STUMP ARTERIAL CIRCULATION AND ITS RELATIONSHIP TO THE PRESCRIPTION OF A PROSTHESIS FOR THE GERIATRIC PATIENT

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The primary purpose of the Research Program in Prosthetics, inaugurated by the Surgeon General of the Army in 1945 and now supported by the Veterans Administration and other agencies, has been to improve or construct artificial limbs that would enable the amputee to assume his place in society with a minimum loss of function. Although research has been mainly devoted to fitting the young, vigorous soldier, fitting the geriatric amputee has become an ever-increasing problem. Recognizing this fact, the National Academy of Sciences authorized a special conference on The Geriatric Amputee, which was held in Washington, D.C. in 1961. At that conference, the Panel on Medical Management (1) chaired by Dr. George T. Aitken, recommended that the geriatric amputee be defined as a person over 55 years of age, and that the terms "old amputee" and "new amputee" be used to designate two subclasses. The panel recognized these terms as somewhat arbitrary since age is a matter not only of chronology but also of physiological fitness.

In my experience, the statement credited to Dr. Osler of The Johns Hopkins University, "You are as old as your arteries," is true in the majority of cases; statistics also bear out the adage. Since arteries may be obstructed in the young as well as in the old, the term geriatric amputee should probably be abolished, and the title, "Amputations and prostheses in cases of decreased arterial supply in the extremities and in the stump" be used instead. This all-embracing title would also have subgroups, such as non-diabetic and diabetic, and would include consideration of amputation sites and technics.

Statistics indicate that vascular diseases, particularly atherosclerosis, cause more deaths than the next five causes, which include cancer. Certainly in most cases, the degree of lower-extremity function is directly related to ar-
terial conditions, such as degree of obstruction. With increasing obstruction, there is a corresponding decrease in function and an “aging” of the limb, which may lead to gangrene, resulting in death. The same symptoms associated with gradually increasing obstruction in the arteries of a limb may also be presented by the stump, i.e., the stump may get tired or develop claudication after a brief walk with the prosthesis; stump abrasions may develop after socket contact during a short walk, and the abrasions may be slow-healing or nonhealing, depending upon the degree of loss of stump arterial circulation. It is evident, therefore, that a prosthesis cannot be properly prescribed unless the arterial circulation of the stump is accurately evaluated. For example, if a patellar tendon-bearing prosthesis were prescribed for a stump with poor circulation, the patient would probably experience serious stump problems in a relatively short time.

The site of amputation and shape of the stump are also factors that profoundly influence the prescription of a prosthesis, and it is the surgeon’s responsibility to select a level that will provide the greatest functional restoration that the circulatory state of stump and contralateral extremity will allow and, of course, in terms of available prostheses. Unfortunately, few surgeons are expert in both circulatory and prosthetic specialties, so poor rehabilitation often results for many patients.

At the VA Hospital in Minneapolis, we are trying to approach a solution in two ways, (1) By developing a method for estimating the stump circulation and (2) By setting up courses of instruction in prosthetics. For the best possible results in amputee rehabilitation, the prosthetic team should schedule a preoperative conference on the selection of amputation level as well as on the choice of a prosthesis. To make such decisions meaningful, however, the functional status of the arterial circulation in the stump as well as in the contralateral extremity should be determined. We have tried to evolve such a method (2, 3, 4) by using a standardized oscillometer to measure the circulation. So far it seems that the method should be very helpful, but more work is required.

**FAILURE RATES OF WOUND HEALING**

An examination of the literature on selection of amputation levels using circulatory and prosthetics criteria reveals a dearth of research in that area, yet the effects of stump circulation upon the prosthetic prescription cannot be ignored if maximum rehabilitation is to be achieved. The surgeon, as a rule, thinks primarily of trying to save as much of the limb as possible, and he gives the least thought to prosthesis or function. The result is that he may select an amputation level where there is circulation sufficient for heal-
ing, but insufficient for healing and weight bearing. Unfortunately, many studies have shown that the surgeon may not be very successful even in choosing a level to achieve optimum healing, although he utilizes all available methods of estimating circulation.

