

SIMPLE SOLUTIONS FOR A COMPLEX PROBLEM: VARIATIONS OF A TRANSRADIAL MYOELECTRIC PROSTHETIC DESIGN

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INTRODUCTION

The prosthetic design being discussed is that of a transradial myoelectric, dual site-dual control system. The residual limb is, in this case, not the factor for variance of prosthetic design, however, it is other extenuating circumstances that resulted from a fairly common surgical procedure. The patient fitted with this prosthesis was scheduled for a coronary artery bypass graft (CABG), better known as the "cabbage procedure". In the weeks subsequent to this CABG the patient became a quadrimembral amputee.

CASE DESCRIPTION

On the evening preceding the scheduled CABG procedure, this patient presented in the emergency room with recurrent chest pains. Several doses of nitroglycerine were administered at this time and subsequently two bypass grafts were performed. Postoperatively she was doing quite well with temperature elevations early on, however subsiding within three days. She was discharged within two weeks feeling quite well and being given an optimistic outlook from her examining physician. Two weeks after being discharged, this woman was rushed to the hospital at 4:00 a.m. feeling terrible. That evening a small area was opened on her incision line where a gram stain and culture were obtained revealing a gram-positive cocci in chains consistent with streptococcus. That night she was brought to the emergency room for an emergency sternal debridement with cultures taken which were in agreement with the previous septic condition. While attempting to recover from the septic shock, the patient's platelet counts were monitored and noted to be decreasing alerting the physicians of a possible heparin-induced thrombocytopenia. Abruptly the heparin was discontinued and after several days this woman began to recover from the septic shock; however, her distal extremities became gangrenous. Being aware of the inevitable future, the patient delayed the amputations slightly trying to cope with the thought of becoming a quadrimembral amputee. After the amputations were performed, an autopsy of the amputated limbs led to the conclusion that the cause of these amputations, bilateral transtibial, left partial hand (amputation of all five distal phalanges), and a right transradial, was a result of the heparin-induced thrombocytopenia and not the septic shock. [1]

DISCUSSION

The previously described patient experiences led to several complications in attempting successful prosthetic fittings. The factors addressed involving the design of the right upper limb prosthesis (secondary to the bilateral transtibial fittings) included psychological status, fear, safety, donning, and maintenance of electronic componentry. The upper limb prosthetic design required some variation from the norm as a result of these complications. Although many upper limb prosthetic designs were presented, the harness system was flatly rejected leaving a myoelectric prosthesis as the sole option for a functional prosthetic device. This patient cooperated well with the myotesting and site selection of two antagonistic muscle groups was quite easily performed. Measurements and molding were taken in the standard fashion in preparation for a test-socket fitting which was successfully completed. The definitive prosthesis was delivered prior to discharge from the hospital where no issues were present.

The situation changed dramatically after discharge from the hospital and independent use began in the household and as an outpatient in therapy. Typical problems of new myoelectric prosthesis wearers, i.e., control, cosmesis, and weight were not initial issues. The problems were unique because of dealing with the other amputation levels, especially the strength and dexterity of the contralateral partial hand. Walking began as soon as possible with the assistance of a walker. The patient was not entirely trusting of the myoelectric prosthesis; she was afraid she would inadvertently open the hand once she grabbed onto the walker. With a contralateral partial hand, she could not locate the on/off relay switch in the Otto Bock hands.TM [2] Even some individuals with two hands cannot locate this switch. Fortunately, cosmesis was not a major issue and a Radio Shack Cat No. 275-1565B, Push On/Push Off soft-feel switchTM [3] was mounted on the forearm anteriorly which, when spliced into the 13E51=2 Battery Connection CableTM [2], could interrupt the power signal to the hand. This button was much easier for her to find and although it was not cosmetically pleasing, it was a confidence booster that the hand would not open. This remained the primary focus of difficulty for this woman followed by donning of the device.

Donning was difficult because of the loss of the distal phalanx on each of the digits on her contralateral hand and the prominences of her humeral epicondyles and olecranon. Several design changes were made to the prosthesis, i.e., thinning out the supracondylar (SC) wings and lowering the trimline of the rigid forearm to allow easier donning of the prosthesis. These resulted in easier donning but lack of suspension vs. the weight of hand with gravity alone. After these unsuccessful design changes, a common design for an uncommon purpose was chosen: a bi-valve socket. This was designed with an anterior overlapping panel rivetted distally with nyloplex rivets allowing it to open like a door. With the anterior panel away from the remaining 3/4 of the socket, the SC wings were now flexible enough to allow the limb to pass through the suspensory modification into the socket. The panel was now let go to overlap the socket creating a rigid SC brim and was pushed into the forearm. This was easily donned by the patient. The difficulty was now two-fold; protecting the electronics and maintaining the socket within the forearm.

