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A pressure-based technique for the detection of acute and chronic venous obstruction

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Summary

A simple pressure-based technique for the detection of venous obstruction is described. The severity of obstruction can be graded utilizing the technique outlined. The method has a high degree of sensitivity and specificity and is easily employed as a routine procedure in the vascular laboratory. The technique provides invaluable haemodynamic information in venous obstruction in a variety of clinical settings as illustrated.

Keywords: chronic venous obstruction, acute venous obstruction, postphlebitic syndrome, arm/foot venous pressure differential.

Introduction

Ascending venography is the mainstay for the diagnosis of venous obstruction in most institutions. As an anatomical technique, it has certain drawbacks — notably, its inability to assess the haemodynamic severity of the obstructing lesion in that the contribution of collaterals to venous outflow cannot be adequately ascertained. In addition, depending upon the technique utilized, some portions of the venous system — especially in the pelvis — are poorly visualized and obstructive lesions can be missed. A simple pressure-based technique for the diagnosis of venous obstruction is described which, when utilized with ascending venography, results in superior assessment of the lesion and provides important pathophysiological information. Illustrative examples are provided in this presentation to highlight the practical uses of the technique in a vascular practice.

Technique

Arm/foot venous pressure differential

With the patient in the supine position, a no. 23 butterfly needle is inserted into a vein in the dorsum of the foot and the pressure measured in mmHg utilizing a venous transducer placed at the level of the venipuncture. A similar pressure measurement is made in a vein on the dorsum of the hand.

Foot venous pressure elevation with reactive hyperaemia

Through a thigh cuff inflated over 300 mmHg for 3 min, reactive hyperaemia of the lower limb is induced. Utilizing the previously inserted needle in the foot, venous pressure before and after the induction of reactive hyperaemia is recorded. Heparinization of the saline drip (1000 u/l) helps to maintain patency of the needle during venous occlusion. A strip chart recording of the pressure changes during the procedure facilitates identification of stable points in the venous pressure curve for measurement. In our own laboratory, the above two measurements are routinely recorded in all patients undergoing ambulatory venous pressure measurements for suspected venous insufficiency.

Results

The arm/foot venous pressure differential and reactive hyperaemia-induced foot venous pressure elevation in a group of limbs with an unobstructed venous system

