

# Rationale for Non-Invasive Blood Pressure Research on Dialysis Patients

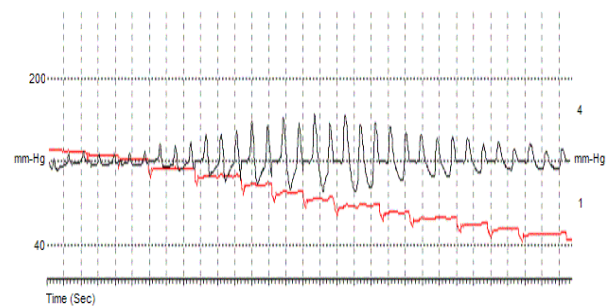
SunTech Medical, Inc. has, for over 20 years, been a leading provider of clinical grade Blood Pressure monitors and OEM BP technologies. Our sole focus on blood pressure has allowed us to study various patient populations and design equipment specific to the needs and environments of those patient groups.

Since 2001, we have had a focus on the dialysis market and the special requirements of taking blood pressure readings on patients during dialysis treatment. The process of renal hemodialysis occasions significant fluid loss from the circulatory system, tissues and interstitial spaces. The affects range from loosening of the BP cuff (edema loss) to potential changes in pulse transmission characteristics. All can affect BP system accuracy. This clinical environment is further complicated because dialysis patients are known to have a higher incidence of cardiovascular issues. We have collected data and completed validations on patients undergoing dialysis. Analyzing these data has identified characteristics unique to and essential for tailoring a blood pressure system specific for this patient population.

1. Many dialysis patients have stiffer arteries than the general population.
2. Systolic and diastolic pressures can be extremely high and extremely low. During treatment it is very important for the monitor to be accurate throughout the entire expanded range.
3. The blood pressure monitor must be able to obtain accurate results on almost every attempt.
4. The blood pressure system must be easy to use. Most dialysis companies export globally and operator training is inconsistent in many parts of the world.
5. Patient comfort is very important since a high number of readings may be taken over several hours. Taking a reliable reading on the first attempt is critical

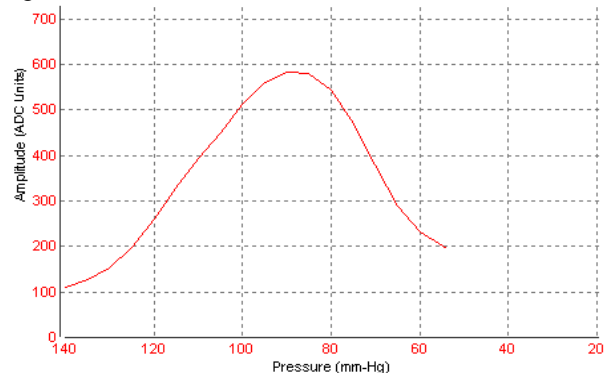
The basic method of taking an oscillometric blood pressure reading has not changed however more sophisticated hardware and software has been developed to improve the accuracy and reliability of blood pressure readings. Most clinical grade oscillometric blood pressure monitors inflate a cuff on the upper arm to a pressure above the subject's systolic pressure to occlude the brachial artery. The cuff is slowly deflated until the cuff pressure approximates the subject's diastolic pressure. Then the cuff pressure is quickly exhausted and the subject's systolic pressure, diastolic pressure, and heart rate can be calculated from small pressure pulses collected during the cuff deflation. The diagram in Figure 1 shows a typical deflation cycle on a normal healthy adult.

Figure 1



The red line shows the cuff pressure and the black line shows the oscillometric pulses. The cuff pressure and the oscillometric pulses are on different scales; the cuff pressure starts at approximately 140 mmHg on the left and decreases to about 50 mmHg on the right. The amplitude of the oscillometric pulses are shown much larger so that they can clearly be seen. The amplitude of the oscillometric pulses on the far left are less than 1 mmHg, the pulses increase in amplitude to approximately 4 mmHg in the center of the diagram, and the pulses then decrease to less than 1 mmHg on the right side of the diagram. Once the cuff deflation is completed and the oscillometric pulses from systolic to diastolic are recorded an envelope curve is created using the amplitude of the oscillometric pulses. The diagram in Figure 2 shows the envelope curve for the oscillometric pulses shown in Figure 1.

