Treatment of Gangrene of the Feet and Legs by Walking

By William T. Foley, M.D.

In addition to the usual procedures in the treatment of arterial insufficiency with gangrene of the feet or legs, the author suggests exercise to stimulate collateral blood flow and improve the metabolic state of the involved tissues. After careful protection of the damaged parts, patients were encouraged to stand and walk. The results of this ambulatory regimen in 22 patients are presented.

During recent decades necrosis of the lower extremities has almost invariably led to the complete bed rest of the patient. The present editions of commonly used medical texts in discussing the treatment of such patients assume that they are confined to bed.

Bed rest results in decreased blood flow. Disuse atrophy follows, bone is absorbed, and muscles waste. The skin loses its turgor, nails and hair grow less rapidly, and pulses become less strong. Dietrick, Whedon, and Shorr1, 2 showed that at bed rest patients were in negative nitrogen and calcium balance. They also demonstrated that this process could be reversed by keeping the patient in motion in an oscillating bed.

One of the greatest stimuli to the development of collateral blood flow in the legs is walking. Thoma3 in 1884 found that the growth of collateral blood vessels was directly proportional to blood flow through them. This work was confirmed by Lewis.4

Along with the rest of the medical profession we were hesitant to allow patients with gangrenous limbs to walk. The success of our surgical colleagues, however, in the treatment of fractures by exercise suggested that we might profit by their experience. We were particularly impressed by the work of Bohler,6 who developed the walking cast for fractures of the ankle.

Before the advent of potent antimicrobial drugs, gangrene was feared because of the spreading infection that followed. Gas gangrene and septicemia often were sequelae. Amputation at a high level was therefore promptly resorted to early in the development of gangrene.

Today infection can usually be dealt with successfully. This gives time to encourage the development of collateral circulation. The medical measures used in the group of patients about to be discussed were as follows:

Avoidance of Tobacco. The early work of Wright,7 Barker,8 Roth,9 and others demonstrated the need for complete abstinence from tobacco in the successful therapy of all occlusive arterial disease. We believe it is harmful because of the vasoconstricting action of its nicotine content. In thromboangiitis obliterans it is also an etiologic factor that excites an inflammatory response. All the present patients avoided the use of tobacco.

Use of Gravity. To aid the flow of blood into collateral channels, the affected limb was kept below heart level. Alternately filling the limb with blood and then draining it by positional changes were preferred. This was accomplished while the patients were in the hospital by placing them in oscillating beds. Some continued using the oscillating bed at home.

In each instance the angle of depression of the oscillating bed was adjusted to suit the physiologic need. Readjustments were made as circulation improved. The aim on the upswing of the bed was to maintain sufficient elevation long enough for the veins to collapse, but not to produce pallor in the capillary bed of the toes.

Warmth. Heat was never applied directly to the foot or leg. Reflex vasodilatation was produced by placing a heating pad over the lower abdomen for periods of 1/2 to 1 hour after each meal if possible. The gangrenous part was maintained at room temperature, or slightly above. Cradles were used to protect it from bed coverings.

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This work was aided by grants from Mrs. Frank Corbett, Mrs. Samuel Milbank, Mr. Isaac Harter, Mr. Jean Lambert, and the Eaton Laboratories.
Local Therapy. The lesion and surrounding areas were covered with antimicrobial ointments to reduce the number of bacteria and fungi. Lanolin or other suitable substances were used to keep the tissues from becoming dehydrated. The entire foot and leg were then wrapped in cotton wool and loosely but securely bandaged to protect them from injury. A white sock was donned.

The lesions were dressed daily. As necrotic tissue mummified, very gentle, meticulous debridement was done. Care was taken not to damage borderline tissue.

Vasospasm. Sublingual nitroglycerin\(^1\) was used to combat vasospasm of the major vessels whenever it occurred. This medication was usually combined with reflex heat.

Induced Fever. Fever produces maximum vasodilatation. The patients with thromboangiitis obliterans received intravenous typhoid vaccine every 2 or 3 days, in increasing doses in the manner described by Wright.\(^2\)

Anticoagulants. The patient (case 6) with the peripheral embolus from a mural thrombus in the left side of her heart received anticoagulants to prevent further embolic phenomena. Case 8 had thrombophlebitis complicating gangrene of the foot. She was also given anticoagulants.

Treatment of Associated Conditions. Four patients were diabetic. They were controlled by diet and insulin. The aim was to keep them symptom free and the morning urine with not more than a trace of sugar. Cardiac decompression was present in 6 cases; the usual measures of digitalis and salt restriction were employed. Seven patients were hypertensive. Usually a reduction in systemic arterial pressure results in a reduction of blood flow through the arterial insufficient limb. Efforts to reduce the pressure were therefore made in only 2 of the 7 cases. These 2 patients were given *Rauwolfia serpentina*. Myocardial infarction was present in case 5. She was placed on anticoagulant therapy and was not ambulated until the infarct had healed (about 1 month).

Exercise

The first patient in whom exercise was used as a therapeutic measure was case 1, in July 1949. He is a young truck driver who had thrombophlebitis obliterans and a gangrenous right first toe (figs. 1 and 2). After a week's hospital stay he was allowed to walk about on crutches. Prompt relief of his intense pain resulted, which was so gratifying that he was then permitted to bear partial weight and walk with a cane. Instead of retarding the healing, it took place with unexpected rapidity. The feared spread of infection did not occur. He has been seen regularly during the past 7 years.

