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A900
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Room Hall E2-Area G,

Modeling the Rate of Decrease in Brain Oxygen Saturation during DHCA with Cerebral Oximetry

Gregory W. Fischer, M.D., Konstandinos A. Plestis, M.D., Randall B. Griepp, M.D., David L. Reich, M.D.
Anesthesiology, Mount Sinai School of Medicine, New York, NY

Introduction: Cerebral Oximetry is a non-invasive optically based technology that measures cerebral tissue oxygen saturation (SctO2). The FORE-SIGHT® (CASMED, Branford CT USA) cerebral oximeter measures absolute SctO2 values without the need for a pre-induction baseline. We characterized the rate of SctO2 decrease during deep hypothermic circulatory arrest (DHCA) at 12-15ºC.

Methods: With IRB approval and informed consent, patients undergoing elective thoracic aortic surgery with deep hypothermic circulatory arrest (DHCA) were monitored intraoperatively using the FORE-SIGHT monitor. Two sensors were placed on the subject's forehead bilaterally for continuous monitoring of SctO2. The subject is in the supine position during surgery. There was no alteration in surgical technique or routine clinical monitoring.

Results: To date, 30 subjects have been monitored. Of the 30 cases, 26 cases demonstrated a typical pattern of SctO2 throughout the procedure. To determine the rate of SctO2 decline during DHCA, SctO2 values were collected from the following events: DHCA Onset (n=26), +5 minutes post DHCA Onset (n=25), +10 minutes (n=25), +15 minutes (n=25), +20 minutes (n=20), +25 minutes (n=11), & +30 minutes (n=7). For each category, the SctO2 mean and SD was determined. See Figure 1. Using non-linear regression, we fitted the data to a two compartment model because SctO2 decreased more rapidly in the first 10 minutes. From this model, the second term appeared linear, so we fitted the data using a simplified two compartment model: SctO2[t] = 73.81 + 10.53*exp(-0.238*t) – 0.51*t

For trending SctO2 (SctO2=0 at DHCA onset) or for any SctO2 value at t=0, this model becomes: SctO2[t] = SctO2[to] – 10.53 + 10.53*exp(-0.238*t) – 0.51*t

As a secondary analysis, a linear model closely fitted the data for +10 minutes after onset of DHCA. From the linear regression equation slope (Figure 1), SctO2 decreased at a mean rate of 0.55% per minute after 10 minutes. This compared well to the simplified two compartment model, where the -0.51*t term approximated the decrease in SctO2 of 0.51% per minute after 10 minutes.

Discussion: At the onset of DHCA cerebral blood flow is arrested. A gravitational redistribution of blood volume occurs resulting in a pooling of blood into the occipital regions of the brain. Subsequently, the frontal lobes, which represent the regions being interrogated by the oximeter, become blood volume depleted. This in addition to ongoing cerebral metabolism explains the rapid decline of SctO2 during the first 10 minutes. Once a new steady state is reached, cerebral metabolism becomes the sole determinant of the linear regression slope (Figure 1). From our data, we show that a simplified two compartment model fits the data whereas the first term {10.53*exp(-0.238*t)} characterizes cerebral metabolism and the redistribution of blood oxygenation by blood volume redistribution from DHCA, and the second term {– 0.51*t} represents elimination (metabolism) of oxygen in cerebral tissue.[figure1]

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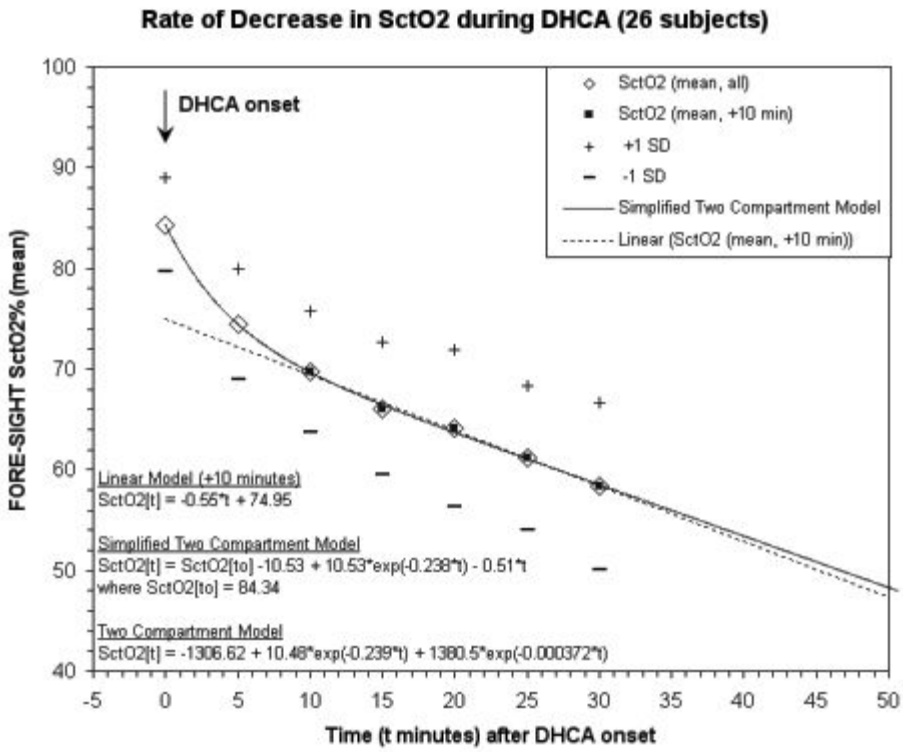
Figure 1


Rate of Decrease in SctO2 during DHCA (26 subjects)
DHCA onset
SctO2 (mean, all)
SctO2 (mean, +10 min)
+1 SD
-1 SD
Simplified Two Compartment Model
Linear (SctO2 (mean, +10 min))
FORE-SIGHT SctO2% (mean)
Time (t minutes) after DHCA onset
Linear Model (+10 minutes)
SctO2[t] = -0.55*t + 74.95
Simplified Two Compartment Model
SctO2[t] = SctO2[to] -10.53 + 10.53*exp(-0.238*t) - 0.51*t
where SctO2[to] = 84.34
Two Compartment Model
SctO2[t] = -1306.62 + 10.48*exp(-0.239*t) + 1380.5*exp(-0.000372*t)