

## Training Improves the Ability of Anesthesia Providers to Visually Estimate Systolic Pressure Variation “Eyeball Technique”

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### Abstract

Inappropriate fluid management may lead to patient morbidity. Systolic Pressure Variation (SPV) in % is a simple measure of arterial respiratory variation and reflects fluid responsiveness. Previous analysis of simulated blood pressure data suggest that physicians usually make correct treatment decisions based on their visual estimate of SPV%, but have poor accuracy. The purpose of this study was to determine whether training could improve the ability of physicians to visually estimate SPV%. Methods 50 anesthesia providers were asked to give their visual estimate of SPV% on 10 arterial waveform tracings displayed for 45 seconds each. At all ten waveforms were played, the true values of SPV% were revealed. After one to two weeks the same group of physicians was reassessed on their visual estimate of SPV% by displaying 10 new arterial waveform tracings for 45 seconds each. The mean bias decreased from 1.2% to 0.032% and the distribution of error was significantly different between the pre-training and the post-training group ( $p=0.018$ ). The percentage of incorrect treatment decisions decreased from 4.4% to 0.85%. Conclusion Physicians experience a learning effect from visually estimating SPV%. As knowledge about how to utilize arterial respiratory variation in clinical practice increases, dedicated training may be useful. Additional studies to determine the ability of clinicians to measure changes in respiratory variation are warranted.

**Keywords:** Arterial waveform; Eyeball technique; Pre-training group; Respiratory pressure variation; Visual ability

### Introduction

Arterial respiratory variation is related to changes of intravascular volume and to the hemodynamic response to volume administration [1]. Commonly used metrics include Systolic Pressure Variation (SPV) [2], pulse pressure variation [3] and stroke volume variation [4].

Systolic Pressure Variation (SPV) is defined as the difference between the maximum and minimum values of systolic blood pressure following a single positive pressure breathe [2]. An increase in SPV is known to occur to occur clinically during hypovolemia [1,2].

Hypovolemia and fluid overload have both been shown to increase perioperative morbidity and mortality [5]. Accurate assessment of the patient's fluid status and fluid responsiveness is an important component of efforts to optimize perioperative outcomes.

Devices to measure respiratory pressure variation exist [4,7-9], but they are not commonly used intra-operatively or in the Intensive Care Unit (ICU). The utility of these devices is predicated on the assumption that anesthesia providers cannot accurately assess respiratory variation using visual estimates alone [2]. In a study designed to test the ability of anesthesia providers to visually estimate the percentage of Systolic Pressure Variation (SPV%) previously published by Thiele et al. in 2012 [2], a substantial amount of error was determined based on approximately 500 recorded estimates [2]. Actual treatment decisions were incorrect in 4.4% of instances and the Clinical significance analysis [10] revealed only 1% of “incorrect” treatment choices, mainly because of a large “indeterminant” zone in which the response to volume is not known [2].

Clinicians have a difficult time accurately estimating SPV%. It is not known whether or not clinicians can be trained to measure SPV% and whether or not such training can lead to more accurate estimates. The purpose of this study was to determine whether or not anesthesia providers experience a learning effect from the feedback given on their estimates of SPV%. We hypothesized that teaching anesthesia providers will lead to a statistically significant reduction in error.

### Methods

This study obtained approval from the Institutional Review Board (Social and Behavioral Sciences) at the University of Virginia and informed consent was waived.

50 anesthesia providers in the Department of Anesthesiology at the University of Virginia were shown ten arterial waveform tracings (derived from a liver transplantation hemodynamic database) of 45 seconds duration using a custom software routine written in LabView (National Instruments, Austin Texas) [2]. Study subjects were asked to give a visual estimate of SPV% after viewing each waveform and they were asked if they would treat the patient with a fluid bolus [2] (round 1, pre-training group). At the end of the study, all waveforms were re-played and true SPV% was provided [2].

