Ultrasound to the Rescue: Improving Intubation in the NICU

Researchers at Drexel are finding a new use for an old technology: ultrasound. Jane McGowan, M.D., professor of pediatrics and director of the neonatal intensive care unit at St. Christopher's Hospital for Children, and Peter Lewin, Ph.D., Richard B. Beard Professor in Drexel's School of Biomedical Engineering, Science & Health Systems, hope that ultrasound may someday replace X-ray imaging as the standard way to determine if an intubated patient's endotracheal (ET) tube is in the proper position. They are particularly interested in developing this for neonatal populations but, if the technology is successful, it could have much broader applications.

The change would promise numerous benefits.

First, it would reduce the neonate's exposure to ionizing radiation. Intubated patients often need tubes replaced or repositioned, and each instance of this requires another X-ray. In the NICU, any change in an infant's respiratory status (such as increased CO_2 or decreased O_2 levels) must be attended to. The culprit is often an ET tube that has been displaced, but this must be confirmed via X-ray. If the tube has moved, it will be repositioned and then rechecked using another X-ray. These repeated exposures to ionizing radiation can add up quickly, which is of particular concern in newborns. In comparison, there are no known hazardous outcomes associated with diagnostic levels of ultrasound exposure. Furthermore, the neonatologist can watch the tube in real time as it is being repositioned, and be assured that it is placed properly without needing before and after images.

The ultrasound technology is also less cumbersome than even the smallest portable X-ray machine. It is about the size of a smartphone, with the ultrasound probe adding some additional bulk. These handheld devices are already present in most hospital emergency rooms. No alterations to the currently available machines would be required. The scan can be performed by NICU personnel on hand, rather than calling in the radiology department.

McGowan first had the idea while she was caring for infants in the NICU and noticed how frequently ET tube placement needed to be checked. She discussed her idea with Dr. Banu Onaral, director of the School of Biomedical Engineering, who then made the connection between McGowan and Lewin, an expert in the field of ultrasonography, and their collaboration began.

With the help of funding from the Coulter Foundation, the Drexel team has already had some success visualizing a typical ET tube via ultrasound in a tissue phantom (in this case, a cube of agar gel with chemicals added to mimic the tissue characteristics of an infant's chest) with a simulated trachea. Hoping to create the best possible chance for success, they are now exploring several avenues to improve the images.

First, they are manipulating various parameters of the ultrasound field, including frequency, pulse duration, and mechanical index. Next, they are modifying the ET tube itself to improve its echogenicity. This involves creating small air voids, or microbubbles, within the walls of the tube.

Once the researchers have found the best model, they will move to preclinical trials, which will likely lead to further modifications of the tube, McGowan said. If those tests are successful, the study will move to human subjects. The modified ET tube would most likely require FDA approval. The FDA also regulates the amount of ultrasound exposure a patient can receive, so it is important that the researchers maximize the accuracy and efficiency of the technology, allowing the scan to be quick and the resultant images easy to interpret, while still complying with FDA guidelines regarding ultrasound exposure levels.

A pediatrician and an engineer are improving the technology for intubating tiny patients.

It is likely that most physicians could learn how to check ET tube position using this device with a minimum of additional training. There is already a push toward additional training in ultrasound technique and interpretation for medical students, due to the large and ever-growing number of uses for this technology. In fact, McGowan's idea has been met with excitement from various other specialists, including a critical care physician who imagined the technology transferring to intubated adult patients, and a nephrologist who thought ultrasound could be used to check the placement of dialysis catheters.