Les effets sur les gaz du sang pendant une hypothermie prolongée.

Pietro Camozzi

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Modifications des échantillons de sang in-vitro

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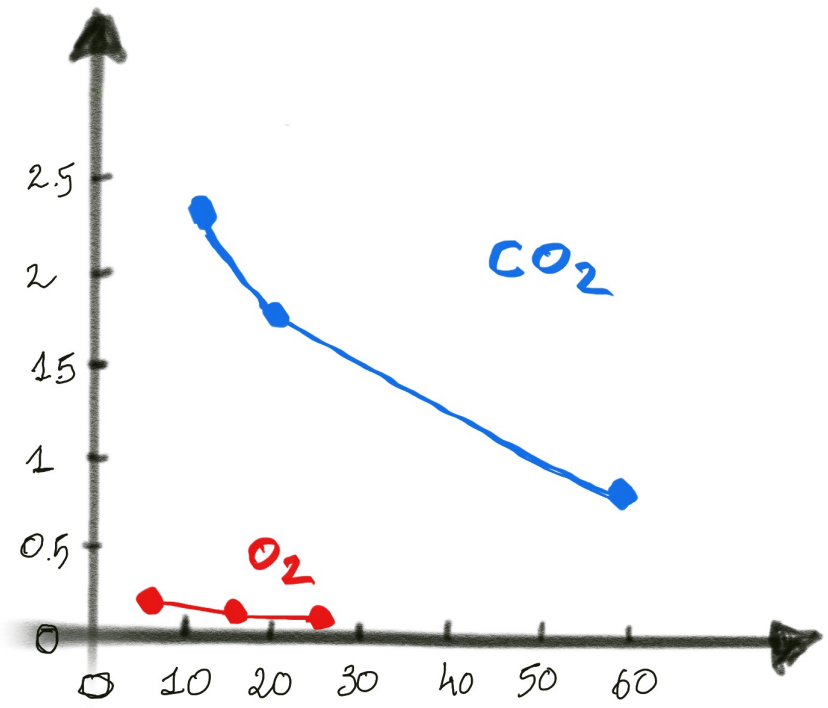
37°C | **Refroidissement simple**

- **pH 7.4**
- **pCO2 40 mmHg**
- **pO2 90 mmHg**

récipient hermétique →

- **augmente**
- **diminue**
- **diminue légèrement**

Loi de Henry sur la solubilité des gaz



Sol = kH x pG

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CLIN. CHEM. 29/11, 1877–1885 (1983)

