Monitoring Consciousness Via Pulse Oximeter Motion Artifact

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Introduction:

Motion artifact vulnerability is generally regarded as undesirable during pulse oximetry. This pilot study examined the feasibility of exploiting induced motion artifact (Figure 1) to identify response to verbal commands, for monitoring consciousness, for example, during procedural sedation or postoperative analgesia.

Methods:

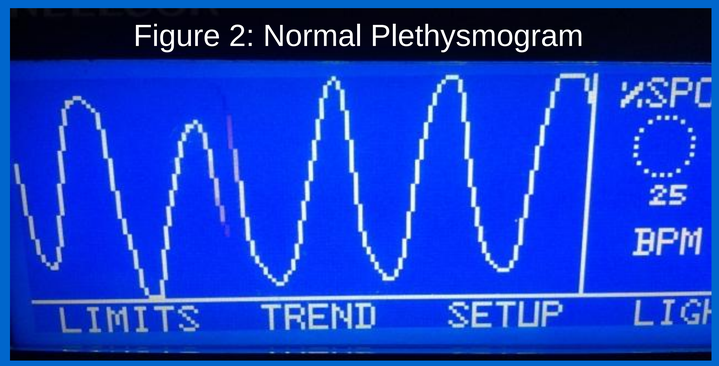
We captured the photoplethysmogram (Figure 2) from a commercial pulse oximeter (N-595, Nellcor, Covidien, Boulder, CO) with a reusable probe (DS100A-1, Nellcor) via a 16-bit analog to digital converter (USB-AI16-16A, Acces I/O Products Inc., San Diego, CA) connected to a generic Windows 7 laptop. A computer program written in C++ (Visual C++ 2010, Microsoft Corporation, Redmond, WA) processed the captured data by counting the number of peaks with an amplitude of more than 40 mV (Figure 3). If the number of peaks exceeded a threshold, i.e. 5, motion artifact was inferred if it occurred within 7 seconds after a computer generated audio prompt. Sixteen volunteers were audibly prompted by the computer to "Shake your finger". No instruction was provided about how to "shake" the finger. Two sets of six prompts each were used with each participant with the probe attached to the right and then left hand middle finger. During the first 3 prompts, the subjects were instructed to ignore the prompt

Methods (continued):

(not shake their finger) and then asked to obey the subsequent 3 prompts. When motion artifact in response to a verbal command was detected, the program would inform the subject by announcing "Good".

Figure 1: Induced Motion Artifact Plethysmogram

Figure 2: Normal Plethysmogram



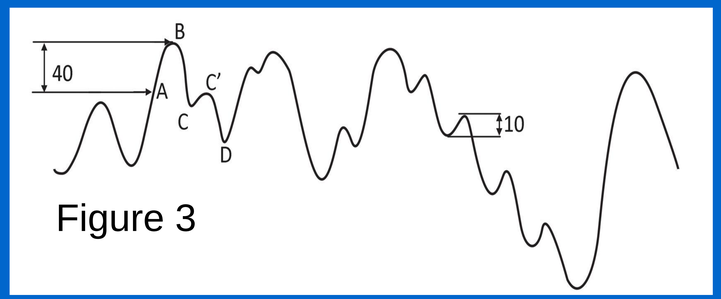


Figure 3

Results:

From the perspective of unconsciousness or more precisely non-responsiveness to verbal commands as the "disease" condition to be detected, the results were: sensitivity 100%, specificity 82.3%, negative predictive value 100% and positive predictive value 85.0% (Table). Of the 17 false positives, 10 were from 2 participants. One was intentionally trying to shake without triggering the program and the other waved the hand side to side rather than shaking the finger perpendicular to the palm plane.

Program output	"Shake" not performed n= 96	"Shake" performed n=96
Motion artifact not detected	96	17
Motion artifact detected	0	79

Conclusions:

Pulse oximetry motion artifact may be usefully employed in an automated system that can check for a time-linked response to a verbal command. The computer program was developed as a proof of concept and thus not optimized. With pre-monitoring coaching on finger shaking as well as acquiring baseline data with and without shaking, specificity and positive predictive value may be further increased.