The socket was required to be removed slightly from the forearm for donning. This allowed the anterior panel to open with the SC wings becoming more flexible. When performing this task, care must be taken to prevent exaggerated pull on the electronic wiring inside the forearm. A positive stop was being sought for this purpose while simultaneously, a means of securing the socket within the forearm was needed. The solution, after much thought, was quite simple. A slit was made on both the medial and lateral proximal forearm allowing a 1/2 inch dacron strap to pass through. The proximal end of the dacron strap was fed through the slit and rivetted to the proximal socket. There was a one inch loop at the distal end of the dacron strap with hook Velcro attached to the forearm side. Just proximal to this loop was the female component of a snap, facing the forearm. Mounted on the forearm was the male

snap component with a piece of pile Velcro distal to it. As the socket was removed from the forearm, the female component of the snap would act as a positive stop to prevent the socket from being pulled too far out of the socket damaging the wires, since the slit in the forearm was more narrow than the snap component. Once the socket was donned, the socket was pushed into the forearm while the patient could fit her middle phalanx into the loop pulling the socket further in to its fully seated position. When the socket was in place, she would secure the snap, holding the socket within the forearm, and lay the loop down, hook to pile, keeping the loop from hanging freely in space. It was now thought that all problems were resolved when one more arose.

Because of the consistency of this woman's tissue, when she would don the bi-valve socket and allow the anterior panel to close, her skin would occasionally get pinched in this junction. This was addressed with a piece of thin horsehide placed inside the anterior panel and overlapping the inner anterior socket similar to the tongue on a shoe. It was sprayed with leather stiffener to prevent the lateral aspects of it from curling and bunching inside the socket. This resolved the final fitting issue.

