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ENG BEE ONG
GERTRUDE E. PERLMANN
The Rockefeller University,
New York.

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Relation between Thrombosis on Metal Electrodes and the Position of Metal in the Electromotive Series

INTEREST in the electrochemical nature of thrombosis[1,2] has prompted us to study thrombus deposition on metal electrodes inserted through side branches into the carotid and femoral arteries of mongrel dogs. Magnesium, aluminium, cadmium, nickel, copper, gold and platinum, which cover a wide range in the electromotive series, were chosen for the present investigation.

The electrodes were carefully cleaned to ensure the absence of any oxides or other impurities on their surfaces, and their spontaneous potentials were measured in normal (0·9 per cent) saline solution. In the first series of experiments four electrodes of the same metal were inserted through side branches into the carotid and both the femoral arteries in healthy anaesthetized (1/2 ml./kg of 'Diabutal' intramuscular injection) mongrel dogs; care was taken to prevent injury to the intimal surface. The spontaneous potential set up by each of these electrodes, after their insertion, was measured with respect to a standard calomel electrode (contained in a beaker with saturated potassium chloride solution). An electrolyte bridge was made between the experimental animal and the beaker containing the calomel electrode by inserting a fine polyethylene tubing into a second branch of one of the femoral arteries. The back flow of blood into this tubing was allowed to clot. The electrodes were kept in position within the lumen of the arteries for a period of 30–40 min.

The dog was killed and the four vessels containing the electrodes were gently clamped both proximally and distally, so as to include the electrode, but without disturbing the position. Formalin was then slowly injected into the portions of the blood vessels between clamps so as to fix any deposits of thrombi on the electrodes. Finally, the vessels were gently slit open and the electrodes within these were examined for any thrombus deposition.

The results were striking. Electrodes of metals establishing a negative interfacial potential (NHE), magnesium, aluminium and cadmium, showed no thrombus deposition (on their electrodes), whereas metals with a positively charged surface—copper, nickel, gold and platinum—showed a measurable deposition of thrombus along the length of the electrode. The interfacial potentials set up by metals in contact with blood *in vivo*, their corresponding standard electrode potentials and the occurrence or otherwise of thrombus deposition on their surfaces, are summarized in Table 1. As expected, there is a direct correlation between the spontaneous potentials set up by these metals in blood *in vivo* and their respective standard electrode potentials.

Table 1. DEPENDENCE OF THROMBUS DEPOSITION AT METAL ELECTRODES ON POSITION OF METAL IN ELECTROMOTIVE SERIES

Metal	M/M^{n+} standard electrode potential (V, NHE)	Resting potential at metal–blood interface (V, NHE)	Occurrence (✓) or non-occurrence (×) of thrombus deposition
Mg	−2·375	−1·360	×
Al	−1·670	−0·750	×
Cd	−0·402	−0·050	×
Cu	+0·346	+0·025	✓
Ni	−0·230	+0·029	✓
Au	+1·420	+0·120	✓
Pt	+1·200	+0·125	✓

In an attempt to confirm these results further, experiments were carried out using electrodes of two different types of metals, one on the electropositive, and the other on the electronegative side. These were inserted into ipsilateral, carotid and femoral arteries in the same animal in the conditions of the previous experiments. The results confirmed the earlier set.

The present series of experiments conclusively proves that thrombus deposition on metals *in vivo* depends, at least partly, on the interfacial potential. The more positively charged interfaces are thrombogenic; those negatively charged are non-thrombogenic. These findings are of considerable fundamental importance in the search for suitable non-thrombogenic surfaces for incorporation into various artificial internal organs.

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P. S. CHOPRA
S. SRINIVASAN
T. LUCAS
P. N. SAWYER
Electrochemical and Biophysical Laboratories
of the Vascular Surgical Services,
Department of Surgery and Surgical Research,
State University of New York,
Downstate Medical Center, Brooklyn.

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Psychotropic Phenylisopropylamines derived from Apiole and Dillapiole

IT is an interesting fact that most of the known psychotropic phenylisopropylamines (amphetamines) possess ring-substitution patterns identical to those of natural essential oils. (The single exception is the active 2-methoxy - 4,5 - methylenedioxyamphetamine (MMDA-2, II*d*[1]); neither the allyl nor the propenyl counterpart has been observed in plant extracts.) Thus 3,4-methylenedioxyamphetamine (MDA, II*a*) is related to safrole (I*a*)[2] (Table 1), 3,4,5-trimethoxyamphetamine (TMA) to elemicin[3], 3 - methoxy - 4,5 - methylenedioxyamphetamine (MMDA, II*c*) to myristicin (I*c*)[4] (Table 1), 2,4,5-trimethoxyamphetamine to asarone, and 2-methoxy-3,4-methylenedioxyamphetamine (MMDA-3a, II*b*) to croweacin (I*b*) (Table 1). C. F. Barfknecht, of Idaho University, tells us that there is preliminary evidence that these olefines may be aminated in the living organism, and this reaction can be readily performed *in vitro*. There are two additional essential oils known that contain the methylenedioxy ring. These are apiole (I*e*) and dillapiole (I*f*) (Table 1).