Intervention Analysis: Access Surveillance by Venous Access Pressure (Vasc-Alert, VA) vs. Flow (Transonic, TS)

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1 Introduction

Access surveillance by markers measuring flow or pressure hold great promise for early diagnosis of stenosis, leading to simple treatments that prevent serious consequences; but the development of these markers is not yet completed and their performance not yet fully understood.

Two current markers are (1) the Vasc-Alert (VA) measurement method that calculates venous access pressure during all dialysis sessions from venous chamber drip pressure using a computer algorithm that adjusts for hematocrit, flow, and blood circuit characteristics; and (2) the Transonic (TS) measurement method that measures access flow by ultrasound dilution.

We developed an approach using access intervention analysis to carry out a program of studies of VA and TS. In this first study reported here we look at how well VA and TS characterize the changes, from before to after, for access interventions for stenoses confirmed by venograms.

For each marker we look at the distribution of the marker value after the change minus the marker value before the change, and compare it to the distribution of the background noise of changes when there are no interventions. A marker with a smaller background change distribution relative to the intervention change distribution has a better performance because the characterization of the outcome of the intervention will be less contaminated by noise.

2 Data & Marker Statistics

Data are from 3 dialysis units:

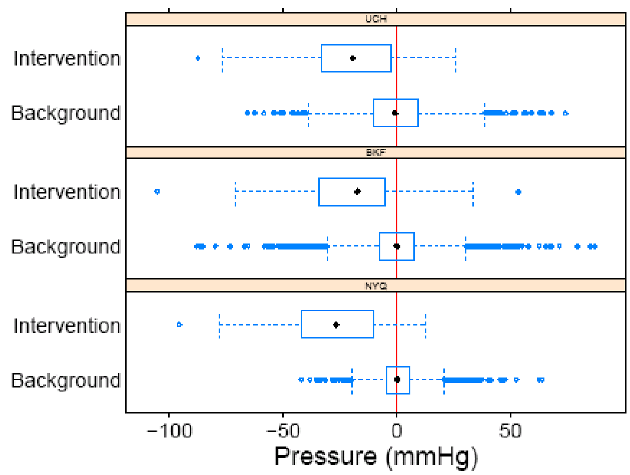
- NYQ: NY Hosp Queens, NYC, NY
- UCH: U Chicago, Chicago, IL
- BK: Bakersfield Dial Unit, Bakersfield, CA

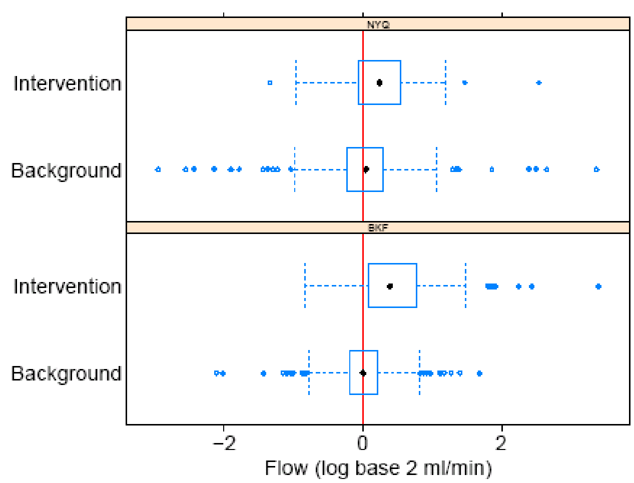
Unit	Interventions		Number Patients	Study Period
	VA	TS		
NYQ	67	59	350	12
BKF	169	147	265	16
UCH	87	0	201	6

Raw VA data were taken approximately every 30 min during dialysis. Raw TS data were taken once per month generally, but at BKF extra measurements were made in some cases. There were all access types except catheters. Data for intervention change distributions came from interventions as shown in the table above. Data for background change distributions came from patients with no interventions. The number of patients in the table includes intervention and non-intervention.

For VA, our marker statistic is a median of all raw measurements in five consecutive sessions. For TS, it is the logarithm of each raw value. For VA, we used two markers before and two after to form a single before-statistic and a single after-statistic. For TS, we took the before-statistic to be the raw observation just before the intervention and the after-statistic to be the raw observation just after the intervention.