review

Temperature Correction of Blood-Gas and pH Measurements

Edward R. Ashwood, Gerald Kost, and Margaret Kenny

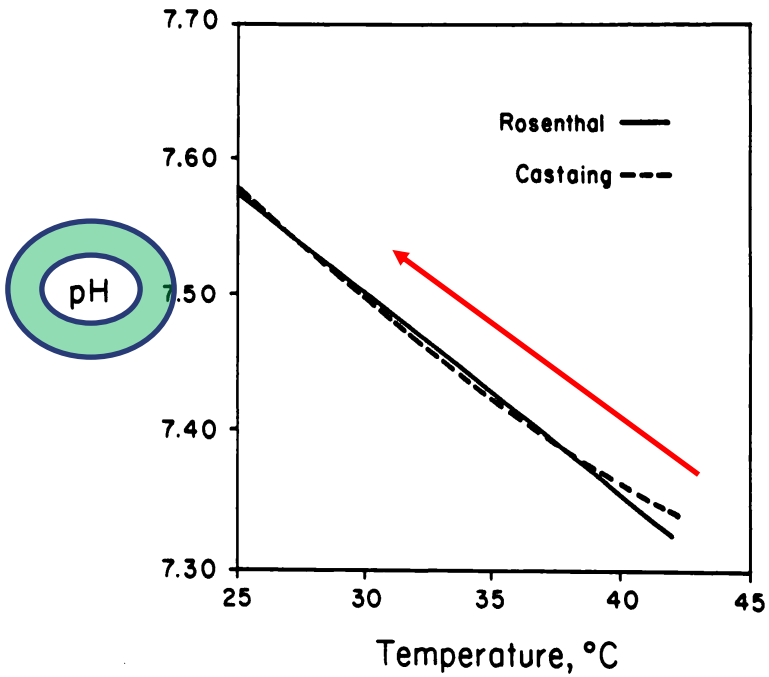

Fig. 1. Temperature corrections for in vitro closed-system pH

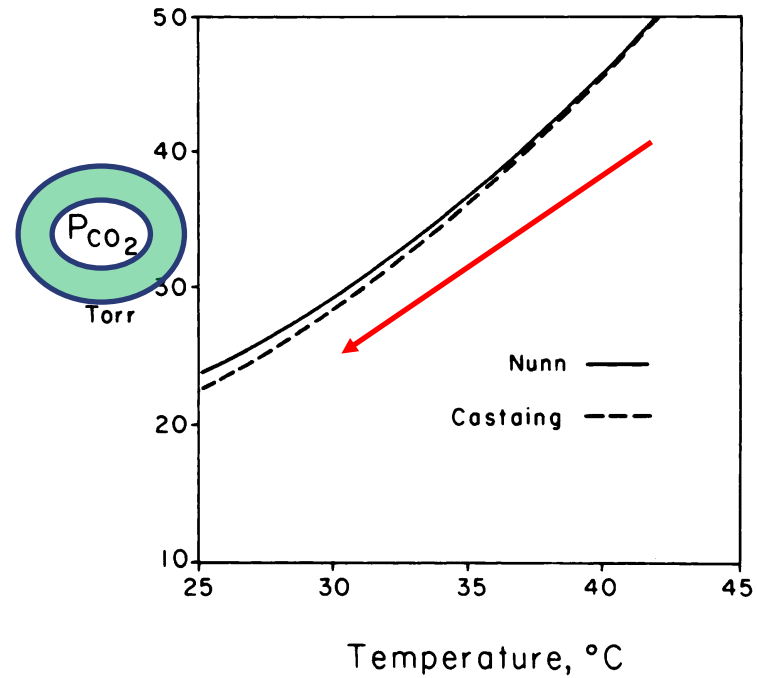

Fig. 2. Temperature corrections for in vitro closed-system p_{CO_2}

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

