MEV analysis and reservoir effect

F. PASSARIELLO

Diagnostic Center “Aquarius”, Naples, Italy

Aim. Recently, an intrasegmentary saphenous reflux was claimed to be due to the aspirating power of the capacitance of an incompetent small accessory vein (the reservoir). The present note outlines a more elementary explanation. A simplified model is digitally rendered, to show an Input-Output open path ShIIB with an intrasegmentary great saphenous vein (GSV) reflux.

Methods. Cutting the reservoir provides a flow inversion in the GSV trunk with reflux suppression.

Results. The analysis of the circuit shows how this result can be achieved even studying only the topographical properties of the venous circuit, without making any hypothesis on the vessel diameters or compliance.

Conclusion. This is an application of the Ockham’s Razor (XIV century) and of the MEV analysis, based on the modern graph theory. The results of this simulation strongly support the hypothesis that the reservoir is not involved in the origin of the reflux.

Key words: Femoral artery - Varicose veins, surgery - Hemodynamics.

Recently, an interesting discussion took place on Vasculab,1 about the important role played by the “venous reservoir” in varicogenesis.

Resuming, the main point of debate regarded the role of an incompetent small accessory vein (the reservoir), as a trigger of an intrasegmentary saphenous reflux, owing to its confluence into an avalvulate great saphenous vein (GSV) segment. This effect was claimed to be due to the aspirating power of the capacity of the reservoir, which would cause the reflux.2 3

The aim of the present note is to show how a more elementary and rigorous derivation can be described in details through these observed data.

Materials and methods

The original draw proposed by Dr. Pittaluga was digitally rendered (Figures 1A, B) by means of the VNet Model,4 5 to simulate some structural properties and the surgical hemodynamic effect.

Following Teupitz classification,6 the reflux could be classified as an Open Path ShIIB, i.e. an Input-Output (I/O) path, which passes through a reversed GSV and re-enters through a perforator on a N3 branch.

The starting GSV reflux (black lines) disappears (becomes light gray) as soon as we cut the reservoir (the N3 branch, according to the terminology of the RIO Hemodynamic Consensus 7), giving a flow inversion in the GSV trunk.

This intuitive result is given automatically by the VNet Surgical Simulator. In addition, it can be also accomplished in a different way, following a general (and mathematical) conceptual frame.

Results

In the cartography of Figure 1A, 11 Input-output paths can be recognised (Figures 2-4). Four of them are
of great interest, as they pass through the N3 branch, which is supposed to be cut (Figure 2).

The other seven paths not passing through the N3 branch can be divided in two groups, whether they pass through an anterograde GSV (Figures 3A-C) or completely out the GSV (Figure 4).

The path in Figure 2A uses the N3 branch in an anterograde way, while the others (Figures 2B-D) use the reversed branch. The paths in Figures 2B and 2C pass through a reversed GSV.

All the other 9 paths pass through an anterograde GSV or out of the GSV.

Suppressing the N3 branch (the reservoir) you will delete also the four paths passing through it and as a consequence also the possibility of using a reversed GSV. Cutting the branch you will leave 11-4=7 paths, all passing through an anterograde GSV or out of the GSV and note that after having performed this procedure these are the only I/O paths available at all.

As a consequence, you will have a flow inversion in the GSV trunk.

**Discussion**

The study of the topographical properties of the venous circuit allows to arrive to the conclusion (flow inversion and GSV reflux suppression), without making any other hypothesis on the vessel diameters or compliance. This basic-sciences-model, which does not adopt biological variables, is a simple “effective” model, able to foresee the observed hemodynamic results.

Symply, if we could explain efficiently a phenomenon using a more restricted set of hypotheses, this
Figure 3A-C.—I/O paths, passing out of the N3 branch and through an anterograde GSV.

Figure 4A-D.—I/O paths, passing out of both the N3 branch and the GSV.
explanation is clearly more acceptable than another one requiring a wider set of assumptions. This is an elementary application of the Ockham’s Razor from William of Ockham (XIV century, *entia non sunt multiplicanda praeter necessitatem*, i.e. “entities must not be multiplied beyond necessity”). In addition, note that adopting a smaller number of hypotheses simplifies the assumptions, but generally requires a more complex theory.