![Fig. 1. Left. Case 1. Thromboangiitis obliterans, gangrene of large toe.](image)

![Fig. 2. Right. Case 1. Toe entirely healed.](image)
years. His health is excellent and he continues his vigorous life as a truck driver. He has not resumed the use of tobacco.

This favorable experience led to the adoption of walking as a therapeutic modality in the next 21 cases in which it could be applied.

While we have not found any reference in the literature to walking as a therapeutic measure in cases of gangrene, there are references to increased blood flow in the legs through walking.12

Walking

The feet were carefully dressed, bandaged and stockinged, as described above. Wherever possible, a shoe was worn over the bandaged foot, in order to support the arches. This support was particularly necessary for patients who had been bedridden for protracted periods when they were about to stand for the first time. Their relaxed musculature could not supply adequate support for their arches. If the bandaged foot were too bulky for a shoe, slippers were used. At first some patients could stand for only a few moments. The attempt was repeated every hour. Gradually they took a few steps. Ambulation was increased progressively with pain as the limiting factor. Eventually most patients were able to walk 1 mile daily at a pace below that which gives rise to claudication.

Case Material

Twenty-two patients have been carefully followed and evaluated. A synopsis of each case history is presented below. The underlying causes of gangrene were thromboangiitis obliterans in 5 patients, embolus in 1 patient, and arteriosclerosis with or without hypertension or diabetes in 16 patients.

Case Histories

The oscillometers were the Von Recklinghausen type. The minimum normal oscillometric readings are for the foot 0.2; above the ankle 1.5; below the knee (calf) 2.0; above the knee (thigh) 3.0.

Case 1

P. H., NYH no. 544287 (figs. 1 and 2), admitted in July 1949, was a 38-year-old truck driver. The diagnosis was thromboangiitis obliterans with gangrene of the right first toe and occlusion of the right popliteal and the right ulcer arteries.

He had suffered from several episodes of superficial phlebitis during the prior 2 years. For 3 months the right foot had been increasingly numb and painful. A cramp consistently developed in the right calf after walking about 100 yards. There was constant burning pain in the right first toe and it became cold and cyanotic. He had been treated with procaine nerve blocks, intravenous procaine, and an oscillating bed, but the lesion became progressively worse and he was bedridden for 2 months.

On admission the right first toe was gangrenous and the foot was cold and pulseless. Pulses and oscillometric readings were as follows:

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<tr>
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<tbody>
<tr>
<td>Femoral pulse</td>
<td>Weak ++</td>
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<tr>
<td>Popliteal pulse</td>
<td>0 ++</td>
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<tr>
<td>Dorsalis pedis pulse</td>
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<tr>
<td>Posterior tibial pulse</td>
<td>0 ++</td>
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<tr>
<td>Radial pulse</td>
<td>++ ++</td>
<td></td>
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<tr>
<td>Ulnar pulse</td>
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Oscillometric readings

- Foot: 0.6
- Ankle: 0.3 3.5
- Calf: 0.6 3.5
- Thigh: 1.2 4.0

Smoking was interdicted. The oscillating bed was set at 0° upswing, 15° downswing. Fever therapy was given with intravenous typhoid vaccine every third to fifth day. The foot was dressed daily. Figure 1 was taken 1 month later when considerable improvement had occurred.

The patient was ambulated on crutches. His intense pain was relieved, and after 1 month he was allowed to bear weight. Improvement was more rapid and he was discharged after 2 months' hospitalization, when the toe was clean and granulating.

Two months later healing was complete and he returned to his job as a truck driver. On his last examination on January 14, 1956, the foot was warm, pink, and dry, and the toe was intact. He could walk any reasonable distance at a moderate pace without claudication.

Case 2

J. S., NYH no. 662892 (figs. 3 and 4), a 35-year-old janitor was admitted in August 1953. The diagnosis was thromboangiitis obliterans with gangrene of toes and fingers. Seven months previously he had developed bilateral thrombophlebitis. Two weeks prior to admission his toes became painful, cold, and blue. The left and right index fingers became cold, and ulcerated at the sites of minor abrasions.

Examination showed partial blockage of right radial and both ulnar arteries. The dorsalis pedis and posterior tibial pulses were absent. Oscillometric readings were 0 bilaterally below the knees.
Despite warnings, the patient continued to smoke. Both first toes developed gangrene. A bilateral sympathectomy was done. No improvement resulted until the patient gave up tobacco. Walking started. Healing was then rapid. The necrotic tissue sloughed on the toes and fingers. The lesions were dressed and gently debrided by Dr. Ellen McDevitt at weekly intervals. The patient returned to work, but it took an additional 6 months before healing was complete. One and a half years have elapsed since complete healing. Oscillometric readings have increased markedly and the hands and feet are warm, pink, and dry. He works a full day, performing his full duties as a janitor and he walks long distances.

Case 3

A. W., a 50-year-old hairdresser entered a hospital in New York in October 1953. The diagnosis was thromboangiitis obliterans, with occlusion of both femoral arteries and gangrene of the right fifth toe. For 2 years prior to admission he had had severe symptoms in his legs, culminating in gangrene. He was a heavy smoker, using 20 or more cigarettes daily. When first seen, he had been confined to bed for several months.