One to two weeks after the initial assessment, physicians were again presented with 10 arterial waveform tracings (distinct from the ten used in the initial testing), again displayed for 45 seconds. Subjects were again asked to estimate SPV% of each of the 10 arterial waveform tracings and if they would start treatment with a fluid bolus based on their estimate of SPV% (round 2, post-training group). The assessment of arterial waveform tracings for each anesthesia provider in round 2 was identical to the assessment of arterial waveform tracings in round 1 and a different set of arterial waveform tracings was presented in round 2 compared to round 1.

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In round 1 and in round 2 participants were provided with both a graphical- and a mathematical explanation of SPV% [2].

$$SPV\% = 100 \times (SBP_{max} - SBP_{min}) / SBP_{average} \quad [1]$$

where, SBP is Systolic Blood Pressure

All data were analyzed using SPSS® v19 (IBM Corp, Armonk, NY) and Excel® Version: 14.0.6129.5000, Part of Microsoft Office Professional Plus 2010 © 2010 (Microsoft Corp, Redmond, WA).

To assess the learning effect on the visual estimation of SPV in % we used the Wilcoxon Sign Rank test to compare the error between both test rounds, after analyzing the normality of the distribution of the differences between estimated SPV% and actual SPV% using the Kolmogorov-Smirnov test.

Clinical Significance Analysis (CSA) [10] was used to determine the accuracy of the physician's estimate in round 2. The clinical significance analysis or error grid analysis is used to assess the clinical accuracy of two different methods of measurement [11]. Thresholds for fluid responsiveness were used as defined in the first assessment by Thiele et al. in 2012 [2]. The red zone was defined by any point in which the patient has been deemed fluid responsive, when he wasn't fluid responsive or a patient has been deemed not fluid responsive when he actually was fluid responsive [2]. All true SPV readings between 7% and 14.5% fell into the yellow zone. Readings in which the patient would have been treated correctly were defined as the green zone and all readings where the patient would have been treated incorrectly fell into the red zone [2].

Limits of agreement for our data in round 2 were assessed using the non-parametric Bland and Altman technique [12]. The limits of agreement were represented by the range of 7.5% above and below the mean bias (+0.032%).

For the comparison of the distribution of readings over the green and the red zone between both rounds, as well as for the comparison of limits of agreement between both rounds we used the Fisher's Exact test.

The actual number of false treatment decisions was calculated by counting the number of treatments when the SPV was <7% and the number of failed treatments when the SPV was >14.5%.

## Results

50 anesthesia providers participated in this study and all study subjects also completed our pilot study.

The mean bias was significantly lower in the post-training group compared to the pre-training group (bias+0.032% versus+1.2%, respectively p=0.018). The distribution of absolute errors in round 1 and 2 is displayed in Figures 1 and 2.

For the first series of waveforms (pre-training, round 1), the mean bias was +1.2% ± 6.9 % and 82% of estimates were within the non-parametric limits of agreement. 49%, 50% and 1% of readings were in the green, yellow, and red zones, respectively. For the second series of waveforms (post-training, round 2), the mean bias for the SPV was +0.032% ± 3.5% and 96% of estimates were within the non-parametric limits of agreement. 30%, 70%, and 0% of readings were in the green, yellow, and red zones, respectively. The number of readings within the non-parametric limits of agreement was significantly higher in round 2 compared to round 1 (p=0.000), 96% of all readings versus 82% of readings, respectively. All zones are displayed in Figure 3.

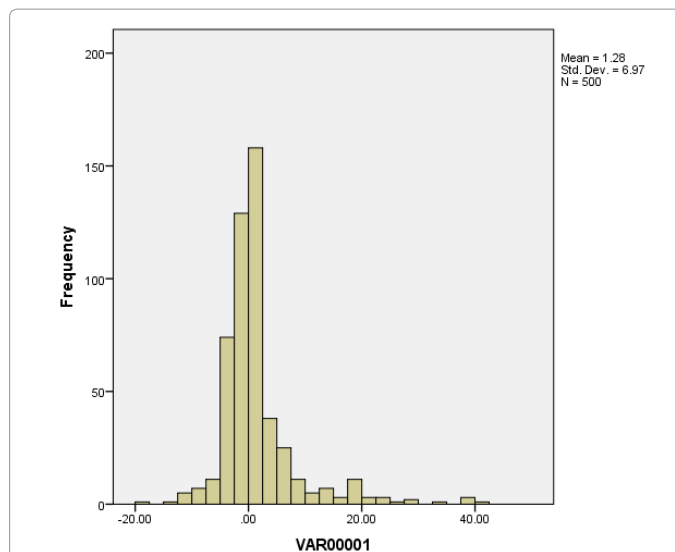


Figure 1: Distribution of the difference between the estimated and the measured SPV in % in round 1.

