the [H⁺] values $(10^{-1} + 10^{-6})/2 \cong 5 \times 10^{-2}$ mol/l is obtained. Finally, the negative logarithm of this average is the mean pH: $-\log 5 \times 10^{-2}$, or pH = 1.3. Since 10^{-6} is far smaller than 10^{-1}, its contribution to the average is trivial and changes little the calculated mean [H⁺]. Obviously, pH = 1.3 is a far different result from pH = 3.5. Since pH is linearly related to chemical potential, then an average value of pH should properly represent the average value of the disposition of hydrogen ion to participate in the physiologic state being studied.[6,7] Thus, in our example, the appropriate mean pH is 3.5, not 1.3.

This recent notion that pH should be converted to [H⁺] for averaging arises from the assumption that random variations of [H⁺] have a normal distribution. No experimental or theoretical evidence supports this assertion.[6,7] To the contrary, theoretical considerations suggest that it is pH that is normally distributed.[6,7]

In some circumstances use of [H⁺] rather than pH is needed.[6] For example, if Stoelting had measured gastric acid production (by use of titration methods in gastric-fluid samples), then the results should have been expressed as [H⁺], not pH. Any statistical manipulations (mean, standard deviation, standard error, confidence intervals) should have also been expressed in terms of [H⁺]. We strongly recommend that in reporting pH results, usual statistical calculations are correct and appropriate without any data transformations.

NATHAN LEON PACE, M.D.
Assistant Professor
AKITO OHMURA, M.D.
Assistant Professor
TAKASHI MASHIMO, M.D.
Research Fellow
Department of Anesthesiology
University of Utah College of Medicine
Salt Lake City, Utah 84132

REFERENCES

1. Giesecke AH Jr: Averaging values for gastric pH incorrect. ANESTHESIOLOGY 50:70–71, 1979
2. Stoelting RK: Responses to atropine, glycopyrrolate, and Riopan of gastric fluid pH and volume in adult patients. ANESTHESIOLOGY 48:367–369, 1978
3. Campbell EJM: RIpH. Lancet, 1962, pp 681–683
4. Howorth PJN: RIpH revisited. Lancet, 1974, pp 253–254
5. Blackburn JP: What is new in blood–gas analysis? Br J Anaesth 50:51–62, 1978
6. Davis RP: Logland: A Gibbsian view of acid–base balance (editorial). Am J Med 42:159–162, 1967
7. Waddell WJ, Bates RG: Intracellular pH. Physiol Rev 49:285–329, 1969

In reply: — I have read with sustained fascination the correspondence by Pace *et al.* and others regarding mean pH as an expression of the central tendency of acidity in gastric specimens. Many arguments have been presented in favor of meaning pH values by adding them all together and dividing by "n" exactly the same as one would derive the mean of any other set of numbers.[1,2] These arguments were so eloquent that I began to doubt my own conviction that this mathematical manipulation was not scientifically valid.[3–5] My conviction was based largely on the knowledge that when one adds logarithms the antilogs that they represent are multiplied, not added. Further, when one divides a logarithm by a number "n", then one achieves the "n-th root" of the antilog which is represented. The controversy boils down to a simple question: "Which of the following is the best expression of the central tendency of acidity in a series of solutions of different pH?"

$$\bar{X} = \frac{\Sigma x}{n}$$

or

$$\bar{X} = \sqrt[n]{X \cdot X \cdot X \cdots}$$

I decided to test the question physically rather than just speculate on the theoretical mathematics. In the laboratory I added 100 ml of distilled water to each of five beakers. Using a continuously reading pH meter, I added hydrochloric acid or sodium hydroxide dropwise until the pH values of the five solutions read 2.045, 3.114, 4.131, 5.192 and 6.063. Triplicate observations and constant stirring were used to assure accuracy of the readings. To determine the central tendency of acidity of the solutions, I poured 25 ml of each of the five solutions together in a mixing flask and measured the pH of the resulting solution. If mean pH were a valid expression of the central tendency of acidity, then the pH of the resulting solution should read 4.109. Alas, the actual reading was 2.758, which happens to be the pH of the mean hydrogen ion concentration in the resulting solution. I, therefore concluded that best expression of the central tendency of acidity in a series of solutions can be proven by

physical means to be the mean of their hydrogen ion concentration and not the mean of their pH values.

I'm reminded of the statistician who drowned while swimming in a Texas creek, the average depth of which was 6 inches from one year to the next.

ADOLPH H. GIESECKE, JR., M.D.
Department of Anesthesia
Parkland Memorial Hospital
Dallas, Texas 75235

REFERENCES

1. Feinstein AR: On central tendency and the meaning of mean for pH values. Anesth Analg (Cleve) 58:1–3, 1979
2. Drummond GB: More on calculation of mean pH values. Anesth Analg (Cleve) 58:63, 1979
3. Krause PD: Statistical analysis of pH data. Anesth Analg (Cleve) 57:143–144, 1978
4. Giesecke AH Jr, Beyer CW, Kallus FT: More on interpretation of pH data. Anesth Analg (Cleve) 57:379–381, 1978
5. Giesecke AH Jr: Averaging values for gastric pH incorrect. ANESTHESIOLOGY 50:70–71, 1979

(Accepted for publication June 12, 1979.)

Hazard Associated with New Foretrend® Anesthesia Machine

To the Editor:—During scheduled follow-up inspection of new equipment recently introduced to clinical service, we found that the table-top surface of a Foregger Foretrend gas machine had acquired a tilt, sloping down from front to rear. When our other identical units, placed in service at the same time, were then examined, we found that three of the four shared the same problem. The rear edge of the table top of one machine had slipped down far enough to expose both the upper and lower O-rings used to seal the chrome vertical gas delivery tube, thereby allowing a gas leak. This tube normally connects the right-hand side of the back bar assembly to the plumbing below the table top. The difficulty was traced to inadequate tightening of the set screws that bind the table top assembly to the vertical support posts. The combined weight of the top itself, any equipment placed thereon, and the suspended gas cylinders gradually pushed the rear mounts lower and lower on the posts. Since the vertical gas delivery tube uses an O-ring seal at both ends, the distance between the two O-ring seats is critical. When the table top assembly is displaced 1 cm, both O-rings come out of their seats and a leak results.

We suggest that all Foregger Foretrend model anesthesia machines now in use be carefully examined to ensure that the table top is in the correct position, with the O-rings on the vertical gas delivery tube properly seated within the hex nut on the table top and in the aluminum block on the back bar, and that the set screws holding the table top be checked for a secure attachment to the vertical posts. Failure to achieve the proper seal with both O-rings will allow a leak. Correspondence with the manufacturer's representative suggests that this problem is less likely to occur in the presence of the full drawer assembly option, as the box that houses the drawer slides serves as additional mechanical support for the table top. Older models do not share the problem, as the table top is held in place by pins that transfix the posts, rather than by set screws.

DANIEL F. DEDRICK, M.D.
Instructor in Anaesthesia
Harvard Medical School
Assistant in Anesthesia
Massachusetts General Hospital

C. DAVID MIERAS
Biomedical Engineering Technician
Department of Anesthesia
Massachusetts General Hospital
Boston, Massachusetts 02114

Optimal Positioning for Cervical and Thoracic Operations

To the Editor:—The Relton-Hall scoliosis operating frame* has achieved considerable popularity among

---

* Imperial Surgical Company, 3585 St. Clair Avenue, E., Scarborough, Ontario, Canada.

orthopedic surgeons and anesthesiologists. While providing patient stability, it allows the anterior abdominal wall to be free from external pressure, thereby decreasing spinal venous plexus engorgement. The height of the operating frame requires the