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Visual metaphors on anaesthesia monitors do not improve anaesthetists' performance in the operating theatre

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Editor's key points

- A monitor interface that displays data metaphorically with normal values and trends was evaluated.
- Data interpretation from a standard monitor and the new one ± trends was compared by 32 clinicians.
- No significant differences were found in time to diagnosis and accuracy between the monitors.
- Visual metaphors did not improve performance and 40% of the complications were identified incorrectly.

Background. Previous research using a metaphorical anaesthesia monitor, where dimensions of rectangles proportionally represent 30 patient variable values, showed improved performance in diagnosing adverse events compared with the standard monitor. Steady-state values were represented by a frame around each rectangle. We developed a similar metaphorical anaesthesia interface, but instead of presenting four relatively simple complications, we presented 10 complications of various levels of difficulty. Our simplified monitor presented variables that anaesthetists and trainees suggested as being essential for diagnosis.

Methods. Thirty-two anaesthetists and anaesthesia trainees participated in the monitoring task. Three types of monitors were presented: standard monitor, metaphorical monitor, and metaphorical monitor with trend arrows emphasizing the direction of change. The subjects were presented with screenshots of the three monitor types displaying anaesthesia-related complications. They were asked to indicate treatment method and diagnosis for the displayed complication.

Results. No significant differences were found in time to diagnosis and accuracy between the metaphorical and standard monitor. There were also no differences between trend and no-trend monitors. Forty per cent of the complications were identified incorrectly.

Conclusions. Visual metaphors on anaesthesia monitors do not improve anaesthetists' performance in the operating theatre. Since all complications in this study were identifiable based on monitor values alone, it seems feasible to develop a decision support system (DSS) based on these values. We suggest that a DSS could support the anaesthetist by calling attention to diagnoses that may not be considered.

Keywords: decision support systems, clinical; diagnostic errors; monitoring, physiological; pattern recognition, visual

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The proportion of anaesthesia-related incidents due to human error is found to be more than 60%.[1–3] Many of these incidents can be attributed to the physician failing to recognize a pattern in the patient's clinical information.[4] Small deviations in patient variables can evolve into incidents causing harm to the patient.[5 6] However, the presentation of patient variables in current anaesthesia monitors is not optimal for fast detection and interpretation of complications.[7–9] For example, numerical values and curves need to be interpreted one-by-one to obtain a diagnosis.[10] An integrated representation of patient variables in a graphical display has been shown to increase the accuracy and speed of diagnosis.[6 11] The integrated view supports the non-analytical, pattern-recognizing nature of diagnosing, especially when the display highlights the physiological relationships between the variables.[12] A promising example of such a display uses rectangles to proportionally represent 30 different patient variable values.[6] The steady-state value for each variable was represented by a frame around each rectangle. Because heights and widths of the rectangles changed proportionally with values of patient variables, deviations from normal values are easily detectable. In a patient simulation, anaesthetists were presented with four critical events: blood loss, inadequate paralysis with spontaneous ventilation, cuff leak, and depletion of soda lime. Their results showed a significant effect in detection time and identification time of these events.

However, this monitor displays variables not routinely measured, such as fluid balance.[6] Inspired by this study,[6] we therefore developed a similar metaphorical anaesthesia interface (MAI), but adapted the design to only show variables that are measured during anaesthesia. We used structured interviews with anaesthetists and anaesthesia trainees to identify preferred variables to include in the design. For example, we included information about the direction in which values change, by adding trend arrows, to emphasize these changes, because it was suggested that would be useful.

We aimed to compare the diagnostic and treatment performance of a standard monitor and our new monitor. In the previous study,[6] four relatively simple complications were presented but we presented subjects with 10 complications of differing complexity. We hypothesized that the subjects would recognize the complications faster with the metaphorical monitor compared with the standard monitor. In addition, we hypothesized that they would recognize the complications faster in monitors with trend arrows compared with those without trend information. Furthermore, we hypothesized increased recognition performance in combined standard and metaphorical monitors compared with single monitors.