His feet and legs showed marked atrophy of skin and muscles. X-ray films demonstrated severe osteoporosis. The right fifth toe was black to its base, due to death of the skin. Cellulitis of the foot was present. Examination showed the following:

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<tbody>
<tr>
<td>Pallor on elevation</td>
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<td>++++</td>
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<tr>
<td>Rubor on dependency</td>
<td>++++</td>
<td>++++</td>
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<tr>
<td>Femoral pulse</td>
<td>+</td>
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After sublingual nitroglycerin, faint pulsations could be felt in the feet, indicating that a severe degree of vasospasm of the major arteries was present. Pain in the foot was extreme.

Ambulation, oscillating bed, and fever induced by means of intravenous typhoid vaccine were employed, and tobacco was interdicted. Relief of pain was immediate. After 2 weeks he was allowed to go home, but he returned each week for dressings. In 2 months the toe was completely healed. The skin of the legs had a healthy look and the muscles were filling out. At his most recent visit in March 1956, the attending nurse, who had not seen the patient before, could not determine which leg had been gangrenous. All pulses were present and strong. He walks 3 continuous miles each day at a normal pace without claudication. He stands on his feet at his trade for 8 to 12 hours daily.

Case 4

M. I., NYH no. 679269, a 41-year-old farmer from the Dominican Republic was admitted in March 1954. The diagnoses were thromboangiitis obliterans, amputation of left leg at midthigh, gangrene of right leg, and occlusion of popliteal artery.

Four years previously, when he was 37, his left leg became infected and he was told he had Buerger's disease. A lumbar sympathectomy was done, but the condition worsened, the leg became gangrenous, and it was amputated at age 40. He did not give up tobacco. The right leg commenced to show changes, and toes 1 and 3 became cold and black.

He decided to come to the United States for medical help. On admission, in March 1954, the large toe was gangrenous in its distal half, with the second phalangeal bone protruding through a necrotic slough. The third toe had sloughed down to the second phalangeal joint. A black spot of spreading necrosis had developed at the base of the fourth toe. The foot was red in dependency, cold, and atrophic. Foot pulses and popliteal pulses were absent. Femoral pulse was weak.

Tobacco was interdicted and the patient was placed in an oscillating bed. He was made to walk every hour on crutches, bearing weight on his gangrenous foot. He was given intermittent fever therapy by means of intravenous typhoid vaccine.

Improvement was rapid. The necrotic areas moistened, the black skin sloughed, and granulations
appeared. The protruding bones were trimmed and the shaft of the exposed phalangeal bone in the large toe was drilled with several holes to allow marrow to lead to granulation.

After 1 month in the hospital he was discharged and treated as an out-patient. During the next 2½ months complete healing occurred, whereupon he was fitted with an artificial limb. He returned to Santo Domingo with his leg healed and walking without a cane.

He was instructed to walk increasing distances at slow pace daily and was warned that if he resumed the tobacco habit, his disease would return.

Case 5

M. L., NYH no. 700969, a 44-year-old business executive, was admitted with gangrene of the left foot from thromboangitis obliterans.

He had had recurrent phlebitis of the legs for 16 years. Two years prior to admission an ulcer formed on his left ankle, which grew larger, deeper, and painful. Six months prior to admission a left lumbar sympathectomy was performed, but the ulcer became worse. The posterior tibial nerve was cut and skin grafts were unsuccessful.

On admission in June 1955 he showed marked disuse atrophy of both legs. A large, necrotic ulcer was present at the left lateral malleolus, surrounded by a red, diffuse area of cellulitis. Both arterial and venous insufficiency were present:

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<thead>
<tr>
<th>Oscillometric readings</th>
<th>Right</th>
<th>Left</th>
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<tbody>
<tr>
<td>Femoral pulse</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Dorsalis pedis pulse</td>
<td>+</td>
<td>0</td>
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<tr>
<td>Posterior tibial pulse</td>
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Varices and venous plexi were present. X-ray films showed marked demineralization of the bone.

He was placed on an oscillating bed with a 10° downswing and upswing, tobacco was interdicted, and walking with crutches for 5 minutes every hour was enforced. At first, weight bearing was extremely painful. At the end of 1 week, however, he was able to give up the crutches and hobble with a cane.

The necrotic lesion responded slowly. After 2 weeks, granulation tissue appeared.

An elastic stocking with light pressure was made to counteract the venous problem. He was discharged after the third week. He returned home where he used an oscillating bed and also walked. One month later he was able to return to work.

He had seen 9 months later in October 1955, when he had gained 30 pounds in weight. He walked without a cane or limp and his feet were warm and pink. The foot pulses had returned and were 2+ in strength. He walks several miles each day as a therapeutic measure, wears the elastic stocking, and sleeps on his oscillating bed.

Case 6

M. S., NYH no. 696317 (figs. 5 and 6). This 51-year-old factory worker had been well until 6 weeks before her admission in November 1954, when she developed severe angina pectoris that culminated in an acute myocardial infarction with admission to another hospital. Anticoagulants were not given, and on the fourteenth day, while straining on a bedpan she developed a sudden pain in her left leg. The leg rapidly became cold and blue, and she was transferred to New York Hospital.