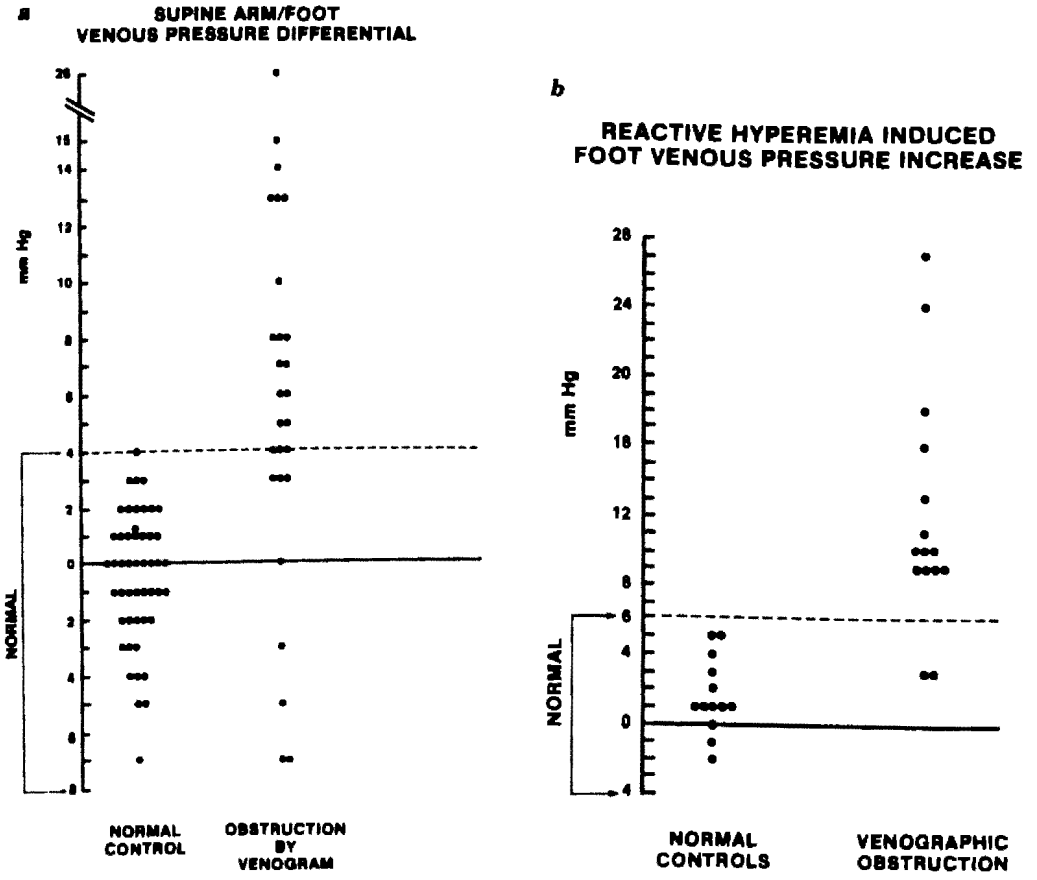

Fig. 1. ***Supine arm/foot venous pressure differential (a) and reactive hyperaemia-induced foot venous pressure increase (b) in a group of 'normal' and venographically obstructed limbs.***

proven by ascending venography are shown in Fig. 1 (*a* and *b*). Based on these data, the 'normal' value for arm/foot venous pressure differential was established as 4 mmHg or less. For reactive hyperaemia-induced foot venous pressure elevation, a value of 6 mmHg or less was considered 'normal'.

The arm/foot venous pressure differentials in a group of limbs with an obstructed venous system in the lower limb confirmed by ascending venography are also shown in Fig. 1 (*a* and *b*). While an abnormal value (>4 mmHg) exists in many patients, a 'normal' value was obtained in several instances. This was attributed to the contribution of collateral venous circulation in those patients with normal pressure values. The reactive hyperaemia test was devised to elucidate the situation further with the expectation that the adequacy of collaterals could be better ascertained by this technique during the increased haemodynamic load of increased blood flow. The values for foot venous pressure elevation with reactive hyperaemia for a group of limbs with proven venous obstruction are shown in Fig. 2. The corresponding arm/foot venous pressure differentials for individual limbs are also shown in Fig. 2. Based on the values obtained for these two parameters, patients with venographic obstruction could be classified into four different groups. Group 1 comprised patients with 'normal' arm/foot venous pressure differential and 'normal' reactive hyperaemia venous pressure response despite venographically proven venous obstruction. These patients have a fully compensated venous system from collateralization despite the appearance of venographic obstruction. Apparently the venous collaterals are fully adequate during rest and during reactive hyperaemia. The next group of patients (group 2) have a higher grade of venous obstruction with collaterals that are adequate at rest, but inadequate during reactive hyperaemia. These patients have normal arm/foot venous pressure differential but have abnormal elevation of

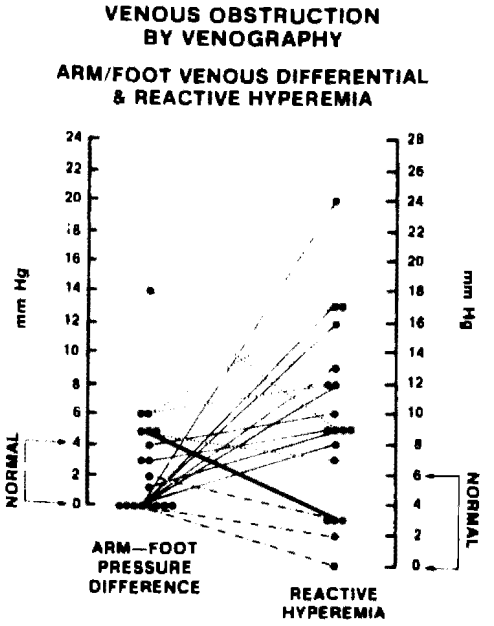

Fig. 2. ***Gradations of severity in venographically obstructed limbs by the pressure-based method. Groups: —·—·— 1; —— 2, ------ 3, —— 4.***

