Plethysmography. Old Fashioned or Still Popular. Why to Use it and for Who?

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Faculty Disclosure

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I have no financial relationships to disclose

Historical Perspective

1. Haemodynamic testing using plethysmography was routine practice (PPG, Strain-gauge, APG) until the advent of duplex
2. Subsequently, routine haemodynamic measurements were abandoned in favour duplex
3. Since then we repeatedly hear the statement:
   "there is a poor correlation between haemodynamic measurements and clinical severity of CVD"

Questions to be Answered

1. What is the relationship between haemodynamic measurements (changes in volume, pressure and flow) and severity of chronic venous disease?

2. What is the significance of such a relationship for daily practice.

Chronic Venous Insufficiency

Result of:

- Reflux (ml/sec)
- Obstruction (resistance: mmHg/ml/min)
- or both: Reflux and Obstruction

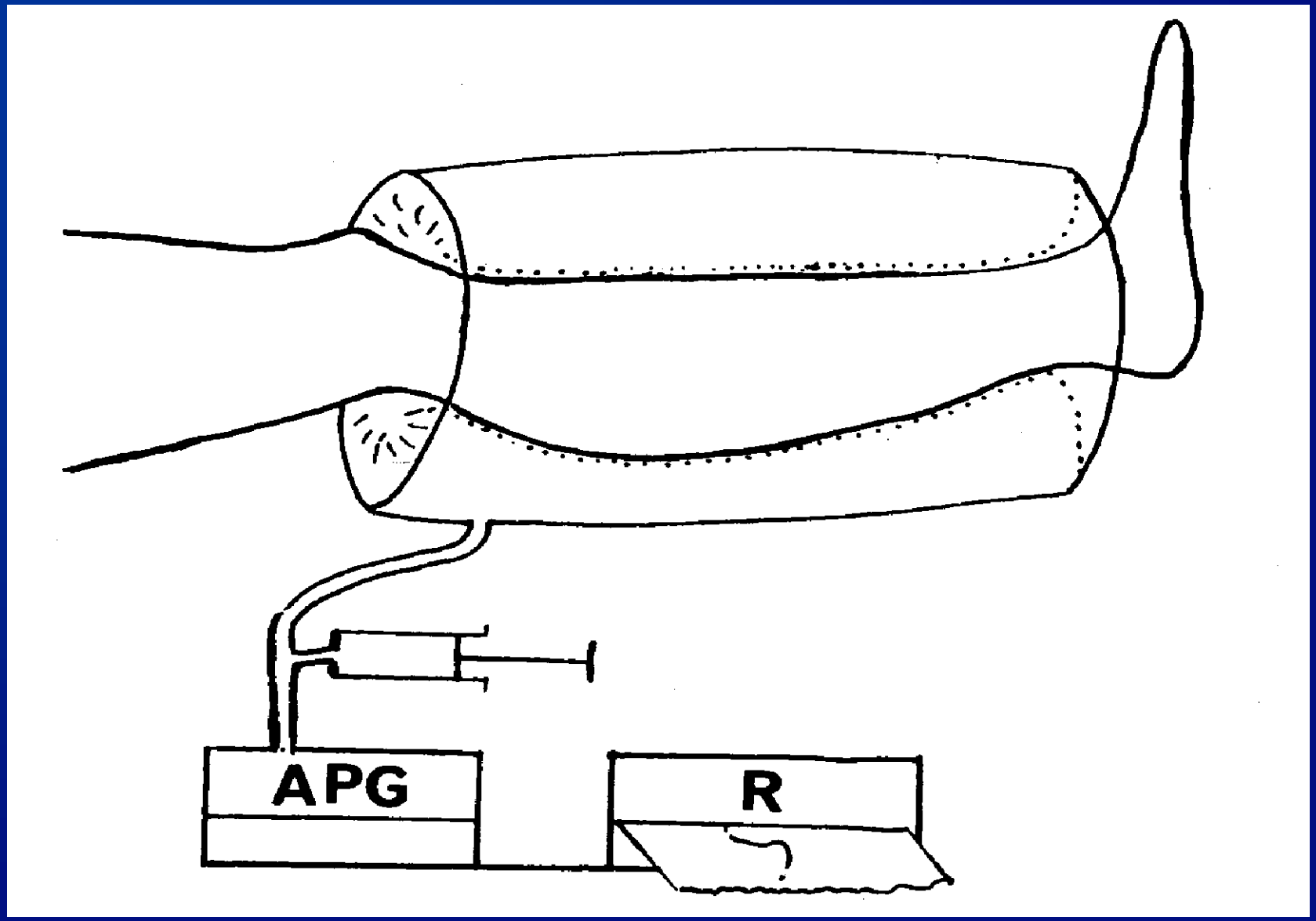
Air-plethysmography

Measures reflux (ml/sec)

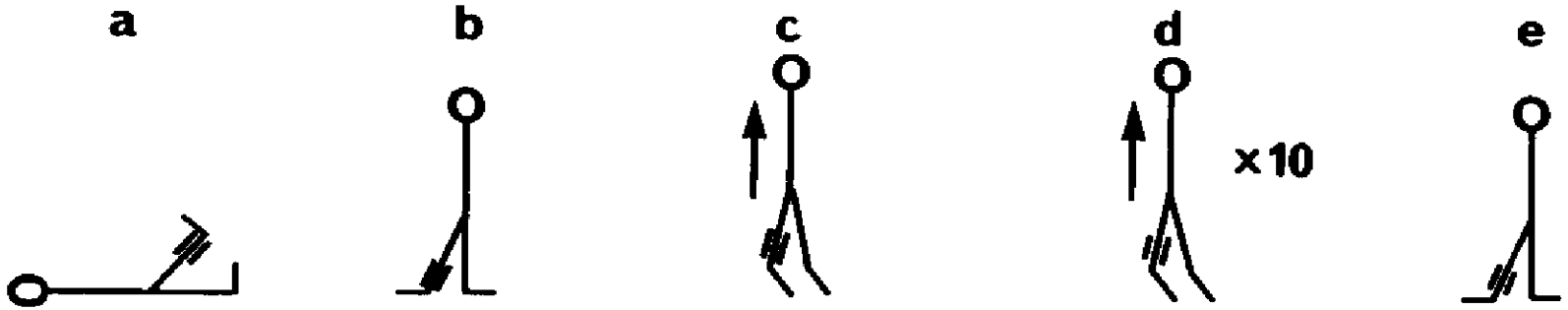
Measures ejection fraction of calf muscle pump (%)

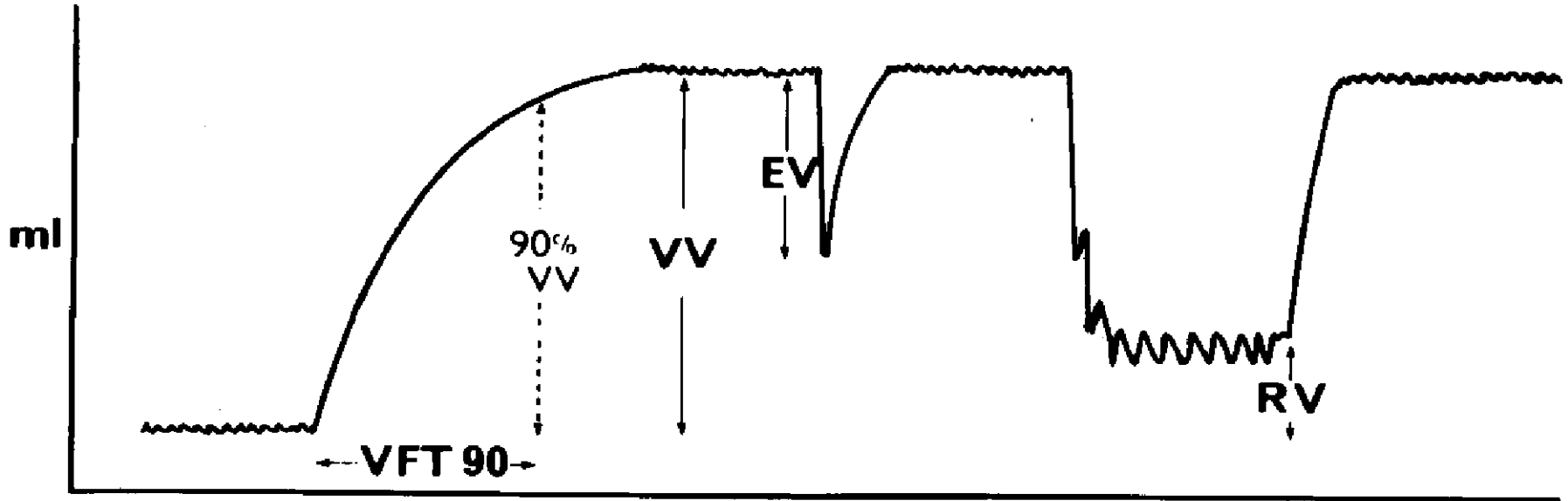
Measures outflow resistance (mmHg/ml/min)

