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ORIGINAL ARTICLE

ANALYSIS OF HAEMOGASOMETRIC DIAGNOSTICS AT INTENSIVE CARE UNITS ANÁLISE DOS DIAGNÓSTICOS HEMOGASOMÉTRICOS NAS UNIDADES DE TERAPIA INTENSIVA ANÁLISIS DE LOS DIAGNÓSTICOS HEMOGASOMÉTRICOS EN LAS UNIDADES DE CUIDADOS INTENSIVOS

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ABSTRACT

Objectives: to characterize the haemogasometric diagnostics by intensivist professionals and identify the knowledge and use of diagnostic methods SBE and Astrup. **Method:** a descriptive and analytical study of a quantitative approach, of cross-sectional cohort, with 34 intensivist professionals (physiotherapists, doctors and nurses) of the hospital units in Jequié-Bahia/Brazil. It was used a semi-structured interview guide and the data were analyzed by Statistics. The research project was approved by the Research Ethics Committee, Protocol n° 104/2009. **Results:** 100% of nurses, 61,5 % of physicians and 44,4 % of physiotherapists do not know the methods. In addition, 100 % of nurses, 76,9 % of physicians and 77,8 % of physiotherapists do not use such methods (statistical significance: $p < 0,05$). **Conclusion:** the haemogasometric diagnoses were not uniform and it was evident the lack of knowledge about the methods SBE and Astrup, with the largest representation of nursing professionals, however, the low use of diagnostic methods was equivalent in the three classes of professionals. **Descriptors:** Diagnosis; Gasometry; Personal Health; Intensive Care Units.

RESUMO

Objetivos: caracterizar os diagnósticos hemogasométricos pelos profissionais intensivistas e identificar o conhecimento e a utilização dos métodos diagnósticos SBE e Astrup. **Método:** estudo descritivo e analítico, de caráter quantitativo, de corte transversal, com 34 profissionais intensivistas (fisioterapeutas, médicos e enfermeiros) das unidades hospitalares de Jequié-BA/Brasil. Foi utilizado um roteiro de entrevista semiestruturado e os dados foram analisados pela estatística. O projeto de pesquisa foi aprovado pelo Comitê de Ética em Pesquisa, Protocolo de n°104/2009. **Resultados:** 100% dos enfermeiros, 61,5% dos médicos e 44,4% dos fisioterapeutas não conhecem os métodos. Além disso, 100% dos enfermeiros, 76,9% dos médicos e 77,8% dos fisioterapeutas não utilizam tais métodos (significância estatística- $p < 0,05$). **Conclusão:** os diagnósticos hemogasométricos não foram uniformes e ficou evidente a ausência de conhecimento sobre os métodos SBE e Astrup, com maior representatividade dos profissionais de enfermagem, contudo, a baixa utilização dos métodos diagnósticos foi equivalente nas três classes de profissionais. **Descritores:** Diagnóstico; Gasometria; Pessoal de Saúde; Unidades de Terapia Intensiva.

RESUMEN

Objetivos: caracterizar los diagnósticos hemogasométricos por los profesionales intensivistas e identificar el conocimiento y el uso de métodos de diagnóstico SBE y Astrup. **Método:** se realizó un estudio descriptivo y analítico, de carácter cuantitativo, de corte transversal, con 34 profesionales de la salud (fisioterapeutas, médicos y personal de enfermería) de las unidades hospitalarias en Jequié-Bahia/Brasil. Se utilizó una guía de entrevista semi-estructurada y los datos fueron analizados por estadística. El proyecto de investigación fue aprobado por el Comité de Ética de Investigación, el Protocolo n° 104/2009. **Resultados:** el 100% del personal de enfermería, el 61,5% de los médicos y el 44,4% de los fisioterapeutas no conocen los métodos. Además, el 100% de las enfermeras, el 76,9% de los médicos y el 77,8% de los fisioterapeutas no usan estos métodos (significación estadística: $p < 0,05$). **Conclusión:** los diagnósticos hemogasométricos no fueron uniformes y era evidente la falta de conocimiento sobre los métodos SBE y Astrup, con la mayor representación de la enfermería, sin embargo, el bajo uso de métodos de diagnóstico fue equivalente en los tres tipos de profesionales. **Descriptores:** Diagnóstico; Gasometría; Personal de Salud; Unidades de Cuidados Intensivos.

