Interruptions and Blood Transfusion Checks: Lessons from the Simulated Operating Room

David Liu, BEng(Hons)*

Tobias Grundgeiger, DiplPsych†

Penelope M. Sanderson, PhD, FASSA*†‡

Simon A. Jenkins, BMBS, FANZCA§

Terrence A. Leane, RN, GDPH GDNursSci§

Interruptions occur frequently in the operating room with both positive and negative consequences. Interruptions can distract anesthesiologists from safety-critical tasks, such as the pretransfusion blood check. In a simulated operating room, 12 anesthesiologists requested blood as part of a "bleeding patient" scenario. They were distracted while their assistant accepted delivery of the product and began transfusing without performing the standard check. Anesthesiologists who immediately engaged with the interruption failed to notice the omission, whereas those who rejected or deferred the interruption all noted and remedied the omitted check ($P < 0.05$). We discuss the role of displays and strategies on safety.

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The operating room (OR) is a highly interruptive environment, with one study reporting an average of 17.4 interruptions per hour.[1] Interruptions can compromise patient safety, such as increasing the rate of medication errors in an ambulatory care pharmacy[2] or leading to uncompleted tasks in computerized medication orders.[3] However, interruptions can communicate new information to the person being interrupted,[4] prevent errors,[5] and provide the interrupter with information to proceed with an otherwise suspended task.[6]

Interruptions have been cited several times as a contributing factor to blood transfusion errors.[7–10] Statistics collected by the Serious Hazards of Transfusion scheme highlight the importance of bedside checks in transfusion safety.[9] For example, in 2003 the most common error in cases of incorrect blood component transfusions was failure of the pretransfusion bedside checking procedure (156 of 588 cases, 26.5%).[11]

In the articles in which it is claimed that interruptions contribute to transfusion errors, there has been no analysis of how such contribution might occur.[7–10] Moreover, the Serious Hazards of Transfusion scheme does not collect information about interruptions in cases of transfusion errors.

As part of a simulator-based study investigating anesthesiologists' ability to detect unexpected events when patient monitoring was augmented with a Head-Mounted Display (HMD),[12] we performed a retrospective analysis of whether an interruption affects whether anesthesiologists will detect an omitted bedside pretransfusion check.

METHODS

Participants

The study received ethical clearance from the Royal Adelaide Hospital and The University of Queensland. Twelve anesthesiologists (5 attendings and 7 residents) from the Royal Adelaide Hospital participated in a simulated OR environment using a METI ECS™ patient simulator after providing written informed consent.

Design

The failure to check blood event was one of 24 events presented to the participant across three 35–40 minute simulator scenarios. For four participants, the HMD was worn but no monocle was attached (HMD-none); for four participants, the HMD monocle displayed the simulated patient's heart rate, saturation of

From the *School of Information Technology and Electrical Engineering, The University of Queensland, St Lucia, Queensland, Australia; †School of Psychology, The University of Queensland, St Lucia, Queensland, Australia; ‡School of Medicine, The University of Queensland, St Lucia, Queensland, Australia; and §Department of Anesthesia and Intensive Care, Royal Adelaide Hospital, Adelaide, Australia.

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Reprints will not be available from the author.

Address correspondence to David Liu, School of Information Technology and Electrical Engineering, The University of Queensland, St Lucia, QLD 4072, Australia. Address e-mail to naskies@acm.org.

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peripheral oxygen, noninvasive arterial blood pressure, end-tidal CO_2, and capnography waveform, all focused at optical infinity (HMD-far); and for four participants the HMD displayed the above vital signs at a near focus of 2 diopters or around 50 cm (HMD-near). A standard visual patient monitor was available in all conditions.

Scenario

Responsibility for blood checks at the Royal Adelaide Hospital is shared between the anesthesiologist and the anesthetic assistant (nurse). Twenty minutes into the third scenario, the participant (anesthesiologist) notes evidence of a major hemorrhage. The participant completes a transfusion request form for the blood bank and administers IV fluids until the blood arrives. Ten minutes later, an orderly (actor) knocks on the OR door and passes the blood to the anesthetic nurse (actor). At the same time as the blood arrives, the surgeon (actor) distracts the participant by asking them to arrange to transfer the patient to the high dependency unit after the operation. After this, the anesthetic nurse carries the blood past the anesthesiologist to the patient, specifically fails to perform the bedside check, hangs the first unit of blood on an IV pole, and begins the transfusion. Three minutes (180 s) were allowed for the participant to detect that the check had been omitted, after which the scenario ended.

Data Collection

Video data were collected in quad format, including two different scene views of the OR, a view from a miniature camera mounted on the HMD providing the participant's perspective, and a view of the patient monitor.

Video Coding

When the event began, the participant's primary task was to supervise the blood transfusion and their secondary (distracter) task was to deal with the surgeon's request. Each participant's behavior in responding to the surgeon's distraction was classified retrospectively into one of four categories (described below and shown in Fig. 1), along with whether they detected the event. The classification scheme was based on the Collins et al. taxonomy of distractions[3] plus a "blocking" category absent from their study.