Duplex cannot do any of the above !



Christopoulos D et al, Brit J Surg 1988:75:352-356





$$\frac{90\%\,VV}{VFT\ 90}=VFI \qquad \frac{EV}{VV}\times 100=EF \qquad \frac{RV}{VV}\times 100=RVF$$

Table X

Incidence of the sequelae of venous disease in relation to VFI in 134 limbs with venous disease studied with air plethysmography

VFI (ml/sec)	Chronic Swelling (%)	Ulceration (%)	Skin Changes + Ulceration (%)
<3	0	0	0
3-5	12	0	19
5-10	46	46	61
>10	76	58	76

Nicolaides AN. Circulation 2000;102:e126-e163

Combination of Duplex and VFI

Clinical severity class	N	VFI	P
0 Asymptomatic	34	1.6 ± 1.6	-------
1 Mild symptoms (ache & swelling)	42	2.3 ± 1.7	< 0.05
2 Moderate CVI (skin changes)	11	8.0 ± 5.6	< 0.05
3 Severe CVI (Ulceration)	31	8.5 ± 5.2	< 0.001

"The combination of VFI and duplex scanning (multisegment score) not only localized the reflux, but also separated severe clinical disease from mild with high sensitivity (83%) and high specificity (86%)"

Neglen and Raju 1993:17:590-5

ORIGINAL ARTICLE

The Role of Venous Outflow Obstruction in Patients With Chronic Venous Dysfunction

Nicos Labropoulos, PhD, DIC; Nicos Volteas, MD; Miguel Leon, MSc, MD; Olalekay Sowade, MBBS, MSc; Alex Rulo MD; Athanasios D. Giannoukas, MSc, MD; Andrew N. Nicolaides, MS, FRCS

Objective: To quantify the functional venous outflow obstruction with different location and extent of obstruction attributed to previous deep vein thrombosis.

Design: Case-control study.