foot venous pressure during reactive hyperaemia. A further gradation of venous obstructive severity can be seen in some patients (group 3) who have both an abnormal arm/foot venous pressure differential and an abnormal response to reactive hyperemia. Finally, the most severe haemodynamic form of obstruction is seen in group 4: patients in whom an arm/foot venous pressure differential of 4 mmHg or more is obtained at rest, but the reactive hyperaemia test is essentially negative for abnormal foot venous pressure elevation as they are fully decompensated. These patients have a high grade venous obstruction with a fixed blood flow such that reactive hyperaemia cannot be induced.

The above two tests when utilized in combination have a high degree of sensitivity and specificity. Among 24 'normal' limbs and 24 obstructed limbs (proven by venography), sensitivity was 90% and specificity was 93%. The few false negatives were in fact due to group 1 obstructions, i.e., venographic obstruction with good functional collaterals.

Discussion

An early description of a pressure-based method to detect iliac vein thrombosis was reported by Negus & Cockett[1]. Femoral venous pressure was monitored by direct venous puncture and values were recorded before and after limb exercise. Resting pressures in the femoral vein were compared to the opposite lower limb, rendering the method ineffective in bilateral venous obstruction and also in obstructive lesions of the venous stream occurring at points more distal to the monitoring site. The technique described herein is easier to perform, avoids limb exercise with the venipuncture needle *in situ*, and is sensitive to bilateral and even distal obstructions. It is recognized that even distal obstruction at the calf or popliteal vein level can be haemodynamically severe[2,3].

The widely used impedance plethysmographic technique in acute venous obstruction was not found useful in chronic venous obstruction in our experience. The mercury strain gauge plethysmograph is reportedly fraught with calibration problems, especially with certain brands of the equipment. Its utility in obtaining reproducible data for the follow-up of patients with chronic venous obstruction has not been established. The pressure-based method described herein has the advantage of simplicity, utilizes standard techniques and equipment readily available in any vascular laboratory, and the technical manoeuvres are easily taught. It is useful in acute as well as chronic obstruction.

This technique has been in use in our laboratory for some years as part of a routine protocol for the assessment of chronic venous insufficiency. In this setting, it has been helpful in all phases of the clinical management of this problem including the diagnosis, evaluation, choice of treatment, and follow-up of patients with venous obstruction. Some practical illustrations of the utility of the technique follow.

Diagnosis

Ascending venography may fail to detect venous obstruction, especially in the iliac vein/vena caval region, owing to dilution of the contrast medium. In several