Examination showed a cold, pulseless, cyanotic left leg. Pulses were present elsewhere. Our diagnosis was embolization of the left iliac artery, from a mural thrombosis secondary to myocardial infarction. Treatment consisted of anticoagulant therapy, use of an oscillating bed, and reflex heat. The leg became warmer, but the large toe became black and mummified. Collateral flow developed down into the foot and all areas became pink and warm except for the black toe. Four months after the embolization at a clinic visit the necrotic toe was gently twisted off with a thumb forceps. The stump quickly epithelial-
ized. Observation for 1½ years showed continuous improvement in collateral circulation. She works at her factory job as before.

Case 7

R. K., NYH no. 705427 (figs. 7, 8, and 9), age 69, entered the hospital on March 13, 1955, with arteriosclerosis obliterans, diabetes mellitus for 18 years, hypertension (170/100), and gangrene of the left foot.

Five months prior to admission the left fifth toe had become infected and gangrenous, and it was amputated. The wound did not heal, however, and spreading cellulitis developed. The surrounding area became black, and necrotic areas developed on the lateral and posterior surfaces of the heel. The patient became septic, was in great pain, and became addicted to narcotics. Amputation had been advised by many consultants. She had not walked for 6 months previous to admission.

Examination showed extensive gangrene of the left foot. Black circular areas were present at the heel tip (2 cm.), lateral heel (3 cm.), and lateral anterior surface (9 cm. in diameter). The remainder of the foot was red, swollen, and cold.

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<tbody>
<tr>
<td>Femoral pulse</td>
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<tr>
<td>Popliteal pulse</td>
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<tr>
<td>Dorsalis pedis pulse</td>
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<tr>
<td>Posterior tibial pulse</td>
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<tr>
<td>Oscillometric readings</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Foot</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ankle</td>
<td>1.2</td>
<td>1.0</td>
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<tr>
<td>Calf</td>
<td>0.4</td>
<td>0.4</td>
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<tr>
<td>Thigh</td>
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</table>

She was made to stand at the side of her bed and take a few steps several times a day. The activity was gradually increased and at the end of 1 week she walked to the bathroom with the help of 2 nurses. An oscillating bed was set at 15° downsing, 0° upsing. The foot was covered with antibacterial ointment and wrapped in cotton and was dressed daily. At the end of 3 weeks she was able to walk every hour for 5 minutes with help, fever subsided, and the narcotic addiction was reduced.

She was sent home where she slept on an oscillating bed and remained on it during the day except when walking. She returned to New York for follow-up visits at 2-week and later 1-month intervals. The necrotic area liquefied and was slowly replaced by granulation tissue. By October (7 months after the first visit) all necrotic areas were replaced by granulations. The fourth toe was loose and without nerve innervation, and the fourth and fifth metatarsal bones had sloughed away. Therefore, this toe was clipped off during a simple dressing. Epithelialization took place. Final healing was complete by February, 11 months after the start of ambulant therapy.

Case 8

R. G. NYH no. 730534, was a 67-year-old grandmother who had arteriosclerosis obliterans with occlusion of the main arteries in the lower legs with gangrene. She had a complicating thrombophlebitis in the veins of the right calf area. She was severely
diabetic, requiring 50 to 70 units of insulin daily. She had moderate hypertension, 175/90, and myocardial damage from coronary artery disease, with pulmonary congestion and dependent edema.

Arterial insufficiency had been present for many years. Gangrenous ulcers had appeared in the right first, second, and third toes 3 months prior to her first visit in December 1955. The lesions were extremely painful, requiring frequent doses of Demerol. She had been in bed for 2 months.

The feet showed marked rubor on dependency, and pallor on elevation. The nail area of the right large toe was infected and black. The tip of the second toe was partially necrotic. The nail bed of the third toe oozed pus and necrotic material. The calf was red and tender. It contained a group of thrombosed veins and surrounding cellulitis.

<table>
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<tr>
<th>Oscillometric readings</th>
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<tbody>
<tr>
<td>Femoral pulse</td>
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<tr>
<td>Dorsalis pedis pulse</td>
<td>0</td>
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<td>Posterior tibial pulse</td>
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Treatment consisted of an oscillating bed, anticoagulants because of the phlebitis, penicillin, digitalis, salt restriction, insulin, and local ointments and dressings. Ambulation was withheld during the first week until the phlebitis subsided. She was then started on weight bearing and was soon walking. The gangrenous areas sloughed and were covered by hard scabs. Warm sitz baths and reflex heat were used.

She was sent home after 3 weeks of hospitalization, but returned every 2 weeks for follow-up visits. Improvement was rapid, and on her last visit (May 1956) she was able to do her homework and walk outdoors on clear days. The black, necrotic area on the second toe sloughed, and granulations developed on the 3 involved toes. Epithelialization followed and complete healing resulted.

**Case 9**

C. V., NYH no. 8928, is a 50-year-old, severely diabetic man with arteriosclerosis obliterans and gangrene of left second toe.

He developed diabetes as a young adult and was followed in the New York Hospital Clinic for 36 years. In March 1953 claudication was present after walking 2 blocks. His feet were cold and painful, and the left second toe had become purple and cold, and then black.

