AI were seen in two cases we examined, but the patients did not undergo sufficient testing to verify the results. Thus, further study with many more patients covering a wide spectrum of disease is needed before true group values are determined for diagnostic purposes.

CONCLUSION

The dual-radioisotope technique has several significant advantages in the evaluation of impotent men. The procedure is easy to perform and takes less than 1 hr. It is much less invasive, painful, or embarrassing than some other techniques, such as selective pelvic arteriography. When a pharmacologic erection is produced, the genital area is shielded by the scintillation camera as well as by drapes and the erection is not readily observed by assisting personnel. More importantly, the study reveals information about both arterial inflow and venous outflow in a continuous manner that other methods of evaluation have been incapable of demonstrating in a routine way. Finally, since most hospitals have nuclear medicine facilities, the technology to implement the study on a wide basis is readily available. The procedure warrants further investigation and is by no means standardized at this point in time. Our early success, however, leads us to believe that this method will be an important diagnostic study in the evaluation of male impotence and may also be an important tool for the study of male erection physiology.

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EDITORIAL

Vascular Testing for Impotence

Miraldi et al. present a scintigraphic method for evaluation of the hemodynamic integrity of arterial inflow and veno-occlusive function during pharmacologically-induced erections. In their paper, they describe a dual-isotope technique to "provide a true measurement of the vascular dynamics."

In this report on 14 subjects, 6 were chosen as "sexually active" controls, 3 had arterial insufficiency on the basis of selective pudendal arteriography, and 5 were diagnosed as having corporal veno-occlusive dysfunction based on abnormal pharmacocavernosometry and pharmacocovernosog-

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raphy. Using their dual-radioisotope technique, patients with arterial insufficiency are identified by exhibiting a lower average peak arterial flow rate than controls. Similarly, patients with corporal veno-occlusive dysfunction were distinguished by recording an elevated average peak venous flow as compared with normal controls.

This study is hoped by the authors to have the potential to be an important diagnostic test in the evaluation of male impotence. Further investigation of the technique is required. It should be appreciated that there is as yet no universally agreed upon diagnostic algorithm for the vascular evaluation of impotent patients. Furthermore, many of the currently available vascular tests, such as pulsed-focused Doppler ultrasound and pharmacocavernosography, are in evolution and their reliability has not been fully determined.

Great strides have been achieved in erectile physiology and the understanding of the erectile mechanism over the last decade. The introduction of the dual-isotope study in 1991, however, must attempt to meet these new physiologic principles and standards. This editorial will discuss the inherent difficulties that are common to diagnostic studies in the area of hemodynamic evaluation of penile erection. It is imperative, that if we as clinicians are to advance in the field of vascular evaluation of impotence, we all must meet these new standards.

First, the six subject control population in this study were considered to have normal hemodynamic function based upon being "sexually active." Most other studies concerning vascular testing in impotence have utilized similar normal controls. There are, however, problems using such control subjects. Erectile potency, the presumed status of the above six subjects, is defined as the ability to achieve an erection of *sufficient* rigidity to achieve penetration and the ability to achieve an erection of *sufficient* sustaining capability to maintain penetration until ejaculation. Potency, however, does not reflect normal hemodynamic status, only functional hemodynamic status. Potency, by representing functional erectile capability may therefore exist in the presence of even moderate hemodynamic impairment. Furthermore, the ability to be "sexually active" is dependent not only on hemodynamic integrity but also upon psychologic well-being and the status of the partner. As an example, a 60-yr-old man in a 40-yr successful marriage with the same partner may be sexually active and potent with a partial penile erection. That same quality partial erection in a 25-yr-old man with different expectations and a younger partner may be considered inadequate and consistent with impotence. Thus, two hemodynamically similar erections were considered potent and impotent under different circumstances. Potency, by virtue of its subjectivity, is not the ideal baseline for establishing normal hemodynamic status of either arterial inflow or corporal veno-occlusive function.

How can one, therefore, define "normal" hemodynamics during erection that is applicable for clinical use? Erection results following penile smooth muscle relaxation. Dilation of the cavernosal and helicine arteries increase blood flow into the lacunar spaces within the corporal bodies. Relaxation of the trabecular smooth muscle enables dilation of these lacunar spaces resulting in penile engorgement. The systemic arterial blood pressure now transmitted through the dilated helicine arteries expands the relaxed trabecular walls against the tunica albuginea and compresses the subtunical venules. The reduction of venous outflow by the mechanical compression of subtunical venules on the surface of the erectile tissue, is known as the corporal veno-occlusive mechanism. This reduces corporal venous outflow and elevates intracavernosal pressure making the penis rigid. The intracavernosal pressure during an erection is the result of the equilibrium between the perfusion pressure in the cavernosal artery and the resistance to blood outflow through the compressed subtunical venules. Normal inflow and outflow hemodynamics may be said to occur only when after appropriate stimulation, intracavernosal pressures approximate the systemic arterial blood pressure (*1*). It thus would be appropriate for Miraldi et al. or others interested in vascular assessment for impotence to test their hypotheses concerning normal hemodynamics using such physiological principles.