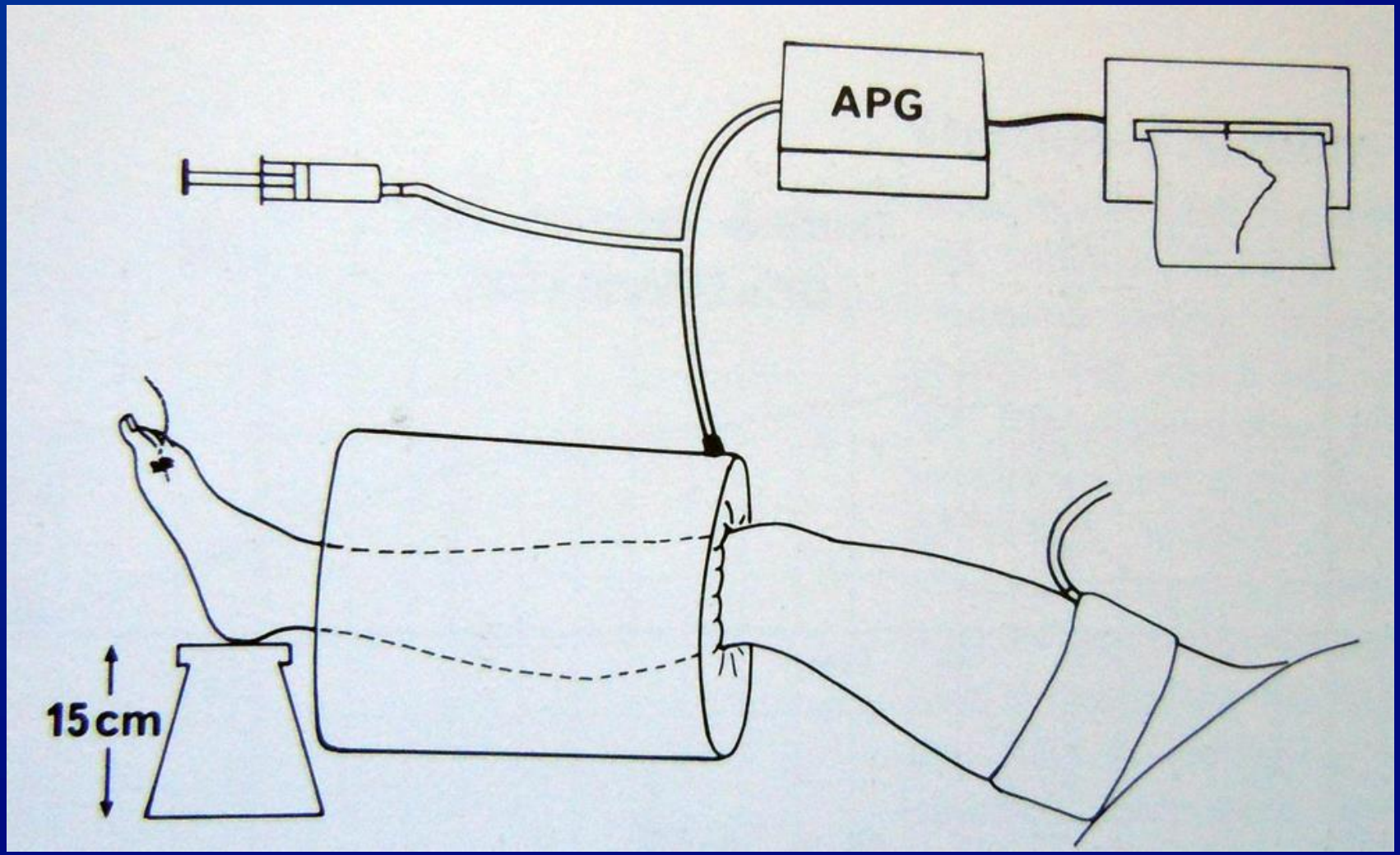
Setting: Vascular Laboratory, St Mary's Hospital Medical School, London, England.

Patients: Two groups: group 1, 25 case patients and 9 control subjects, and group 2, 45 case patients and 30 control subjects.

