Development of an Animal Model to Test an Active Noise Cancellation System for Infant Incubators

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Medical, therapeutic and technological advancements, including the use of neonatal incubators and the development of neonatal intensive care units (NICUs), have significantly increased the survival of premature and ill infants. However, high levels of noise in the NICU result in numerous adverse health effects, including hearing loss, sleep disturbances and other forms of stress. Even normal levels of ambient noise may be of considerable risk for the most premature infants. It is well documented that the mammalian auditory system is most vulnerable to environmental influences immediately after the time that it first begins to function. In humans, the critical period spans approximately weeks 24–30 of gestation, which corresponds to the age when the most extremely premature infants are now able to survive ex utero. Premature infants are, therefore, at high risk for environmentally-induced hearing loss. Development of techniques that increase the amount of protection against noise-induced hearing loss (NIHL) could significantly improve quality of life, both while neonates are in the NICU, and long term. The long-term goal of our research is to develop a version of an existing active noise cancellation (ANC) system that can be used to reduce sound levels in NICU incubators, in a manner that does not require considerable space. The core component of the ANC system is a carbon nanotube-based transparent actuator, which is controlled by an adaptive controller so that an exact out-of-phase anti-noise can be produced from the actuator (Yu et al, 2005, 2007). The basic principle of the ANC system is to cancel the unwanted primary noise through the introduction of a destructive anti-noise sound. Experimental results showed that a reduction of greater than 15 dB in the primary noise can be achieved by the ANC system (Yu et al. 2007). Ultimately, this transparent actuator could be built into the side of an infant incubator, providing noise protection without adding equipment to the already crowded NICU environment. Before human trials can begin, animal studies must be completed to demonstrate that the ANC system can prevent the hearing loss that results from exposure to incubator noise during the critical period. One complication in animal testing is that individual species respond to different frequency ranges. For example, the human cochlea is most sensitive to sound frequencies between 2 and 5 kHz, while mice respond best between 8 and 16 kHz. It was hypothesized that a frequency translation based on the cochlear frequency/place relationship could be used to convert incubator noise into an appropriate stimulus for testing of the ANC in mice. Neonatal mice were exposed to untranslated incubator noise (IN) or frequency-shifted incubator noise (FSIN) during the critical period, and hearing sensitivity was measured following the noise exposure. IN had no effect on acoustic thresholds, but FSIN caused a moderately severe (60–70 dB) high frequency hearing loss in all mice tested. Based on these data, the FSIN stimulus represents the first accurate model of neonatal noise-induced hearing loss. Future experiments will use this model to test the ability of the ANC system to protect against NIHL.

Transcatheter Aortic Valve Deployment: Interactions Between Native Leaflets and Coronary Ostia

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During the delivery of a transcatheter aortic valve, the native leaflets are pressed toward the vessel wall when the stented valve is deployed, but the proximity of the native leaflets to the coronary ostia following deployment is not fully understood. Fluoroscopic (F) and endoscopic (E) video footage was gathered from isolated human hearts (n=3). Balloon valvuloplasty (BAV) was performed with a non-compliant balloon, followed by contrast injection into the coronary ostia. Images (F) captured the perpendicular distance from the balloon to the ostia (ostium depth). A nitinol stent was delivered to the aortic position trans-apically. Images (E) measured the distance between the native aortic leaflet and the lowest point of the coronary ostium (ostium height). Additionally, cadaveric hearts (n=23) underwent extensive anatomical analyses using a 3D digitizing arm in addition to the described procedures. BAV in perfusion fixed hearts gave left and right ostium depths of 5.28 ± 1.49 and 5.34 ± 1.85. Images (E) from the perfusion fixed human hearts showed left and right ostium heights of 3.2 ± 2.9 mm and 4.3 ± 2.4, respectively. 2 of the 23 perfusion fixed human hearts studied had negative ostia heights, but the effect on coronary flow is not known.