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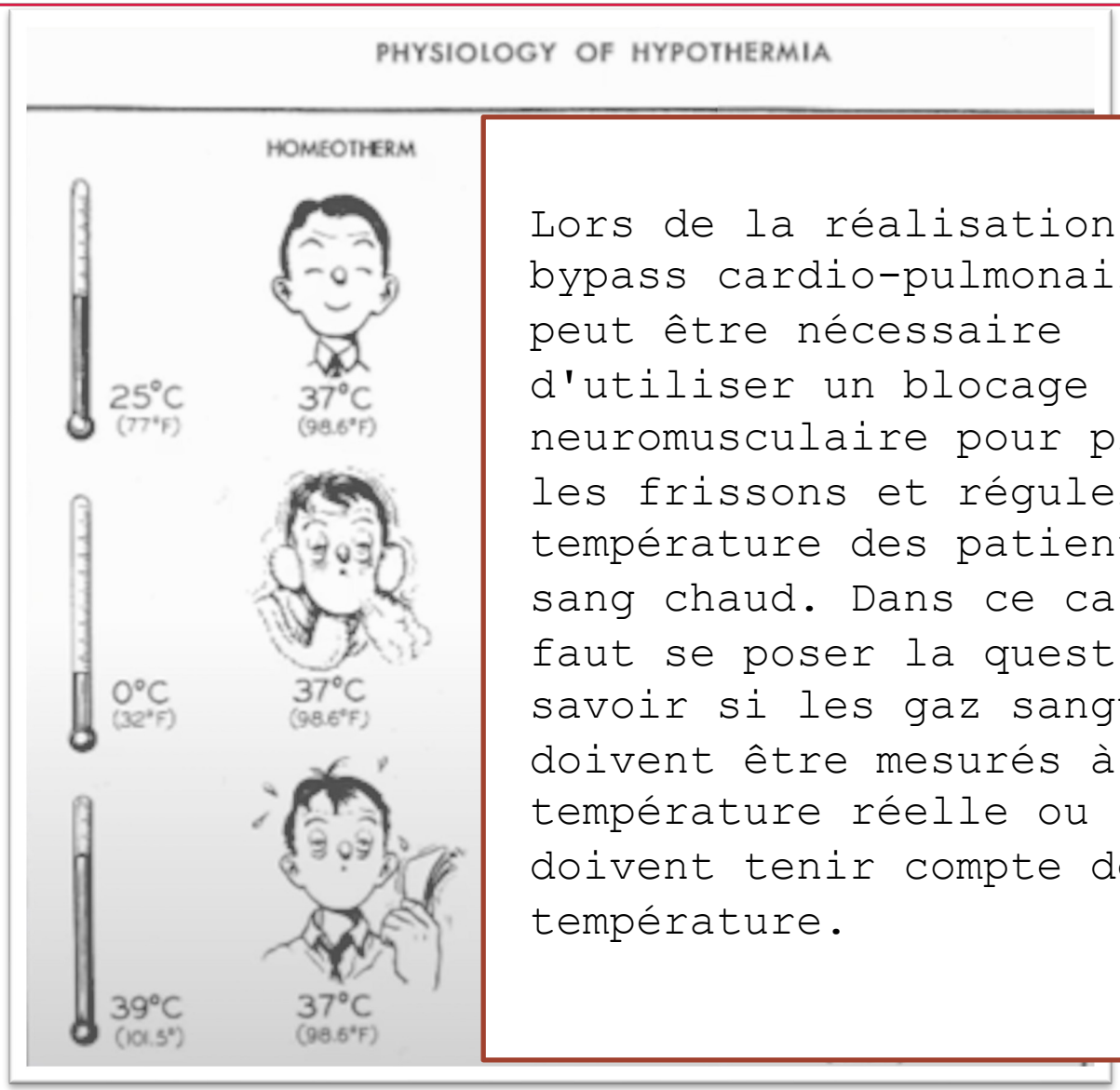
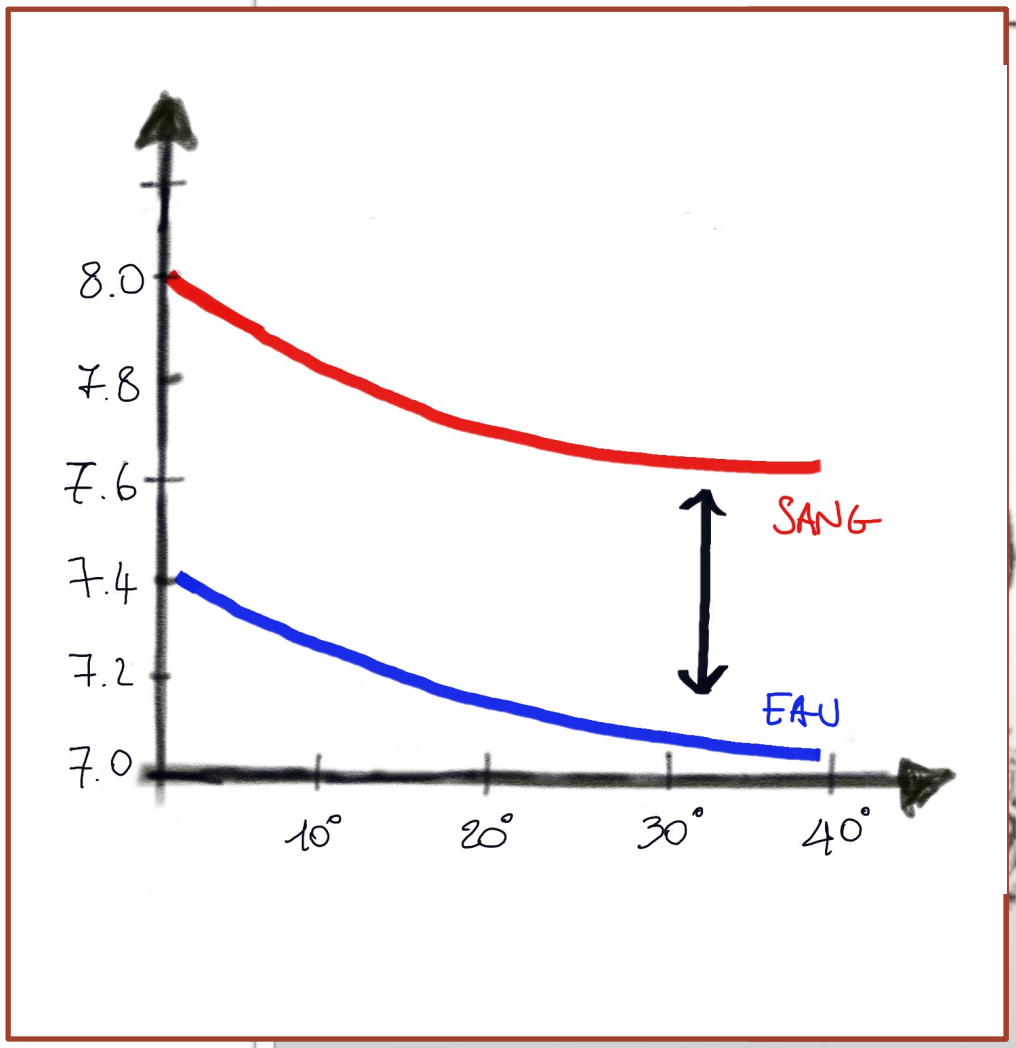
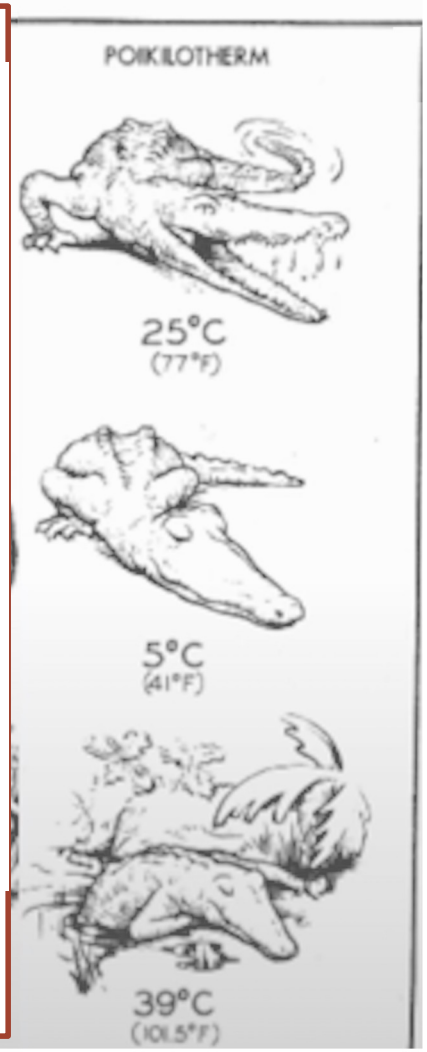
Et donc cela soulève la question: est-ce que c'est bien? Voulons-nous que la CO2 chute naturellement avec la température ou voulons-nous maintenir une quote normale de CO2 à travers cette range de températures? Et voilà le véritable enjeu de la question que nous allons aborder aujourd'hui.