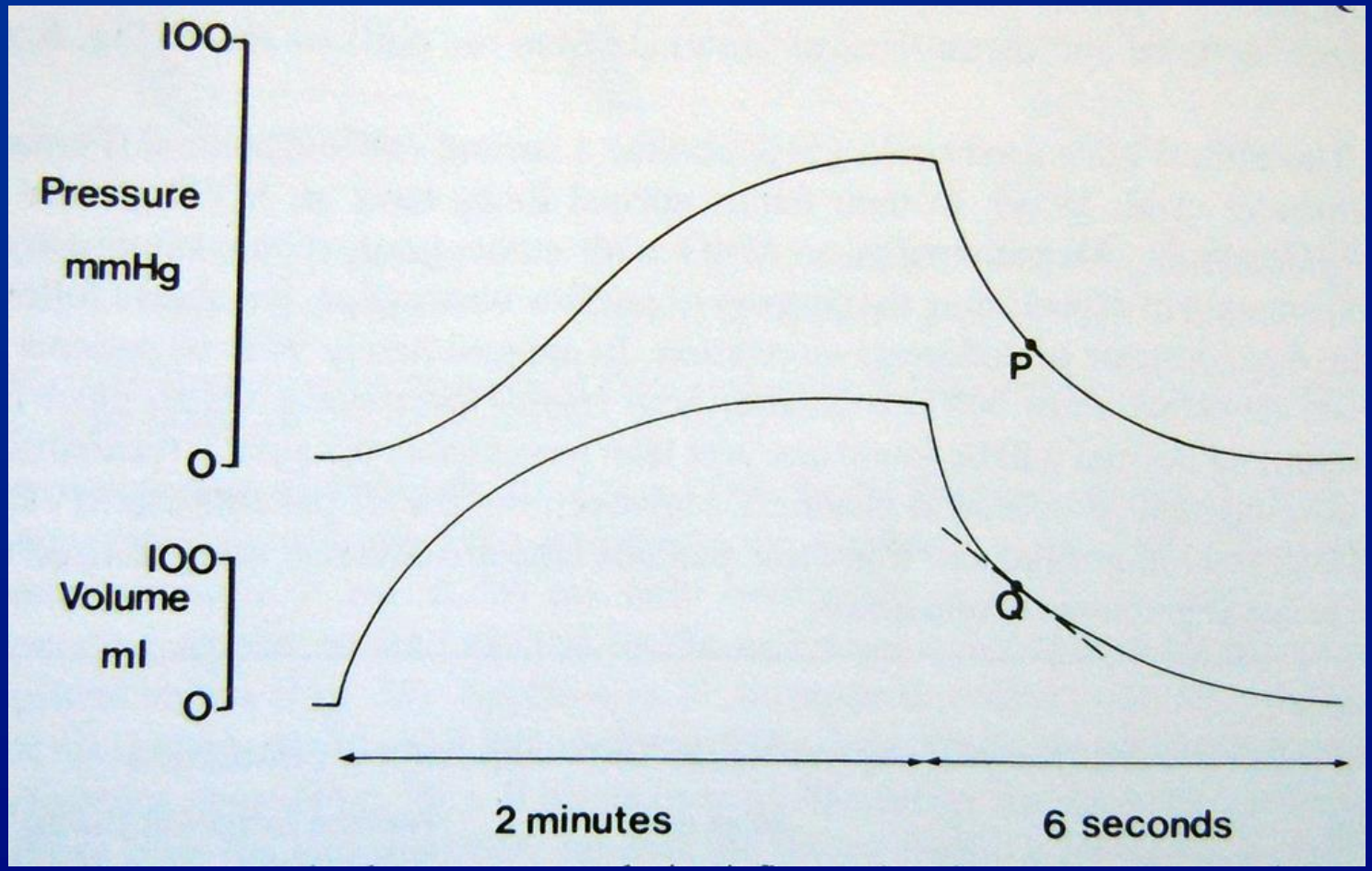
changes were noted in about 30% and ulceration in 10% of patients. The results of all tests showed no evidence of obstruction in control subjects. In most case patients with popliteal vein obstruction, test results were similar to those in control subjects: the more proximal the veins involved, the more severe the obstruction. In 16 case patients, all 3 tests were performed and agreement between A-F PD and VOR test results was found in 14 of them. The VOF test results agreed with the results of A-F PD and VOR tests in 9 case patients. In group 2, 50% of the limbs with obstruction proximal to the popliteal vein had a reduced VOF, which became worst in the limbs

