases the chance for successful outcomes.

Volatile anesthetics has potential disadvantages, including the need for expensive equipment and materials, dedication of facility space to housing equipment, and potential exposure of personnel to anesthesia. A complete system would require a source of oxygen or medical air to mix with the anesthetic, a flowmeter, a vaporizer, an induction chamber, a ventilator, a scavenging device to capture excess gas and analyzers to monitor animal health throughout the course of the procedure. The amount of equipment required for using inhalant anesthetics may seem prohibitive for some laboratories.

Designed for Small Animals

The design of a new system based on the physiological characteristics of small animals, specifically rats and mice, offers advantages over existing systems. Anesthesia equipment for small animal use has historically been based on designs intended for use with larger species. For example, vaporizers marketed for use with laboratory mice have the same design characteristics as those used to anesthetize humans or horses. Veterinarians and technicians are accustomed to anesthetic vaporizers with a liquid capacity of 150ml to 350ml, weighing 8 or 9 kg (18.6 or 19.4 lbs.). Dosage adjustments are set with a large dial that regulates the mixture

of anesthetic gas with a carrier gas. Periodically, vaporizers require calibration and certification to assure safe and efficient operation, and require being decommissioned and sent to a professional service.

Kent Scientific redesigned the electronic and fluid controls used in traditional anesthetic vaporizers intended for small animal use, which resulted in a new system with significant performance improvements. Included are an Integrated Digital Vaporizer (IDV) that is significantly smaller than traditional units, combined with a digitally controlled syringe, an internal airflow pump and a flowmeter mounted on a compact panel slightly larger than a telephone book (21.5 cm x 29.5 cm x 7.5 cm) weighing 1.7 g (3.75 lbs.). Airflow to the Integrated Digital Vaporizer is provided by a compressed gas source connected to the rear panel or by the system's internal airflow pump. Digital controls allow users to set the exact temperature and flow rate of the IDV. The temperature and airflow remain constant regardless of environmental changes.

A standard gas-tight glass syringe used to deliver anesthetic agents replaces the typical 300ml vessel used by traditional vaporizers. The system accommodates syringe sizes from 1ml to 25ml. Precise dosage of anesthetic agents is administered with minimal waste occurring from filling or evaporation. Using a traditional vaporizer, a 30-minute surgery with a gas concentration of 2.5% isoflurane may consume as much as 25ml of anesthetic agent. The same procedure performed with this system consumes only 0.3ml of isoflurane.

Precision performance is afforded with the small size and solid-state digital design of the Integrated Digital Vaporizer (IDV). The system is pre-calibrated for use with isoflurane, eliminating the requirement for periodic calibration. Initial anesthesia using the induction chamber supplied with the system, results in very little waste being generated. A charcoal filter is supplied to capture unused and exhaled anesthetic, so there is no gas scavenging system required.

Additional Components

Unless the surgery is of extremely short duration, the animal must be maintained under anesthesia outside of the induction chamber while surgical manipulations are carried out. After initial anesthetization, a breathing system is required.

A sophisticated automatic ventilator module can be added to the same panel on which the Integrated Digital Vaporizer (IDV) and pump are installed, maximizing space utilization in crowded laboratory settings. The automatic ventilator module employs allometric formulas to determine the correct tidal volume and respiration rate for normal artificial ventilation based on the animal's weight as entered by the system user. Volume-controller and pressure-controlled ventilation are both available offering the user convenient choices in operating parameters to assure animal safety.

The system design improves sensitivity and precision by delivering vaporized anesthetic to the animal directly from the IDV through the inspiratory tubing line. This configuration also reduces waste and diffusion of anesthetic agents that result when vaporized anesthetic flows from the IDV through an external ventilator to the animal. Proper procedure for using anesthesia includes continuous monitoring of the animal's vital signs. Pulse oximeters measure the adequacy of lung gas exchange, an important indication of respiratory function. In the process, heart rate is determined as well. As an additional module for the system, the pulse oximetry/heart rate monitoring module measures and tracks oxygen saturation, heart rate, perfusion and respiration rate. Measurements are taken using paw sensors specifically designed for use on mice, or a large Y-clip sensor, which is recommended for use with rats and larger animals. The sensors use miniature LEDs and light sensors to transmit and receive the red and infrared light, proportional to the size and translucence of the mouse paw.

