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STATISTICAL ANALYSIS OF pH DATA

To the Editor:

Easy access to computers has encouraged researchers to use statistical tests with which they are unfamiliar, tremendously increasing the potential for mistakes. Research involving pH data seems to be especially prone to such mistakes. Table 4 of Minuck and Sharma[1] provides an example of this problem. Because of statistical errors, the accuracy of the means and standard deviations is questionable and the comparisons between treatments are invalid.

Most researchers know that pH = $-\log [H^+]$, but there is a difficult conceptual jump from that memorized fact to a realization that pH values will have a lognormal distribution. However, this concept is critical, because the arithmetic mean, standard deviation, and standard error, as well as such statistical tests as analysis of variance (ANOVA), correlation, and regression, assume that the data is normally distributed. This problem is compounded by the fact that statisticians use synthetic data to develop and test new statistical procedures. As a result, the use of a statistical test on data from the "real world" always requires more judgment and involves more uncertainty than is commonly appreciated. The purpose of this letter is to describe an analysis protocol that may help researchers avoid such mistakes.

The first step in the analysis of pH data should be to convert all pH measurements to $[H^+]$ and then calculate a mean, standard deviation, and, if desired, a standard error. These values can then be reconverted to pH units. Deviations calculated in this manner will be asymmetrical; therefore any published pH values with symmetrical confidence limits have probably been calculated incorrectly.

Once this has been done, the researchers will usually want to compare group means (such as between treatment and control groups) and test for significant differences. This has traditionally been done with ANOVA, but if the Kruskal-Wallis test (Zar, 1974[2]) is used, it will provide the same information, but is free of assumptions about normality or equality of variances.

Before the researcher can use ANOVA, the data should first be tested for equality of variances. This is a critical assumption and one which most biological data will violate. The F-Max test (Sokal and Rohlf, 1969[3]), which measures this, is very simple; it will provide a quick and easy method for identifying data that *must not* be analyzed by ANOVA because treatment and control group variances are unequal.

In the event that the variances are equal, the data should still be tested for normality before proceeding with the ANOVA. A sample size of about 30 is the minimum necessary for such a test to work properly and many experimenters will not have this large a sample. A computer program nevertheless will test for normality with fewer than 30 items, but then an answer of "not significantly different from normal" reflects the inadequacy of the test, not a statement of reality. ANOVA should be used only after the data is known to be normally distributed, with equal variances.

The development of statistical tests that are less restrictive about the data they can use is an active area of biometrics research, so this has been a shallow discussion of a complex issue. My hope is that it will give

your readers a feel for what questions to ask a biometrician.

Paul D. Krause, PhD
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MORE ABOUT INTUBATION OF PATIENTS WITH FULL STOMACHS

To the Editor:

The recent article by Dr. Cucchiara[1] on esophageal intubation for control of gastric contents and the reply of Dr. Roberts[2] have served as important reminders of a valuable procedure in the anesthetic management of patients with full stomachs.

However, their historical documentation is not complete. In 1957 Drs. Giuffrida and Bizarri[3] advocated the use of esophageal blocking and diversion of gastric contents by use of a special tube.

In 1966[4] I advocated having available 2 endotracheal tubes during endotracheal intubation of patients with full stomachs. One tube could be inserted into the esophagus if regurgitation occurred; then the 2nd tube could be inserted into the trachea after clearing the throat. This "two-tubes" technic has been a part of our program in managing general anesthesia for patients with full stomachs for several years. Fortunately the need for the esophageal intubation has been rare, when the other precautions are employed, including use of the head-up position, preoxygenation, avoidance of positive-pressure ventilation, cricoid pressure, and pretreatment with competitive neuromuscular blocking agents prior to the use of succinylcholine before intubation.

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PEEP MEASUREMENT

To the Editor:

In the description by Drs. Weeks and Comer of a PEEP device for anesthesia circuits[1] it is stated that PEEP is reflected by the canister pressure gauge on the Ohio circle system. I have not found this to be true. PEEP pressure must be measured with a manometer inserted distal to the inspiratory valve and proximal to the PEEP valve in the Ohio circle system. Perhaps the authors interchanged the description of the Ohio and Foregger circle systems.

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To the Editor:

I owe an apology to the readers of ANESTHESIA AND ANALGESIA and an expression of gratitude to Dr. Glick for pointing out an error in our paper, "A PEEP Device for Anesthesia Circuits."

All of the observations reported are true and valid, with one exception. The values of PEEP in the patient circuit which were recorded on paper as well as back pressures reflected in the anesthesia machine are as stated. The error concerns the statement that PEEP values may be read from the canister pressure manometer of the Ohio machine, #20 carbon dioxide canister. The only model that I could find which would reflect PEEP is the Ohio #18 canister manometer. So long as the manometer is not on the patient side of the directional valves, PEEP, which is present if applied as sug-