Simulated autonomous aerial vehicle impacts to the pediatric head

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There are about four million autonomous aerial vehicles currently operational for consumer (recreational, sports), public (disaster relief, traffic control, scientific and military), and commercial (package delivery) use. With this number likely to increase in the future, the injury implications of potential crash impacts with these vehicles is important to be studied. The American Society for Testing and Materials (ASTM) is working on developing standards to make these vehicles safe and operable at a minimum risk to humans. The objective of this project was to gain insight into injuries sustained to the pediatric head by using simulated autonomous aerial vehicle impacts utilizing human body finite element models.

The PIPER 6-year-old human body finite element (FE) was utilized. The test environment consisted of a 1 kg autonomous aerial vehicle colliding with the child's head at a speed of 15.64 m/s (35 miles per hour). The vehicle used was a quadrotor with a total span of 363.44 mm. The CAD model for the quadrotor was obtained from open sources, and its finite element model was developed with rigid material properties. A total of six simulations were carried out to examine two impact velocities, two angles of impact and two different copter masses. Head, chest, and pelvis accelerations, neck forces and moments, HIC36 were extracted for different impact scenarios and compared relatively with each other.

From the frontal impact simulation, it is observed that even with a considerably small weight of 1kg, an impact at 35 MPH results in the child's head being pushed back, causing extension in the neck. The chest and pelvis numbers are non-injurious. However, due to impact with the rigid vehicle, a spike in the head acceleration is seen when the blade impacts the head, and a second higher spike is seen when the body of the vehicle collides with the head. Even in the scenario where head acceleration is not severe, there are possibilities of ocular injuries and other bruises/lesions based injuries these autonomous aerial vehicles could potentially cause to the child.

The advantage of using a finite element model is the ability to recreate crash impacts with variations in testing parameters such as impact velocity, angles, positions, materials, and weights. By altering these parameters, we can evaluate the kinematics and kinetics of children exposed to autonomous aerial vehicle crashes. A wide range of scenarios could be simulated to cover various outcomes caused by these impacts. Additional finite element models need to be simulated to identify these injury implications.

This is the first study to document human-vehicle crashes with autonomous aerial vehicles. The data is useful in developing safety technologies and standards that could potentially mitigate pediatric injury in such impacts.