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"Reducing Whole-Body Vibrations in Neonatal Transport"

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Tong BME Design Award Executive Summary

Transport of critically ill neonates via ambulance to neonatal intensive care units (NICU) is necessary to gain access to life-saving equipment and personnel. Transport induces stressors such as whole-body vibrations (WBV) to neonates, who have fragile biological support systems. Vibrational forces experienced during transport increase the odds of severe brain injury, including intraventricular hemorrhaging (IVH), which can lead to neurodevelopmental impairment or death. Currently, there is no standardized device to mitigate vibrational forces during neonatal transport.

The current methods of minimizing vibrations and mechanical forces by the UW Hospital's neonatal transport teams involve the use of a Geo-Matrix gel mattress which is placed under the neonate with a five-point harness securing the neonate in place using straps across the shoulders, hips, and thighs. The current method does very little to attenuate vibrations and it features many rigid parts directly in contact with one another. Several attempts were made to redesign the existing isolette mechanism to address this issue, however, most of these proposed designs involve substantial alterations to the current transport setup, have a complicated design, and lack experimental testing to verify their ability to reduce whole body vibrations.

Working closely with employees of UW-Health, a spring and damper combination design is proposed to lessen these harsh vibrations. A total of four springs and dampers are to be placed in parallel between the inner and outer trays of the transport isolette to isolate the neonate from the vibrations felt by the incubator system. Combining both oscillating and damping components in the design allows for maximal vibration reduction, without requiring a redesign of the existing infrastructure of the system. As a result, it can be universally and inexpensively implemented in all transport vehicles, unlike other proposed solutions.

This spring and damper design has a large potential customer base, catering to the over 398 neonatal transport teams across 1384 level II, III, and IV NICUs currently in service in the United States according to Karlsen et. al. in 2011. Of those, each has multiple ambulances, and potentially transport helicopters, utilized for the transport of ill neonates. The design can also be competitively priced, as it does not require major revisions to the current systems that would add expenses. Current manufacturing and production costs are only $27 per device, and would likely decrease in mass production.

Preliminary testing without the device was conducted and demonstrated that, relative to the floor of the ambulance, there are increased vibrations felt within the incubator that exacerbate the detrimental effects on the neonate. Using a wireless accelerometer, the vibration frequencies measured in the isolette both with and without the spring and damper design were compared to illustrate a mitigation of the issue upon placement of the device.

The spring stiffness and damping coefficient were calculated to target frequencies in the 17 Hz range for a load of about 6 kg which consists of the neonate, mattress, and tray that rest atop the device. The height of the device is less than 1.5 cm and is able to fit into the incubator without impeding access to the neonate or posing a risk to the medical staff.

Implementation of this device has the potential to drastically improve the safety of transport, delivering the neonate in a more stable condition to the NICU. It also reduces the need for intervention by transport personnel, which can be dangerous and challenging to perform while in motion.