- Engaging–the participant engaged with the distraction by immediately agreeing to organize the high dependency unit transfer and did not return to the transfusion task.
- Multitasking–the participant engaged with the surgeon to discuss transfer options while concurrently helping the nurse set up the transfusion.
- Deferring–the participant acknowledged the surgeon's request, completed or delegated the blood check, then returned to plan the high dependency unit transfer.
- Blocking–the participant immediately indicated to the surgeon that the patient did not need high dependency unit care and returned to the transfusion task.

One researcher, an expert on the scenario design, applied the above scheme. A second researcher, an expert on interruptions, reviewed the coding and any discrepancies were resolved by discussion.

Statistical Analysis

Fisher-Freeman-Halton Exact Tests for $r \times c$ tables were used to determine the relationship between HMD condition (three levels), strategy for handling the interruption (four levels), and whether the participant detected or missed the transfusion event (two levels) (StatXact™ 8, Cambridge, MA). With a Bonferroni correction and the Type I Error rate (α) set at 0.05, the critical level of P for each Exact Test was $P = 0.0167$.

RESULTS

The number, expertise, and display condition of participants who either detected or missed the transfusion event for each of the four classification categories is shown in Table 1.

The only two participants who did not detect the omitted check within the 180 s window had immediately engaged with the surgeon to initiate the high dependency unit transfer (Engaging). Both participants were in the HMD-near condition. A third participant initially missed the event because he was busy organizing the high dependency unit transfer while concurrently directing a nurse to apply pressure to the blood bag (Multitasking). The participant detected the omitted check after completing the discussion and returning his full attention to the transfusion task.

The remaining nine participants detected the omitted check relatively quickly. Four participants immediately acknowledged the surgeon's request, but deferred discussion, detected the omission, asked the nurse to perform the check, and finally organized the high dependency unit transfer (Deferring). The remaining five participants briefly addressed the surgeon's medical concerns in order to deny the request and close the conversation (Blocking). Four of the five participants who responded by blocking were in the HMD-none condition.

Under the corrected critical level of $P = 0.0167$, the Fisher-Freeman-Halton Exact Tests indicated that display was marginally associated with strategy, $P = 0.018$, strategy was significantly associated with detections, $P = 0.015$, but display was not significantly associated with detections, $P = 0.273$. Figure 2 shows the results of the tests.

DISCUSSION

According to a recent survey,[13] this study is the first to examine the relationship between interruptions and