He was kept on an ambulant regimen. Cellulitis of the foot developed, but it responded to penicillin. The necrotic skin sloughed, leaving a granulating surface, which healed slowly.

On his last examination in February 1956 the feet were warm and pink and the claudication distance had increased to 10 blocks.

**Case 10**

Mrs. F., NYH no. 66524 (fig. 10), a 61-year-old Negro, Puerto Rican housewife, had diabetes since 1948. She was first seen in the Vascular Clinic in December 1954, when her right leg was cold and painful and the first 2 toes were gangrenous. Vascular examination was as follows:

<table>
<thead>
<tr>
<th>Oscillometric readings</th>
<th>Right</th>
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<tbody>
<tr>
<td>Femoral pulse</td>
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<td>++</td>
</tr>
<tr>
<td>Popliteal pulse</td>
<td>+</td>
<td>0</td>
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<tr>
<td>Dorsalis pedis pulse</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Posterior tibial pulse</td>
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She was instructed in a medical regimen and sent home. She returned 1 week later with a burn of the left foot from soaking it in hot water, despite specific instructions. She was hospitalized from January 3 to February 19, 1955. There she was placed in an oscillating bed and given the medical measures outlined above. Marked improvement took place, and she was discharged with instructions to carry on her treatment at home, including walking.

At home, her family rejected the treatment. They refused to let her get out of bed, saying it was cruel to make her walk on her black, gangrenous toes. Disuse atrophy and spreading cellulitis in the foot followed,
which necessitated amputation of the leg in May 1955.

Case 11

M. W., a 65-year-old automobile dealer, entered New York Hospital (no. 669097) in October 1953. The diagnosis was arteriosclerosis obliterans with occlusion of both popliteal arteries and a gangrenous ulcer on his skin, which measured 7 by 3 cm. He was severely hypertensive (220/120), but did not have diabetes. Vascular examination is listed below:

<table>
<thead>
<tr>
<th>Elevation pallor</th>
<th>Right</th>
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<tbody>
<tr>
<td>Dependent rubor</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Femoral pulse</td>
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<tr>
<td>Popliteal pulse</td>
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<td>Posterior tibial pulse</td>
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He had been fearful of walking for several months. Ambulation was started at once. The oscillating bed, warm sitz baths, and reflex heat were employed. He remained in the hospital for 3 weeks and then continued treatment at home. The health of the tissues of his legs improved slowly. The necrotic skin at the site of the lesion was removed.

The skin broke down over the outer malleolus at a point of pressure from the patient’s habitual crossing of his feet in bed. A second large necrotic ulcer formed, but gradually both ulcers granulated. After 6 months all tissues appeared healthy, but the 2 ulcers had not epithelialized. They were covered with powdered blood cells and a hard coagulum formed over them. Six months later the epithelium had grown across and the skin was intact. He continues well, walking 1 mile each day at a slow pace, as a therapeutic measure.

Case 12

S. C., NYH no. 383939, was a 60-year-old construction worker, who suffered frostbitten feet during World War I, and again in 1944. He had painful, burning feet and associated “chilblains.” These symptoms were relieved by bilateral lumbar sympathectomy in 1946.

Intermittent claudication developed 1 year prior to admission. His walking distance was gradually reduced to 2 blocks. The feet became cold and red and the right fourth toe became dark purple and very painful.

Examination in September 1954 showed only faint femoral pulses, absent foot pulses, greatly reduced oscillometric readings, and early gangrene of the right fourth toe. It was cold, purple, and contained a black, mummified circular crest, 0.5 cm. across on its dorsal surface. The diagnoses were arteriosclerosis obliterans, partial occlusion iliac arteries, complete occlusion femoral arteries, and early gangrene of the right fourth toe.

He was placed on the oscillating bed with downsling only. He was encouraged to walk the hospital corridors and when not walking to return to the oscillating bed. Warm sitz baths and reflex heat were also administered. Improvement was slow. In 3 weeks pain had gone. He was discharged to continue treatment as an out-patient. One month later the toe had desquamated. By the second month it had an intact, normal pink color. He has been followed at monthly intervals for the past year. He has increased his walking distance to 1 mile at a slow pace (30 minutes). The feet remain painless and pink.

Case 13

E. S., NYH no. 202207, housewife, was admitted in April 1955 at age 74. The diagnoses were arteriosclerosis obliterans, narrowing of vessels, occlusion of left pedal vessels, gangrene of all 5 toes of left foot, congestive failure, moderate hypertension, but no diabetes. She had been a cardiac cripple for several years, but did not follow her cardiac regimen carefully. She had not walked for at least 6 months.

Examination showed an elderly woman in marked cardiac distress. Pulmonary edema was present. Pitting edema of both legs and ankles was 3+. All 5 toes on the left showed black necrotic tips. The distal half of the large toe and its base were necrotic. Femoral pulses were present but pedal pulses could not be felt. Oscillometric readings were markedly reduced.

The congestive failure responded to the usual measures of dehydration and digitalis.

The oscillating bed was used. Patient was ambulated after her cardiac status improved. At first she took only a few steps, leaning against the bed. Soon she was able to walk to the lavatory with help. By the end of the month she was walking about the room and was sent home with an oscillating bed.