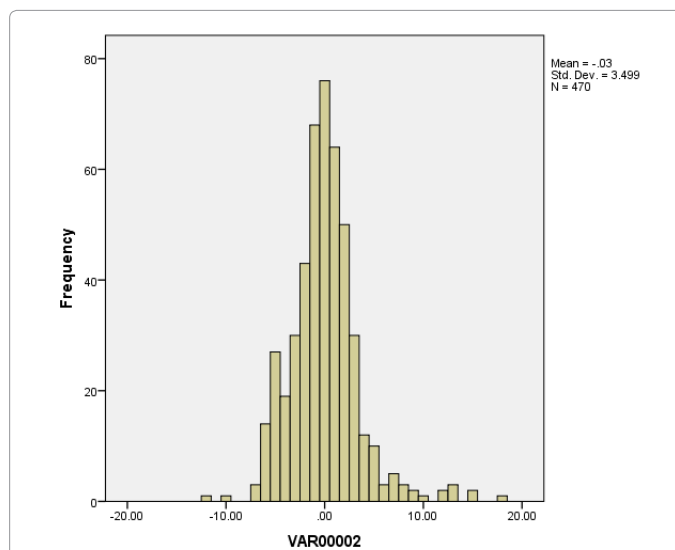


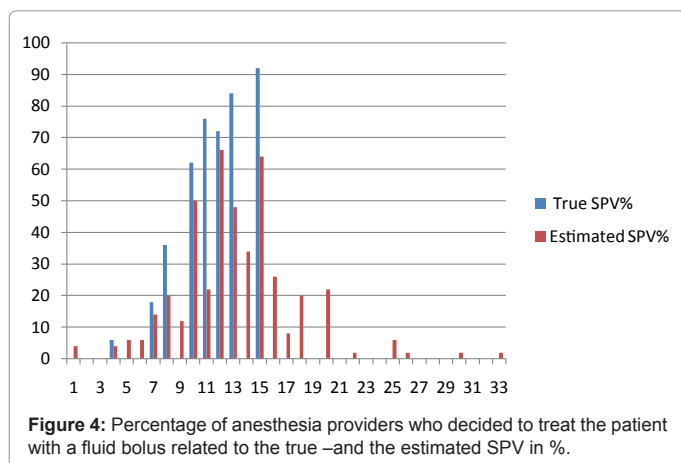
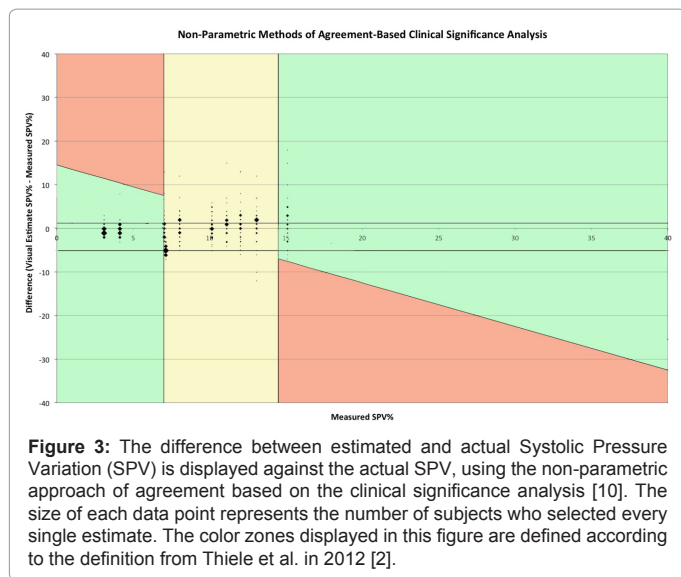
Figure 2: Distribution of the difference between the estimated and the measured SPV in % in round 2.