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INTRODUCTION

It is of utmost importance to understanding and control of acid-base disturbances in the intensive care units, especially when these disorders develop rapidly in severe abnormalities, which may be the direct cause of organ dysfunction.¹⁻³ For this reason, knowledge of the physiological mechanisms of homeostatic control of acid-base balance is crucial within the ICU.

The methods most used for the diagnosis of disorders of acid-base balance are Astrup and the analysis method *Standard Base Excess* (SBE). The first evaluates the pH, PaCO₂, bicarbonate (HCO₃⁻), and gaps. By contrast, the *Standard Base Excess* (Excess Base modification of Van Slyke equation) is a method that measures the pH, PaCO₂ and the own SBE.⁴⁻⁶

Many care professionals have difficulties in the clinical interpretation of arterial blood gases, and generally only use the data to develop haemogasometric diagnosis, however, the literature recommends the use of more accurate and reliable forms the composition of diagnoses, such as compensation formulas and dosage of electrolytes.^{4,7}

The haemogasometric data can be used when the risk factors are present, to reassess the patient's health status, but are not relying solely on them, but convalidating by methods have proven effective, such as calculating the SBE.⁸ Despite the importance of the knowledge of acid-base balance by all specialties, many professionals have varying degrees of difficulty in its practical understanding.⁹

The objectives of this study are:

- Characterizing haemogasometric diagnoses provided by care professionals.
- Identifying the knowledge and use of diagnostic methods SBE and Astrup.

METHOD

Quantitative study of descriptive and analytical cross-sectional, in which data were collected from 34 intensive care professionals (physiotherapists, doctors and nurses) of Hospitals: Hospital General Prado Valadares-HGPV (ICU ADULT - TYPE II) and Helena Hospital-MSM (intermediate unit) in the city of Jequié-BA (Brazil) from March to April 2010, and was approved by the Ethics Committee in Research of the State University of Southwest Bahia (UESB) under protocol n° 104 / 2009.

Inclusion criteria should be professional practitioners intensivist at least one of the hospitals assessed for at least six months.

Were excluded from the study professionals missed work on the day of the interview and refused to sign the consent form.

For data collection we used a semi-structured interview guide consists of data identifying six closed multiple choice questions and three open.

The research was conducted in three stages, namely:

In the first step, to test the applicability of the interview, a pilot study was conducted with 10 students from the stage of Physiotherapy in ICU UESB, which analyzed response time, doubts on some issue or some other need to change the instrument. In the second stage, after completion of this pilot study were made the changes necessary for a better understanding and clarity in the answers. Soon after, check for possible failures, the survey instrument has been tested for reliability analysis, which marked the change of measure of stability or consistency of measurement, which were used percentage concordance correlation coefficient (rho) and Kappa index (k=0,99).

In the third stage, the interviews were conducted in hospitals. There was still checking through form, of which practitioners recorded their respective diagnoses gasometrical, the records of ICUs.

Numerical variables were first checked for normality and homogeneity using the Kolmogorov-Smirnov test. Checked for normality, the data were expressed as mean±standard deviation for age and sex in the frequency distribution for the normal reference values of pH, bicarbonate and PCO₂. Already validation methods of gas analysis, the existence or not of this validation, as well as knowledge and use of diagnostic haemogasometric SBE and Astrup variables were compared using the chi-square test, and considered statistically significant when p<0,05. When you find an expected value less than five in the cell of a contingency table, we used the Fisher exact test. In the creation of the database were used Excel 2003® and the computing results of the statistical program Statistical Package for Social Sciences for Windows version 11.5.

RESULTS

During the interval studied, 36 care professionals were part of the professional staff of the ICU's (HGPV and MSM) Jequié-Bahia. Of these, 34 were interviewed individuals of both sexes, with 52,9% (n = 18) male and 47,1% (n = 16) were females, divided into three groups according to their functional classes: Nursing (ENF), Medicine (MED) and

Physiotherapy (FISIO). Are therefore excluded two intensivists: one for missing work days in the interviews and the other for refusing to sign the informed consent of research.