Lors de la réalisation d'un bypass cardio-pulmonaire, il peut être nécessaire d'utiliser un blocage neuromusculaire pour prévenir les frissons et réguler la température des patients à sang chaud. Dans ce cas, il faut se poser la question de savoir si les gaz sanguins doivent être mesurés à la température réelle ou s'ils doivent tenir compte de la température.

PHYSIOLOGY OF HYPOTHERMIA





Alpha STAT Rationale

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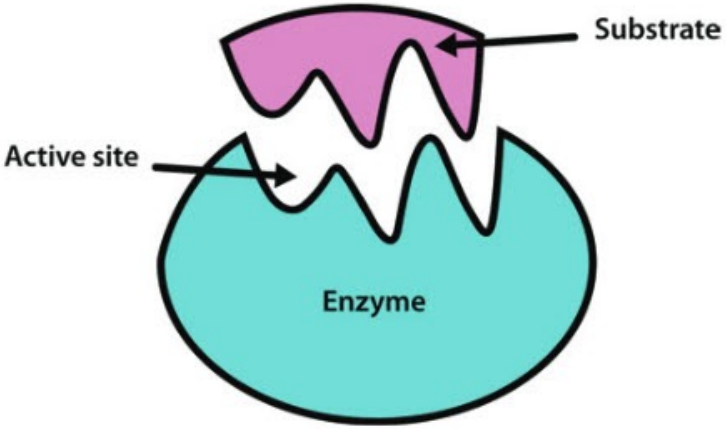
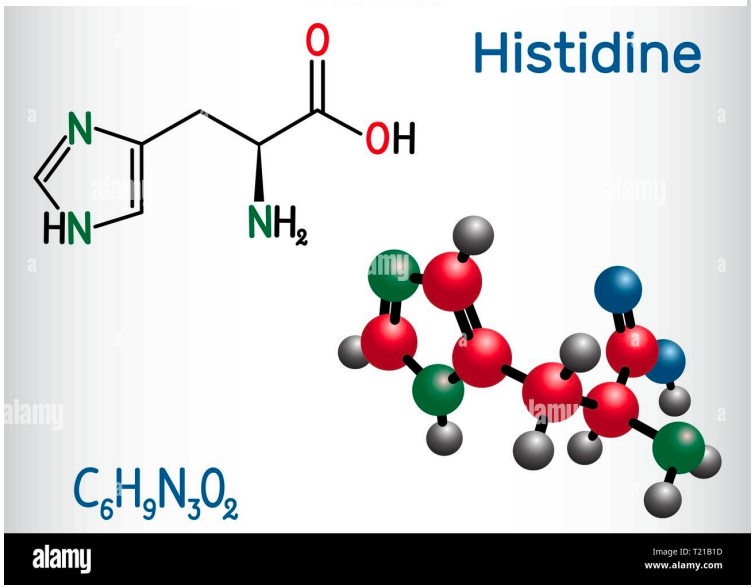
H+/OH- neutralitè

L'imidazole a un degré de dissociation (appelé alpha) de 0,55 dans le compartiment intracellulaire et cela reste constant malgré les variations de température (c'est-à-dire que le pK change pas avec le changement de température).