The gangrenous toes responded rapidly after ambulation. They were dressed each day with Furacain and loose cotton, then covered with a fluffy sock. The black necrotic material sloughed off. Granulation took place and was covered by clean epithelium 6 weeks after initial admission.

One year follow-up showed the feet to be warm and intact. She remained compensated. She walks about her house and grounds.

Case 14

J. S., NYH no. 656712, a 66-year-old shop owner was admitted in January 1955. The diagnoses were arteriosclerosis obliterans, gangrene of right fifth toe, essential hypertension for 20 years, but no diabetes. Intermittent claudication had commenced 8 years
before. His walking distance had gradually decreased to 1 block.

Two weeks before admission the toe had become cold and purple. It was very painful.

Examination disclosed a blood pressure of 245/128.

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<tbody>
<tr>
<td>Femoral pulse</td>
<td>2+</td>
<td>2+</td>
</tr>
<tr>
<td>Popliteal pulse</td>
<td>1+</td>
<td>1+</td>
</tr>
<tr>
<td>Dorsalis pedis pulse</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Posterior tibial pulse</td>
<td>1+</td>
<td>1+</td>
</tr>
</tbody>
</table>
| Oscillometric readings
  Foot                | 0.1   | 0.1  |
  Ankle               | 0.3   | 0.2  |
  Calf                | 0.4   | 0.4  |
  Thigh               | 1.5   | 1.0  |

A regimen was started of oscillating bed, walking, tobacco interdiction, warm sitz baths, and reflex heat. Improvement was rapid. The dead skin on the toe sloughed and was replaced and he was discharged in 2 weeks.

On his last examination in February 1956, the feet were warm and pink. The dorsalis pedis was strongly palpable. Under the influence of rauwolfia therapy, the blood pressure has fallen to 174/110.

Case 15

J. T., NYH no. 628491, was a 70-year-old farmer. The diagnosis was arteriosclerosis obliterans, with occlusion of major vessels below the knee and gangrenous areas of both feet. He was mildly hypertensive (170/100) and not diabetic. He had been well until several months before admission in May 1952, when his feet became cold, painful, and bright red. He had resorted to very hot soaks, which precipitated gangrene by speeding up metabolism in areas of insufficient oxygen supply.

Examination was as follows:

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Pallor on elevation</td>
<td>4+</td>
<td>4+</td>
</tr>
<tr>
<td>Rubor on dependency</td>
<td>4+</td>
<td>4+</td>
</tr>
<tr>
<td>Femoral pulse</td>
<td>2+</td>
<td>2+</td>
</tr>
<tr>
<td>Popliteal pulse</td>
<td>1+</td>
<td>1+</td>
</tr>
<tr>
<td>Dorsalis pedis pulse</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Posterior tibial pulse</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
| Oscillometric readings
  Foot                  | 0     | 0    |
  Ankle                 | 0.2   | 0.2  |
  Calf                  | 2.0   | 1.2  |
  Thigh                 | 2.5   | 1.5  |

Gangrenous ulcers were on the first, third, and fifth toes of the left foot. The right first toe had a necrotic ulcer under the nail.

The regimen of tobacco interdiction, ambulation, oscillating bed, reflex heat, warm sitz baths (at body temperature), and local dressings was begun. He remained in the hospital 1 month and was followed at fortnightly intervals as an out-patient. The general nutrition of the foot improved and by the third month all ulcers but that of the left fifth toe had healed. A large slough developed in this area, exposing the fifth metatarsal bone, and the toe became mumified. It was cut off with a scissors during a dressing. No anesthetic was needed. Six additional months were required for complete healing.

He was able to resume work on his farm, returning for consultation every 2 months. He walked a minimum of 3 miles each day. This program was continued for the next year until he died in his sleep. It was reported he had a “heart attack” presumably from a closure of a coronary artery with a secondary myocardial infarction.

Case 16

F. A., NYH no. 589998, housewife, was admitted in January 1951, at age 66. She was not diabetic or hypertensive. Four days before admission the left third toe had become very painful and cold. During the next 2 days it became black.

Examination showed the pulses in the left foot to be very weak. Oscillometric readings were reduced. The entire foot was deep purple on dependency.

She was treated with an oscillating bed, walking, reflex heat, and warm sitz baths. Circulation of the foot improved rapidly. The black skin sloughed and was slowly replaced by healthy epithelium.

Two years ago, during a European trip, the third toe on the other foot became black in a similar manner. She immediately returned to New York. Good healing resulted following repetition of the therapeutic regimen. Now, at age 71, she enjoys good health. The feet are warm, pink, and dry. She walks at least ½ mile daily as a therapeutic measure.

Case 17

J. B. was a 56-year-old telephone company executive, who entered Doctors' Hospital, New York in November 1952. The diagnoses were arteriosclerosis obliterans, narrowing of right iliac and occlusion of the femoral artery, and gangrene of the right foot. He was normotensive and nondiabetic.

Intermittent claudication began 8 years previously. One month before admission his walking distance decreased to 50 feet, and the day before admission the right leg had become cold, painful, and mottled purple.

The right leg was pulseless by palpation and oscillometric examination. From the midcalf downward it was cold and purple. The toes were a deep blue. Pulses and oscillometric readings were normal on the left side.

