Evaluation and Treatment of Chronic Digital Ischemia

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who were treated during the past five years at the Union Memorial Hospital Hand Center.

Evaluation

Proximal vessel disease is first ruled out by noninvasive techniques or contrast angiographic examination. No patient in this series had significant proximal disease. All patients were then subjected to a variety of noninvasive tests, including use of the Doppler Ultrasonic Flow Detector to record distal pulses. Alternate compression of each artery at the wrist, the so-called Allen’s test, yields useful information about vessel patency. The same test is applied to the fingers for evaluation of individual digital artery flow. The second test involved radioisotope imaging of the distal circulation. In this test, previously reported by Wilgis, we routinely used 20 mCi of Technetium 99 (99mTc) injected intravenously for a dynamic flow study, with exposures obtained at three second intervals, for approximately 50 seconds. Blood pool and delayed studies are then obtained which depict the perfusion of the digits with radionucleide-tagged cells. Peripheral pulse volume recordings with digital perfusion pressures measured in the resting state and then after cold stress constitute the third test. Cold stress involved immersing the hand in water at 12 °C. The peripheral sympathetic nerves were temporarily blocked by injecting 2 cc of 0.5% bupivacaine into the distal palm, which effectively stops the conduction of the digital nerves and their sympathetic contributions to the digital vessels. The patients were again subjected to cold stress and pulse volume recordings.

Treatment

The patients were divided into three groups: 1) those with correctable vascular lesions such as thrombosis of the radial or ulnar artery and palmar arch, with appro-
priate run off; 2) those patients with essentially vasospastic disease, which could be treated by thermal biofeedback; and 3) those patients with impending tissue loss and severe pain or failed thermal biofeedback, which were treated by peripheral digital artery sympathectomy. All patients were followed through a winter following their treatment with a minimum time of six months.

Results

Of the ten patients with direct microvascular reconstruction of wrist or palmar vessels, eight were improved and had no further complaints. Seven of these eight patients had patent vein grafts as evidenced by the Allen test with Doppler examination and/or pulse volume recordings. All patients who underwent microvascular reconstruction had evidence of thrombosis of the radial or ulnar artery at wrist level or distant for at least one year prior to surgery. Six of these patients had had a diagnosis of peripheral thrombosis made five years prior to this study, and had been treated conservatively. Chronic ischemic complaints of pain and whiteness in the ulnar two digits necessitated further treatment. The operative approach to this group of patients consisted of exploration of the affected artery, resection of the involved segment and replacement with an interpositional reversed vein graft taken from the dorsum of the forearm. In three patients, a branched vein graft was necessary due to branching of the distal arterial tree.

Thermal biofeedback was used in 22 patients, and was helpful in 20. Testing with pulse volume recordings and cold stress showed that all patients could initiate an increase in digital perfusion using this technique; however, only 70% could sustain this improvement. This particular modality of treatment was most helpful in the patient in whom anxiety and stress played an important part of the initiation of the vasospastic episode. The patients could usually obtain a temperature rise as much as 4.5°C with each biofeedback session.

Digital sympathectomy requires isolation of the terminal branches of the sympathetic nerves which travel with the peripheral nerves, dividing these terminal branches and stripping adventitia from the common digital and proper digital arteries. This procedure is done with the aid of the operating microscope. In this study, we performed 18 digital sympathectomies in ten patients. All of these patients responded before operation to the digital block, with measured improved digital perfusion. Of these ten patients, nine gained improved digital flow both clinically and manifested by pulse volume recordings after operation and radioisotope studies. Wound healing with pain relief occurred in all patients with digital ulcers in whom a sympathectomy was performed. All but one of these patients have had significant improvement of intolerance which has lasted through an average winter's cold exposure. The longest follow-up group of patients is four years.