Allan and Lambert (5) gave a failure rate of 45 percent in toe amputations and 32 percent in metatarsal amputations. Bickel and Ghormley (6), Dale and Jacobs (7), and Tolstedt and Bell (8) cited failure rates of 24 to 28 percent in below-knee amputations. In a survey at the Minneapolis VA Hospital for the years 1959 through 1962, there was a failure rate of 51 percent in toe amputations, 38 percent in transmetatarsal operations, 30 percent in below-knee amputations, and 80 percent in Syme’s amputations. These rates are most unsatisfactory. The Veterans Administration Technical Bulletin TB 10-111 (9), discussed the problem and then stated, “It must be admitted, however, that a more accurate means of evaluating collateral circulation at a given level is needed.” (The collateral circulation is the arterial circulation that remains after a major artery has been closed. It is furnished by small arteries bridging the site of occlusion.) It is not, however, a matter of evaluating only the collateral circulation. The total circulation in the stump or the extremity must be evaluated, including the major arteries as well as the collateral arteries, for the collateral circulation usually provides only enough blood for wound healing and very little for function. This circulatory problem is especially acute in below-knee amputations. If the surgeon could safely predict healing levels, undoubtedly the number of revisions would be minimized and prolonged hospital stays reduced.

CIRCULATION CRITERIA FOR SELECTING AN AMPUTATION LEVEL

In selecting an amputation level, the surgeon should consider the following points:

1. A minimum of arterial blood circulation is needed for wound healing.
2. For wound healing plus weight bearing, the stump must have an additional blood supply, depending upon the type of prosthesis prescribed, the patient’s weight, his occupational activities, and such factors as the length of time, the distance, and cadences at which he is most likely to use the prosthesis.
3. Provision should be made for possible deterioration of the circulation postoperatively. In cases where there appears to be a rather rapid deterioration, as in some diabetics, a higher level should be selected to avoid, if possible, re-amputation.
4. The circulation of the other extremity must be taken into account. In many patients functional ability is limited to the claudication distance of that extremity, i.e., the distance he can walk before developing cramps in the contralateral leg. If the claudication distance is short, there is no point in preparing a stump for a prosthesis that will permit unlimited walking since the patient's walking distance cannot exceed that of his remaining leg.

**REHABILITATION FAILURE RATES IN GERIATRIC AMPUTEES**

The high failure rate in the rehabilitation of vascular amputees is, I believe, due to nonrecognition of above-mentioned points; however, exact failure rates are difficult to obtain because of lack of standard definitions and lack of followup. McKenzie (10) of England defined successful rehabilitation as "Regular and appreciable use of the prosthesis for at least 6 months after completion of a rehabilitation program." On the basis of this definition, there were 50 percent failures in his 344 cases. Bertelsen of Denmark, Chief Surgeon at the Orthopedic Hospital in Copenhagen, as quoted by Haddan (11), concluded that "You have to reckon with a 'hard core' of about 50 percent unsuccessful prosthetic rehabilitation in geriatric patients."

A 50-percent failure rate was indicated from a very limited survey of the Minneapolis VA Hospital rehabilitation results with geriatric patients. At present a survey is being made in the United States under the auspices of the National Academy of Sciences—National Research Council Committee on Prosthetic-Orthotic Education. Even from that survey, it is impossible to relate rehabilitation failures to the state of the arterial supply since there is no generally accepted method of estimating the arterial circulation. I believe firmly that if criteria are developed for estimating the arterial blood supply needed at various levels and related to the type of prosthesis the patient is to wear and to the amount of activity he is to sustain, that the rehabilitation failure rates will be materially reduced.

