Symposium: Recent Advances in Amputation Surgery and Rehabilitation

Editorial Comment: Symposium: Recent Advances in Amputation Surgery and Rehabilitation

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Performing or completing an amputation creates an interesting paradox – *primum non nocere* through the removal of a major extremity. It seems contradictory to believe this simultaneously amazing and horrific process is for a patient's medical benefit. Likewise, public encounters with amputees can be indelibly striking to the uninitiated – the person's loss is both visible and

palpable, the natural question being, "What happened?"

While less than 20% of the nearly 200,000 amputations performed annually in the United States are done to treat the sequelae of trauma, posttraumatic amputees account for nearly half of all surviving amputees [14]. The reason for this discrepancy is that, sadly, amputations performed to treat the skeletal complications of vascular

disease, diabetes, and cancer tend to occur late in the patients' lives. By contrast, amputations for trauma generally are performed in younger, more-active patients, with nearly 1,000,000 posttraumatic amputees in the United States alone. Consequently, the surgical care, rehabilitation, and prosthetic care of this important patient population remains a critical public health issue. Trauma-related amputee care provides a unique opportunity to restore function to generally younger, active individuals with excellent pre-morbid status, high expectations, and long life expectancies.

According to the Department of Defense Amputee database, the recent wars in Iraq and Afghanistan have produced more than 1600 wounded warriors who have sustained the loss of more than 2200 limbs. These numbers are remarkably similar to those observed in World War I and Korea, but dwarfed by World War II and the US Civil War at nearly 15,000 and 50,000 amputees, respectively [1, 3, 4, 8]. Despite ubiquitous personal body armor, rapid aeromedical evacuation, and the far forward movement of advanced medical resources resulting in greater survival of increasingly devastating injuries (including a

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majority of injury burden to the extremities), amputations continue to represent a minority of major battlefield injuries [7]. Even so, these patients represent an important minority.

Unfortunately, amputation surgery is often viewed as a simple procedure with predictable outcomes, and therefore, frequently relegated to junior trainees. Amputations are further maligned as ablative treatment failures – less “sexy” than advanced, complex, and often novel limb salvage techniques. In reality, the procedures are anything but simple, the techniques nuanced and fraught with complications. Furthermore, amputation as a reconstructive procedure can often improve patient function and outcomes, and may be actively requested by some patients [10] – this is simply treatment, not failure. Most importantly, if functional and psychosocial outcomes following amputation are predictable, they are predictably poor for many patients [2, 5].

There is hope. As this symposium demonstrates, advances in amputation surgery, prosthetic technologies, and rehabilitation continue at an impressive pace. Despite the somewhat storied and lengthy history of both amputation surgery and prosthetics – many common procedures and prostheses utilized today are veritable antiques – the related fields are anything but stagnant. Indeed, recent years have seen the advancement and

refinement of osseointegration technologies for direct skeletal attachment of prostheses, with promising results found in Europe [11, 13]. Targeted muscle reinnervation (TMR) techniques can now improve intuitive terminal device control, while also potentially decreasing neuroma-associated and/or phantom pain as suggested by two papers in this symposium [6, 9]. Advanced pattern recognition, myoelectric signal interpretation, and transformation systems

are complementary technologies which yield greater output from TMR, as well as some nonTMR patients via two small chips. These chips are compatible with most commercially available myoelectric upper extremity prostheses. Translational research continues on other advanced techniques of terminal device control, including implantable myoelectric sensors, direct neural or cortical interfaces, and numerous haptic feedback technologies.

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More than 20 years have passed since the release of the first microprocessor knee, but recent prosthetic developments include powered lower extremity prostheses and newer prosthetic hands, wrists, and fingers with additional functions and degrees of freedom. Lower extremity myoelectric prostheses also are on the near horizon. In the meantime, functional outcome and gait studies remain important to maximize the results of rehabilitation, and to demonstrate objectively the benefit of recent surgical and prosthetic advancements.

Lastly, vascularized composite tissue allotransplantation (such as the hand transplant) has become a reality. Although debate and concerns regarding patient selection, outcome quantification, immunosuppression and immunomodulation regimen optimization, and secondary health effects remain [12], proof-of-concept success has been achieved via impressive functional outcomes from patients at multiple investigational sites.

Surgical, rehabilitative, and prosthetic technologies appear to be catching up with the functional potential of motivated amputees. There has never been a more exciting time to contribute to the care of these challenging and rewarding patients. If recent history is any indicator, we can look forward to many exciting advances in all fields related to amputation

surgery and amputee care in the months and years to come.

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