Table 1 contains a description of the sample size, sex and age in years (mean, standard deviation and confidence interval) of each group of functional class.

Table 1. Characteristics of the sample (n = 34).

	NUR		DOC		PHY	
Characteristics	n	%	n	%	n	%
N	12	37,4	13	39,7	9	28
GENDER						
Male	3	16	10	77	5	66
Female	10	84	3	23	4	44
Age (years)		-		-		-
Average + DP	35,9(±10,1)	-	36,3(±6,5)	-	28,7(±2,89)	-
IC (95%)	30,19-41,63	-	32,77-39,83	-	26,89-30,65	-

ENF-Group I: Nurses, MED-Group II: Doctors, PHYSIO-Group III: Physiotherapists

Most intensivists working in shifts, with 92% (n=31) and 8% (n=3) of routine, accounting professionals both units.

Regarding the charts of units of blood gas data, it was found that 100% of physiotherapists, 100% of physicians and 33% of nurses recorded in their medical records.

The chi-square association between function and normal values was statistically significant (p<0,05). Table 2 presents the

percentages of care professionals who use the normal reference values recommended internationally pH, bicarbonate and PCO₂ (7,35-7,45; 22-26 and 35-45 respectively) of using other values and those who did not use these data do not perform analysis hemogasometric.

Table 2. Frequency distribution of intensivists associated with the normal reference values of pH, bicarbonate and PCO₂--.

	NUS (n=12)		DOC (n=13)		PHY (n=9)	
Normal values	%		%		%	Valor de p *
Ph						0,001
7,35- 7,45	33,3		76,9		100	
Outro	8,3		23,1		0	
No use	58,3		0		0	
Bicarbonate						<0,001
22-26	0		15,4		66,7	
Other	33,3		84,6		33,3	
No use	66,7		0		0	
PCO ₂						<0,001
35-45	25		46,2		100	
Other	8,3		53,8		0	
No use	66,7		0		0	

ENF-Group I: Nurses, MED-Group II: Doctors, FISIO-Group III: *Physiotherapists Association between function and normal values using the Chi-square and Fisher's exact Test (p<0,05, statistically significant) .

During the study, which was asked to intensive diagnostic methods haemogasometric SBE or Astrup was used in the respective ICUs. It was observed that 8,82% of the two intensive care units believed to be the SBE and/or Astrup, matched against,

91,18% of intensive believed to be any method.

The functions of each class of professionals interviewed (ENF, MED, FISIO) were associated with the existence of validation of arterial blood gas analysis, and validation methods (Henderson-Hasselbalch or otherwise) these haemogasometries (Table 3).

Table 3. Association between the existence and the methods of validation of arterial functional classes of professionals intensivists.

	NUR (n=12)		DOC (n=13)		PHY (n=9)	
Variables						Value of p *
Validation (%)						0,039*
Yes	0		38,5		11,1	
No	100		61,5		88,9	
Methods (%)						
H-H	0		38,5		11,1	0,039*
None	100		61,5		88,9	

H-H - Henderson-Hasselbalch Equation. ENF-Group I: Nurses, MED-Group II: Doctors, FISIO-Group III: Physiotherapists. * Association

using the Chi-square (x²) with Fisher's Exact Test (p<0,05, statistically significant).

The association between the variables knowledge and professional use of diagnostic and SBE Astrup with functional classes (ENF, MED and FISIO) was statistically significant ($p < 0,05$). It was observed that 100% of nurses,

61,5% of physicians and 44,4% of physiotherapists do not know the methods. In addition, 100% of nurses, 76,9% of physicians and 77,8% of physiotherapists do not use such methods (Figure 1).