**OSCILLOMETRIC METHOD OF EVALUATING CIRCULATION**

In the Physical Medicine and Rehabilitation Department of the Minneapolis VA Hospital, the oscillometric method of evaluating arterial circulation is being used. The oscillometer, invented by the French physician Pachon (12) for the determination of blood pressure by the observation of changes in the amplitude of pulsations in the arteries, consists essentially of a blood pressure cuff connected to an aneroid chamber with a metallic diaphragm, an amplifying mechanism, and a needle showing the amplitude of pulsation.
The pulse amplitude depends mainly upon the heart stroke volume and the ability of the arteries to distend.

According to Poiseuille's law for the flow of liquid through a tube, an increase in the radius of the tube is the most important factor in increasing fluid flow since doubling of the radius of a tube increases the rate of flow sixteenfold. Since the oscillometer expresses the pulse amplitude, which expresses the internal radius of the arteries, which in turn expresses their blood transmission rates, it follows that the oscillometer can be used to express pulsatile blood flow. Although there are many different types of oscillometers on the market, no norms have been established for oscillometric expression of pulsatile arterial blood flow. This difficulty was overcome by the use of a standardized oscillometer and cuff (Universal) and by the development of norms (Table 1) for this instrument.

To obtain an oscillometric index, the oscillometric cuff is applied to the desired segment of the extremity and inflated to systolic blood pressure. Air is then gradually let out of the cuff until diastolic pressure is reached. With each pulse beat, the needle makes an excursion, and the highest that occurs during the deflation of the cuff is noted. This excursion high point, which occurs when the pressure in the cuff is barely sufficient to overcome the tissue resistance and the diastolic pressure, is called the oscillometric index. The excursion of the oscillometric needle at this point expresses the maximum radius of the arteries and their maximum transmittal of blood for a particular heart-stroke volume. The oscillometer measures the total ability of all the arteries in the examined segment to transmit blood. With this method, the pulse can be measured and evaluated in small or large masses such as the little finger or the upper thigh. Readings below the established lower limit of normal for a particular segment are expressed as percentage of loss. Since the lower limit of normal reading below the knee is 4 (Table 1) a reading of 2 indicates a 50 percent loss.

The norms thus far established have so far proven extremely useful in peripheral vascular disease work for estimating degree and site of arterial occlusion, function, and onset of gangrene in more than 5,000 cases. The reliability of these norms has been proven by pathologic examinations, gross observations, and arteriographic comparisons. Figures 1 through 4 compare oscillometric evaluations with arteriographic observations. The reliability of the method in predicting the degree and site of obstruction is evident. With further work, the method should prove equally valuable in selection of suitable amputation sites in relation to prosthetic prescriptions. The following cases illustrate the four points that should be considered when selecting an amputation level and a prosthesis; these cases also indicate how the oscillometric method might possibly help to solve some of the problems of young or old amputees with "geriatric" leg or legs.
<table>
<thead>
<tr>
<th>Index on</th>
<th>Above-wrist</th>
<th>Above-elbow</th>
<th>Instep</th>
<th>Above-ankle</th>
<th>Below-knee</th>
<th>Above-knee</th>
<th>Midthigh</th>
<th>Upper Thigh</th>
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<tbody>
<tr>
<td>Upper Extremity</td>
<td>2</td>
<td>3</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Lower Extremity</td>
<td></td>
<td></td>
<td>½</td>
<td>2½</td>
<td>4</td>
<td>3½</td>
<td>2½</td>
<td>2½</td>
</tr>
<tr>
<td>Running</td>
<td></td>
<td></td>
<td>¾</td>
<td>3</td>
<td>6½</td>
<td></td>
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<tr>
<td>Walking</td>
<td></td>
<td></td>
<td>½</td>
<td>2½</td>
<td>4</td>
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<td></td>
</tr>
<tr>
<td>Slow-healing Ulcer b</td>
<td></td>
<td></td>
<td>Trace</td>
<td>¾</td>
<td>¾</td>
<td></td>
<td></td>
<td>With these indices, chances are that ulcer on foot can be healed slowly.</td>
</tr>
<tr>
<td>Nonhealing Ulcer b</td>
<td></td>
<td></td>
<td>0</td>
<td>¾</td>
<td>½</td>
<td></td>
<td></td>
<td>With these indices, it is almost impossible for ulcer on foot to heal.</td>
</tr>
</tbody>
</table>

Adequate circulation for running.
Adequate for ½ mi. walk at 120 s.p.m.; barely tiring.
With these indices, chances are that ulcer on foot can be healed slowly.
With these indices, it is almost impossible for ulcer on foot to heal.
These norms, which have been found indispensible in the management of obstructive arterial disease, apply only to adult males, not to women and children, and only to noncomplicated, i.e., nondiabetic, cases of atherosclerosis.

