The artificial trachea: A mission of creativity, perspiration, and perseverance

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Central Message

Development of a successful and repeatable artificial airway segment is attainable, but not without significant challenges and inspiration.

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“So attracted have surgeons been by the illusory simplicity of developing a conduit to replace native trachea.”

— Hermes Grillo, 2002¹

When I ponder amazing advances in science, I often reflect on the inception of space travel. The Apollo space program was an all-hands-on-deck race to the moon that was launched not long after the Russian artificial Earth satellite, Sputnik 1, streaked like a comet across global skies. That 3-month orbital event sparked inspiration and challenged the world's great thinkers to push farther into space and explore the boundaries of technology, creativity, and nerve. Like Sputnik and then later Project Apollo's lunar landing in 1969, circumferential segmental tracheal replacement represents the zenith of tracheal surgery in our time. I will be the first to admit that reading about scientific breakthroughs in tracheal replacement research never fails to induce awe and wonder in me much like what I experience when I read about early experiences with space travel. Yet, despite decades of innovative research in tracheal replacement,^{2,3} we have yet to fully realize our ambition.

What obstacles remain in the path to achieving this goal? First of all, inasmuch as the airway seems like a simple, hollow conduit, it is a uniquely adapted and highly specialized organ that has proven very difficult to replicate. Also, one has to recognize that advancements in surgical techniques have enabled the resection and primary reconstruction of up to half of the adult airway. This revelation altered the landscape of artificial trachea research. Once the knowledge gap in surgical techniques was surmounted, the indications for tracheal replacement became rare, to the point that only the most specialized centers on the planet saw enough volume in these diseases to generate interesting research.

Sakaguchi and colleagues⁴ present a portion of their animal research on an artificial tracheal construct. It is important to

recognize that this is preliminary work, but like space travel, it is pioneering and inspiring. Praise is due to this research group for describing the mechanical force characteristics of the trachea (in this case of a beagle) and creating an alloy construct that can imitate the natural properties of the wind-pipe. But before we can celebrate this victory and translate this for human patients, further study is needed. A critical theme to Dr Sakaguchi's study was that only 2-cm defects were tested. Defects like these are too small to ever be considered a challenge for primary repair, no matter how alluring the idea of a construct seems. Another point of criticism can be leveled at our methods of publication. This study reports on 5 dogs that did well with 2-cm defects, but it is important to evaluate the body of work that details the scientific failures as well as the successes. The results in this article represent an advance in the field and are significantly better than similar experiments performed in previous decades during a time when bioengineering was still fairly young.⁵ I believe that Sakaguchi and colleagues⁴ are planning to hone their research and replace long segments of the airway before suggesting that their modality is ready for clinical trial. History in this field leads us to implore that from an ethical standpoint we ensure that new devices have gone through the rigor of scientific testing, peer review, and hospital approval, and that clear indications are adhered to before offering this to human patients.

Finally, I offer that the goal of successfully and repeatedly implanting an artificial airway segment is attainable, but I doubt that it will be a single discovery that leads to an answer. Rather like in this study, the solution will be a

combination of tissue-regeneration methods, tissue transfer, and mechanical engineering. It is only a matter of time before the key combination is unlocked and becomes efficient enough for translation into our operating theaters.

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