Alternative Locations for the Cardio Cuff

Is it safe? Are the data similar?[1]

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One of the common waveforms collected and analyzed during Psychophysiological Detection of Deception (PDD), or polygraph, examinations is the cardiograph. It is collected using a partially inflated blood pressure cuff usually placed on the upper arm over the brachial artery and inflated to about 55-65 mmHg. Phasic changes in pulse wave amplitude and waveform baseline are related to changes in relative blood pressure (Handler, Geddes, & Reicherter, 2007). Traditionally, only the change in the diagnostic waveform is used in manual scoring using where the diastolic points' slope changes from negative to positive. Waveform baseline can also be evaluated using the systolic peak points, and laboratory studies have describe the use of the average of all systolic and diastolic peaks (Kircher, Kristjansson, Gardner, & Webb, 2012; Kircher & Raskin, 1988).

Typical cuff pressure partially occludes venous return distal to the cuff location resulting in vasocongestion (Podlesney & Kircher, 1999). Test subjects sometimes report unpleasant feeling in those areas including tingling and loss of sensation (Yankee, 1965), and the resultant skin color changes can alarm some test subjects. Researchers have tested alternative technologies such as the Finapres (Podlesney & Kircher, 1999) and alternative devices like a finger cuff (Dollins& Cestaro, 1997) in search of a replacement for the upper arm cuff. In order for any device to be considered an acceptable "drop-in" replacement there should be a strong correlation between the traditional and experimental waveforms.

The Finapres works on the theory of Peñáz principle where a force exerted by a body can be determined by measuring an opposing force that prevents physical distention or changes. The Finapres offered significant correlation with the traditionally measured cardiograph. For diastolic changes the regression coefficient mean was r= .84. For systolic changes, the mean was r= .74. The Finapres has been replaced by a device called the Portapres (Finapres Medical Systems, The Netherlands). Unfortunately, the price of the device (approximately $40,000 U.S.) is cost prohibitive (Gerin, Goyal, Mostofsky, & Shimbo, 2008).

The one study we found on the finger cuff (Dollins& Cestaro, 1997) suggests it is not a suitable drop-in replacement for the traditional arm cuff. These researchers suggested a minimum point-biserial correlation of .90 was needed in the waveforms to consider the finger cuff a drop-in replacement. They collected simultaneous cardiographs from the upper left arm and both thumbs. The investigators reported congruence of .9 or greater less than 75% of the time overall. Additionally, they reported having to make about 150% more centering corrections with the thumb cuff than with the arm cuff. Their final recommendation was the finger cuff on the thumb not be used as a drop-in replacement for the arm cuff.

One alternative cuff location reported in the literature (Prado et al, 2015) is the lower leg or calf. The primary artery monitored here is the posterior tibial artery. Medical concerns about test subjects with deep venous thrombosis (DVT) warrant caution if selecting this location. DVT occurs when blood clots or thrombi form, usually in the large veins of the legs and many people with DVT are asymptomatic, and unaware of their condition. A very serious condition can occur if a blood

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clot should break loose, travel to the lungs, and block blood flow to a portion of the lungs. When this happens it is called a Pulmonary Embolism and it can be a serious health risk. The American Association of Critical Care Nurses (AACN) cautions that blood pressure cuffs should not be applied to extremities with DVTs or on patients who have a risk of DVTs. The concerns are that mechanical agitation for extended periods of time can increase the risk of an embolism (AACN, 2015). The Wound Ostomy and Continence Nurses Society WOCN) has also cautioned that applying compression with the blood pressure cuff may dislodge blood clots (WOCN, 2012).

Risk factors for DVT include; increased age, cancer treatment, smoking, taking birth control pills & other hormone therapy, diabetes, being sedentary for extended periods of time, obesity, heart disease, blood disease, injuries to veins, pregnancy or recent birth, and slow blood flow through veins. Many people with DVT are asymptomatic and thus unaware of their condition. This should be a concern to examiners seeking to collect cardiograph data from the leg and warrants a consideration of the benefits versus the risks. While cardiograph collected from the lower leg has been described by examiners as relatively stable, the potential health risk of an unknown DVT suggests alternative cuff placement. Examiners desiring to collect cardiograph data from these locations may want to query their subjects about whether they have any of these risk factors.

Other medical conditions cause concern with maintaining prolonged pressure to a person's lower extremity. People with peripheral vascular disease, specifically peripheral arterial disease (PAD), already have narrowing in the lower extremity arteries. While PAD can occur in any artery it is much more common in the lower extremities, thus raising concern with putting the blood pressure cuff on the lower leg. PAD screening is limited because many people are asymptomatic and unaware of the medical condition. Also, people with diabetes can have vascular disease and nerve damage and prolonged pressure from a blood pressure cuff may result in pain, swelling, increased numbness, and changes in skin color.

Another suggested alternative location for cuff placement is the forearm. The AACN suggests the forearm as the second choice location for blood pressure measurement following the upper arm (AACN, 2015). When the blood pressure cuff is placed on the forearm it may be better tolerated by some test subjects, even at pressures of 80-90 mmHg. In order for this to be an acceptable alternative for polygraph we should have data showing a high degree of correlation with the traditional cuff. Unless the replacement is very similar in design and use, we expect to have differences in the two tracings, which can introduce unknown variability into the polygraph scores. If the correlation (or covariance) is sufficiently high, we can expect the scores to differ by less than a normal rounding coefficient. In the case of manual scoring with integer points, the rounding coefficient will be ½ of one point. The impact of rounding will, of course, be slightly different whether using subtotal or grand total scores, due to the differences in variance. Initial simulations suggest that a correlation coefficient of .97 will be sufficient to constrain differences in scores to within ½ point with both subtotal and grand total scores.

The practical meaning of this is that any sensor that can achieve a correlation coefficient of .97 or greater with the current cardio arm sensor can be expected to serve as a drop-in replacement. This is without the need for revalidation of the structural models or recalculation of normative data. For field examiners this will mean that drop-in sensors that achieve this correlation can be used without concern for adjustment of decision cutscores. We can expect the test precision and error rates to be within known and established alpha boundaries.

Caution is warranted whenever we are attempting to substitute proven technologies with improved replacements. As a general rule, new replacement technologies should offer more advantages and fewer disadvantages. The substituted part should have performance that equals or exceeds the technology being replaced. We recommend continued interested in the forearm cuff as a potential drop-in replacement for the traditional arm cuff.

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