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Vascular System Pressurization Techniques

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This technical note describes the procedures used at HSRI for the pressurization of various regions of the vascular system in unembalmed human cadavers. This technique is applicable to both direct impact tests and whole body impact sled testing and has the advantage of needing access to only one point on the body -- the carotid artery -- thus minimizing possible interference between the pressurization system and the test apparatus. This technique is based on modifications of the method developed by Tarriere, et al. of the Peugeot-Renault Association, Paris, France. The technique involves catheter construction, surgical installation, and pressurization methods.

Catheter construction starts by taking a Foley balloon catheter and removing the center tube section and replacing the section with suitable lengths of polyethylene tubing. Two diameters of tubing are necessary, one for the pressurizing fluid and one for the balloon inflation. The two tubes are inserted in the inlet end and the tip of the catheter. A small lead shot is inserted in the end of the exit port of the tip for the later radiographic location and the port is sealed with epoxy. Holes are then made in the polyethylene fluid pressurization tube before the occluding balloon to allow the fluid to flow out into the occluded blood vessel.

Surgical installation of the catheter consists of locating the carotid artery in the neck and making a short longitudinal incision in it just long enough to allow the catheter to pass through the

artery and into the descending aorta. When it is desired to measure pressure in the ascending aorta, a balloon catheter is inserted through the carotid artery into the descending aorta, just below the level of the heart. A length of additional polyethylene tubing, to act as a pathway for a miniature pressure transducer, is then inserted next to the catheter and into the ascending aorta.

In order to measure pressure in the internal carotid artery as close to the brain as possible, a balloon catheter is inserted through the carotid artery and down into the descending aorta just past the branch of the left subclavian artery to allow for pressurization through both the left and the right carotid arteries. One end of the section of polyethylene tubing is inserted along the outside of the catheter into the ascending aorta while the other end is inserted into the internal carotid artery. A second tube is inserted into the internal carotid artery to allow a miniature pressure transducer to be placed up the internal carotid artery near the base of the brain.

Once all the tubes have been placed in the appropriate arteries, the carotid incision is sealed with quick setting plastic to prevent fluid leakage. The pressurization fluid has consisted of various mediums -- water, water and black india ink, and thickening agent with black india ink. The purpose of the ink is to mark ruptures due to impact while the purpose of the thickening agent is to prevent the fluid from entering the very small blood vessels that communicate with the venous system. By varying the amount of thickening agent in the fluid, the degree of perfusion can be somewhat controlled.

For sled mounted pressurizing a 10 liter air filled container is connected to a 5 liter fluid filled container which, in turn, is connected to the catheter inlet tube. When air pressure is applied to the air container, the fluid is forced into the cadaver. Prior to pressurization, the catheter balloon is inflated to block off the descending aorta. During pressurization, the air pressure in the air container is increased until the pressure in the cadaver vascular system reaches approximately 100 mm Hg as indicated by the pressure transducer. After reaching the desired pressure level, the air tank inlet is shut off leaving the air tank to maintain the fluid pressure.

Some difficulties which have been encountered with this method include encountering carotid arteries which were too small to allow a suitably large balloon catheter to be inserted for complete blocking the descending aorta. This occurred in about 10% of the subjects tested and resulted in slowly filling the remaining regions of the vascular system with the pressurizing fluid, but the desired pressure level could usually be maintained for the test period. Another problem is that complete flushing of the brain vascular system does not always occur -- leading to incomplete perfusion. Also, if other instrumentation has been surgically attached to the body, fluid leakage can occur by this means and precautions must be taken to keep the fluids contained.