Discussion

Many authors have recommended reconstructing the distal arterial tree of the upper extremity, including radial and ulnar arteries in the acute thrombotic section. In the patient with chronic vascular obstruction, which has been present for more than one year, the operative technique is somewhat different in that the diseased segment must be resected from the first branch proximally to the branching of the palmar arch distally. Sometimes the digital artery to the ulnar aspect of the little finger is resected to get to the main branches of the common digital artery to the ring and little finger. Moz
e showed by dynamic studies that even the radial or ulnar artery predominately perfused the hand in 98% of the patients. The radial artery was domine in 12% of his subjects. It is our impression that the reason patients thrombose a distal artery and some years later develop pain and signs of digital ischemia is because that vessel provided dominant circulation to the hand prior to the occlusion. Postthrombotic circumsie is not enough to accommodate the needs of the hand and chronic digital ischemia is the net result. Therefore, these patients will respond to reconstruction. However, if the patient does not injure his dominant artery, he will not develop chronic digital ischemia in the absence of damage to the dominant vessel. Our operative approach is standard excision of the damaged segment and interpositional vein graft replacement. Microscopic techniques are used, and following vein graft anastomoses, when the tourniquet is released, the noninjured arteries are occluded by finger pressure so that the entire circulation to the hand must be delivered through the interposition vein graft. This pressure is maintained for approximately 20 minutes, so that the circulatory dynamics will be given a chance to stabilize.

Thermal biofeedback is essentially the process of gaining voluntary control over automatically, reflex-regulated body functions such as circulation. The term "biofeedback" was conceived as a term to describe the process of feeding back physiologic information to the patient. The technique involves monitoring a selected physiologic activity, such as circulation, with an instrument which senses by electrodes or transducers, signals of physiologic information about such body functions as heart rate, blood pressure or temperature. The signals obtained are then amplified and
in the instrument to activate a display which portrays changes in the physiologic activity. Most of the instruments have been designed so that the individual undergoing biofeedback training can “see or hear” changes in his selective biologic activity. This modality can be demonstrated by using an ordinary thermometer purchased from a drug store. The thermometer is taped to the pulp of the middle finger and after five minutes in quiet sitting, preferably with the eyes closed, the temperature of the finger is noticed. The individual then repeats a few autosuggestion phrases to himself such as “my hand feels warm” and/or “I feel calm and relaxed.” Most people will tend to show a rise in finger temperature after 10–20 minutes, some increasing their finger temperature three to five or even 10°C. With repeated practice, everyone of our patients was able to learn to increase finger temperature voluntarily. Additionally, we noticed that the patients with pulse volume recordings demonstrated an increase in pulse volume and digital perfusion following biofeedback activity. While this is easily achieved in the controlled environment, only 70% of the patients could use this technique at home. This has been most helpful in those patients in whom there was an emotional contribution to the vasospastic ischemia episodes. Inasmuch as this technique is beneficial and, so far, without complications, we routinely recommend that patients with cold intolerance and vasospasm undergo biofeedback training.

Digital sympathectomy was first described by Flatt, who devised a very distal sympathectomy for use in digital circulatory problems. Pick, in his anatomy textbook, points out that the brachial plexus does not receive its rami communicantes exclusively from the cervicothoracic sympathetic trunk. Another set of rami communicantes to the sympathetic trunk. These pathways, especially the intermediari ganglia, remain untouched by the operation and later play an important role in residual sympathic activity.

The distal sympathectomy is performed by one filament from the superficial branch to the radial nerve and by eight additional twigs from the radial cutaneous nerve of the forearm. The distal third of the ulnar artery receives three direct branches from the radial nerve and a branch from the medial cutaneous nerve of the forearm. This branch usually travels the volar surface of the ulnar artery and can be visualized at wrist level. The deep palmar arch receives branches from the deep branch of the ulnar nerve one from the median nerve. Within the hand, the superficial palmar arch receives approximately 12 branches from the common digital nerves.

The digital arteries themselves receive from three to 12 twigs from the proper digital nerves (Fig. 1). In considering the patient with distal arterial problems, most of these patients exhibit ischemia in the fingers from the level of the midpalm to the tips. It seems reasonable that if there are sympathetic nerves which are present in the distal peripheral nerves and the objective is relief of symptoms in the digits, then the sympathetic interruption should be performed as far distal as possible. Blocking of the distal sympathectomies before operation allows one to predict the effect of the digital sympathectomy. In our patients, only those who had a positive response from the peripheral blockade with bupivacaine were subjected to the operative procedure. In 17 of 18 digits, the operative procedure was beneficial. So far, we have had no recurrence of symptoms following the operative treatment in these patients, in spite of being exposed to the cold for a winter season. The operative approach varies with the number of symptomatic digits. A zig-zag transverse palmar in-
Digital Ischemia
Cold Intolerance
↓
Noninvasive Evaluation
↓
Sympathetic Block with Cold Stress
↓
Digital Sympathectomy