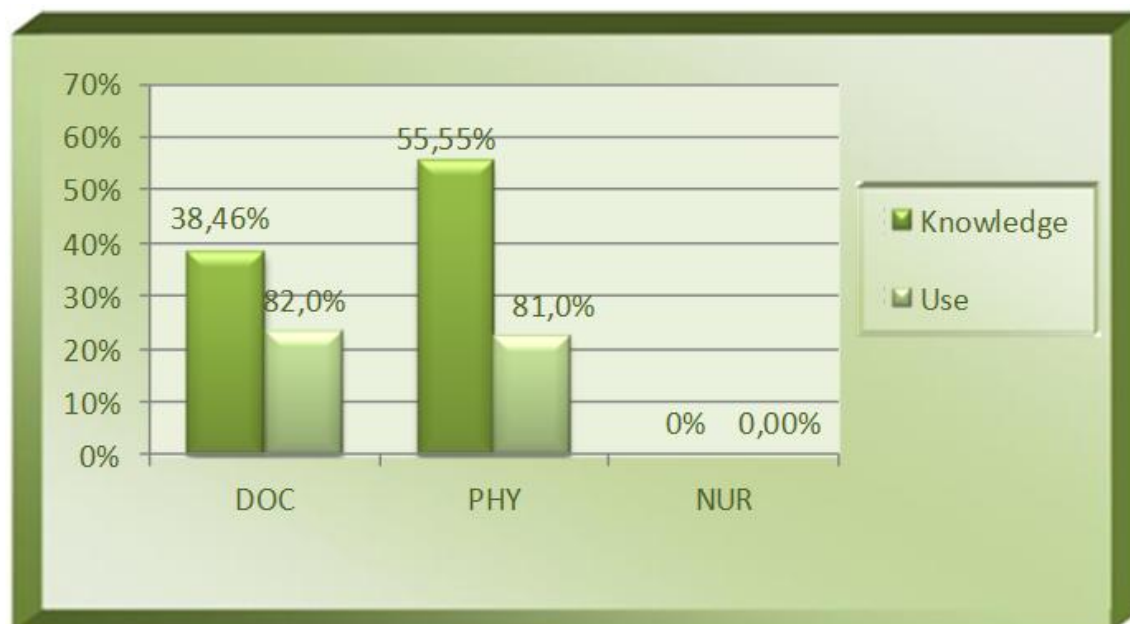


Figure 1. Relationship between knowledge and use of diagnostic haemogasometric methods SBE and Astrup, with functional classes ($n = 34$, Chi-square-Fisher's exact Test and Chi-square $p = 0.009$).

The association between the use of forms with the application of the methods also achieved statistical significance in the Fisher's exact Test ($p = 0,000$), noting that 100% ($n = 5$) of the professionals that used diagnostic methods SBE and/or Astrup (physiotherapists and doctors) do so through manual calculation.

DISCUSSION

The present study demonstrated that intensive care professionals in both hospitals were mostly adults ($34,17 \pm 8,06$ years, $n = 34$), as consistent with other studies on knowledge of health professionals in hospitals abroad.¹⁰⁻¹ The majority of respondents worked mainly on duty physicians (92%). Data corroborate another study¹² of knowledge intensive care after brain death where most professionals were also on duty.

It was found in this study the fact that some practitioners did not adopt the values of data normality haemogasometric pH, bicarbonate and PCO_2 postulated in the literature specifically for use in intensive care, which are respectively: 7,35- 7,45; 22-26nmol and 35-45mmHg. It was noted that from the point of view of arterial blood gas analysis, the adoption of the Danish School of Siggaard Andersen is practically a unanimous international.¹³ Other authors also corroborate this idea by referencing this school and using the reference values of normal.^{1,2,14}

Besides the lack of standardization of reference values for pH, bicarbonate and PCO_2 , fleeing the international

recommendations for long established, it is important to note that intensive care units do not have consensus on the use of these methods, perhaps for lack of protocols and routines in these ICU's on the diagnosis of acid-base imbalances. We emphasize the importance of systematizing and organizing the work of the nursing staff in the ICU with the establishment of routines, because they are essential to quality care, efficiently and effectively.¹⁵

Association functional classes and the existence validation of arterial blood gases, as well as the validation of these haemogasometric methods was statistically significant ($p = 0,039$). It was found that 100% of nurses, 61,5% of physicians and 88,9% physiotherapists not validate arterial blood gases and not use the Henderson-Hasselbalch equation (Table 3). However, these professionals Intensive have the power to intervene in disorders of acid-base balance, especially for the clinical importance of these ICU.^{2,4,16} In addition, arterial blood gases is subject to errors in measurement and, consequently, to an incorrect interpretation of blood gas values, thus wonders why the non-validation.¹⁷