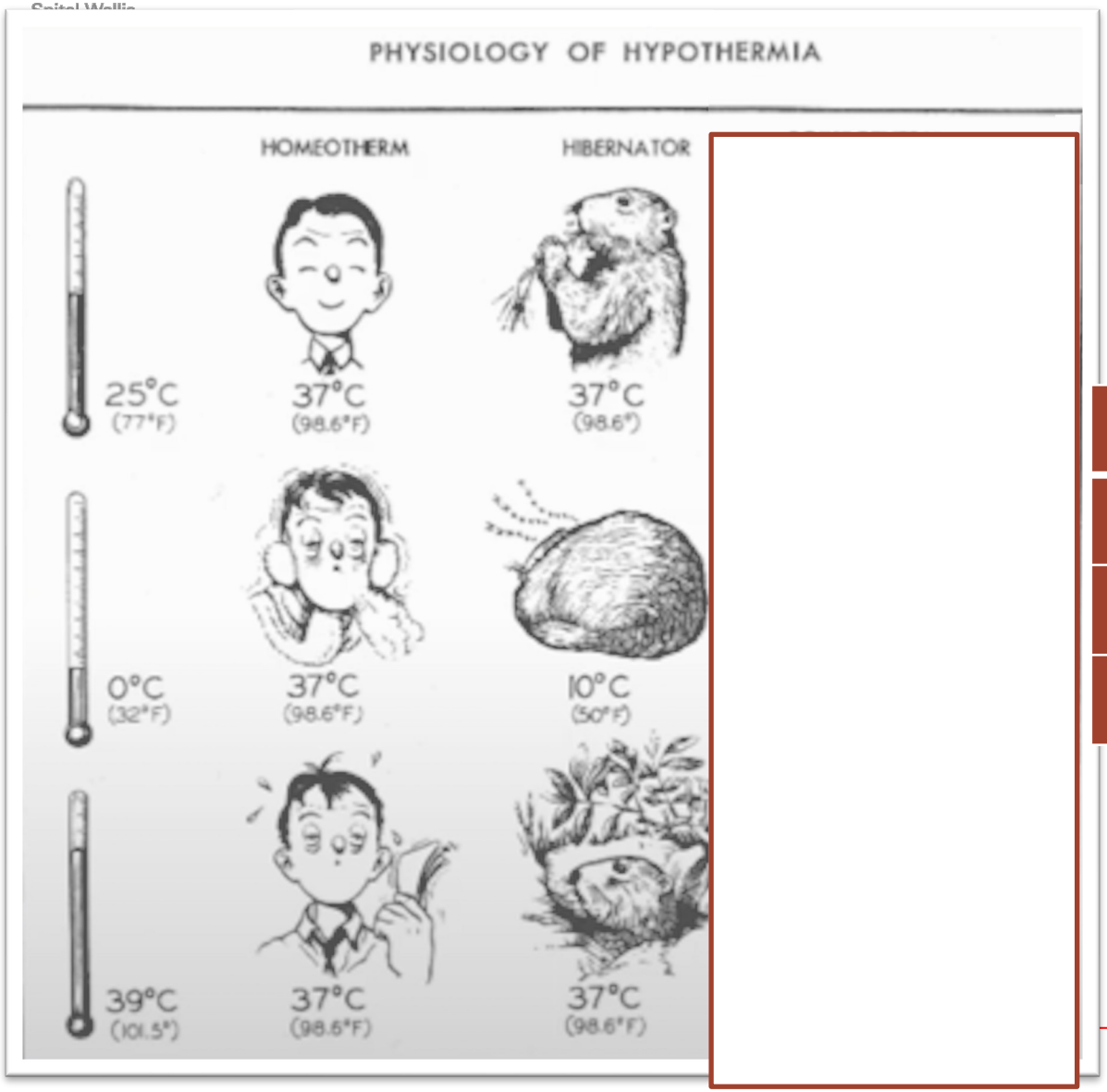
Alpha Stat pro

- Le rapport constant de H+/OH- est l'élément important à maintenir pour conserver la neutralité [H+] = [OH-]

- Les structures protéiques normales et leur fonction, en particulier la fonction des enzymes, dépendent d'un environnement électrochimique constant et neutre car les états de charge électrochimiques et les liaisons sont en grande partie responsables du maintien de la configuration protéique normale.

- Maintenir l'autorégulation cérébrale.

pH Stat: pH stable corrigé en fonction de la température



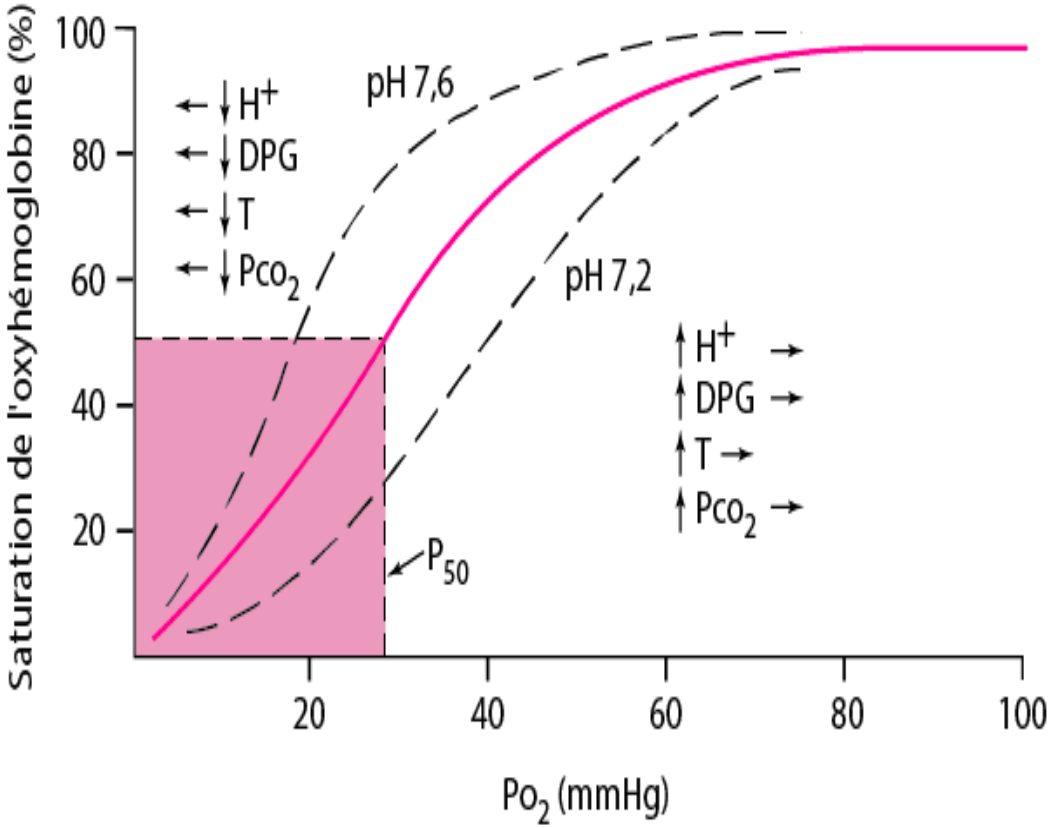
	37°C	Hypothermie
pH	7.40	7.40
P_aCO_2	40 mmHg	↑ Teneur Totale
P_aO_2	90 mmHg	Légère diminution

pH Stat Rationale

- **Ajout de CO2 au circuit maintient le pH = 7.40**

- Peut être bénéfique car:

