Ambulatory Venous Pressure Measurement Via Column Interruption Duration

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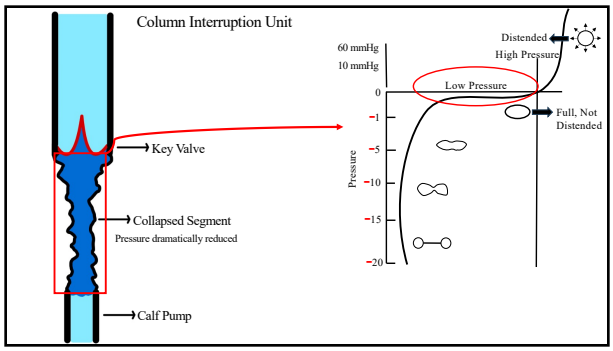
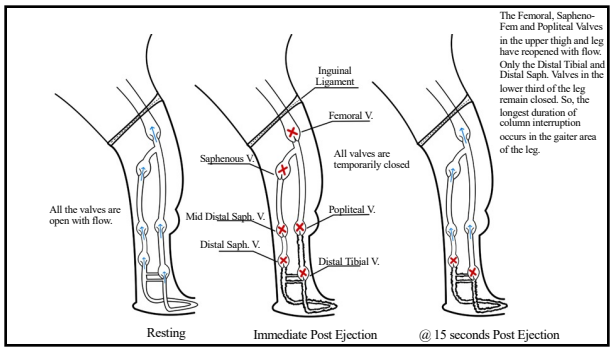
Disclosure

1. U.S. Patent: Measurement of CID

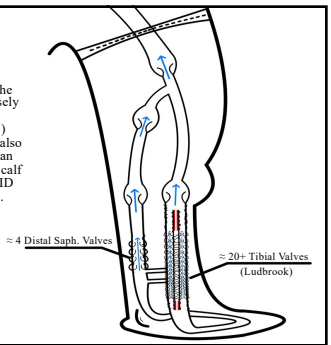


Characteristics of Collapsed Vein Segment Below the Closed Valve

- Local internal Pressure is very low ≈ 0-5 mmHg.
- Degree of collapse depends upon calf pump ejection.
- Both obstruction above the valve and reflux at the valve will impair ejection fraction and the degree of collapse; refill time is reduced which results in early reopening of the valve.
- Recovery time will be less if the segment below the valve is large (↑ residual volume) or refilling through named and unnamed tributaries (e.g., muscular veins) occurs. For example, the femoral and popliteal valves close for relatively short periods of time, with short recovery times due to inflow refilling from named and unnamed tributaries.
- It is now known that proximal valves in the thigh (Femoral, Sapheno-Femoral, and Popliteal Valves) stay closed after valve closure only for a brief period (< 5-15 seconds).
- Collapse is most in terminal or nearly terminal veins; this is the Posterior Tibial Vein for the calf pump. Valves in the Posterior Tibial Vein stay closed for up to two minutes or more.
- High degree of collapse of long duration is desired to give pressure relief to the calf pump.



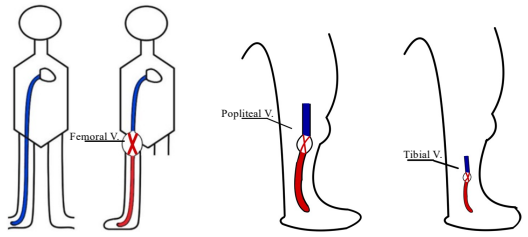
- Anatomy favors column segmentation in the calf pump. Tibial veins are paired but densely interconnected. One of the two is easier to image. There are more Tibial Valves (≈ 20) than anywhere else in the body. There are also about ≈ 4 valves in Distal Saph.V. These can short circuit the Tibial Valves refilling the calf pump prematurely in some patients. So, CID must be measured separately in both veins.



Measuring CID

- The Tibial Valves are so small, they cannot be readily imaged by standard probes. However, you can determine if the Tibial Valves are closed collapsing the tibial vein or open with tibial flow.
- The calf pump is ejected by rapidly inflating a calf cuff to 300 mmHg. while monitoring the Tibial Valve flow. Flow is suddenly stopped with cuff inflation. Flow will reappear after 1-2 minutes in normal individuals. This is the column interruption duration (CID). CID < 20 sec. is considered abnormal similar to Amb. Ven. Pr.

Residual Calf Pump Pressure After Valve Closure and Column Segmentation



Residual Pressure = **80mmHg**

Residual Pressure = **50mmHg**

Residual Pressure = **30mmHg**

Residual Pressure = **10mmHg**

Conclusion

- Venous doppler developed in the 1970's was initially used to study the large Proximal Valves in the thigh. Clinical interest continues to focus on reflux at these valve sites. However, it is now known that these valves close only transiently with calf pump ejection i.e., durable column segmentation is not achieved at these valve locations.
- It is also clear that calf pump efficiency is dependent on more distal valves in the Tibial Vein. They are much more numerous - as many as ≈ 40 in number. Anatomically they are better suited to provide durable valve closure and column segmentation. Breakup of the hydrostatic column at this level provides the lowest calf pump pressure in comparison.
- Tibial Valves cannot be imaged with standard doppler probes, but their opening and closing actions can be timed by doppler monitoring of tibial flow with calf pump ejection. "CID" is a high-fidelity noninvasive surrogate for ambulatory venous pressure. In fact, it may avoid errors known to be present through the multivalve dorsal foot vein.

Key References:

Raju S, Walker W, May C. Measurement of ambulatory venous pressure and column interruption duration in normal volunteers. ***J Vasc Surg Venous Lymphat Disord.*** **2020 Jan;8(1):127-136. doi: 10.1016/j.jvsv.2019.06.012. Epub 2019 Sep 5. PMID: 31495767.**

Noninvasive measurement of ambulatory venous pressure via column interruption duration in chronic venous disease Raju, Seshadri et al. ***Journal of Vascular Surgery: Venous and Lymphatic Disorders*****, Volume 12, Issue 4, 101861**

THE END