A New Monitoring Display Improves Intraoperative Hemodynamic Management: Alert Watch

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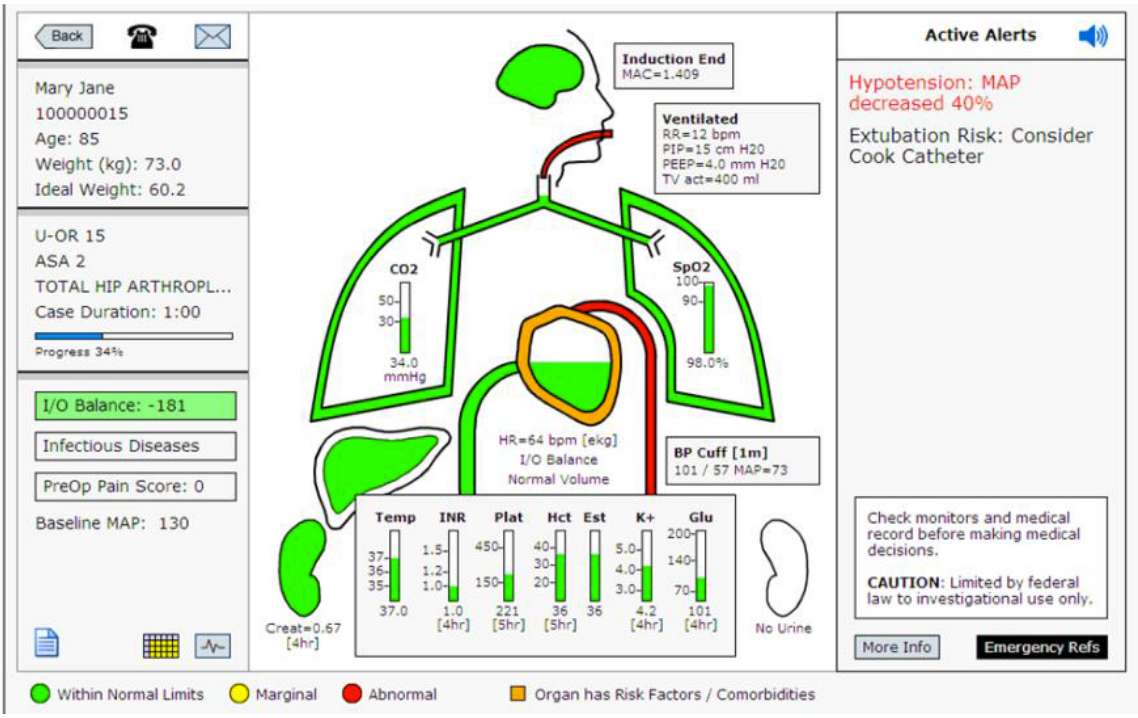
Introduction: In the operating room, the anesthesiologist is responsible for assimilating the wide range of real-time second-to-second physiologic monitor data, clinical observations, and patient history and physical information. The sheer volume of data and the frequency of artifact signals can overwhelm sustained vigilance of practicing clinicians and has been documented as a major patient safety issue. AlertWatch™ (AW) is a web-based multifunction display which receives, integrates, and presents data from physiologic monitors, electronic health records, and laboratory systems to provide evidence-based alerts. The display is comprised of readily identifiable icons of human organs, whose colors change as measured and calculated parameters go from normal to marginal to abnormal risk-adjusted ranges (Figure 1). AW includes real-time alerts for more than 30 intraoperative processes of care, ranging from hemodynamics to ventilator strategy and malignant hyperthermia. We hypothesized that the use of AW would improve the intraoperative hemodynamic management across a broad range of surgical procedures and patients.

Methods: AW was implemented as a supplementary screen on May 1, 2012 in the adult operating rooms at the University of Michigan Health System. After implementation, individual clinical providers could voluntarily choose to use AW during their case. No additional clinical care protocols were instituted, publicized, or recommended. For blood pressure management, the aortic arch represents the mean arterial pressure (MAP) and changes color to yellow when the MAP drops 30% below the patient's preoperative baseline and changes to red when it drops to 40% of the patient's preoperative baseline. Simultaneous with the color change, there is a three tone audible alert which decreases from high to low pitch. This tone repeats every minute until the blood pressure increases above the 40% drop. For this analysis, all cases that were 60 minutes or greater in length were included; outpatient and cardiothoracic procedures were excluded from this analysis. Data were analyzed in two ways. First, two analysis groups were studied from 5/1/2012 to 11/1/2013: a case was considered "AW-assisted" if it was used for 75% or more of the intraoperative case duration versus "control" if it was used for less than 75% of the case duration. Second, historical controls for 17 months prior to the implementation of AW were compared against "AW-assisted" cases. A sensitivity analysis was also performed comparing "AW-assisted" cases to controls were AW was not used at all during the case (0% of duration).
The primary outcome was hypotension, defined as the percentage of case duration with a MAP below 60 mmHg or 55 mmHg. The secondary outcomes included

myocardial ischemia (MI) defined as a postoperative troponin ≥ 0.30 within seven days of the operation. Acute kidney injury (AKI) was defined using the most recent preoperative and peak postoperative serum creatinine within seven days. We used the KDIGO staging criteria (stage 1 = 1.5 x baseline or 0.3 mg/dl increase, stage 2 = 2.0 x baseline). SPSS version 21 and tests appropriate for observed normalcy were used for the analysis.

Results: A total of 35,612 cases were included in the primary analysis: 7,391 "AW-assisted" cases, 11,315 parallel controls, and 16,906 historical controls. "AW-assisted" cases exhibited significantly less percentage of the case with MAP below 60 mmHg (median 2.13 IQ range [0-6.7] vs 2.33 [0-7.6] parallel control; 2.13 [0-6.7] vs 2.62 [0 – 8.0] historical control) and 55 mmHg (0 [0-2.08] vs 0 [0 – 2.43] parallel control; 0 [0-2.1] vs 0-2.6] historical control) all p-value < 0.01). In addition, in the parallel control period there was a statistically significant lower incidence of MI for "AW-assisted" versus control cases, 0.7% versus 1.0% (p = 0.0025). There was no difference in AKI in this group. In the historical control analysis, both Stage 1 and 2 AKI were significantly less common in the AW-assisted group (stage 1: 12.5% vs 14.8%; stage 2: 1.6% vs 2.5%), p-value < 0.001. MI demonstrated a lower incidence in AW cases when compared against the historical controls but it did not reach statistical significance, 0.7% versus 0.9% (p = 0.141). The sensitivity analysis demonstrated the same findings for hemodynamic control but did not reach statistical significance for MI or AKI.



Conclusion: Our findings suggest that the use of an integrated display that alerts providers to moderate relative hypotension is associated with a decrease in the incidence of moderate and severe absolute hypotension. We also observed a decreased incidence of myocardial ischemia and acute kidney

injury. Caution should be noted when interpreting these results. First, this is an observational study so it cannot causality; second, the historical controls have the bias of time while the parallel controls are subject to treatment or selection bias by the provider choosing to use AW. In spite of these limitations it appears this type of display may allow for improved management and postoperative outcomes.