It is further considered that haemogasometers in hospital units MSM and HGPV (Cobas b 121 <BGE> system from Roche Diagnostics) perform validations of blood gases, however, but still it is recommended to professionals carrying out the validation by the individual application of the formulas specific.^{3,7,18}

The equation of Henderson-Hasselbalch (HH) is one of the validation methods used in blood gas more specific literature in Intensive despite being widely discussed and compared with the method of Stewart.^{3-6,14,19-23}

The use of both methods was assessed in interviews with intensivists, but prioritized the Henderson-Hasselbalch equation in the presentation of the results for practical reasons, ie, those who validated the arterial blood gases used only HH.

Figure 1 showed that there was a statistically significant association between the variables knowledge and professional use of diagnostic methods with professional features ($p=0,009$).

One author was one of the pioneers sistematizar⁴ in level of national literature on the methods used for the diagnosis of disorders of acid-base balance: Standard Astrup and Base Excess (SBE). Concluded in his work that the time to make a diagnosis based only acid-analyzing blood gases remained behind, and it is crucial to analyze these data together with the electrolyte in the light of the patient's condition. There is no disagreement about the need to use methods to understand the nature of these disorders and hence identify attitudes that can avoid them and/or fix them.²⁴

It was presented in 1960⁵, an estimation method of PCO_2 and HCO_3 also defining the "standard bicarbonate" and "base excess". This method has been widely used for diagnostic and therapeutic management of patients with acid-base, despite criticism to the contrary. Proponents of the method are both Astrup, as the method of analysis of SBE; however, these particularities of one another are unnecessary for this search method, since beyond the scope proposed.

It was found that 100% of the professionals that used diagnostic methods SBE and/or Astrup (physiotherapists and doctors) manually calculate formulas provided. However, international studies recognized recommend the use of diagrams in order to streamline the diagnosis of disorders of acid-base balance.²⁵⁻⁶

In a paper published in Brasil²⁷ aiming to analyze the knowledge of nurses on arterial blood gases in a public hospital Fortaleza-CE/Brazil, noted that more than half (53,3%) of this professional class interprets the exam, however, few nurses working in clinical discussions on acid-base disturbances.

Limitations of this study are related to the fact not collect data on providers' specialties,

and relate them to the level of knowledge of these individuals

For future work it is recommended:

- Creation and validation of the survey instrument in order to standardize the assessment of the level of knowledge about haemogasometric diagnostics in Intensive Care.

- Realization of regional studies, also including large urban centers.

CONCLUSION

The diagnoses Haemogasometric issued the ICU's (HGPV and MSM) are not uniform, given that functional classes studied, within the same ICU, use of reference values (pH , bicarbonate and PCO_2) and Validation Methods differentiated. Furthermore, it was an obvious lack of knowledge about methods SBE and Astrup, with the largest representation of nursing professionals. However, the low use of specific diagnostic methods was deficient in all three classes of professionals.

It becomes crucial in establishing routines and protocols in these units in addition to the three training classes targeted at professional diagnostics acid-base imbalance, whereas they are essential for quality care in pursuit of professional excellence. It is also essential to spread specific national consensus in the literature about the acid-base disturbances, so that new methods of diagnosis and recommendations reach the international world of Professional Intensive interiors urban Brazilians.