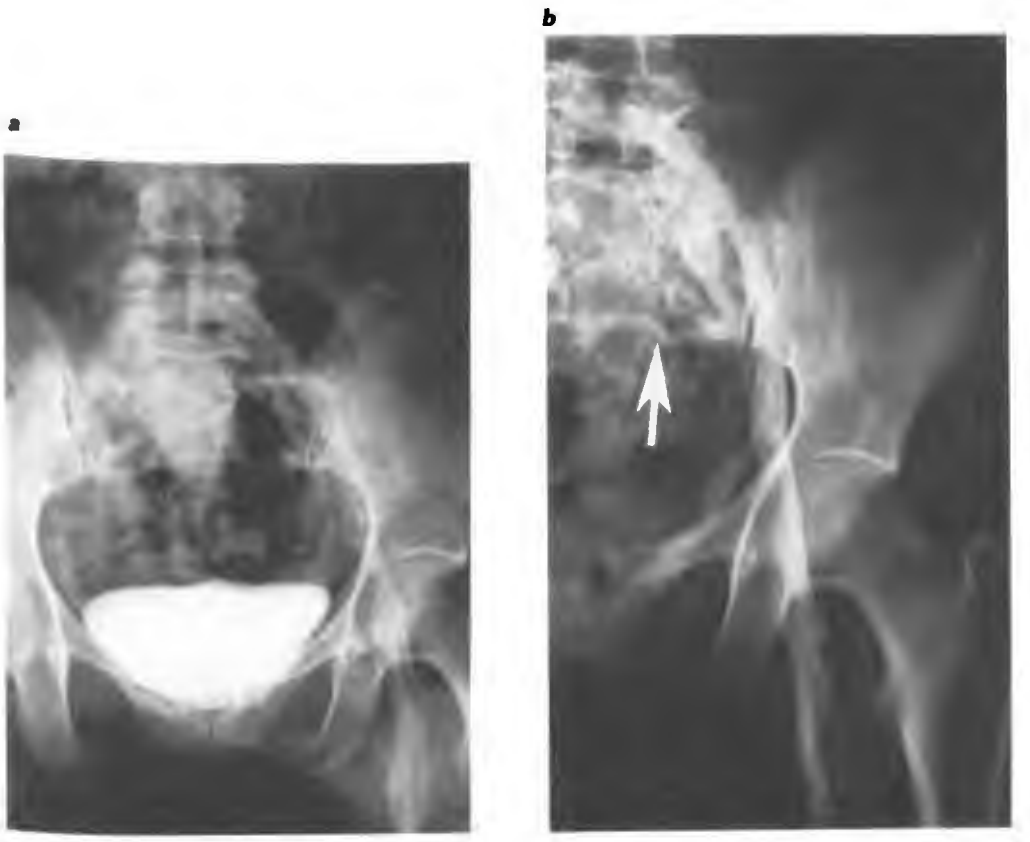

Fig. 3. ***Patient with iliac vein obstruction. The diagnosis was initially missed due to poor technique (a). The obstruction and transpelvic collaterals are more clearly evident on a subsequent venogram (b).***

instances, the radiographer was able to demonstrate the obstruction by modifying his technique after being alerted to the presence of obstruction indicated by the pressure method. In a symptomatic patient, an initial venogram was reported as normal (Fig. 3*a*). The arm/foot pressure differential was 5 mmHg, prompting a repeat venogram (Fig. 3*b*). An iliac vein obstruction with recanalization and collateralization is now evident.

Assessment of collaterals

In our experience, the haemodynamic contribution of collaterals varies widely. In certain types of obstruction, collateral formation may be completely adequate, or nearly so, with normal pressure parameters. In other instances, even in the presence of collaterals, elevated arm/foot pressure differential and/or reactive hyperaemia are often found. We have found venography to be a poor guide in the assessment of collaterals. Since radiographic visualization of collaterals depends so much on technique (site of dye injection and dilution), poorly visualized

Fig. 4. ***Prominent but functionally inadequate perforator collaterals in a patient with popliteal vein obstruction. Arm/foot venous pressure differential was 0 mmHg, but reactive hyperaemia-induced foot venous pressure elevation was 17 mmHg.***

collaterals may be haemodynamically adequate. Conversely, some impressive-looking collaterals, large in size and numerous, may be functionally inadequate owing to kinking, stenosis or valves oriented against the direction of collateral flow (Fig. 4). Assessment of the haemodynamic adequacy of collaterals is especially important in determining the need for venous bypass surgery for obstruction. Two patients with iliac vein obstruction are presented in Fig. 5*a* and *b*. While the films appear radiologically similar, the patient represented in Fig. 5*a* was fully compensated (arm/foot pressure differential 2 mmHg — reactive hyperaemia elevation 2 mmHg). Bypass surgery was obviously not indicated in this instance. The patient represented in Fig. 5*b*, however, had grade III obstruction (arm/foot pressure differential 5 mmHg — reactive hyperaemia 6 mmHg), prompting venous bypass surgery.

