An Autonomous, Low-Cost Bag Valve Mask for Emergency Responders

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Problem
Acute respiratory failure leads to over 1 million people in the US being admitted to the emergency department per year [3]. The current method of treatment, bag valve masks, does not have a way of measuring pressure or flow, often resulting in lung damage [2].

Background
Acute respiratory failure is a sudden onset of:
- Difficulty breathing [4]
- Shortness of breath or rapid breathing [4]
- Unconsciousness [4]

Responders often use bag valve masks (BVM) (See Figure 2) to establish emergency airway support for the patient [2]. However, there is no feedback of the pressure and flow being delivered, leading to:
- Lung injury [4] (barotrauma)
- Over ventilation [4] (hyperventilation)
- Increased morbidity and mortality [4]

Objectives
Design a portable, non-invasive, low-cost bag valve mask with autonomous pressure and flow regulation for patients needing emergency airway support in low resource areas to address BVM complications and in turn reduce mortality rates amongst patients with acute respiratory failure. The current methods of treatment, bag valve masks, does not have a way of measuring pressure or flow, often resulting in lung damage.

Methods

3a) Diagram showing the components of the bag valve mask.

3b) Diagram showing the autonomous bag valve mask.

4) Diagram showing the prototype device.

Our prototype device was evaluated for:
- Whether air is supplied at sufficient volume for patient ventilation with safe pressure/flow vitals (See Table 1)
- Linear regression mapping motor speed to volumetric flow rate (See Figure 5)

Results

Our design (See Figure 3a and 3b) and prototype (See Figure 4) was tested using:
- An adult BVM bag
- Pressure bulb and sensor
- BioRadio spirometer (measures flow rates)
- Python code and EXCEL

Conclusions
We were able to satisfy at least 2 of our criterion:
✓ Non-invasive (Requires no intubation)
✓ Pressure and flow regulation/sensors

Future Work
- Time and budget being a major constraint here are some potential areas of improvement for the future:
  - Design an integrated circuit to reduce electrical interference and improve portability
  - Perform pressure testing to determine if the supplied inspiratory pressure is sufficiently low to avoid barotrauma
  - Determine optimal materials for the final product (we were limited in our materials due to our budget)
  - Add a power source (12+ volts to accommodate both the motor and Arduino)

Acknowledgments
We would like to thank Dr. Conrad Zapanta, Samuel Moss, Kyle Bannerman, Ryan Bates, Sarah Hargett and Keshav Reddy for helping and supporting us throughout our design process.

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