- Le CO2 peut contrecarrer la courbe de dissociation
- Le CO2 est un puissant vasodilatateur cérébral et favorise un débit sanguin cérébral élevé.
- Refroidissement plus complet et homogène.
- Prévient le vol cérébral dû aux collatéraux aorto-pulmonaires.



Résumé rapide: méthode pH-stat et Alpha-stat

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pH-stat

- Objectif: Maintenir le pH artériel = 7,40 à chaque variation de température.

ÉCHANTILLON à la température réelle du patient.

- Pour y parvenir, il faut permettre à la CO_2 de s'accumuler

Alpha-stat

- Objectif: Maintenir le pH = 7,40

dans un ÉCHANTILLON NON CORRIGÉ par température, par exemple 37°C

- Techniquement facile. Effectuer des analyses de sang ordinaires en fonction des résultats de l'échantillon.

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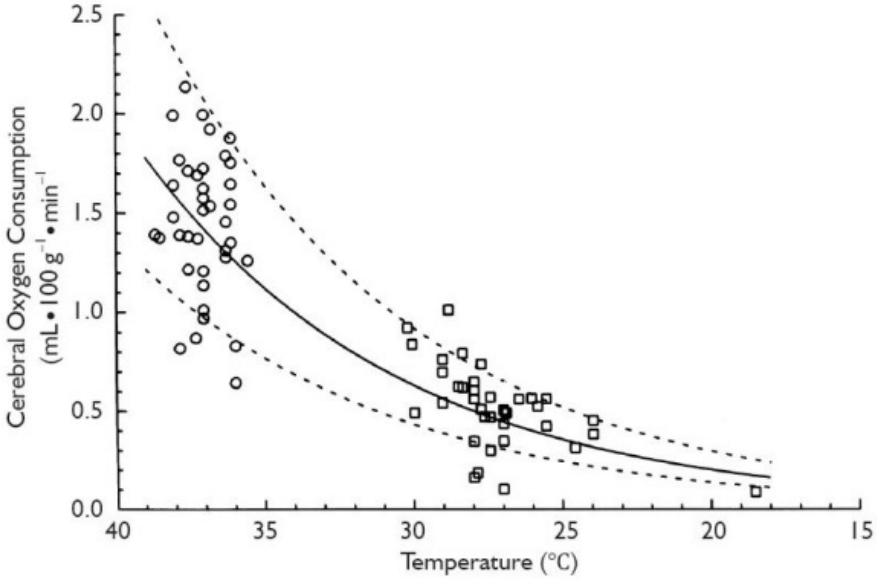
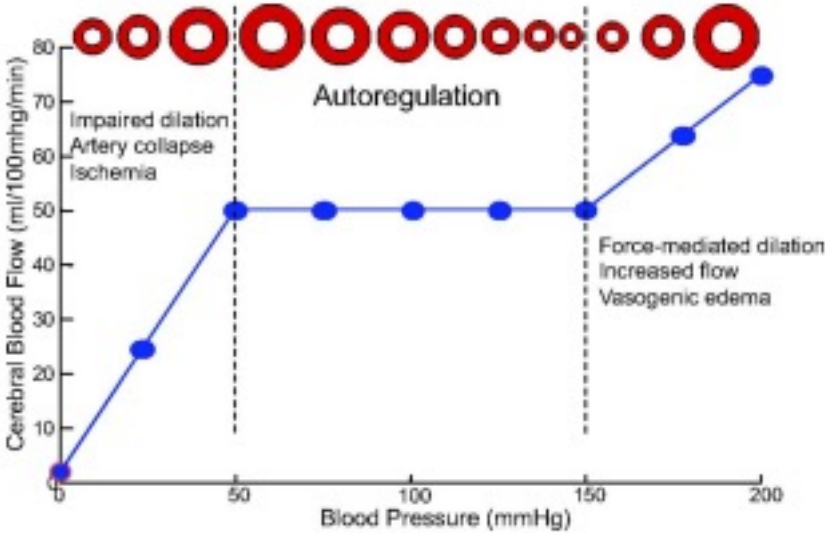
- La circulation sanguine cérébrale est étroitement liée aux exigences métaboliques cérébrales
- Est constante dans une large gamme de pressions de perfusion
- La régulation autonome cérébrale est maintenue en hypothermie modérée
- La régulation autonome cérébrale est compromise lors de l'hypothermie profonde (<22°C)