Combining these functions in one digital device enables users to view the parameters of different functions on one interface. Different alarms may be set for different out-of-range values giving users an extensive report of the procedure. Data may be exported using the USB port to computers for archive and additional evaluation. For certain applications, such as laboratory procedures in compliance with federal regulations, the system enables digital signatures.

Conclusion

An anesthesia system designed to accommodate the physiological characteristics of small animals during surgery, particularly rats and mice, provides great practical value to the biomedical research community. By combining the capabilities provided by stand-alone vaporizers, ventilators and monitoring equipment into a compact, digitally controlled system, performance is enhanced. Anesthesia is achieved in a manner that is safer to personnel and the animal patient, while use of anesthetic materials and facility space is optimized. Surgical outcomes relating to utilization of anesthesia are improved.

Agent Duration Chart

Isoflurane

Anesthesia Percentage (in hours)

Minute Volume

	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5
25	26.7	21.3	17.8	15.2	13.3	11.9	10.7	9.7	8.9	8.2	7.6	7.1	6.7	6.3	5.9	5.6	5.3
50	13.3	10.7	8.9	7.6	6.7	5.9	5.3	4.8	4.4	4.1	3.8	3.6	3.3	3.1	3.0	2.8	2.7
75	8.9	7.1	5.9	5.1	4.4	4.0	3.6	3.2	3.0	2.7	2.5	2.4	2.2	2.1	2.0	4.7	4.4
100	6.7	5.3	4.4	3.8	3.3	3.0	2.7	2.4	2.2	2.1	4.8	4.4	4.2	3.9	3.7	3.5	3.3
125	5.3	4.3	3.6	3.0	2.7	2.4	2.1	4.8	4.4	4.1	3.8	3.6	3.3	3.1	3.0	2.8	2.7
150	4.4	3.6	3.0	2.5	2.2	2.0	4.4	4.0	3.7	3.4	3.2	3.0	2.8	2.6	2.5	2.3	2.2
175	3.8	3.0	2.5	2.2	4.8	4.2	3.8	3.5	3.2	2.9	2.7	2.5	2.4	2.2	2.1	2.0	3.8
200	3.3	2.7	2.2	4.8	4.2	3.7	3.3	3.0	2.8	2.6	2.4	2.2	2.1	2.0	3.7	3.5	3.3
225	3.0	2.4	2.0	4.2	3.7	3.3	3.0	2.7	2.5	2.3	2.1	2.0	3.7	3.5	3.3	3.1	3.0
250	2.7	2.1	4.4	3.8	3.3	3.0	2.7	2.4	2.2	2.1	3.8	3.6	3.3	3.1	3.0	2.8	2.7
275	2.4	4.8	4.0	3.5	3.0	2.7	2.4	2.2	2.0	3.7	3.5	3.2	3.0	2.9	2.7	2.6	2.4
300	2.2	4.4	3.7	3.2	2.8	2.5	2.2	2.0	3.7	3.4	3.2	3.0	2.8	2.6	2.5	2.3	2.2
325	2.1	4.1	3.4	2.9	2.6	2.3	2.1	3.7	3.4	3.2	2.9	2.7	2.6	2.4	2.3	2.2	2.1
350	4.8	3.8	3.2	2.7	2.4	2.1	3.8	3.5	3.2	2.9	2.7	2.5	2.4	2.2	2.1	2.0	1.9
375	4.4	3.6	3.0	2.5	2.2	2.0	3.6	3.2	3.0	2.7	2.5	2.4	2.2	2.1	2.0	1.9	1.8
400	4.2	3.3	2.8	2.4	2.1	3.7	3.3	3.0	2.8	2.6	2.4	2.2	2.1	2.0	1.9	1.8	1.7
425	3.9	3.1	2.6	2.2	2.0	3.5	3.1	2.9	2.6	2.4	2.2	2.1	2.0	1.8	1.7	1.7	1.6
450	3.7	3.0	2.5	2.1	3.7	3.3	3.0	2.7	2.5	2.3	2.1	2.0	1.9	1.7	1.6	1.6	1.5
475	3.5	2.8	2.3	2.0	3.5	3.1	2.8	2.6	2.3	2.2	2.0	1.9	1.8	1.7	1.6	1.5	1.4
500	3.3	2.7	2.2	3.8	3.3	3.0	2.7	2.4	2.2	2.1	1.9	1.8	1.7	1.6	1.5	1.4	1.3

Syringe Size: 2ml 5ml 10ml

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