The Feasibility of Anesthetic Drug Delivery by a Valve-Less Micro-Pump

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Introduction: Globally, one of the biggest health inequalities is the lack of access to essential surgical services in low resource settings [1]. Safe delivery of anesthesia is crucial to address the need for increased surgical services. Intravenous administration of agents such as ketamine requires less complicated equipment (i.e. syringe pumps) than the administration of volatile agents that need gas delivering anesthesia machines fitted with vaporizers. Even so, conventional syringe pumps remain large, complex and costly. In this study, an alternative method of drug delivery by disposable valve-less diffuser micro-pumps [2] is explored.

Method: A valve-less diffuser pump is realized by the 3D printing of the pump body in resin with 25 µm resolution stereolithography (Fig. 1a). The body is a 6.4 mm thick disc, 25.4 mm in diameter. The driving element is a 20 mm brass disc with piezoelectric coating (a widely available piezo "buzzer"). The disc is driven by an off-the-shelf audio power amplifier causing large oscillations at ~300Hz (Fig. 1b). The difference in flow resistance at ingress and egress of the pump chamber below the disc results in liquid being forced through the pump. The pumped liquid (water was used during testing) is measured by a precision scale as a function of time.

Results: The prototype demonstrated the ability to pump at a rate of 0.85 ml/min (51 ml/h) in the absence of back-pressure, and displayed a linear infusion profile over time (Fig. 1c). This rate is adequate for maintenance of anesthesia but insufficient for induction and bolus action. In addition, the prototype is currently not able to overcome the back-pressure observed in drug delivery when connected to a patient. More optimization is needed to determine whether these shortcomings are fundamental to the valve-less design, or if a more accurate pump body design and a dedicated high-voltage piezo driver can increase rates and overcome the back-pressure.

Conclusion: With further development, it may be possible to realize a coin-sized, disposable anesthetic delivery system, which can be manufactured for a few cents and provide safe drug delivery in resource constrained environments around the world. Such a system might also prove useful for delivering other medications, such as oxytocin.

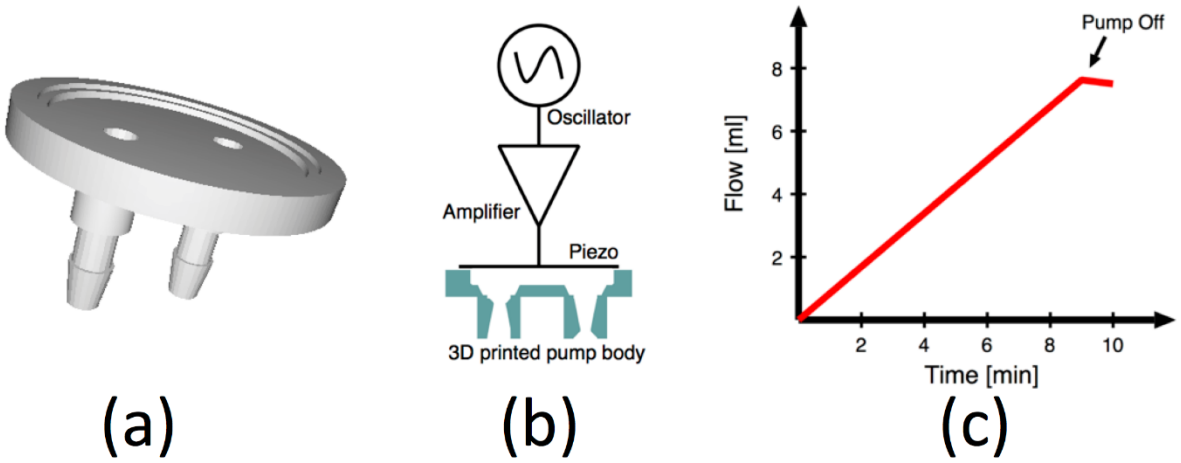

Fig.1: 3D printed micro-pump body (a), system diagram (b) and infusion profile using initial measurements (c).

References: [1] Anesthesiology 2016 Mar;124(3):561-9. [2] Sensors and Actuators 84 (2000) p. 165