- Chute du taux métabolique cérébral avec l'hypothermie





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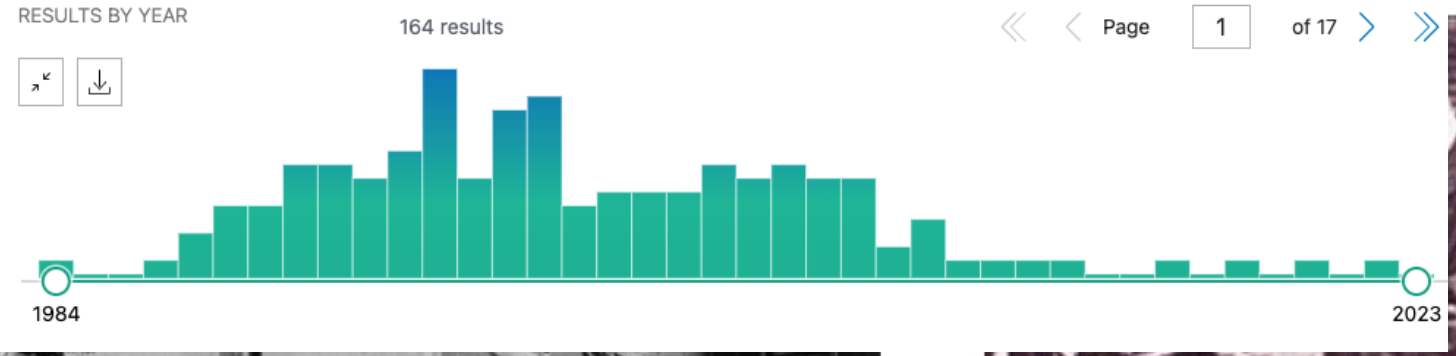

Cardiopulmonary Support and Physiology

An evidence-based review of the practice of cardiopulmonary bypass in adults: A focus on neurologic injury, glycemic control, hemodilution, and the inflammatory response

Kenneth G. Shann, CCP,[a] Donald S. Likosky, PhD,[b] John M. Murkin, MD,[c] Robert A. Baker, PhD CCP(Aust),[d] Yvon R. Baribeau, MD,[e] Gordon R. DeFoe, CCP,[b] Timothy A. Dickinson, MS,[f] Timothy J. Gardner, MD,[g] Hilary P. Grocott, MD,[h] Gerald T. O'Connor, PhD, DSc,[b] David J. Rosinski, CCP,[i] Frank W. Sellke, MD,[j] and Timothy W. Willcox, CCP(Aust)[k]

pH Management

The clinical team should manage adult patients undergoing moderate hypothermic CPB with alpha-stat pH management. (Class I, Level A)

Table 1. Methodologies and policies from the American College of Cardiology/American Heart Association Task Force on Practice Guidelines

Classification of recommendations	Level of evidence
Class I: Conditions for which there is evidence, general agreement, or both that a given procedure or treatment is useful and effective	Level A: Data derived from multiple randomized clinical trials
Class II: Procedure-treatment should be performed-administered	Level B: Data derived from a single randomized trial or nonrandomized studies
Class IIA: Additional studies with focused objectives needed	Level C: Consensus opinion of experts
Class IIB: Additional studies with broad objectives needed; additional registry data would be helpful	
Class III: Procedure-treatment should not be performed-administered because it is not helpful and might be harmful	

Adapted from Eagle KA, Guyton RA, Davidoff R, et al, ACC/AHA 2004 Guideline Update for Coronary Artery Bypass Graft Surgery: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1999 Guidelines for Coronary Artery Bypass Graft Surgery): 2004.

Fig 5. The patient is currently submerged in an ice bath. Courtesy of the US National Library of Medicine.

John Gibbon and his wife Mary Hopkinson developing the first heart-lung machine.

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CARDIOTHORACIC ANESTHESIOLOGY:
The Annals of Thoracic Surgery CME Program is located online at http://www.annalsthoracicsurgery.org/cme/home. To take the CME activity related to this article, you must have either an STS member or an individual non-member subscription to the journal.

Deep Hypothermic Circulatory Arrest Effectively Preserves Neurocognitive Function

Katherine H. Chau, AB, Tamir Friedman, MD, Maryann Tranquilli, RN, and John A. Elefteriades, MD

Section of Cardiothoracic Surgery and Department of Diagnostic Imaging, Yale University School of Medicine, New Haven, Connecticut

DEVELOPMENTAL AND NEUROLOGIC EFFECTS OF ALPHA-STAT VERSUS PH-STAT STRATEGIES FOR DEEP HYPOTHERMIC CARDIOPULMONARY BYPASS IN INFANTS

The Journal of Thoracic and Cardiovascular Surgery

David C. Bellinger, PhD, MSc[a]
David Wypij, PhD[e]
Adre J. du Plessis, MBChB, MPH[a]
Leonard A. Rappaport, MD[b]
James Riviello, MD[a]
Richard A. Jonas, MD[c]
Jane W. Newburger, MD, MPH[d]

CPB was associated with a trend toward lower postoperative morbidity and with a significantly shorter recovery time to first EEG activity.[6] The current study explored the effect of pH management strategy on longer term developmental outcome in the same study cohort. We found that infants randomized to the pH-stat and alpha-stat methods of pH management did not differ significantly at 1 year of age in their scores on the Bayley Scales of Infant Development or in their neurologic examination. Similarly, at 2 to 4 years of age, the treatment groups had similar development, as assessed by parental responses to mailed questionnaires, including the Child Development Inventory and the Child Behavior Checklist.

