The quest for the bionic arm

June 3 2014

In the past 13 years, nearly 2,000 veterans returned from Iraq and Afghanistan with injuries requiring amputations; 14 percent of those injured veterans required upper extremity amputations. To treat veterans with upper extremity amputations, scientists continue to pursue research and development of bionic arms and hands with full motor and sensory function. An article appearing in the June issue of the *Journal of the American Academy of Orthopaedic Surgeons* (*JAAOS*) reviews the recent advancements in upper extremity bionics and the challenges that remain in creating a prosthesis that meets or exceeds the abilities of a human arm and hand.

During the next 50 years, "I truly believe we will be able to make artificial arms that function better than many injured arms that doctors are saving today," said article author Douglas T. Hutchinson, MD, associate professor of orthopaedics at the University of Utah Medical School, and chief of hand surgery at Primary Children's Medical Center, the Veterans Affairs Medical Center, and Shriners Intermountain Hospital. Advancements in prostheses technology will not only benefit injured veterans but also, eventually, the civilian population with upper extremity injuries that require amputations.

One of the most commonly used upper extremity prostheses continues to be the myoelectric prosthesis. Created more than 50 years ago, this prosthesis allows residual muscles to act as natural batteries to create transcutaneous signals (transmitted through the skin) to control the movements of the prosthetic arm and hand. However, the muscles used most often are the biceps and triceps, which do not naturally translate to

the opening and closing of a hand. In addition, myoelectric prosthetics do not look natural and are heavy, hot, uncomfortable, and not waterproof. Sometimes the socket interface used to attach the prosthesis may interfere with the function of a residual joint such as the elbow.

Because of these challenges—as well as the inability to "feel" the prosthesis—the wearer never achieves fine motor control, the simultaneous use of multiple joints, or full rotation and use of the hand. The prosthesis also requires a long period of learning and adjustment. As a result, only about two thirds of patients properly fitted for upper extremity prosthesis use it daily, with many patients instead choosing to wear a body-operated "hook" device, invented during the Civil War and refined during World War I and World War II. Others choose not to use their prostheses because they prefer the ability to have physical sensation from their stump.

The 2014 federal budget for prostheses research alone is $2.5 billion. The U.S. Department of Defense Advanced Research Project (DARPA) has already invested more than $150 million into their Revolutionizing Prosthetics Program, which is charged with creating an upper extremity prosthesis that will function as a normal human arm does, complete with full motor and sensory functions. According to Dr. Hutchinson, the program has created several advanced upper extremity prostheses, "providing function and ease of learning superior to those of conventional myoelectric prostheses."

However, these prosthetic devices have a long way to go for effective and broad use in patients. Many are heavy and uncomfortable with short-life batteries. Current infection rates with osseous-integrated devices at the prosthesis-skin interface also remain high at approximately 45 percent. Most challenging is the problem of efficiently and accurately sending brain signals through the muscles and peripheral nerves of the arm and hands, which may require the creation and use of a reliable

wireless device or direct wiring through an osseous (bone tissue)-integrated implant.

Answers may be found in combining recent advancements in prosthetic devices with breakthroughs in maintaining nerve and muscle function in badly damaged limbs.

"Orthopaedic surgeons who do peripheral nerve surgery (hand surgeons) will be part of the team that puts these devices into patients, but perhaps more relevant than that will be the way we treat severe near amputations or complete amputations differently," said Dr. Hutchinson. "In an amputation surgery, we will need to preserve muscles and nerves even more than we already do to make this type of later reconstruction more successful."

"We currently spend a lot of time, energy, and money saving hands and arms that truly have a poor prognosis because the alternative, an amputation and an insensate myoelectric prosthesis attached by a socket, is even worse," Dr. Hutchinson added. "As we improve the prosthesis, the options for these severely injured upper extremities will increase."

In addition, the perfection of nerve utilization could potentially aid other conditions, such as cerebral palsy, chronic nerve pain, and brachial plexus injuries.

More information: Read the interview with Dr. Hutchinson, author of "The Quest for the Bionic Arm, appearing in the June issue of AAOS Now.

Provided by American Academy of Orthopaedic Surgeons