Tobacco was interdicted. Therapy consisted of oscillating bed, reflex heat to groin, sublingual nitroglycerin every 4 hours, and ambulation. At
first he stood at the bedside for only a moment. In a week he was walking about his room each hour for 5 minutes.

After 3 weeks in the hospital he went home with the same treatment, including the oscillating bed. In another 3 weeks he was able to return to his office. His walking distance gradually increased and by February 1953 he was able to walk 3 blocks at his usual pace. At his last visit in February 1956, his walking distance had increased to 6 blocks.

At that time physical examination showed slight pulsations in the right femoral and popliteal arteries. Oscillometric pulsations were present but small from right foot to thigh.

Case 18

M. L., NYH no. 684626, a 65-year-old machine operator, with gangrene of the left second toe due to arteriosclerosis obliterans with occlusion of lower leg vessels, was admitted in May 1954. He did not have diabetes or hypertension. Intermittent claudication began 3 years previously. His walking distance had diminished in the previous 6 weeks to 3 blocks at a slow pace. The left second toe became numb, purple, and cold; the foot became very painful, and the distal half of the toe turned black.

Examination indicated narrowing of the vessels of both legs below the knee. The left second toe was cold and purple in its proximal half, black and inspissated on its distal half. The regimen of oscillating bed and walking was started. He left the hospital in 2 weeks and was seen as an out-patient at weekly intervals. The dead skin sloughed and the toe healed. After 2 years his feet were warm and pink and claudication distance had increased to 2 blocks.

Case 19

T. F., NYH no. 698935, a 69-year-old, retired executive entered the hospital with arteriosclerosis obliterans, occlusion of the left dorsalis pedis artery, plantar arch, and digital vessels, and gangrene of second and third toes. He had a brachial blood pressure of 130/78 and a fasting blood sugar of 86.

He suffered a myocardial infarction 15 years ago from which he recovered with adequate cardiac function. While crossing the Pacific Ocean on a liner he suddenly experienced pain, numbness, coldness, and blanching of his left foot. He was hospitalized in Hawaii where the second toe was amputated. The amputation site did not heal and the third toe became gangrenous.

He was examined by us 8 months later. During this time he had not walked. The leg was shrunken. The skin of the foot was shiny, red, and tense with edema. An infected ulcer was present at the site of amputation and the third toe was black on its dorsal surface and purple elsewhere.

Treatment consisted of oscillating bed and walking. The nutrition of the foot improved at once. He was discharged on the twelfth hospital day to continue treatment at home. The ulcer healed 1 week later. The necrotic skin of the gangrenous toe sloughed. Granulation developed and complete healing took 6 months. He has been followed for 1 year since then. The foot is warm, pink, and dry. He walks more than 1 mile each day in comfort.

Case 20

A. W., NYH no. 565323, a 54-year-old cotton broker, was admitted in March 1950 with arteriosclerosis obliterans, gangrenous ulcer between right third and fourth toes, and occlusion of popliteal artery. He was not hypertensive or diabetic.

He complained of intermittent claudication in the right calf after walking 1½ blocks. Examination showed normal pulses and oscillometric readings. He was advised to give up tobacco and to walk slowly, at least 1 mile daily.

In June 1953 he complained of severe pain and coldness in the right foot and an ulcer developed. He had not given up tobacco, nor had he carried out the other instructions. Examination showed an occlusion of the right popliteal artery. The foot was cold, venous filling was slow, and a necrotic ulcer had formed between the third and fourth toes.

Tobacco was interdicted and an oscillating bed, walking, reflex heat, and warm baths were started. He improved sufficiently in a 3-week period to return home to a distant city and he took an oscillating bed with him. The ulcer healed in 2 months. He gradually increased his walking distance and resumed golf. In follow-up visits the foot has been warm, dry, and pink, and the dorsalis pedis artery can be palpated. He plays a full game of golf several times weekly and continues to abstain from tobacco.

Case 21

J. A., a 63-year-old tavern keeper, was first seen in October 1952. He had arteriosclerosis obliterans
with occlusion of the vessels in both legs below the popliteal artery. The right foot was gangrenous and the second toe was gangrenous. He was normotensive and non-diabetic.

The previous winter he had developed intermittent claudication in the right leg. The foot became cold and painful and ulcers formed between the first 2 toes. On hospitalization elsewhere various local treatments and "vasodilating" procedures were used, but he failed to give up tobacco and the necrosis progressed.

On examination in the office the following observations were made:

<table>
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<tr>
<td>Elevation pallor</td>
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<tr>
<td>Dependent rubor</td>
<td>4+</td>
<td>2+</td>
</tr>
<tr>
<td>Femoral pulse</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Dorsalis pedis pulse</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Posterior tibial pulse</td>
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<tr>
<td>Oscillometric readings</td>
<td></td>
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<tr>
<td>Foot</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ankle</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Calf</td>
<td>1.4</td>
<td>1.6</td>
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</table>

The right second toe was black, a gangrenous ulcer was located between its base and the first toe, and the foot was swollen and cold. Signs of cardiac decompensation were evident. The patient was sent home to carry out the program of walking, abstinence from tobacco, digitalis, salt restriction, and the other medical measures described previously. For the first time he gave up tobacco. He returned for weekly visits and dressings and by January complete healing was effected.