Labropoulos et al, Arch Surg 1997;132:46-51

Simultaneous Pressure and Volume Measurements



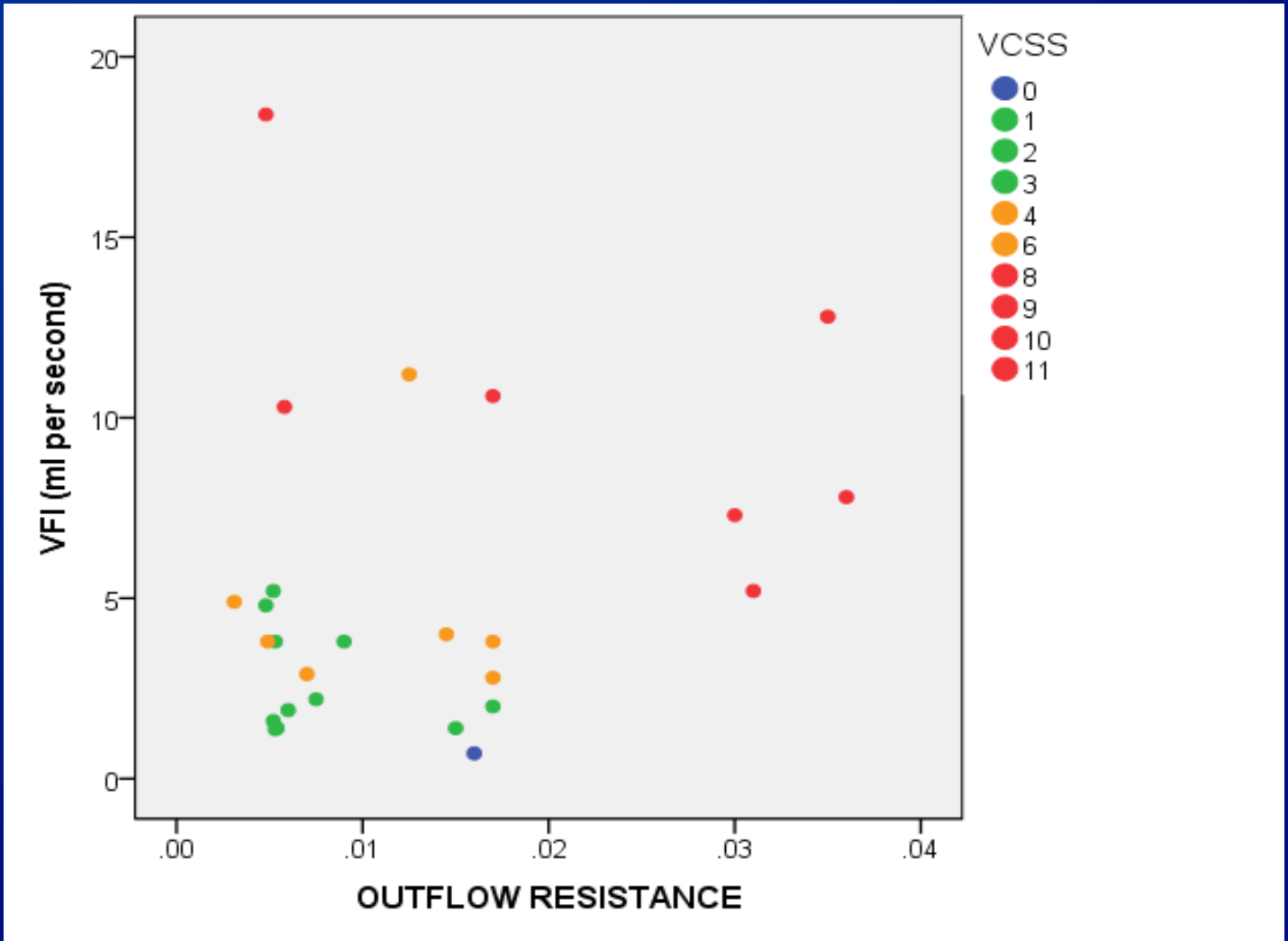
Simultaneous Pressure and Volume Recordings



