NEPA Scientific Products

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Sweeney Arterial Demonstration Device™ User Manual

Understanding the Function of Arteries

Elastic arteries are the *pressure reservoirs* of the cardiovascular system, storing in their elastic walls the cardiac energy generated during the heart's contraction phase – *systole* – and gradually releasing it during the heart's relaxation phase – *diastole*.

This essential function not only smooths the fluctuations in pressure and flow through the cardiac cycle; it also dramatically reduces cardiac workload as the heart drives life-sustaining blood flow.

The Sweeney Arterial Demonstration Device™ (*ADD*) enables the instructor to identify several key drivers of normal cardiovascular function – a competent aortic valve, opening fully and then sealing completely; the elastic arteries, helping to propel blood continuously to the periphery; and the peripheral vascular resistance, controlling total flow output and its distribution among the body's organs.

The *ADD*'s visual and interactive demonstrations show how these elements drive normal cardiovascular function, and illustrate the dramatic effects when these elements are dysfunctional.

Demonstration Instructions

Illustrating Arterial Function.

The *ADD* includes a one-way "aortic" valve, an elastic balloon, and a pinhole flow restrictor. The operator takes on the role of the ventricle.

- Begin by identifying each device element and the aspect of the cardiovascular system that each element models.
- To operate the *ADD*, about once every two seconds, *vigorously* blow into the wide end of the device to inflate the balloon significantly. **Your first breath should expand the balloon to about 5 inches in diameter.** Mimicking the heart beating in a slow, repetitive cycle, allow the balloon to *partially* deflate (to about 3 inches in diameter) and then re-inflate the balloon with your next breath, returning it to its 5-inch diameter. Keep this cycle going.
- This exercise makes evident these principles:
  - *inflow* is intermittent, but *outflow* is continuous;
  - the refilling of the instructor's lungs is analogous to the rest and refilling of the ventricle after ejection.

Illustrating Dysfunctional **Inelastic** *Arteries*

To best illustrate the utility of elastic arteries, the instructor can show the effect of dysfunctional *inelastic* arteries.

- Operate the device as above, but with this important change:
  - Just before you begin, position your hand to surround the balloon and prevent its expansion as you repeatedly blow into the device.
  - Allow the air to pass through the balloon unrestricted, but with the use of your surrounding hand, don't allow the balloon to expand.
- This exercise makes evident these principles:
  - ejection of air into the device is made *dramatically more difficult*;
  - inflow *and* outflow are now *both* intermittent;
  - analogously, as the ventricle ejects into *inelastic* arteries, ventricular workload is increased and flow is reduced, as the ventricle must now **immediately** overcome the high downstream resistance during ejection, rather than simply working to expand the normally elastic arteries.

Understanding the Function of Veins

The veins are the *volume reservoirs* of the cardiovascular system. Veins achieve this function through their *excess capacity*. Veins often are only partially full, taking on a flattened configuration, so volume changes that further flatten or more fully round out veins may cause little change in venous pressure. As venous pressure is critical to adequate ventricular filling, this ability to change total venous volume with little change to venous pressure is critical to sustaining normal cardiovascular performance.

- To illustrate, use the device's balloon in its *natural flattened state* to represent a vein that is only partially rounded out. Blowing gently into the device, one sees that the volume in the vein changes dramatically, but pressure changes only modestly.
- By partly collapsing the balloon with your hand, you also can demonstrate how, if central venous pressure – the venous pressure just outside the heart – drops, **nerve-mediated constriction of the peripheral veins** can decrease peripheral venous capacity, redistributing venous volume to the central venous compartment and raising central venous pressure, restoring ventricular filling.