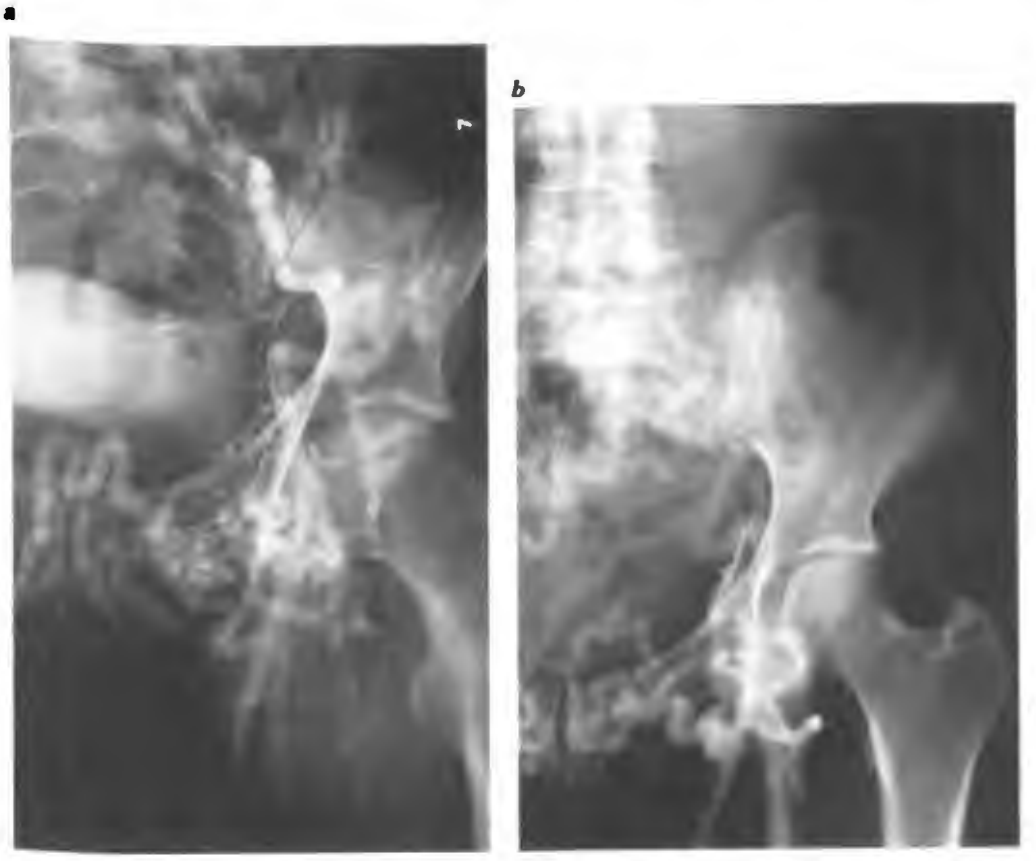

Fig. 5. ***Two patients with radiologically similar iliac vein obstruction. The patient on the left (a) had fully compensated collaterals while the patient shown on the right (b) had grade III obstruction.***

It has been stated that iliac vein obstruction is haemodynamically and symptomatically more severe than more distal forms of obstruction in the popliteal vein and calf. We have not found this to be universally true. In several instances we have observed popliteal venous obstruction to be haemodynamically quite severe.

Follow-up of patients undergoing venous bypass surgery

The patency of venous bypass can be determined quite reliably by the pressure method. The preoperative and postoperative follow-up values for arm/foot pressure differential and reactive hyperaemia test for two patients undergoing stented Goretex bypass for iliac vein obstruction are shown in Table 1 (patients S.P. and C.A.).