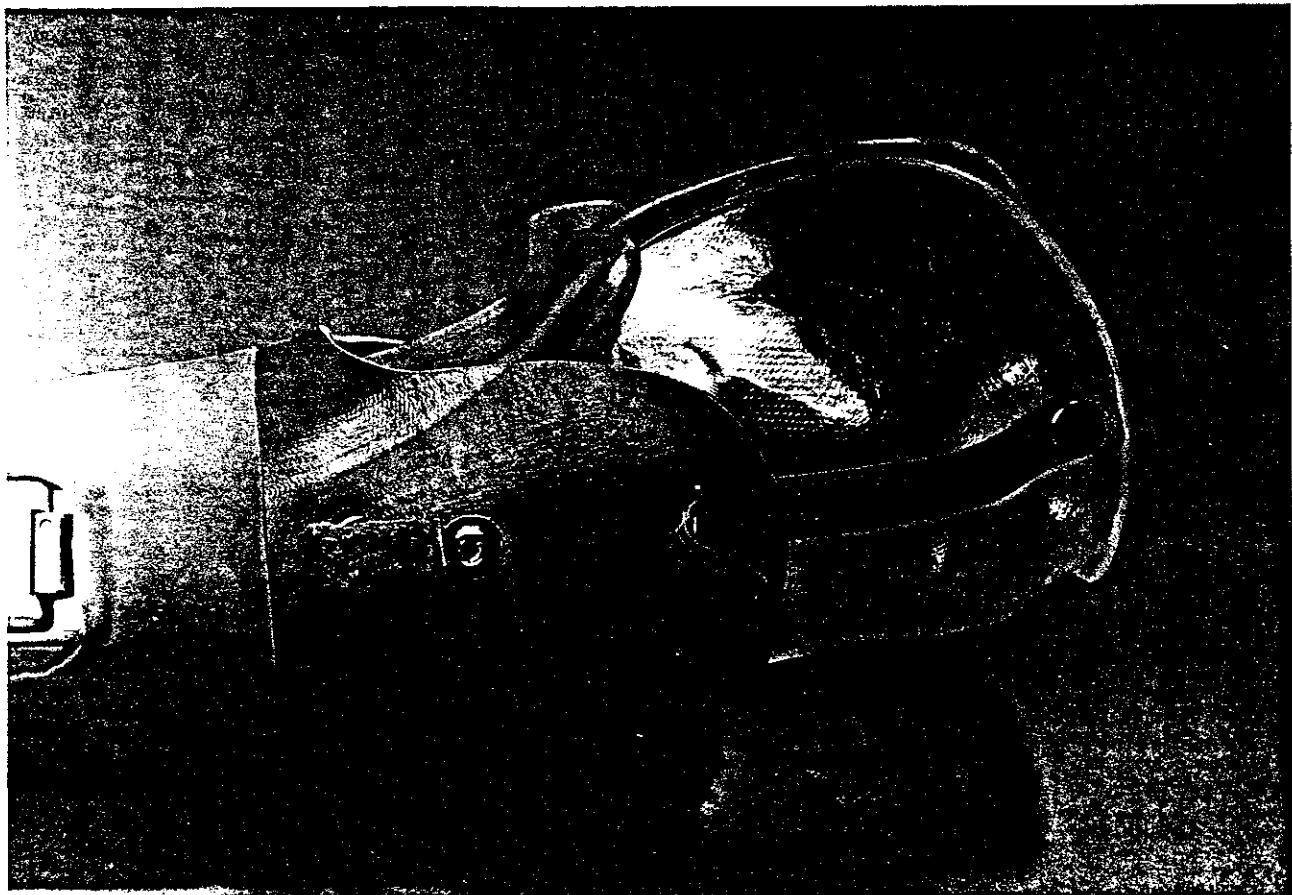


Figure 1

CONCLUSION

Coronary artery bypass grafting (CABG) is a common procedure performed over 240,000 times per year in the United States in 1988 [3]; however, heparin-induced thrombocytopenia is a rare

entity but is becoming increasingly well known by physicians. It has been known to cause distal amputations but scarcely to this level without causing death to the patient. Due to the severe level of involvement, much attention had to be paid to the patient as a whole, not just to the single limb itself.

None of these design changes were startling revelations. Each of these components and designs have been utilized in the fields of electronics, prosthetics, and orthotics, but not in this combination. Problem solving for this variation was mentally challenging, but very inexpensive. The total cost of the materials used, including the plastic for the newer socket was minimal, especially in comparison to the degree of "normalcy" which was returned to this individual who has faced enormous adversity. All options should be explored when providing patients a means to regain the independence to which they are entitled.

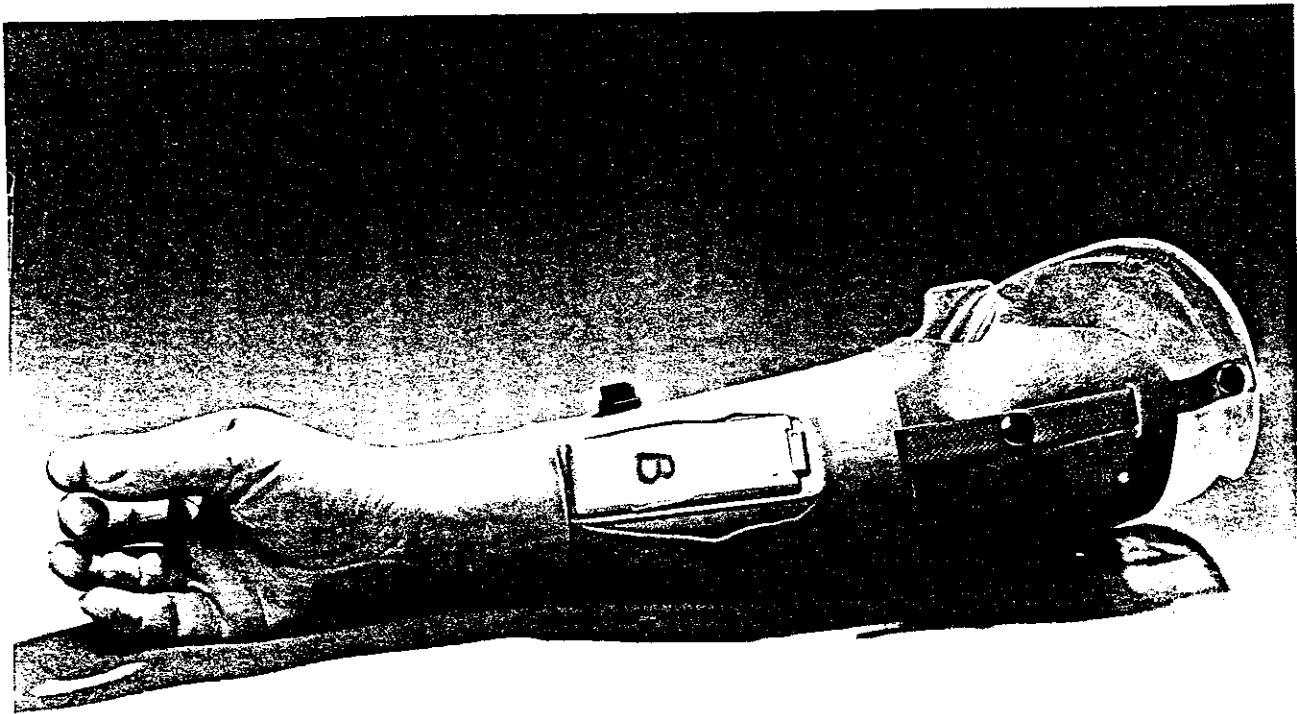


Figure 2

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