Author's healing criteria for ulcers: "slow-healing ulcer" can be healed in less than 3 months; "nonhealing" ulcer is not healed in 3 months.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Score</th>
<th>Score</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gangrene</td>
<td>0</td>
<td>0</td>
<td>⅔ With these indices, spontaneous gangrene is very close or may already have started in toes.</td>
</tr>
<tr>
<td>Nonhealing BK Amputation</td>
<td></td>
<td></td>
<td>⅔ Chances of healing stump are questionable.</td>
</tr>
<tr>
<td>“Well-healing” BK Amputation</td>
<td></td>
<td></td>
<td>1½ Stump should heal without difficulty.</td>
</tr>
</tbody>
</table>

* These norms, which have been found indispensible in the management of obstructive arterial disease, apply only to adult males, not to women and children, and only to noncomplicated, i.e., nondiabetic, cases of atherosclerosis.

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Case Reports

Case I. S. C., a 54-year-old man, was admitted on May 1, 1960, with a small ulcer on the heel of the left foot. He had had diabetes for 13 years and was also mildly hypertensive; his blood pressure was 155/95. The ulcer was infected with beta hemolytic streptococci and staphylococci. In spite of vigorous medical treatment, the infection progressed and on June 17, 1960, a left above-knee amputation was performed. One week later the patient fell out of bed; the wound opened, became infected, and did not heal for 2 months. After transferral to the Rehabilitation Service on Sept. 1, 1960, and subsequent sessions in the amputation clinic, the patient

Figure 1. H.W.P. The oscillometric test is corroborated by the arteriogram, showing the reliability of the test. Above the knee, the artery appears wide open in the arteriogram, indicated by an oscillometric index of 7 1/2, more than twice the lower limit of the norm of 3 1/2. Below the knee, the arteries show sclerosis and narrowing, indicated by an oscillometric index reduced from 4 to 2 1/2, a loss of 40 percent. The anterior tibial, the posterior tibial, and the peroneal arteries are occluded in upper midcalf, giving an oscillometric index of 1/4 above the ankle, or a 90-percent loss when compared with the lower limit of normal of 2 1/2.

Figure 2. R.E.H., a case of nonhealing ulcer of the left ankle for 3 years. The oscillometric index above the knee was found to be reduced from the lower limit of normal of 3 1/2 to 1 1/4, a loss of approximately 90-percent of the arterial circulation. The arteriogram shows a complete occlusion of the main arteries in the lower thigh, again indicating the close correlation between the test and the arteriogram.
was fitted with a left above-knee conventional quadrilateral socket with Silesian belt suspension and a single-axis knee and ankle.

After one week's training, the plantar surface of the right fourth toe developed gangrene, which progressed in spite of treatment. On Dec. 23, 1960, a right lumbar sympathectomy was done without effecting improvement. On Feb. 1, 1961, a midmetatarsal amputation was done, but the wound did not heal and the gangrene progressed. On Feb. 13, the right leg was amputated below the knee. Following surgery, the patient developed pneumonia in the right lung and also glomerulonephritis. He was discharged without prosthesis on April 15, 1961, after 11 months in the hospital, and was followed in the Outpatient Clinic until May 4, 1961.