His endurance and walking distance increased. By June 1953 he was able to hunt and do manual labor in his garden. The following winter he had an accident with his formerly gangrenous foot: a bottle fell on his second toe cutting it open, but it healed rapidly.

Three years have elapsed since the gangrenous foot healed. He continued to work a full day in his tavern and also to hunt and to do gardening.

**Case 22**

H. S., NYH no. 713033, was a 57-year-old real estate broker with gangrenous ulcerations of the right leg from arteriosclerosis obliterans. He was not diabetic or hypertensive.

In 1951 he developed intermittent claudication and the arterial circulation gradually worsened. In October 1954 an ulceration appeared on the leg and would not heal. A variety of topical and parenteral medications resulted in an exfoliative dermatitis and he became bedridden.

Examination in April 1955 showed a faint right femoral pulse with no pulses below it. Gangrenous ulcerations were present over the lower half of the right leg. The leg was cold and the skin was macerated. Findings were as follows:

- **Femoral pulse**
- **Popliteal pulse**
- **Posterior tibial pulse**
- **Dorsalis tibial pulse**
- **Oscillometric readings**

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<tr>
<td>Foot</td>
<td>0</td>
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</tr>
<tr>
<td>Ankle</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Calf</td>
<td>1.5</td>
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He had developed sensitivity to many medications. For this reason, upon hospitalization in June 1955, only saline applications could be used on his skin. He was placed on an oscillating bed and encouraged to walk every hour. After 5 weeks he was discharged and continued treatment at home. He visited us each week for dressings.

In September he developed thrombophlebitis in the same leg, which required an additional month in the hospital for anticoagulant therapy.

The skin improved slowly. By December, healing was complete, except for an ulcer 2 cm. across at the ankle. It gradually epithelialized, but took an additional 4 months for complete healing.

**RESULTS**

Failure occurred in case 10 (fig. 7). She had improved during her hospital stay, but when she returned home, her family refused to allow her to walk because of her gangrenous toes. Atrophy and spreading infection developed and led to amputation of the leg.

The other 21 cases healed with only minor loss of tissue.

**Selection of Cases**

At first we used walking only in patients with sharply localized gangrene, who had stabilized over a period of weeks or months. As our experience has increased, we have used it in more recently developed gangrene. If the toes are involved, we encourage the patient to hobble on the heel. If that too is involved, the foot is carefully bandaged and weight bearing is distributed over the entire foot.

Below is a list of tentative indications and contraindications. As experience increases, they may change.

**Indications.** Localized necrosis due to arterial insufficiency from, (a) thromboangitis obliterans; (b) arteriosclerosis obliterans; (c) embolic phenomena.

**Contraindications.** (a) Severe debility; (b)
TREATMENT OF GANGRENE OF FEET AND LEGS BY WALKING

recent myocardial infarction; (e) high fever;
(d) severe myocardial insufficiency; (e) thrombophlebitis, until it subsides; (f) spreading cellulitis; (g) recent gangrene actively spreading;
(h) cerebral damage with paralysis.

SUMMARY AND CONCLUSION

Twenty-two patients with gangrene of legs or feet were treated medically and, in addition, were made to walk progressively. Twenty-one cases healed. One case was a failure and resulted in leg amputation. This patient did not walk after leaving the hospital.

The profession should reconsider the long accepted practice of insisting on bed rest for patients with gangrene of feet or legs from arterial insufficiency. Success in the treatment of 21 patients suggests that walking should be added to the medical regimen of oscillating bed, reflex heat, abstinence from tobacco, antimicrobial ointments, bandages, the release of vasospasm, and the treatment of associated conditions, such as diabetes and cardiac decompensation. Where multiple therapeutic measures are employed, credit for improvement cannot rightly be attributed to one alone. The introduction of walking has not hindered healing and improvement, but appears to have aided it. Ambulation results in a decreased need for nursing care. Patients are able to walk to the bathroom and attend to their personal needs. They are able to leave the hospital sooner. While at home they are also less of a burden. Many are able to return to work while still under treatment.

SUMARIO IN INTERLINGUA

Le membros del profession medical deberea reconsiderar le establite practica de insister super allevamento pro patientes con gangrena del pedes o gambas in consequentia de insufficiencia arterial. Successos obtenite in le tractamento de 21 patientes suggere que ambulation deberea esser addite al regime medical del lecto oscillante, de calor reflexe, de abstinentia ab tabaco, de uguentos antimicrobial, de bandages, de relaxation de vasospasmo, e del tractamento de conditiones associate como diabete e discompensation cardiac.

Sub conditiones de tractamento per multiple mesuras therapeutic, il non es possibile attribuer le melioration del stato del patiente a un mesura individual. Le introduction de ambulation non ha obstruite le melioration e curation sed pare haber avantiato los. Quando un patiente pote ambular, su requeriments de servicii del parte de infirmeras es reduce. Ille pote ir a il lavatorio e satisfacere su desiros personal. Ille pote quitar le hospital plus tosto. Retornate a su domicilio, su presentia representa minus problemas pro su familia. In multe casos ille pote recomenciar travaliar ante le fin de su tractamento.

REFERENCES

Treatment of Gangrene of the Feet and Legs by Walking

WILLIAM T. FOLEY

_Circulation_. 1957;15:689-700
doi: 10.1161/01.CIR.15.5.689

_Circulation_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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