R = P/Q

mmHg/ml/min

26 Limbs with CVD



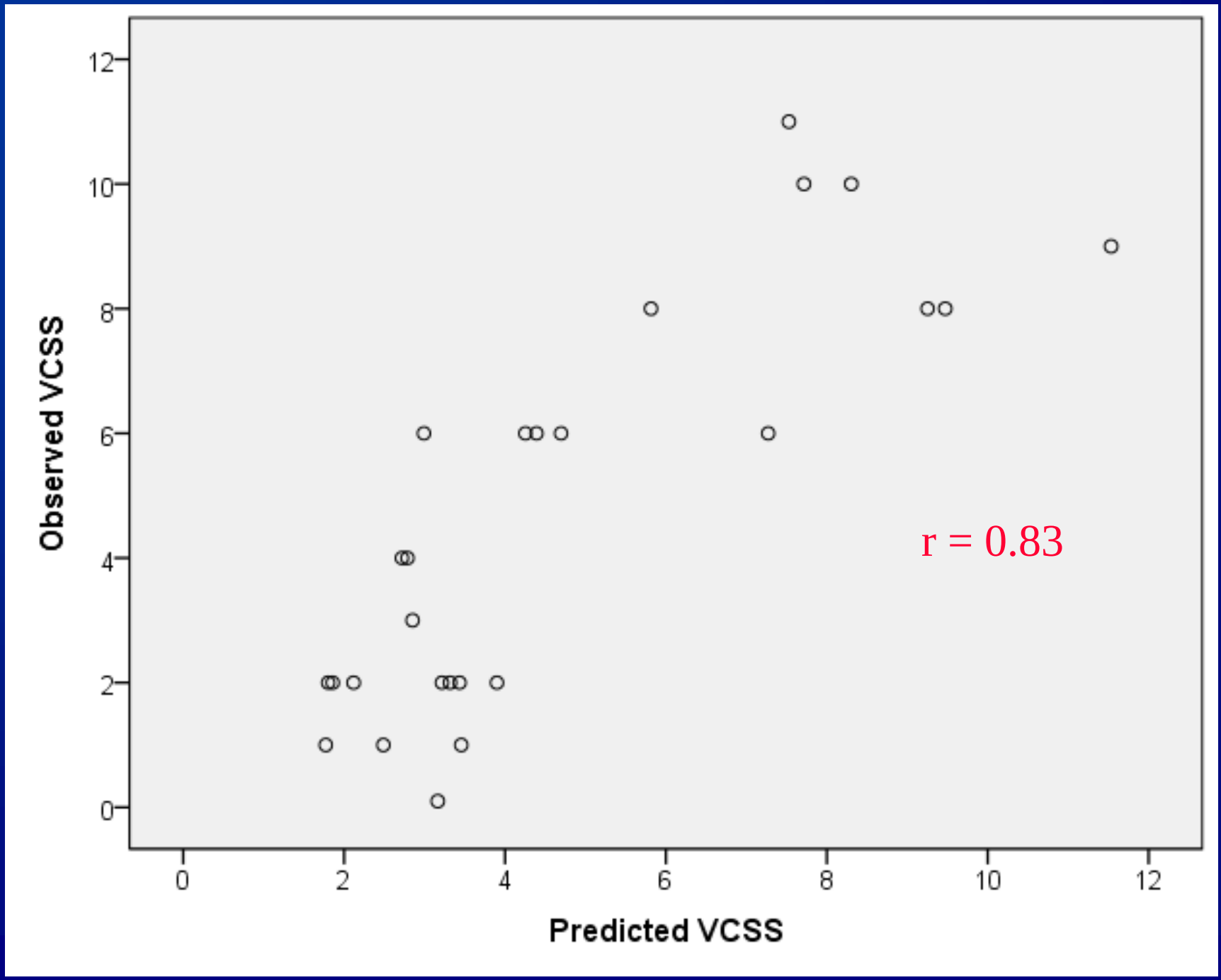
Nicolaides et al, Int Angiol 2014:33:275-81

Multivariable Regression

- Dependent Variable: VCSS

- Both VFI and R
  were independent predictors of VCSS ($P < 0.001$)

Predicted VCSS (or HI) = 0.33 + (VFI x 0.44) + (R x 158)


Observed VCSS
Predicted VCSS
0
2
4
6
8
10
12
r = 0.83

Conclusions

1. There is a high correlation between the combined measurements of reflux and resistance (estimated VCSS or HI), and observed VCSS (r = 0.86)

2. The statement:
"there is a poor correlation between **haemodynamic** measurements and clinical severity of CVD"
should be modified to:
"there is a poor correlation between **duplex** measurements and clinical severity of CVD"

Conclusions

3. Duplex provides information on presence or absence and anatomic extent of reflux or obstruction

4. If quantitative information is needed (how much reflux or how much obstruction there is) for clinical decisions, duplex should be complimented by plethysmography

5. Plethysmography is not used in routine practice, but it should be used in complicated cases with CVI