Fig. 2. Methods of evaluating chronic digital ischemia to see if there is a surgically correctable arterial lesion.

cision exposes the palmar arch and the common digital arteries permitting one to effectively treat all four digits. In the isolated digital ischemic condition, we have elected to proceed farther distally in the finger to the level of the proximal interphalangeal joint so that all possible connections between the digital nerve and the digital arteries are divided. The neurovascular structures are exposed and with the aid of the operative microscope, all connections between the nerve and vessel are divided by sharp dissection. Then, using two jeweler's forceps and some sharp dissection, the loose adventitia around the common digital and proper digital arteries is removed in a circumferential fashion. This effectively removes all of the terminal sympathetic branches from the vessel. We routinely do this for a distance of 2 cm. It must be emphasized that the vessel is not to be damaged, and the media and intima must be left untouched or thrombosis will occur. Many times there is not an immediate response due to the strong humoral component of sympathetic activity which may still be present in the digit. However, one begins to see a response several hours after operation, and by the following day, the finger is usually warm and there is a temperature difference of as much as 6°C between the operated and nonoperated digits. In our patients, the pain usually healed within two weeks and the pain was alleviated almost immediately. Part of the pain relief may have been due to the temporary neuropraxia of the digital nerve secondary to manipulation. All working patients have returned to work and there have been no complications of the operative procedure.

In summary (Fig. 2) the patients with chronic digital ischemia must first be evaluated to see if there is a surgically correctable arterial lesion. The evaluation consists of a series of noninvasive studies including diagnostic testing with cold stress and sympathetic blockade of the peripheral nerves. If vascular reconstruction is not indicated, then two methods of treatment may be employed: thermal biofeedback of surgical digital sympathectomy. The results have been encouraging and, although we realize that many operative and therapeutic approaches have been presented for this problem, this is an attempt to deal with the problem at a distal, and hence, more effective level.

References


In 1944, or thereafter, at New York Hospital Drs. Bronson Ray and A. D. Console did some superb studies in humans and demonstrated that some sympathetic fibers in a few patients were carried through the somatic nerves as Dr. Wilgis pointed out. In our patients all the fibers went through the upper sympathetic chain.

Further, I feel strongly that the supraclavicular approach, the so-called Atkins and Telford approach, in vasospastic patients is a risky one. The anterolateral transthoracic approach of Palumbo, or the transaxillary one of Goetz, or the posterior approach of Wall and Smithwick, should be employed. I'd like to cite one case which presents some horrors of that phenomenon.

F.M., a 42-year-old white woman, a nonsmoker with marked hirsutism, entered the hospital on December 9, 1953, with a two-week history of pain, blueness, and coldness of the fingers of the right hand. The radial, ulnar, and proximal digital arteries pulsated. Conservative therapy was of no avail, and a distal ganglion block brought temporary complete relief for a short time. It was then decided an upper thoracic sympathectomy should be performed, and this was performed by a skilled neurosurgeon, using the supraclavicular approach.
chronic digital ischemia

Dr. Calvin B. Ernst (Baltimore, Maryland): I rise only to emphasize Dr. Stallworth's admonition of ruling out proximal large vessel disease which might serve as an embolic focus for digital ischemia. Pulse volume recordings as well as Doppler blood pressure measurements are helpful but the simple expedient of taking bilateral arm blood pressures serves as well, particularly when there are significant gradients.

(slide) Here we see a stenotic lesion in the proximal left subclavian artery in a 55-year-old woman who presented with left index finger ischemia. To identify this proximal embolic lesion required two arteriograms, because during the first study the angiographer, upon performing a selective left subclavian injection, passed the angiographic catheter beyond the lesion. Upon restudy, the ulcerative-stenotic lesion was identified. This underscores the need for studying the entire proximal arterial tree to detect such lesions. Parenthetically, brachial artery pressure gradients between right and left upper extremities measured 45 mmHg, a difference which documented proximal stenosis.