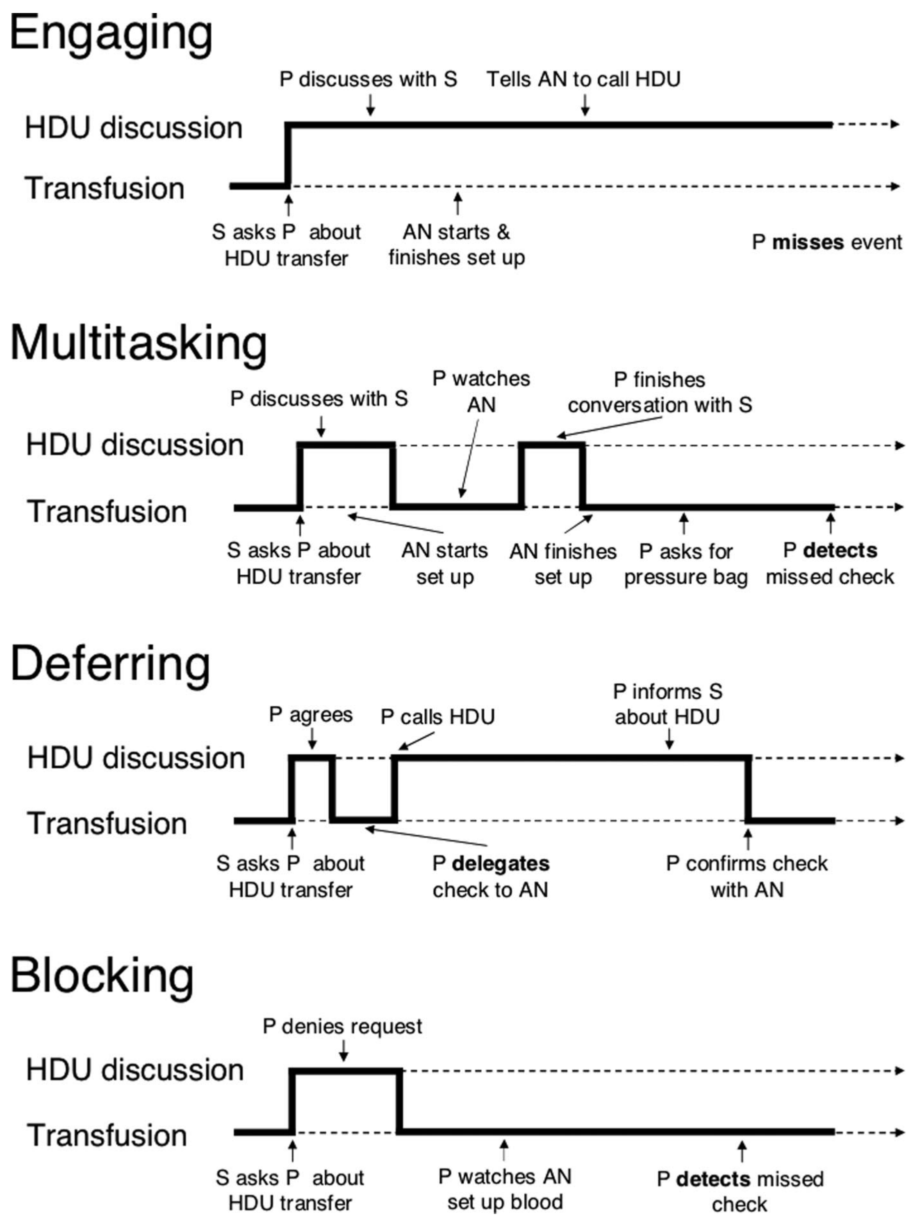

Figure 1. The four ways in which participants responded to the surgeon's distraction. The line represents the anesthesiologist's focus of attention on either the blood transfusion task (primary) or the high dependency unit discussion with the surgeon (distraction). The overall pattern is generic, but the specific details given are examples. P = participant; AN = anesthetic nurse; S = surgeon.

adverse events in a controlled empirical environment with replications over participants, and to find a relationship. The results show that anesthesiologists can miss a clinically relevant event in the OR, such as the need to check blood, when they are interrupted. The pattern of data (Table 1) suggests that the more the anesthesiologist engaged with the surgeon's interruption, the less likely they were to detect the event.

The display being used was associated with the anesthesiologist's strategy for handling the surgeon's request, but only the strategy (not the display) was directly associated with whether the anesthesiologist detected the omitted blood check. Two of the four participants who could easily reaccommodate visually between the HMD vital signs and the surgeon (HMD-near condition) engaged with the surgeon's request, possibly believing the patient was adequately monitored. In contrast, all participants who had no patient vital signs in the forward field of view (HMD-none condition) blocked the surgeon's request, possibly to avoid distraction from monitoring with standard monitors.

One potential concern is that the two participants who failed to check blood may not have considered the check to be part of the simulator scenario.[14] We suggest this is not the case. Given the series of activities these participants engaged in after the blood arrived, such as not looking at the first steps of the transfusion task and directing their attention to the high dependency unit task, independent theories of prospective memory (remembering to remember) can provide an adequate account of why these participants alone forgot to check blood, whereas the other 10 participants remembered.[15]

In general, it may be safer for busy anesthesiologists to handle interruptions by delegating current tasks or temporarily denying requests than by immediately engaging with interruptions. It is important for

Table 1. The Number of Events Detected and Missed for Each Strategy and the Mean Event Detection Time, Where Applicable

No. of participants and condition			
Strategy	Detected	Missed	Mean detection time
Engaging	0	2 A/HMD-near R/HMD-near	Undetected in 180 s
Multitasking	1 R/HMD-far	0	117 s
Deferring	4 A/HMD-far A/HMD-near R/HMD-far R/HMD-near	0	18 s
Blocking	5 A/HMD-none A/HMD-none R/HMD-none R/HMD-none R/HMD-far	0	28 s

Letters under counts represent the expertise and display condition of participants in each cell. A = attending; R = resident; HMD-none = HMD mounting worn but no monocle attached; HMD-far = HMD with monocle display at far focus; HMD-near= HMD with monocle display at near focus.

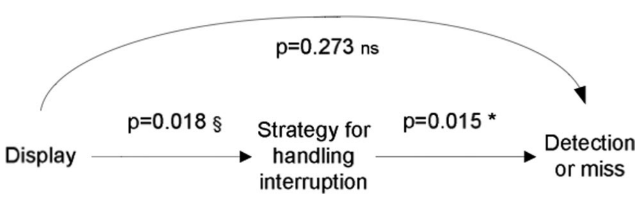

Figure 2. Correlogram showing significance or otherwise of Fisher-Freeman-Halton Exact Tests for associations between detection of omitted blood check, display, and strategy for handling interruption. Significance levels preserve a Type I Error rate of 0.05 after Bonferroni corrections are applied to the outcome of the Exact Tests. *Significant; §Marginally significant.

anesthesiologists to be aware of factors that might influence their strategies for handling interruptions. Such factors extend beyond displays to status relationships, fatigue, workload, and so on. Anesthesia Crisis Resource Management principles[16] outline effective methods by which anesthesiologists can manage such factors and delegate tasks appropriately.

Despite the limitations of the small number of participants and the retrospective analysis used, the simulator provided a highly controlled and replicable environment for examining the effect of an interruption on anesthesiologists' performance of an important clinical task. Future prospective simulator-based studies may help to determine the best ways to mitigate any impact.

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