Relationship between two different functions derived from diffusion-based decompression theory.

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Ashida H, Ikeda T, Tikuisis P, Nishi RY. Relationship between two different functions derived from diffusion-based decompression theory. Undersea Hyperb Med 2005; 32(6):429-435. Hempleman's diffusion-based decompression theory yields two different functions; one is expressed by a simple root function and the other by a complex series function. Although both functions predict the same rate of gas uptake for relatively short exposure times, no clear mathematical explanation has been published that describes the relationship between the two functions. We clarified that (1) the root function is the solution of the one-dimensional diffusion equation for a semi-infinite slab, (2) the series function is an applicable solution for a finite slab thickness, (3) the parameter values of the root function can be used to determine the parameter values of the series function, and (4) the predictions of gas kinetics from both functions agree until an adequate amount of diffusing inert gas reaches the boundary at the opposite end of the finite slab. The last point allows the use of the simpler root function for predicting short no-stop decompression limits. Experience dictates that the inert gas accumulation for a 22 min at 100 feet of seawater (fsw) dive is considered safe for no-stop decompression. Although the constraint, $\text{Depth}\sqrt{\text{Bottom Time}} = 100\sqrt{22}$, has been applied as an index to determine either the safe depth or bottom time (given the other) for no-stop decompression, it should not be applied more broadly to dives requiring decompression stops.

INTRODUCTION

Two solutions of the diffusion equation were proposed by Hempleman (1,2) for solving the decompression problem based on a simple single tissue approach. One solution of the gas kinetics is expressed by a relatively simple square root function and the other by a complex series function. These functions appear to yield different results, specifically, when the elapsed time, *t*, is infinite, the former becomes infinite while the latter converges to a finite value. Despite this basic difference, the results of both models coincide very well when *t* is relatively short. Thus, the root function solution appears to be adequate for diffusion-like processes occurring over short periods of time. For longer bottom times, the series function is a more accurate determination of gas uptake in finite tissue. Hempleman stated that the square root relationship was correct for exposures up to 100 min and due to its simple mathematical form, it was convenient to use for no-stop decompression.

More recently, the root function has been used as a pressure-duration exposure index for dives requiring substantial decompression (3) and used to some extent as an index for decompression since there appeared to be some correlation to decompression safety when applied to dive tables used in the North Sea. Since the root function does not include decompression information, applying it in this manner is contrary to its original intent. Indeed, for dives requiring decompression stops, Hempleman used the series function.

The agreement between the two functions when *t* is limited is occasionally said