REFERENCES

1. De Moraes HA, Bach JF, DiBartola SP. Metabolic acid-base disorders in the critical care unit. Vet Clin North Am Exot Anim Pract [Internet]. 2008 [cited 2010 Apr 15];38(3): 559-74. Available from: <http://www.sciencedirect.com/science/article/pii/S019556160800065X>
2. Kellum JA, Gunnerson KJ, Srisawat N. Is there a difference between strong ion gap in healthy volunteers and intensive care unit patients? J Crit Care [Internet]. 2010 [cited 2010 Apr 15];25(3):520-4. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/19942401>
3. Corey HE. Bench-to-bedside review: Fundamental principles of acid-base physiology. Crit Care [Internet]. 2005 [cited 2010 Apr 15]; 9:184-192. Available from: <http://europepmc.org/abstract/PMC/PMC1175910/reload=0;jsessionid=EBjwgaVwg1YBOTG0s3BA.36>

4. Rocco JR. Diagnóstico dos Distúrbios do Metabolismo Ácido-base. Rev Bras Ter Intensiva [Internet]. 2003 [cited 2010 Apr 15];15(4):184-192. Available from: http://www.rbti.org.br/rbti/download/artigo_2010623145045.pdf.
5. Astrup P, Jorgensen K, Siggaard Andersen O, Engel K. The acid-base metabolism: A new approach. Lancet. 1960; 1(7133):1035.
6. Park M, Noritomi DT, Toledo-Maciel A, De Azevedo LCP, Pizzo VR, Da Cruz-Neto LM. Partitioning evolutive standard base excess determinants in septic shock patients [Internet]. Rev Bras Ter Intensiva. 2007 [cited 2011 Mar 15];19(4):437-443. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103507X2007000400006&lng=pt&nrm=iso&tlng=en
7. Rowe KJ, Arrowsmith JE. Interpretation of measurements of arterial blood gases. Surgery [Internet]. 2007 [cited 2011 Mar 15];2007;25(9):[about 5 p]. Available from: <http://www.surgeryjournal.co.uk/article/S0263-9319%2807%2900156-1/abstract>
8. Otani N, Ohde S, Mochizuki T, Ishimatsu S. Reliability of anion gap calculated from data obtained using a blood gas analyzer: is the probability of error predictable? Am J Emerg Med [Internet]. 2010 [cited 2011 Mar 15];28(5):577-81:[about 5 p]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/20579552>
9. D'Incao RB, De Azevedo VC, Kalil M. Distúrbios do equilíbrio ácido-básico na prática clínica. Acta médica (Porto Alegre) [Internet]. 2008 [cited 2011 Mar 15];29:360-9. Available from: <http://bases.bireme.br/cgi-bin/wxislind.exe/iah/online/?IsisScript=iah/iah.xis&src=google&base=LILACS&lang=p&nextAction=lnk&exprSearch=510215&indexSearch=ID>
10. Schaeffner ES, Windisch W, Freidel K, Breitenfeldt K, Winkelmayr WC. Knowledge and attitude regarding organ donation among medical students and physicians. Transplantation [Internet]. 2004 [cited 2011 Mar 15];77:1714-18. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/15201671>
11. Kim JR, Fisher M, Elliott D. Knowledge levels of Korean intensive care nurses towards brain death and organ transplantation. J Clin Nurs [Internet]. 2006 [cited 2011 Mar 15];15:574-80. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/16629966>
12. Schein AE, Carvalho PRA, Da Rocha TS, Guedes RR, Moschetti L, La Salvia JC et al. Avaliação do conhecimento de intensivistas sobre morte encefálica. Rev Bras Ter Intensiva [Internet]. 2008 [cited 2011 Mar 15];20(2):144-8. Available from: www.scielo.br/scielo.php?script=sci_arttext&pid=S0103507X2008000200005&lng=pt&nrm=iso&tlng=pt
13. Évora PRB, Garcia LV. Equilíbrio ácido-base. Medicina (Ribeirão Preto) [Internet]. 2008 [cited 2011 May 21]; 41(3):301-11. Available from: http://www.fmrp.usp.br/revista/2008/VOL41N3/SIMP_6Equilibrio_acido_base.pdf
14. Sirker AA, Rhodes A, Grounds RM, Bennett ED. Acid-base physiology: the “traditional” and the “modern” approaches. Anaesthesia [Internet]. 2002 [cited 2011 Mar 15];57:348-56. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/16629966>
15. Truppel TC, Meier MJ, Calixto RC, Peruzzo SA, Crozeta K. Sistematização da Assistência de Enfermagem em Unidade de Terapia Intensiva [Internet]. Rev Bras Enferm. 2009 [cited 2012 Jan 15]; 62(2):221-7. Available from: <http://www.scielo.br/pdf/reben/v62n2/a08v62n2.pdf>.
16. Severinghaus JW, Astrup P, Murray JF. Blood Gas Analysis and Critical Care Medicine. Am J Respir Crit Care Med [Internet]. 1998 [cited 2012 Jan 15];157(4):S114-22. Available from: <http://www.atsjournals.org/doi/full/10.1164/ajrccm.157.4.nhlb1-9#.Uj64ZRChdKA>
17. Viegas CAA. Gasometria arterial. J Bras Pneumol [Internet]. 2002 [cited 2012 Jan 15]; 28:(Supl 3):[about 5 p.]. Available from: http://www.jornaldepneumologia.com.br/detalhe_artigo.asp?id=25
18. Dubin A, Menises MM, Masevicius FD, Moseinco MC, Kutscherauer DO, Ventrice E et al. Comparison of three different methods of evaluation of metabolic acid-base disorders. Crit Care Med [Internet]. 2007 [cited 2012 Jan 15];35(5):1264-7028. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/17334252>
19. Henderson LJ. The theory of neutrality regulation in the animal organism. Am J Physiol [Internet]. 1908 [cited 2012 Jan 15]; 21:427-8. Available from: <http://ajplegacy.physiology.org/content/21/4.toc>
20. Hasselbalch KA. Die Berechnung der Wasserstoffzahl des blutes auf der freien und gebundenen Kohlensäure desselben, und die Sauerstoffbindung des Blutes als Funktion der Wasserstoffzahl. Biochem Z [Internet]. 1916 [cited 2012 Jan 15];78:112-44. Available from: <http://www.worldcat.org/title/berechnung->

