ULTRA-COMPACT ANESTHESIA INHALATION AID DEVICE FOR ZERO GRAVITY AND MULTIGRAVITATIONAL ENVIRONMENTS

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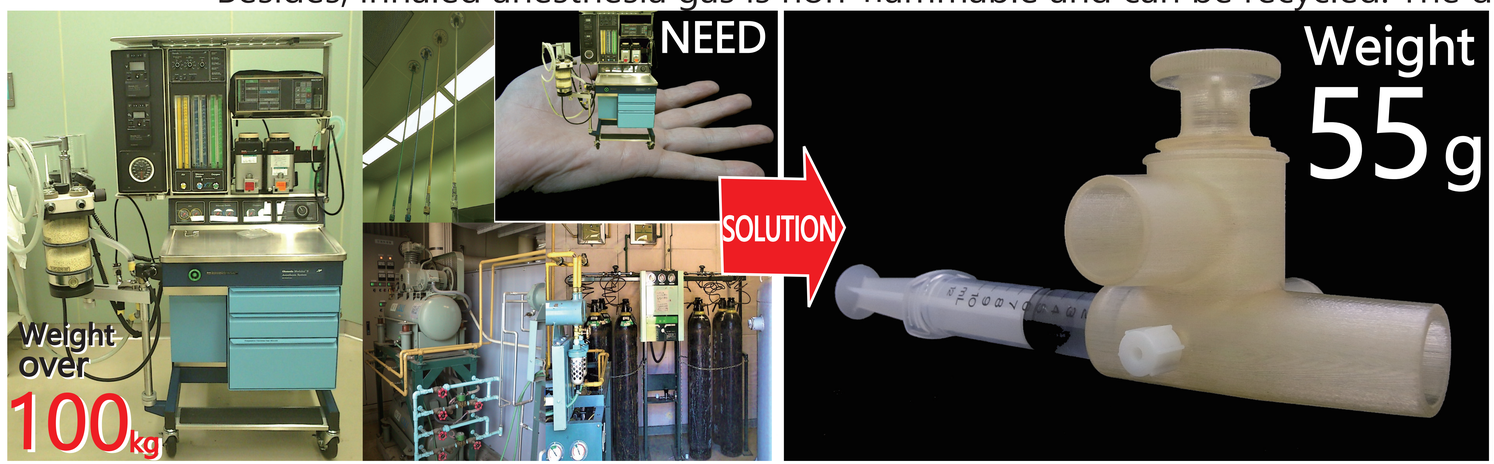
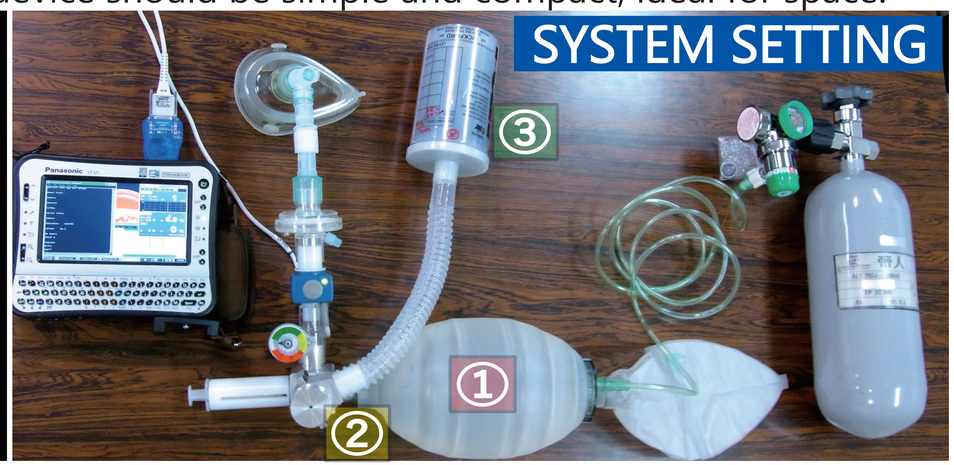
Background: Inhaled anesthesia can be modulated by ventilation, which is safer and more comfortable than intravenous anesthesia. Besides, inhaled anesthesia gas is non-flammable and can be recycled. The device should be simple and compact, ideal for space.