The diagnosis of arterial insufficiency in the abnormal population was based upon arteriographic abnormalities. What is the most appropriate clinical investigation to be used for arterial insufficiency of the hypogastric-cavernous arterial bed leading to impotence? Selective internal pudendal pharmaco-arteriography is usually reserved for only those patients being considered for arterial reconstructive surgery. The study is invasive, requires sedation, and is associated with potentially serious, albeit rare, vascular complications. The arteriogram is an anatomical study, and its interpretation should be corroborated with the results of other erectile function studies. Arteriographic studies are controversial as definitive assessments of arterial occlusive disease because there is a lack of data in normal control populations. Moreover, all dynamic state testing, especially arteriography, is subject to the problems of excessive adrenergic constrictor tone secondary to anxiety and the possibility of misinterpreting vasospasm as stenosis. Finally, the ideal anesthetic (general versus local) necessary for the procedure has not yet been defined. For the above reasons, arteriography alone is not the ideal method of establishing arterial insufficiency against which radioisotope techniques are to be compared (*2*).

Functional evaluation of penile arteries during impotence testing is presently most commonly performed using focused-pulsed Doppler ultrasonography in conjunction with intracavernosal vasoactive agent administration to determine changes in the cavernosal artery diameter and in

blood flow velocity (*3*). Cavernosal arteries with atherosclerotic occlusive disease show minimal change in diameter and low blood flow velocity measurements in the dynamic state. Another method of determining cavernosal artery systolic pressure in the dynamic state is by recording intracavernosal pressure and simultaneously determining cavernosal artery pulsatile flow by Doppler ultrasound. Typically, such cavernosal artery systolic occlusion pressure is performed during pharmacocavernosometry. The intracavernosal pressure may be increased by infusion of heparinized saline until the Doppler signal disappears. When saline infusion is terminated, the intracavernosal pressure will diminish below the cavernosal artery systolic pressure with the resultant reappearance of cavernosal artery pulsatile flow. The intracavernosal pressure at which cavernosal artery pulsations return is defined as the effective cavernosal artery systolic pressure implying the maximal arterial pressure which can be delivered to the lacunar space during erection (*4*). Arterial occlusive disease of the hypogastric-cavernous arterial bed decreases perfusion pressure and arterial flow to the lacunar spaces, thus decreasing the rigidity of the erect penis and the time to maximum erection, respectively. Functional studies measuring the above variables, not exclusive anatomic studies, are required for disease correlation to radioisotope testing.

The diagnosis of corporal veno-occlusive dysfunction in the abnormal population in this study was based upon cavernosometric findings. Corporal veno-occlusion is the result of the passive compression of the subtunical venules against the tunica albuginea by relaxed, expanding erectile tissue. Corporal veno-occlusive dysfunction has two basic etiologies. The first is insufficient relaxation of the corporal trabecular smooth muscle secondary to excessive adrenergic constrictor tone due to anxiety. The second is the inability of the tissue to expand secondary because of either smooth muscle myopathy or poor compliance of the erectile tissue. These latter pathophysiologic mechanisms are associated with proposed structural alterations in the fibroelastic components of the trabeculae secondary to vascular risk factors such as aging, hypercholestereolemia, diabetes mellitus, previous priapism, surgery or trauma to the penis (*1*). To document corporal veno-occlusive dysfunction primarily related to organic pathology and not interfered with by the effects of anxiety, testing must adequately address the need for sufficient pharmacologically-induced corporal smooth muscle relaxation.

The dual-isotope technique of Miraldi et al. utilized to identify venous leak does not meet the above concerns. We have found using cavernosometric indices that complete smooth muscle relaxation exists when the relationship between the variables flow to maintain (ml/min) and intracavernosal pressure (mmHg) are linearly related (*5*). Such a linear relationship implies a constant outflow resistance based upon the equation of flow = pressure/resistance. Furthermore, we have shown that in cases in which this linear relationship is not present, redosing with a second dose of intracavernosal vasoactive agents can achieve this linear relationship between flow and pressure and result in the necessary complete smooth muscle relaxation (*6*).

Specifically, it is unclear as to the benefit of intracorporal injection of xenon and recording average peak venous flow prior to the attainment of complete smooth muscle relaxation. Such methodology had been tried with previous cavernosographic techniques using standard iodinated agents. Based upon the aforementioned as well as the decade of experience with cavernosography, it would appear that the diagnosis of corporal venoocclusive dysfunction would best be documented by injecting the xenon after complete smooth muscle relaxation had been realized. Recording this phenomenon earlier is too dependent on test conditions and does not reflect erectile quality "in the bedroom."

The dual-isotope technique may yet prove to be a less invasive, painful, and embarrassing testing technique that will be an important diagnostic study in the evaluation of male impotence. Further investigation of the technique is required using contemporary physiologic principles.

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