Patient V.P. undergoing a Dale bypass had substantial relief of symptoms, but continued to complain of residual swelling and pain. The bypass was shown to be

Table 1. ***Arm/foot venous pressure differential and reactive hyperaemia in patients treated for venous obstruction.***

Patient name	*Arm/foot venous pressure differential*/ reactive hyperaemia***	*Comments*
S.P.	3/9 preop; 0/3, 6 months postop after femoral caval vein bypass (PTFE)	Graft open with normalization of RH venous pressure elevation.
C.A.	7/17 preop; 0/3 early postop; 6/12 at 6 months postop PTFE bypass	Graft open early postop, but occluded at 6 months.
V.P.	Preop pressures not recorded. 0/9 postop Dale bypass with residual symptoms despite venographically open bypass	The bypass was not functionally adequate even though it remained open. RH high.
A.P.	0/12 preop; AV fistula (primary) to induce collaterals around obstructed femoropopliteal venous segment; 0/2 late postop after spontaneous closure of fistula	AV fistula-induced collaterals had normalized venous pressure parameters.
C.C.	1/10 after episode of deep venous thrombosis; 0/5 after 3 months of anticoagulation	Anticoagulation was stopped after normalization of pressure parameters at 3 months.
B.E.	6/12 after severe deep venous thrombosis; 1/4, 3 years later on anticoagulation	Normalization of venous pressures with recanalization demonstrated on venography.
M.H.	5/3 preop; 1/4 postop following illiac vein web resection	Pressure based technique useful in diagnosis and assessment of surgical result.

*Arm/foot venous pressure differential — 'normal' < 4 mmHg.
**Reactive hyperaemia-induced foot venous pressure elevation (RH) — 'normal' < 6 mmHg.

open on venography. In the vascular laboratory, the patient was found to have residual (grade II) obstruction, explaining the persistence of symptoms. Because of inadequate size or kinking not immediately apparent on venography, the bypass was not functioning well.

Patient A.P. underwent a primary distal AV fistula between the posterior tibial artery and vein for extensive calf/vein thrombosis in an effort to induce collateralization. Even though the fistula occluded spontaneously at 12 months, there was considerable improvement in symptoms presumably due to fistula-induced collateral formation. This was well documented by sequential pressure studies, which had become normalized following surgery (Table 1).

We have found the technique to be useful in managing anticoagulation in patients with deep venous thrombosis. The pre- and post-anticoagulation values for this technique in one patient (patient C.C.) are shown in Table 1. The obstruction, which was initially grade IV, had progressed to grade I with anticoagulation with satisfactory recanalization/collateralization, resulting in normal haemodynamics. Anticoagulation was stopped at this point and the patient returned to full-time work.

Fig. 6. ***Patient with recanalized superficial femoral vein that appears radiologically quite patent. It was, however, functionally obstructed with arm/foot venous pressure differential of 7 mmHg and a reactive hyperaemia-induced foot venous pressure elevation of 0 mmHg (group 4).***

Recanalization

The process of recanalization following a bout of deep venous thrombosis can be reliably followed by this technique. Table 1 (patient B.E.) demonstrates the progress of recanalization in one such patient with bilateral extensive deep venous thrombosis. Many such patients may appear to have satisfactory recanalization on venography (Fig. 6), but nevertheless have a haemodynamic venous obstruction revealed by the technique. Some of these patients mistakenly undergo anti-reflux valve reconstruction procedures in some centers. Not surprisingly, a poor outcome may be expected as venous hypertension is a result of residual obstruction and not reflux. In our view, the haemodynamic technique should be employed in all patients who are candidates for anti-reflux procedures to ensure the absence of venous obstruction. This is particularly important in patients who have recanalized veins following deep venous thrombosis.

Iliac vein compression syndrome

The significance of iliac vein compression revealed by phlebography is debated. Some consider the appearance of segmental vein compression by the artery to be 'normal'. Haemodynamic testing in the vascular laboratory provides an objective basis for possible therapeutic intervention in such instances. Patient M.H. (Table

1) in fact had a severe form of obstruction, requiring resection of an iliac vein web. Follow-up pressure studies confirmed haemodynamic improvement reflected in marked relief of symptoms.

The technique described is invaluable in providing an objective measurement of venous dysfunction from obstruction. The basis of symptoms can be assessed objectively as due to functional factors or real pathophysiological disturbances, which aids the physician in recommending appropriate therapy and declaration of disability when indicated.

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