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Rectal pH in children

In an attempt to establish normal values for rectal pH in children, we have measured pH in 100 paediatric patients. Measurement of rectal pH was performed in 25 infants and 75 children (27 girls and 73 boys) using a monocrystalline antimony electrode. Rectal pH was 9.6 ± 0.9 (mean $\pm$ SD, range 7.2 to 12.1) and was independent of sex, age and nutrition. This wide range of rectal pH values offers a possible explanation for the widely scattered bioavailability of drugs administered by the rectal route. Mean rectal pH was considerably higher than that reported for adults; this unexpected alkalinity should be taken into account, when drug formulations are considered for rectal administration in children.

Widely scattered plasma concentrations and poor bioavailability have been reported following the rectal administration of barbiturates in paediatric anaesthesia¹ but the reasons are not fully understood. The rectal absorption of drugs is in accordance with the "pH-partition-hypothesis"² and thereby a function of rectal pH.^{3,4} Further knowledge of the rectal milieu pH may facilitate the prediction of bioavailability of rectally administered drugs which are either weak acids or bases. While pH in the rectum of adults is reported to be in the range of 6.8–7.9^{5–8} no such data exist for children. We have measured rectal pH in infants and children and investigated possible dependence on sex, age and nutrition.

Methods

Following institutional approval and informed parental consent the study was carried out on 100 children presenting for minor elective surgery. No child with

gastrointestinal disease or disorders of alimentation was included.

Rectal pH was measured between 6 and 8 a.m. by one of the authors. Measurements were preceded by digital examination of the rectum and only carried out when the ampulla was free of faeces. No enema was given in order to maintain an undisturbed pH milieu.

Following a daily calibration procedure, all measurements were performed with the same monocrystalline antimony pH catheter (pH METER SYN-02®, Synectics AB, Stockholm, Sweden). The tip of the flexible catheter was positioned at a distance 2 cm proximal to the anal sphincter and the reading was taken after one minute. Under these conditions the measuring device has an accuracy of ± 0.1 unit. The pH meter employed in this study is equipped with three sensors at the tip and requires contact of one or more sensors with a wet surface. As the absence of bowel contents at the time of measurement was established by rectal examination, the pH values can be viewed as being obtained from rectal mucosal contact and thus to reflect the "microclimate" or "contact pH".⁹

The pH data were analysed for dependence on gender, age and nutrition. Patients were divided into two groups: infants, >4–52 weeks, and children, >52 weeks, —14 years. For nutrition three groups were defined: "breast/bottle," baby soft food ("bsf") and "mixed-food." With respect to age, the larger group were children ($n = 75$; $n_{inf} = 25$). Allocation by nutrition revealed 22 patients in the breast/bottle group (2/20), 24 for bsf and 54 for mixed-food categories.

For statistical analysis Mann-Whitney's statistic was used. The number of comparisons performed was three. A multiple significance level of $P < 0.05$ was guaranteed relying on Holm's sequential procedure.¹⁰

Results

Twenty-seven girls and 73 boys were studied. Mean ($\pm$ SD) rectal pH was 9.6 ± 0.9 with a range of 7.2–12.1 (Figure). The pH values for sex, age and nutrition subgroups are listed in the Table. No differences among groups were found with respect to sex, age or nutrition.

Discussion

The most commonly reported problem associated with rectal administration of drugs is unpredictable efficacy.¹¹ This becomes a major concern when a rapid and predictable onset of action is required, as is the case in

Key words

ACID-BASE EQUILIBRIUM: pH; ANAESTHESIA: paediatric;
MEASUREMENT TECHNIQUES: pH rectal; PHARMACOKINETICS: absorption, rectal.

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Presented at the IARS 63rd Congress, Lake Buena Vista (Orlando), Florida, March 1989.

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FIGURE Distribution of rectal pH values in 100 subjects.

anaesthesia. Sleep induction by rectal administration of anaesthetic drugs was pioneered by Pirogoff in 1848¹² and has become increasingly popular in paediatric anaesthesia. However, bioavailability is poor and unpredictable with rectal administration.¹ Although pH is a recognized factor in absorption^{13,14} it has received only sporadic attention.^{15,16,17}

Our results show that mean rectal pH in the investigated age group is 9.6 ± 0.9 , when measured in the early morning, 2 cm proximal to the anal sphincter. An empirical range including 95 per cent of all rectal pH values in this age group would extend from 7.3 to 11.8. The extent of that range might contribute to the unpredictability of bioavailability following the rectal administration of drugs. The pH in children appears to be largely independent of gender or age although some of the subgroups are too small to substantiate this.

Rectal pH in children was found to be considerably higher than in adults. This alkalinity in the rectum is possibly maintained by active secretion of bicarbonate from the rectal mucosa.¹⁸

Rectal pH should be taken into account when drug

formulations are considered for rectal administration in children.

Acknowledgement

We are indebted to Dipl. Phys. R. Lippold, Department of Medical Statistics and Documentation, Johannes Gutenberg-University Medical School, Mainz, F.R.G., for help in the statistical analysis of the data.

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TABLE Mean rectal pH

	n	pH	± SD	Range
Total	100	9.6	0.95	7.2-12.1
Boys	73	9.7	0.96	7.2-12.1
Girls	27	9.4	0.89	7.3-10.9
Infants	25	9.4	0.85	7.6-10.9
Children	75	9.7	0.96	7.2-12.1
Breast/bottle	22	9.5	0.99	7.2-10.9
Bsf	24	9.6	1.13	7.3-12.1
Mixed food	54	9.9	0.72	8.3-11.8

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Résumé

Dans une tentative d'établir les valeurs normales du pH rectal chez les enfants, on a mesuré le pH chez 100 patients pédiatriques. La mesure du pH rectal fut faite chez 25 nouveau-nés et 75 enfants (27 filles et 73 garçons) utilisant des électrodes d'antimoine monocristalline. Le pH rectal était de 9.6 ± 0.9 (moyenne $\pm$ SD, écart 7.2 à 12.1) et fut indépendant du sexe, âge et nutrition. Cet grand écart du pH rectal nous offre possiblement une explication quant à la raison du grand écart de bio-disponibilité des médicaments administrés par voie rectale. Le pH moyen rectal est considérablement supérieur à celui rapporté chez l'adulte; cette alcalinité inexpliquée doit être prise en considération quand on formule des médicaments pour administration rectale chez les enfants