No significantly different distribution over the green and the red zone was found between the readings of round 1 and round 2 (p=0.105), although the results of this assessment indicate a trend towards a change of the distribution over these zones between groups.

There were significantly fewer red zone estimates in round 2 as compared to round 1 (0 vs. 5, p=0.036) but at the same time fewer green zone readings in round 2 than in round 1 were found (141 vs. 245, p=0.000). However significantly more values were in the yellow zone in round 2 compared to round 1 (p=0.000).

Based on the clinical significance analysis the treatment failure was 0% in the post-training group and 1% in the pre-treatment group.

The percentage of actually incorrect treatment decisions was 0.85% (4 treatment decisions) in the post-training group compared to 4.4% (22 treatment decisions) in the pre-training group.



The distribution of treatment decisions based on the estimated– and based on the calculated SPV% is shown in Figure 4.

## Discussion

Fluid imbalance, such as hypovolemia, hypervolemia and fluid shifts can contribute to increased morbidity and mortality in addition to increasing the cost of patient care [13-16]. Arterial respiratory variation is an important tool for the detection of changes of the intravascular volume [1] and it is also known to be a reliable tool in predicting fluid responsiveness [14,17]. Current data indicate that treatment decisions based on respiratory variation may improve patient outcome [18-20].

The results of our study show that it is possible to train anesthesia providers to estimate SPV% visually and that such training leads to a statistically significant increase in accuracy. Based on the clinical significance analysis [10], we did not observe any incorrect treatment decision in the post-training group compared to 1% of incorrect treatment decisions in the pre-training group. The actual decision to treat was incorrect in 0.85% of instances in the post-training group compared to 4.4% of instances in the pre-training group. This suggests that anesthesia providers are accurate at estimating respiratory variation from a CSA standpoint, however the variance of the error is relatively high (+1.2% ± 6.9% in the pre-training group and +0.032% ± 3.5% in the post-training group respectively). Because the arterial

waveform tracings in round 2 were different from the tracings that were used in round 1, the learning effect cannot be attributed to memorizing previously displayed and therefore familiar waveform tracings.

The fact that a larger percentage of data points fell into the yellow zone in the post-treatment group may have contributed to study subjects in round 2 making fewer incorrect treatment decisions compared to the study subjects in round 1. Furthermore a significantly higher number of readings were within the non-parametric limits of agreement after training compared to the pre-training group ( $p=0.000$ ). That said, the mean bias decreased after round 2 and this cannot be accounted for by changes in the distribution of true values of SPV%. These findings are displayed in figure 4 and these results suggest that a single training session may improve the ability of clinicians to estimate SPV%.

Our study has several limitations. First, while subjects were played recordings of previously recorded blood pressure tracings from surgical procedures that took place at our institution, it is not possible to know whether or not the decision to treat would have been made in a real life environment. Second the utility of CSA is affected by the size of the yellow zone. As the size of the yellow zone changes (with increased knowledge about the predictive abilities of SPV%), the results of the CSA will be affected. Third, we used SPV% because it is the easiest measure of respiratory variation to calculate. Data suggest that PPV and SVV [21,22] are more accurate predictors of fluid responsiveness (although they are likely more difficult to estimate visually). Lastly, our study is limited by the relatively small number of study subjects (50) at a single institution.

Future studies should address the broader applicability of our findings, whether or not the observed learning was durable beyond two weeks time, whether or not individuals can measure changes in SPV% (i.e., assess the trending ability), and determine whether PPV and SVV can be estimated visually. Ultimately, a clinical study comparing treatment decisions and outcomes when respiratory variation is estimated visually, as compared to calculate by an arterial waveform analyzer, may be indicated.

## Conclusion

The assessment of systemic arterial respiratory variation using the “eyeball method” leads to correct treatment response despite wide limits of agreement. A single, brief episode of training appears to reduce bias in addition to significantly improving the limits of agreement between predicted SPV% and true SPV%.

## Conflict of Interest

The authors declare that they have no conflict of interest.

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