Is α-Stat or pH-Stat the Best Strategy During Hypothermia After Cardiac Arrest?*

Cornelia Hoedemaekers, MD, PhD
Johannes G. van der Hoeven, MD, PhD
Department of Intensive Care
Radboud University Nijmegen Medical Centre
Nijmegen, The Netherlands

The post–cardiac arrest syndrome includes post–cardiac arrest brain injury, post–cardiac arrest myocardial dysfunction, the systemic ischemia/reperfusion response, and the persistent precipitating disease. Changes in macro- and microcirculatory flow, combined with activation of the innate and adaptive immune system, are the major pathophysiological features of this syndrome. Changes in Pa_{CO_2} may interact with this complex interplay of events at several levels. Profound dyscarbia should be avoided. It remains difficult and perhaps impossible to establish at the bedside how smaller changes in pH and Pa_{CO_2} induced by a pH-stat or α-stat strategy at different moments in time will affect the risk of secondary brain damage and prognosis in patients after cardiac arrest.

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INTERACTIVE
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Interactive CardioVascular and Thoracic Surgery 10 (2010) 271-282

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Best evidence topic - Cardiopulmonary bypass

Is pH-stat or alpha-stat the best technique to follow in patients undergoing deep hypothermic circulatory arrest?

Khairul Anuar Abdul Aziz*, Ayo Meduoye

Department of Cardiothoracic Surgery, Glenfield Hospital, Leicester, LE3 9PQ, UK

In conclusion, there is evidence to suggest that the best technique to follow in the management of acid-base in patients undergoing deep hypothermic circulatory arrest during cardiac surgery is dependent upon the age of the patient with better results using pH-stat in the paediatric patient and alpha-stat in the adult patient.

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Hyperoxia for Management of Acid-Base Status During Deep Hypothermia With Circulatory Arrest

Jeffrey M. Pearl, MD, Donald W. Thomas, CCP, Gary Grist, CCP, Jodie Y. Duffy, PhD, and Peter B. Manning, MD

Children's Hospital Medical Center, Cincinnati, Ohio, and Children's Mercy Hospital, Kansas City, Missouri

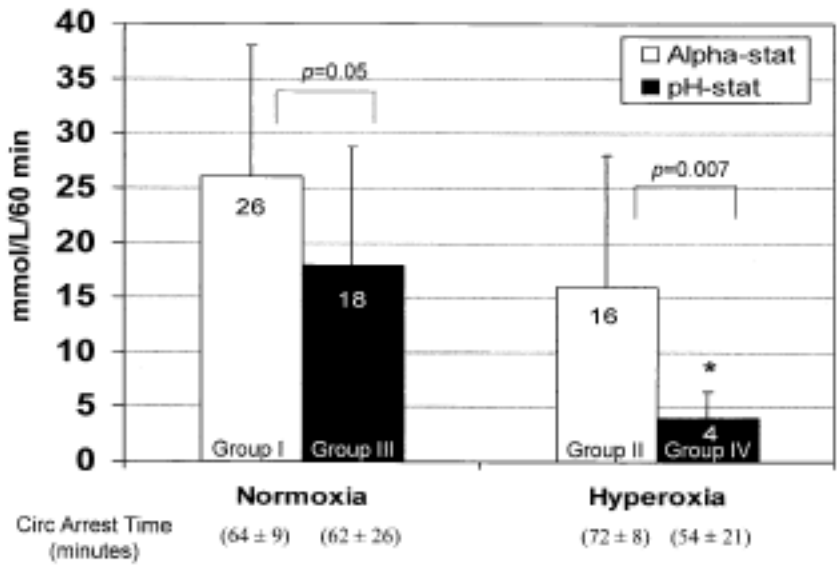

*Fig 3. Acid production corrected for the time of circulatory arrest in normoxic and hyperoxic patients. Patients treated with hyperoxia before deep hypothermic circulatory arrest had less acid generation during deep hypothermic circulatory arrest than their respective normoxic cohorts. Patients in group IV (pH-stat and hyperoxia) had only 25% as much acid generation during 60 minutes of bypass than the next closest group. (*p < 0.05 compared with groups I through III.)*

Results. **Both hyperoxia groups had less acidosis after deep hypothermic circulatory arrest than normoxia groups. Group IV had less acid generation during circulatory arrest and less base excess after arrest than groups I, II, or III ($p < 0.05$). Group IV produced only 25% as much acid during deep hypothermic circulatory arrest as the next closest group (group II).**

Conclusions. **Hyperoxia before deep hypothermic circulatory arrest with α-stat or pH-stat strategy demonstrated advantages over normoxia. Furthermore, pH-stat strategy using hyperoxia provided superior venous blood gas values over any of the other groups after circulatory arrest.**