This case presents many features worthy of note. Several oscillometric tests had been made on this man since his 1959 admission. At that time, a 45 percent arterial circulatory loss below the right knee was recorded. In 9 months, failure had progressed to a 70-percent loss, which could be ac-

![Figure 3](image1.png)

**Figure 3.** H.W.H., a patient with gradually increasing tiredness in his right leg for 5 years. The oscillometric index in the right upper thigh was ¾, a 90-percent loss when compared with the lower limit of normal 2%. The arteriogram showed a complete occlusion of the right common iliac artery. In the left upper thigh, the oscillometric index was 1½, a 40-percent loss. The arteriogram showed a partial occlusion of the left common iliac artery. Close correlation between the oscillometric test and the arteriogram is indicated.

![Figure 4](image2.png)

**Figure 4.** A.A.M., a patient with 8 years of leg tiredness, ascribed to an old back injury. The oscillometric index in both upper thighs was found to be 2, a 20-percent loss in each thigh when compared with the lower limit of normal of 2½. Aortogram showed beginning obstruction at the bifurcation of the aorta.
counted for by the fact that diabetes, and hypertension are two conditions known to favor development of atherosclerosis. Another interesting feature of the case was the slow healing rate of the stump with 60 percent circulatory loss. The third noteworthy feature was the development of gangrene in the remaining leg after the prosthesis had been fitted and gait training initiated. In consequence, extensive efforts of rehabilitating this man were nullified in the course of one week, and the prosthesis was a total loss. The question is: On the basis of circulatory loss of the right leg, could it have been predicted that gangrene would develop when the patient started walking? Preprosthetic training included walking with crutches but not with a pylon. If the patient had been fitted with a pylon or temporary prosthesis, would manifestations of gangrene have precluded the prescription of a permanent prosthesis?

A fourth noteworthy fact of this case was that the right transmetatarsal amputation wound did not heal. It has been my clinical impression that when infection or gangrene is present in a diabetic, it is almost impossible to save any part of the foot when the loss below the knee exceeds 50 percent. This patient had a 70 percent loss, and the results of this case confirmed my impression. There was another feature worthy of attention in this case: before his first amputation, the patient could walk only 1½ blocks, and that probably at a slow pace. The lower limit of normal for below the knee is 4, which permits a walk of about 1,320 ft. (¼ mile) at a pace of about 120 steps a minute before tiredness sets in. Norms for the oscillometric index indicated that with a 45 percent preoperative loss, a patient should be able to walk about 660 ft. at 120 steps a minute or at a slow pace, about 990 ft. It can thus be seen that the oscillometric test can be very valuable in giving an objective measurement of walking capacity, an important factor to take into account when prescribing a prosthesis. In this case, however, rehabilitation was unsuccessful.

Case 2. H. C., a 71-year-old man, with a 20-year history of progressive tiredness in his legs, finally suffered claudication after walking one short block. One month previous to his admission, which was on July 11, 1957, the tip of the right first toe had started to turn bluish-black. An oscillometric test showed a 60-percent obstruction in the aorta and complete occlusion of the superficial femoral arteries in midthigh with a 90-percent loss below the left knee and a 95-percent loss below the right knee. On July 22, 1957, he had a right above-knee amputation. Following surgery, he was started on the amputee rehabilitation program but because of the 90-percent loss in the nonamputated extremity below the knee, with the concomitantly reduced walking distance and the possibility of gangrene, this man was discharged on pylon and crutches to a nursing home. During his 2½-month hospital stay, he received whirlpool treatments, massage, and vascular exercises; there was a 10-percent circulatory improvement, sufficient in our
opinion to put him out of danger temporarily. He was doing well 6 months later.

Case 3. W. K., a patient with conditions somewhat similar to Case 2, was discharged on crutches but with no pylon or prosthesis. He went home, constructed his own whirlpool and did vascular exercises (a modification of Buerger’s exercises). He came back to the hospital at the end of 6 months; the oscillometric index showed improved circulation, and he was given a prosthesis.