3 Boxplots of Distributions





In the first figure above, we use boxplots to compare the intervention change distributions with the background change distributions for VA. Each panel has the comparison for one hospital or unit. This is also done in the second figure above for TS. On the boxplot, the dot

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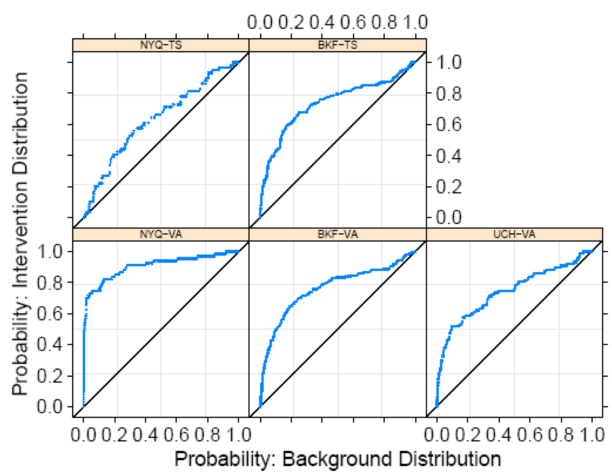
plotting symbol is the median of the distribution, the right side of the rectangle is the upper quartile (75th percentile), and the left side is the lower quartile (25th percentile). The ends of the horizontal dashed lines are the adjacent values; on average, 99.3% of the data would lie between these values if the data were normally distributed. Data outside of the adjacent values are plotted individually.

VA intervention distributions at the three units are shifted lower than the noise distributions, which are centered at 0. This happens because the results of an intervention is reduced pressure, and our VA change statistic measures after minus before. UCH and BKF are very similar. NYQ has a greater separation of the distributions and the background distribution is a smaller magnitude (concentrated close to 0) than the other two sites. Thus we would expect for our ensuing analysis that studies the separation of the two distributions, NYQ will do best.

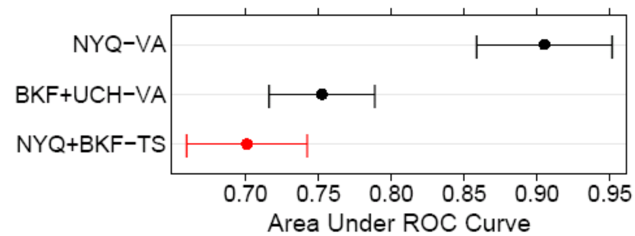
TS intervention distributions at the two units are shifted higher than the background distributions, which are also centered at 0. This happens because the result of an intervention is increased flow and our TS change statistic measures after minus before. Results at the two units are very similar.

4 PP-Plots and Areas



We have two distributions to compare for each of the five cases: NYQ-VA, UCH-VA, BKF-VA, NYQ-TS, and BKF-TS. We want to show their separation by a visual display and by a metric based on the display. For this purpose we will change our VA statistic to before minus after so that its distribution is greater than the noise distribution just like TS. This will make our interpretations simpler.

We will use probability-probability plots (pp-plots) and areas under the curves. This is the same methodology used in ROC curve analysis, but the application and interpretation is completely different here. In ROC analysis, probabilities for true positives are compared with probabilities for false positives. Here, on the pp-plot, the probability that the intervention data are greater than a value on the marker scale is plotted against the probability that the background data are greater than that value. This is done for a collection of values on the marker scale. The figure above shows the pp-plots. The higher the curve on the plots, the greater the separation of the two distributions.



Our metric for separation will be the area under the pp-plot curve — the greater the area, the greater the separation. Because of the above observations about similarity of VA distributions for UCH and BKF and similarity of TS distributions for NYQ and BKF, we merged the data NYQ-TS and BFK-TS to form NYQ+BKF-TS, merged the data UCH-VA and BKF-VA to form UCH+BKF-VA, and estimated the areas under the curves for the two merged data sets for NYQ-VA. Using the bootstrap sampling method we found that the estimates have a normal distribution, and we used the estimated standard deviations to determine 95% confidence intervals. The estimates and 95% intervals are shown in the figure above.

Both VA estimates are greater than the TS estimate. The NYQ-VA is highly significantly different from each of the other two. The significance level of the difference between UCH+BKF-VA and NYQ+BKF-TS is 0.062.

5 Conclusions and Discussion

VA does better than TS in this study. The intervention change distributions have greater separation from the background change distributions for VA than TS.

It is possible that the poorer performance of TS is the large time between raw measurements, that is, the sparsity of the data. Standard procedures are to measure once per month because TS is invasive and requires a trained technician to carry out the procedure. VA on the other hand is not invasive, coming from already existing information, and can be measured automatically throughout dialysis treatment; the result is a much greater amount of data.