Methods

Metaphorical display design

In consultation with five anaesthetists, five anaesthesia trainees, and five nurse anaesthetists of the Department of Anesthesiology of the University Hospital Groningen, we developed a graphical display based on the interface described by Michels and colleagues.[6] Based on the perceived need for accentuating the direction of change in the measured values, we developed two versions of the display: the 'normal' MAI (Fig. 1), and a monitor with trend arrows showing the direction of change (tMAI) (Fig. 2).

The anaesthetists indicated that nine patient variables should be presented, which we grouped according to the physiological system they represented: the respiratory and the vascular system, specified at the top of the screen by two icons. Inspiratory O_2 (steady state: 45%), expiratory CO_2 (4.3 kPa), respiratory rate (15 resp. min^{-1}), tidal volume (450 ml), PEEP (2 cm H_2O), and PAW (18 cm H_2O) pressures were shown for the respiratory system, and Sp_{O_2} (100%), heart rate (75 beats min^{-1}), and arterial pressure (125/83 mm Hg) for the vascular system. Each variable was presented as a rectangle, in a black frame that represented the steady-state value for this particular patient. Variables below this value did not completely fill up the frame, while variables above it spilled over the top of the frame; variables at the steady-state value fitted exactly. Inspiratory O_2 and expiratory CO_2 were presented in a stacked manner, because that was the preference of the majority of interviewees. Heart rate and arterial pressure were stacked, as a physiological relationship was suggested. A change of height in one of the stacked variables (e.g. arterial pressure) resulted in a higher fragment of that variable in the stack. This means an increase in the height of that particular variable and an equal increase in the height of the total stack (i.e. the other variable in the stack is 'pushed' upwards). The steady state and the changed values for the variables were determined by one of the authors, an experienced anaesthetist with 33 yr experience.

Trend

In our group of professionals, there was no consensus about the value of trend information in monitoring. We decided to add trend arrows in two monitor conditions. These trend arrows indicated the speed and direction of change for each cardiovascular variable typical for the simulated complication.

Experimental methods

Subjects

Members of the Department of Anesthesiology at the UMCG Groningen participated in the experiment: 16 anaesthetists (mean age=44.3 yr; SD=9.9 yr; mean experience: 15.4 yr;

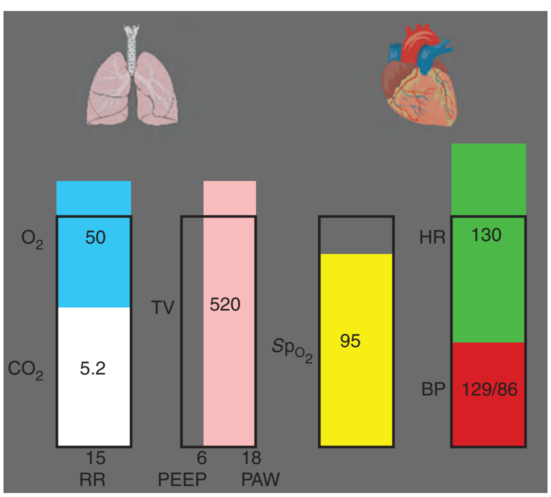

Fig 1 Metaphorical anaesthesia interface (MAI).

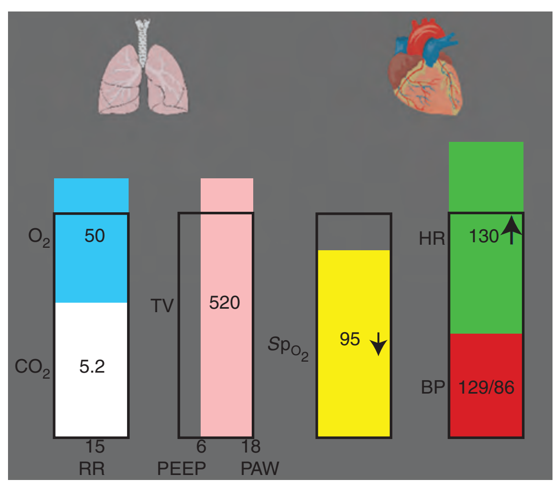

Fig 2 Metaphorical interface with trend information (tMAI).