Case 4. W. M., a 66-year-old man, in excellent physical condition, was admitted on December 21, 1959. After bilateral below-knee amputations were done because of diabetic gangrene, the patient was fitted with patellar tendon-bearing prostheses and did well. His oscillometric test had shown a 50-percent circulatory loss in the left stump and a 45-percent loss in the right stump, but wound healing was excellent in spite of the loss. After discharge, he did such chores as wood-sawing and berry-picking, walking about 2 miles each day. The only problems he had were blisters which developed on the stumps on hot summer days. He returned 18 months later with ulcers which had developed on both stumps after a 5-mile walk. At that time, he had an 80-percent arterial circulatory loss in both stumps. The PTB prostheses were converted to medium-high thigh lacers after the ulcers healed. This case confirms the belief that PTB prostheses are not indicated when there is more than a 50 percent loss of arterial circulation in the stumps and the patient is expected to engage in extensive physical activity. Other cases of a similar nature are in my files, indicating that PTB prostheses are by no means to be prescribed indiscriminately and that knowledge of the circulatory state is very valuable in their prescription.

There are also many other cases of a different nature where the evidence is unequivocal that we must pay attention to the circulation when prescribing prostheses. Thus one patient with a complete and total obstruction in the iliac arteries and an AK amputation could walk only 250 feet before he developed claudication in the stump. The socket was slightly constrictive on a very precarious blood supply. When the constriction was removed, he could walk 6,000 feet around a circular distance of 300 feet before claudication developed in the stump.

Although it is not too difficult to relate functional problems of the stump to a decreased arterial blood supply, it is more difficult to relate other conditions such as pain, phantom pain, and neuroma to arterial circulation. The following case illustrates the difficulties.

Case 5. H. P., a 27-year-old machinist, was admitted April 9, 1958, complaining of pain in the right foot. The patient had previously had a plantar wart excised and the heads of the second, third, fourth, and fifth metatarsals resected; he had tried special shoes and arch supports but found no relief. On May 22, 1958, he had a Syme’s amputation, but heal-
ing was slow and the stump painful; with treatment, however, these problems were overcome. A Syme prosthesis was prescribed, but the patient promptly developed pain and ulceration of the stump. In October of the same year, an evaluation of the arterial circulation showed a 70-percent circulatory loss below the knee and a 90-percent loss at the end of the stump. Subsequently this patient was in and out of the hospital, bitterly complaining about the pain in the stump and his inability to use the prosthesis. Finally a below-knee amputation was done. The patient was fitted with a prosthesis, did well, and went home. Five months later pain returned. Following a sciatic neurectomy on April 7, 1960, he did well and returned to work as a machinist. He worked for 2 years without loss of time and then came in again, asking for a new prosthesis because the old one had “worn out.” Tests at that time showed that his extensive arteriosclerosis had increased and that there had been a further deterioration of the circulatory state. Aching had now developed around the hip.

There were as many conflicting opinions about this case as there were physicians. The patient became discouraged and disappointed many times. At first he was thought to have Buerger's disease. Pathological examination of the excised tissues showed extensive atherosclerosis. Our tests showed involvement not only of the lower extremities but also of the aorta and the upper extremities, with a 60-percent occlusion of the aorta. Examination of the excised tissue failed to disclose any evidence of neuroma. My opinion was that we had been dealing the whole time with ischemic pain, in a rather rapidly advancing atherosclerotic process, in a young man. Chronologically the patient was not old, but arterially he was. If the severity of his vascular problem had been recognized from the beginning, much trouble could probably have been avoided. At least the test showed that there was insufficient circulation for a weight-bearing Syme prosthesis.