Figure 2



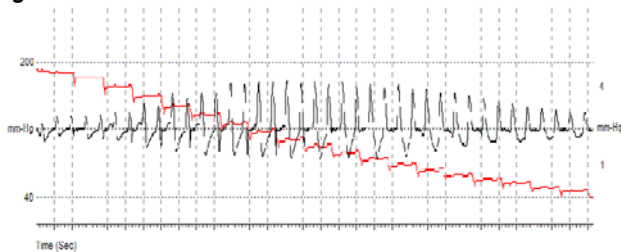
The oscillometric pulses start increasing in amplitude around 140 mmHg, they continue to increase in amplitude to a maximum just below 90 mmHg, then start to decrease and they continue to decrease below 60 mmHg. This amplitude peak represents the Mean Arterial Pressure (MAP). From this envelope curve the systolic and diastolic pressures are

calculated using coefficients on the rising side of the curve for systolic and coefficients on the falling side for diastolic. The maximum point on the curve (MAP) is easy to detect and the changes in the slope throughout the curve are gradual. A clearly defined MAP and correct determination of the slope is obviously key to the calculation of systolic and diastolic blood pressures.

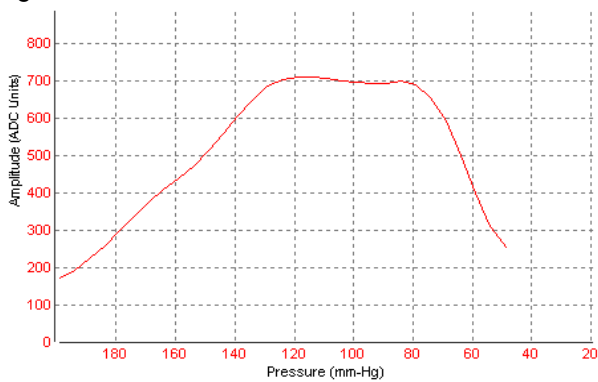
The curve shown in Figure 2 is a good example of data collected on a normal healthy, relatively motionless adult. Under these conditions most blood pressure monitors are capable of producing accurate readings.

The next sets of curves in Figure 3 and Figure 4 are from a dialysis patient taken during treatment.

**Figure 3**



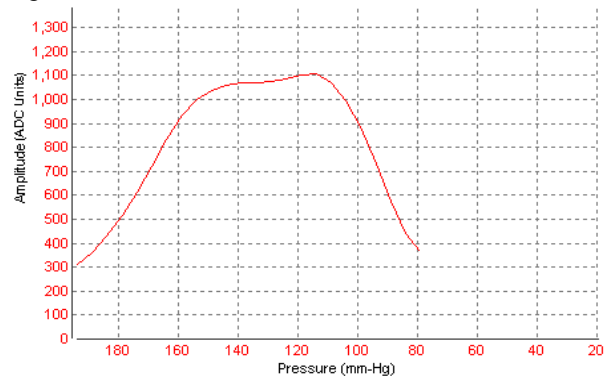
**Figure 4**



The oscillometric pulses shown in Figure 3 are large and easy to detect, and there is no motion artifact to interfere with collecting all of the pulses. However, the envelope curve shown in Figure 4 is very different than the curve of the normal healthy patient in Figure 2. This curve has no clear maximum point (MAP); the maximum point measured by the algorithm could be anywhere between 120 mmHg and 80 mmHg. This uncertainty could lead to a 40-mmHg error in the systolic or diastolic measurement.

In another hypertensive dialysis patient (Figure 5), the maximum point (MAP) on the curve is easier to measure, but the rising edge of the curve does not have a gradually increasing slope and then a decreasing slope until it reaches its maximum point.

**Figure 5**



Current validation protocols do not require blood pressure monitors to be validated on any specific types of patients. Consequently, most are validated on readily available, normal healthy volunteers with a small sample of hypertensive and hypotensive patients. In this regard, our efforts exceed most by including thousands of readings on hypertensive, hypotensive and notably, dialysis and diabetic patients.

Consolidation of this data together with experience gained from our ongoing research in emergency medicine systems (EMS), ambulatory blood pressure and cardiac stress monitoring serves to continually optimize our algorithms. This minimizes the effects of poorly defined MAP and non-linear slope thereby ensuring reliable, accurate readings on a more diverse patient population.

**Data Collection/Validation Summary**

We have conducted a significant number of domestic and international data collections and validations in order to secure an accurate representation of the diverse, dialysis-treated, patient population. Data collection at local dialysis clinics gives us convenient access to a few hundred patients. Efforts in several other states and internationally, expand the breadth of our patient database and minimize any geographical effects on patient distribution. The latest data collection effort on dialysis patients in a clinical setting in Mexico reiterated the accuracy of our technology consistent with AAMI SP10 accuracy requirements (see Annex). This is particularly important since we are currently supplying OEM blood pressure modules to major, global manufacturers of dialysis equipment.

The addition of a board certified, global opinion leader nephrologist to the SunTech Medical Advisory Board not only brings a wealth of relevant expert knowledge but also reiterates our commitment to the dialysis patient.