[der-wasserstoffzahl-des-blutes-aus-der-freien-und-gebundenen-kohlensaure-desselben-und-die-sauerstoffbindung-des-blutes-als-funktion-der-wasserstoffzahl/oclc/650953332](#)

21. Dietz JR. Using Willie's acid-base box for blood gas analysis. Adv Physiol Educ [Internet]. 2011 [cited 2012 Jan 15];35(4):454-5. Available from: http://www.unboundmedicine.com/washingtonmanual/ub/citation/22139785/Using_Willie%27s_acid_base_box_for_blood_gas_analysis

22. Stewart PA. How to understand acid base balance. In: A Quantitative Acid-Base Primer for Biology and Medicine. New York: Elsevier; 1981.

23. Stewart PA. Modern quantitative acid-base chemistry. Can J Physiol Pharmacol [Internet]. 1983 [cited 2011 Mar 15]; 61:1444-61. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/6423247>

24. Boniatti MM, Cardoso PRC, Moraes RB. Distúrbios ácido-básicos em pacientes críticos: método de Stewart; Sci Med (Porto Alegre) [Internet]. 2006 [cited 2012 Jun 18];16(2):68-72. Available from: <http://revistaseletronicas.pucrs.br/ojs/index.php/scientiamedica/article/viewDownloadInterstitial/1623/7914>

25. Schlichtig R, Grogono AW, Severinghaus JW. Human PaCO₂ and standard base excess compensation for acid-base imbalance. Crit Care Med [Internet]. 1998 [cited 2012 June 18];26:1173-1179. Available from: <http://revistaseletronicas.pucrs.br/ojs/index.php/scientiamedica/article/viewDownloadInterstitial/1623/7914>

26. Schlichtig R, Grogono AW, Severinghaus JW. Current status of acid-base quantitation in Physiology and Medicine. Anesthesiol Clin North America [Internet]. 1998 [cited 2012 June 18]; 16:211-33. Available from: <http://www.sciencedirect.com/science/article/pii/S0889853705700158>

27. Rolim LR, Melo EM, Frota NM, De Almeida NG, Barbosa IV, Caetano JÁ. Knowledge of The Intensive Care Unit Nursing Professional About Arterial Gasometry. J Nurs UFPE on line [Internet]. 2013 Mar [cited 2013 Feb 20];7(1):713-21. Available from: http://www.revista.ufpe.br/revistaenfermagem/index.php/revista/article/view/3736/pdf_2156.

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