Case 6. L. L., a 65-year-old man, had had a Syme's amputation in 1918 following a gunshot wound. His prosthesis had been end bearing, and he had been able to walk with it from 25 to 30 miles a day. After his retirement in 1952, he had been able to walk less and less because of leg fatigue. One week previous to admission, he had traumatized his stump, resulting in infection and a large ulcer that would not heal. Skin grafts did not take. Oscillometric test showed an almost complete occlusion of the iliac arteries with a 95-percent circulatory loss in the stump, which indicated insufficient blood supply for healing. Midthigh amputation was recommended, but the patient refused surgery and left the hospital. The results of this case and the preceding substantiate the fact that a Syme prosthesis is not indicated when there is a 95-percent loss of arterial circulation. The next case, I think, demonstrates even more clearly the importance of being able to evaluate arterial circulation in relationship not only to the stump but also to the other leg.
Case 7. M. R. W., a 35-year-old carpenter, was admitted on May 2, 1957. In 1953, he had had a below-knee amputation of his right leg following frostbite. He had been fitted with a prosthesis, but repeated breakdowns of the stump occurred in the form of ulcerations and infections, which made it necessary for him to take time off from work. The last such breakdown had occurred 4 months previous to admission and had not healed with conservative treatment. The patient knew of no particular injury to the stump, but he stated that his prosthesis did not fit well. Bilateral sympathectomies had been performed in the past. Physical examination showed a nonhealing ulcer, the size of a quarter, on the inferior-anterior aspect of the stump. The oscillometric test showed a 60-percent loss of arterial circulation above the knee and a 95-percent loss below the knee.

It was my opinion that the circulation in the stump was so poor that the patient would have constant trouble because of occupational weight-bearing and walking needs. The left leg, however, had excellent circulation sufficient for all purposes. Although I advised an above-knee amputation, it was believed by the majority of the clinic team that the below-knee stump could be saved by changing the prosthesis from a thigh-lacer to a gluteal weight-bearing lacer. The patient was discharged on June 27, 1957, with the gluteal-lacer prosthesis.

On February 19, 1958, he was readmitted with recurrence of the ulcer, which was then about 2 × 4 cm. The oscillometric index still indicated a 95-percent loss of arterial circulation in the stump. My comment written on the patient's report was "The loss of arterial circulation in the right BK stump is of such magnitude that the stump will never be of any use to this patient. He was advised, when in the hospital last year, to have an AK amputation, and that is still my advice. There is sufficient circulation in the thigh to insure healing and weightbearing." An above-knee amputation was done, and wound healing proceeded without complication. The patient was fitted with a quadrilateral suction-socket prosthesis with a single-axis knee and discharged on May 23, 1958, having spent 3 months in the hospital. This patient refused to consider any change of vocation, expecting to return to carpentry, but with less climbing than previously.

SUMMARY

The geriatric amputee, as a rule, has poor arterial circulation not only in the stump but also in the contralateral extremity, whereas the young amputee seldom has this problem. The function of the stump and its ability to withstand trauma depend primarily upon its arterial blood circulation, as is true for the normal leg. For this reason, the stump with a reduced blood supply is subject to the same symptoms as a leg with a reduced blood supply. It is my belief that the high failure rate in the rehabilitation of geriatric amputees is due in great part to a lack of standardized and
universally accepted methods of determining the arterial circulation in the
stump and in the opposite extremity.

In selecting an amputation level, there are four points that the surgeon
should consider:

1. A minimum of arterial blood circulation is needed for wound healing.
2. For wound healing plus weight bearing, the stump must have an addi-
tional blood supply, depending upon the type of prosthesis prescribed, the
patient’s weight, and his occupational activities.
3. Provision should be made for possible deterioration of the circulation
postoperatively. In cases where there appears to be a rapid deterioration, a
higher level of amputation should be selected to avoid, if possible, the neces-
sity of early revision.
4. The circulation of the opposite leg must be taken into account. If it is
excellent, then an amputation site and a prosthesis should be selected that
will be functionally equal to the good leg. If, however, the arterial circula-
tion is so poor that gangrene is threatened, only a temporary prosthesis, or
none at all, should be provided.

For successful prescription of a prosthesis and maximum rehabilitation,
it appears essential to develop a standardized method of assessing the arterial
circulation of the stump as well as of the contralateral extremity. An oscillo-
metric method developed at the Minneapolis VA Hospital for the evaluation
of the arterial circulation in the extremities may have great potential in this
field, as indicated by several case reports herein presented.

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