CAUTION: This product contains natural rubber latex, which may cause allergic reactions

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Use of the *Low Resistance Flow Restrictor* – Understanding How Changes in Peripheral Resistance drive Increases in Cardiac Output

The beginning student of cardiovascular physiology might have the impression that the main determinant of increased cardiac output is increased cardiac performance (e.g., via elevated heart rate (HR), or increased contraction strength.) Use of the ADD's *Low Resistance Flow Restrictor* will help the student understand that the primary driver of increased cardiac output is actually a *drop in peripheral resistance* (via vasodilation), and that it is primarily *subsequent activation* of feedback mechanisms that *then* lead to increased in HR and cardiac performance.

- To illustrate, first operate the ADD normally, as described under *Illustrating Arterial Function* above. Note the outflow rate and the effort needed to keep the balloon partially inflated as the ADD is operated.
- Next remove the *normal flow restrictor* and replace it with the *Low Resistance Flow Restrictor* (identified by the gray end cap with a larger hole). Secure the open end of the balloon in the flow restrictor gap closest to the end cap. Be sure to save the normal flow restrictor.
- Begin again to operate the ADD with the *Low Resistance Flow Restrictor* in place. *Adjust your operation of the device* so that you continue to keep the balloon inflated during ADD operation.
- This exercise makes evident these principles:
  - outflow from the ADD is *dramatically increased*;
  - in order to keep the balloon partially inflated, the ADD operator must dramatically increase the rate of inflation of the ADD;
  - this is analogous to a drop in arterial pressure (precipitated by a drop in peripheral resistance) triggering an increase in HR through the baroreceptor reflex (which stabilizes arterial pressure via a negative feedback loop).
- Remove the *Low Resistance Flow Restrictor* and replace it with the normal flow restrictor.
- *Briefly* operate the ADD at the high HR that was required when the *Low Resistance Flow Restrictor* was in place
- Note the amount of flow that is achieved, compared to that possible when the *Low Resistance Flow Restrictor* was in place
- This exercise makes evident these principles:
  - an increase in cardiac performance (increased HR, etc.) does little to increase cardiac output when peripheral resistance in not decreased;
  - instead, the balloon simply becomes more inflated because it is under increased pressure;
  - Overall, this *comparison of the ADD in two different states of peripheral resistance* makes evident that it is a decrease in peripheral resistance – not increased cardiac performance – that drives increases in cardiac output. The increase in cardiac performance *instead follows* the drop in peripheral resistance in order to maintain a stable arterial pressure.

Demonstration Instructions for *Regurgitant* and *Stenotic Valve* versions of the Arterial Demonstration Device

Illustrating Aortic Valve Dysfunction

The effects of *regurgitant* (leaky) and *stenotic* (poorly opening) aortic valves can be easily demonstrated with **distinct versions** of the Arterial Demonstration Device.

- ***Regurgitant Version*** – a regurgitant aortic valve reduces *forward cardiac output* - the portion of ejected blood that actually flows to the periphery - due to leakage back into the relaxing ventricle. Regurgitation reduces arterial pressure and ultimately leads to progressive cardiac dysfunction.
  - To illustrate, the instructor operates the device normally (see *Illustrating Arterial Function*), but points out 1) the rapid deflation of the balloon, indicating loss of arterial pressure, and 2) the air lost through the input end, indicating regurgitation.
- ***Stenotic Version*** – a stenotic valve's reduced orifice increases resistance to cardiac ejection, diminishing cardiac output and increasing ventricular workload, which also leads to progressive cardiac dysfunction.
  - To illustrate, the instructor attempts to operate the device normally, but points out the dramatically increased effort required to inflate the balloon.

Other Uses of the Arterial Demonstration Device

For additional information on other uses of the *ADD*, please visit nepascientific.com/otheruses for further instructions.

- The effects of Continuous Compression CPR approaches, versus Compressions interspersed with breaths.
- Demonstration of the Law of LaPlace in blood vessels
- The risk of Aortic Aneurisms
- Neural Signal Transmission – Effects of Temporal Summation of Graded Potentials on the Amplitude of the Grand Synaptic Potential.

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