This method is also an example of the so called “MEV Analysis” and is completely derived from an application of the modern Graph Theory to the venous network. Details cannot be completely given here, as they would need an in-depth mathematical explanation.

We can, however, add something about the reservoir theory.

First of all, it is quite strange that the name reservoir was given to something that is not used as a reservoir. Apart from air bubbles, which we can sometimes inject (accidentally or in foam therapy), veins are always full of blood, i.e. there is no empty space inside the veins, either when they are big or small in calibre. So, changes in the volume must necessarily be in correspondence with the volume of the venous content, i.e. the blood.

Capacity is the property of producing great volume changes for small pressure changes. Mathematically, it is the volume derivation in respect to pressure (dV/dP). The capacity disappears if the volume is fixed, i.e. if vessel walls become rigid.

As an example of the fact that a big volume does not imply a big capacity, remind the properties of the aortic arch which in young people is of small calibre and great compliance (the Windkessel theory, by Otto Frank, 1899), while in the elderly it becomes dilated and loses its compliance, becoming rigid.

The following remarks try to set a clear conceptual separation between the physical effects of resistance and capacity in the veins.

1) Suppressing the reservoir in a pure manner should be accomplished increasing the rigidity of the walls of the N3 venous branch, maybe by sclerotherapy, respecting instead the calibre;

2) the reservoir can be suppressed substituting the N3 branch with a rigid tube of the same calibre, but reflux will always be the same, demonstrating that reflux does not depend on capacity;

3) increasing the vein wall rigidity in the N3 branch but at the same time decreasing the calibre will bring to a resistance increase and a flow reduction, until the complete reflux abolition in N3 and the inversion in GSV. But this effect is due to resistance increase;

4) cutting the N3 branch means destroying the vessel, i.e. we get an infinite resistance and suppress the capacity in the same time. But as stated before, resistance increase alone is sufficient to abolish the reflux;

5) an aspiration effect can be present also in absence of a reservoir, just because aspiration could derive from a high velocity I/O open path, which is active during muscular systolic phase.

**Conclusions**

In conclusion, even if the “reservoir effect” theory has an undoubtedly fascinating property, it seems, in my opinion, not completely in line with known phenomena.

As to the direction of varicogenesis, ascending or descending or anarchic, these remarks cannot be of any usefulness about.

Finally, as to this hemodynamic structure (open path and in detail an intra-segmentary or intervalsular reflux) I would like to underline that this cannot be matter of practical clinical study, but it can only be done for a research purpose (which however is a very important purpose).

**Riassunto**

**MEV analisi ed effetto reservoir**

**Obiettivo.** Di recente, è stato sostenuto che un reflusso safenico intrasegmentario sia dovuto al potere aspirante della capacitanza di una piccola vena accessoria insufficiente (il reservoir). Questa nota descrive una spiegazione più elementare. Un modello semplificato è reso in forma digitale, per mostrare un percorso input-output aperto ShIIB con un reflusso intrasegmentario della safena interna.

**Metodi.** Il taglio del reservoir provoca una inversione di flusso safenico con scomparsa del reflusso.

**Risultati.** L’analisi del circuito mostra come questo risultato possa essere ottenuto anche studiando soltanto le proprietà topologiche del circuito venoso, senza fare alcuna ipotesi sui diametri o la capacitanza vasale.

**Conclusioni.** Si tratta di una applicazione del Rasoio di Ockham (XIV secolo) e della MEV analisi, basata sulla moderna Teoria dei Grafi. Il risultato di questa simulazione sostiene con forza l’ipotesi che il reservoir non sia coinvolto nell’origine del reflusso.

**PAROLE CHIAVE:** Arteria femorale - Vene varicose, chirurgia - Emodinamica.
References

1. Vasculab, the Vascular List!, an on line Internet Yahoo! Mailing list. Available at: http://it.yahoogroups.com/vasculab. Subscribed members are actually 1,263.


