Preventing Stroke (Dr. Vince)

Each year about 800,000 Americans experience a new or recurrent stroke, or “brain attack.” Many strokes are caused by a blockage in the arteries carrying blood to the brain; if oxygen carried by blood cannot get to the brain, the result is brain damage and often other physical harm. Carotid stenosis – a blockage caused by plaque build-up in the carotid arteries on either side of the neck – is a significant but treatable risk factor for stroke. In the US, physicians perform more than 100,000 active procedures each year to clear such blockages. However, it is estimated that another 2%-8% of the US population have some carotid stenosis, but do not show the usual symptoms (including high blood pressure, lightheadedness, etc.), making it unclear whether to treat them urgently or not.

Such stenosis can often be detected, without surgery (noninvasively), by devices outside the body that focus ultrasound waves onto targeted arteries. The most often used technique, carotid duplex ultrasound, can visualize the location and extent of plaque and detect changes in blood flow, allowing the doctor to determine how much plaque build-up is already in the arteries. This technique, although valuable, cannot give the doctor enough information to say what kind of plaque is in there. Unstable plaques, from which pieces may break off to block the entire blood flow within an artery, are more dangerous: these must be treated immediately to prevent a stroke. If a plaque is stable, it presents less risk. So it is essential that medical personnel find out quickly and reliably which type is threatening the patient.

Dr. Vince’s team is developing computer software that can do more to analyze ultrasound images of carotid arteries. The new system creates a spectrum where different colors indicate how, where, and how bad the plaque build-up is by using information from scattered ultrasound points that is obtained but not considered during the creation of standard ultrasound images. The team’s goal is to provide a tool that will predict which patients are at increased risk of having a stroke and will aid the physician in determining the best treatment approach.

Summary: Dr. Vince and his team are developing a noninvasive approach to determine quickly an individual patient’s risk of having a stroke and allow the physician to deliver the most effective therapy.

Artificial Heart (Dr. Golding)

Over 23 million patients suffer from heart failure, with 100,000 having no other option but a heart transplant. Unfortunately, the supply of human hearts donated for transplant is very limited, and fewer than 2% of patients who need one will get a transplant. Each year, 25,000 patients die while on the waiting list.

Over the past two decades, considerable research has been aimed at developing artificial hearts that can replace failing human hearts and therefore reduce the need for donor hearts. Although there have been some tremendous successes from a research standpoint, the few existing FDA-approved devices are complex, bulky, and able to fit in only 20% of women and 50% of men.
Researchers in BME have developed a unique total artificial heart that operates silently. It has an elegantly simple design, with only a single moving part, and will fit essentially all adults and many teens. The pump is a continuation of work on rotary pumps, which simplify the operation of the device by eliminating the need for heart valves. Initial testing of our "continuous flow" total artificial heart has shown good results, including very little damage to red blood cells. This device now even has an option for producing a pulse to more closely imitate a heartbeat.

Summary: Dr. Golding and his laboratory team have developed a unique total artificial heart that operates silently, with only a single moving component, and will fit all adults and many teens.

Helping Hearts (Dr. Fukamachi)
Heart failure is the leading cause of death and disability in the United States. About three quarters of a million people die each year due to heart disease, and many hundreds of thousands of patients have a very limited, poor quality of life because their heart is not able to pump enough blood for their activities of daily living. To help the main pumping portion of the heart (the ventricles), pumps called “ventricular assist devices” have been developed and used with some success in patients to boost the blood output of the natural ventricle. However, existing technologies cannot be used in all patients or under all medical indications.

Researchers in BME have built and tested a new ventricular assist device design. The pump design can be scaled up or down to fit different sized people and, with simple modifications to its outside shape, can be adapted to different methods of clinical application. Studies have proven that this prototype device, measuring not quite half an inch in diameter (10 millimeters, 0.45 inch – about the width of a marble) will fit in infants, and yet still provide enough blood flow assistance in adults. A larger prototype (14 millimeters, or about 0.55 inches in diameter) will provide high-level assistance to children and adults. A more miniaturized prototype (4.5 millimeters or 0.17 inches in diameter) can be placed under the skin for emergency resuscitation and other situations where surgery cannot be done; two pumps can easily be placed in patients with right- as well as left-ventricle heart failure. Testing to date has shown high durability and good performance.

Summary: We have developed a small, light, and elegantly simple heart-assist device that is compact enough to be suitable for implantation in infants.

Alternatives to “Triple-A” Surgery (Dr. Ramamurthi)
An abdominal aortic aneurysm (AAA or “triple-A”) is a potentially fatal condition caused by a ballooning of part of the wall of the body’s major blood vessels. AAAs affect nearly 10% of U.S. seniors, with men over 60 and smokers at high risk. As in a tire wall, this condition may lead to a catastrophic explosion (rupture). Surgery is the usual treatment to repair a potential rupture area as no drugs exist to prevent this condition. AAAs develop from an initial subtle injury to the blood vessel; as they progress the protein elastin, which allows blood vessels to expand and contract with normal blood flow, is lost, causing reduced aortic flexibility.

The Ramamurthi team focuses on identifying molecules that can rebuild elastin and the cells that can make elastin. We are trying to prod adult stem cells, obtained from skin samples of triple-A patients, to transform into blood vessel cells that can be used to restore elastin. We are engineering microscopic devices called nanoparticles to ensure predictable release of elastin-preserving or elastin-restoring drugs. This approach is much more precise than giving drugs system-wide by mouth or injection. We think these “nanotherapy” approaches will help speed the development of new, nonsurgical treatments that could stabilize or reverse existing AAAs to a healthy state and provide an option for high-risk elderly patients who are poor candidates for surgery.
Summary: Dr. Ramamurthi’s team is developing new drug- and cell-based approaches to restoring cells and tissues for nonsurgical treatment of abdominal aortic aneurysms.

Improving Angioplasty and Bypass Results (Dr. Graham)

Balloon angioplasties or bypass grafts of the blood vessels to the heart are among the most common procedures performed in the United States, with more than 2,000,000 done each year. Over 500,000 additional procedures are performed annually on blood vessels away from the heart. All these interventions cause damage to the cells lining the blood vessels. These cells must migrate over the injured area to restore the normal lining and prevent narrowing and recurrent blockage of the blood vessels. Oxidized lipids (bad cholesterol) stop the cells from healing these injuries. We have found that this is caused by the abnormal opening of certain calcium channels in the cells. We are developing new treatments to stop the undesirable opening of these channels and promote healing of the blood vessels. In addition, we have found the high-density lipoprotein (good cholesterol) blocks the opening of some of these channels and improves healing. We are studying how this occurs so we can develop better ways to promote the healing of the injured blood vessels after surgery or balloon angioplasty.

Summary: The Graham laboratory is studying the healing of blood vessel injuries after balloon angioplasty or bypass grafts and is developing ways to promote normal healing. This will improve the long-term results of angioplasties, stenting, or bypass grafts for the benefit all patients with cardiovascular disease.