Some proximal embolic lesions may be far more subtle, however, particularly when upper extremity blood pressures are equal. (slide) This arteriogram documents intimal roughening in the left subclavian artery in another individual who also had the blue digit syndrome. (slide) Upon exploring this subclavian artery, an ulcerated plaque was identified.

Finding proximal embolic vascular lesions requires excluding such foci from the circulation, either by excision of the arterial segment and vein graft interposition, or by extra-anatomic reconstruction, such as axilloaxillary bypass. We have favored axillary-axillary bypass over the past few years, performing the ipsilateral anastomosis end-to-end, distal to the embolic lesion. This procedure is technically simple and the morbidity and mortality rates are low.

Therefore, careful arteriographic study is necessary in evaluating individuals with digital ischemia because overlooking a proximal embolic lesion precludes successful management since repetitive embolic events will continue. Local operative procedures on the hand will not succeed under these circumstances in preventing progressive digital ischemia.
Since some proximal arterial lesions are subtle, I would like to know if you have identified any such lesions during follow-up, particularly among those individuals who have not improved.

Dr. B. Shumacker, Jr. (Indianapolis, Indiana): If I understood him correctly, I find myself in disagreement with the author’s opening statement that proximal sympathectomy in digital lesions of this sort is ordinarily a failure. Perhaps the occasional failures which occur may have something to do with the manner in which the proximal sympathectomy is carried out.

I have a large experience with the original White-Smithwick posterior preganglionic operation. I believe that the number of extremities so denervated for various ischemic lesions approaches 500. There has been no death. Most of the patients have left the hospital in 4 or 5 days; and I consider it a very simple and effective operation and better than a postganglionic procedure.

There are two conditions in which the operation not infrequently yields less than desirable results. One is in idiopathic Raynaud’s disease, where there is, I firmly believe, in addition to sympathetic overactivity, a local fault, as Sir Thomas Lewis pointed out long ago. I don’t see how operating distally could remove any local arterial fault.

The other is in progressive arteritis of small arteries not treatable by any known medical means; that is, not treated in such a way that the disease process will always cease to progress. Once again, I don’t see how the site of the operative procedure carried out can alter the progression of the disease.

I am confident that if a known distal lesion is present, either embolic or intrinsic in the artery itself, and simple proximal preganglionic sympathectomy is not effective, one certainly would be justified in immediately resorting to an effort at microvascular reconstruction of the blocked artery or arteries.

I do not mean for my remarks to detract from the remarkable contribution which Dr. Wilgis has made. It is new, thought-provoking, and, in their hands, it has been certainly most successful, and I expect that it will be used with greater frequency in the future.

Dr. E. F. Shaw Wilgis (Closing discussion): In an attempt to answer some of your questions, we have not seen regenerates in these small sympathetic branches in the patients that we have done so far.

And to try to answer some of the questions on cervical sympathectomy, our interest in this particular subject was shown by the fact that the first three patients in this study had been done 2 years ago, and they all have responded to the more distal operations.

Since this study has been completed a year ago, we have performed approximately 30 more of these operations. Six of the patients had been failures of cervical sympathectomy.

We haven’t seen any patients with proximal disease in the arm who have not responded to any of the approaches that we have presented. However, in all of the preoperative testing we have effectively ruled out problems in the subclavian and upper thoracic tree.

I’d like to emphasize two points: 1) that we do insist on our patients not smoking. (slide) This simple slide shows the difference between the pulse pressure and pulse wave, and then after one cigarette. We show this slide to all our patients to insist that they give up smoking.

I did have one patient who said, “Well, if this operation works well, then I can just smoke twice as much,” but we were reluctant to do it.

In answer to Dr. Jabaley’s question, (slide) and if you remember this slide, it’s oriented a little differently now. This is the nerve and the sympathetic connection here. We have been doing chemical studies, as well as histologic studies on these nerves. Dr. Flatt has shown that this nerve, with electron microscopy, has unmyelinated fiber, indicating that it may well be a sympathetic.

We have been taking the adventitia from the vessel and the nerve and subjecting this to catecholamine fluorescence studies, and we show you one of these. If we can just darken the auditorium completely, this may show up. (slide) But this is a digital artery here, these little dots along here, and especially right through here, the catecholamine-rich sympathetic trunk coming into the artery. We’re hoping to do this in more extensive fashion.