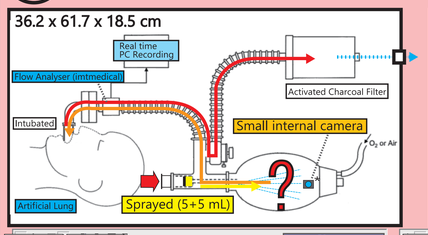


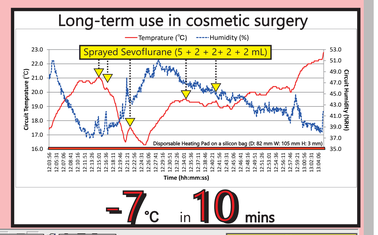


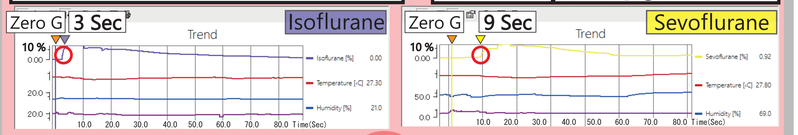
A new 3D printable device was invented which, by fitting to a conventional bag valve mask (BVM), allows the addition of 3 KEY functions of inhaled general anesthesia systems: ①Vaporizer, ②Ventilator, ③Scavenger. Already tested on Animal subjects (Rat, Dog, Micromini Pig) and Human sedation, with good results.
Our device is ultra-compact, ideal to be used on a spaceship or a space station, but no one knew whether the inhalation anesthesia method would work in a zero gravity environments.

Objective: To effectively and safely perform Modified inhaled anesthesia in zero gravity environments.

① Q: Can the anesthetic be vaporized even in Zero Gravity?



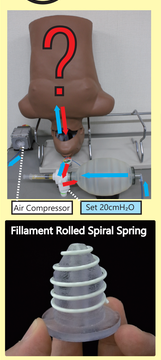




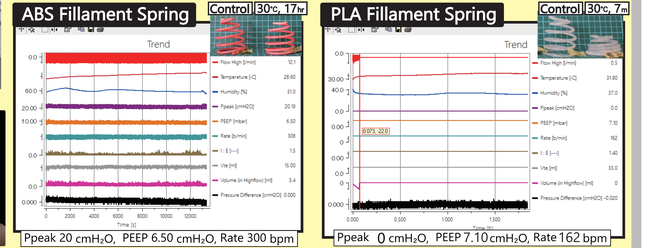
A: YES. But when used for a long time, the temprature drops and the efficiency decreases.

* We couldn't observe the vaporization of sprayed isoflurane & sevoflurane by the small internal camera.

② Q: Can ventilator valve work even in weightless?



The device was attached upside down to a flow analyzer (PF-300, imtmedical), an endurance test was carried out on the ground **(300 bpm, 29-31 °C, 50 % of humidity)**.



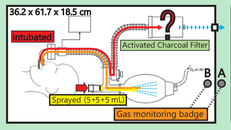
A-1: Cleared for **1 MONTH** of continuous operation*

*864000 Continuous Strokes (Record is still being updated)

A-2: Completely stopped after **7 mins**

③ Q: Can anesthetic gas contamination be prevented?

"VetEquip's VaporGuard™ Activated Charcoal Filter that prevented a waste anesthetic gas break-through. Effective in any position or orientation." - by VetEquip's WEB



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Analytes Requested	Quantity Found Total	RptLmt	Units	Sample Vol. (L)	Time	Concentration Found	RptLmt	Units
SEVOFLURANE	45.7	3.0	UG	1.42	180	3.9	0.28	PPM
SEVOFLURANE	38.1	3.0	UG	1.42	180	3.3	0.26	PPM

Approved On: 12/7/20

A: Experiment Cabin Space (**123 m³**)

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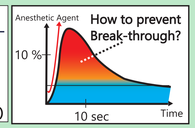
Analytes Requested	Quantity Found Total	RptLmt	Units	Sample Vol. (L)	Time	Concentration Found	RptLmt	Units
ISOFLURANE	969	3.0	UG	1.42	180	91	0.28	PPM
SEVOFLURANE	2780	3.0	UG	1.42	180	240	0.26	PPM

Approved On: 9/14/20

B: Experiment Hard Container (**0.01 m³**)



A: It might be possible to reduce air contamination when there is no need for drug refill. By using a LM or ET tube some leakage can be prevented.

Discussions:

- To maintain anesthesia, just add agent as needed.
- To lower the temperature in the anesthesia circuit due to heat of vaporization, it is good to heat the silicone bag with the physician's hands or body heat.
- It is also useful to heat the anesthesia delivery tube with an electric heating coil.

- Manual foot pump that does not require electricity is useful in space.
- Spiral spring is superior to plate-shaped spring, it is more flexible and has a wide stroke width.
- The spiral spring can be easily produced in a short time by wrapping a filament around the 3D printed shaft and heating it. (put it into space food warmer for 15 mins)
- ABS is the most suitable material for the ventilator.

- It was necessary to develop a pressurized bottle for the administration of the anesthetic agent in the weightless environment.
- Leak of anesthetic gasses might be prevented by a thicker seal of the tubbing of the activated charcoal filters or by increasing the size of the filter.
- However, in order to contribute to an efficient use of limited resources in space, development of the device for recycling exhaled anesthetic gas is now considered to be our most important development and research. (Recycled Anestesia)

Conclusions: Our devices could be useful for the interplanetary, deep space and space long term manned missions, there will also be spinoffs for having in Earth more simple and compact devices.