UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"
FACULDADE DE MEDICINA

Glênio Bitencourt Mizubuti

Identificação de Eventos Intraoperatórios em um Vídeo de Simulação em Laparotomia: Estudo Multinacional Sobre Cegueira por Desatenção Entre Anestesiologistas

Tese apresentada à Faculdade de Medicina, Universidade Estadual Paulista "Júlio de Mesquita Filho", Câmpus de Botucatu, para obtenção do título de Doutor em Anestesiologia.

Orientador: Profª. Drª. Laís Helena Navarro e Lima

Botucatu – SP
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Palavras-chave: Anestesiologia; Cegueira por desatenção; Consciência situacional; Simulação.

ATA DA DEFESA PÚBLICA DA TESE DE DOUTORADO DE GLÊNIO BITENCOURT MIZUBUTI, DISCENTE DO PROGRAMA DE PÓS-GRADUAÇÃO EM ANESTESIOLOGIA, DA FACULDADE DE MEDICINA.

Aos 28 dias do mês de junho do ano de 2024, às 08:30 horas, no Departamento de Anestesiologia da Faculdade de Medicina de Botucatu, Unesp, reuniu-se a Comissão Examinadora da Defesa Pública, composta pelos seguintes membros: Profa. Dra. LAIS HELENA NAVARRO E LIMA – Orientadora do Depto. de Anestesiologia/FM/Botucatu – Unesp (participação virtual), Profa. Dra. NORMA SUELI PINHEIRO MODOLO do Depto. de Anestesiologia – FM/Botucatu – Unesp (participação presencial), Prof. Dr. GUILHERME ANTONIO MOREIRA DE BARROS, do Depto. de Anestesiologia – FM/Botucatu – Unesp (participação presencial), Prof. Dr. LEOPOLDO MUNIZ DA SILVA, do Serviço de Anestesiologia CMA – Hospital São Luiz – Rede D'Or (participação virtual), Prof. Dr. RAFFAEL PEREIRA CEZAR ZAMPER do Depto. de Anestesia e Medicina Perioperatória da Universidade Western ("Western University", London, ON, Canadá) (participação virtual), sob a presidência da primeira, a fim de proceder a arguição pública da DEFESA DE DOUTORADO de GLÊNIO BITENCOURT MIZUBUTI, intitulada **Identificação de Eventos Intraoperatórios em um Vídeo de Simulação em Laparotomia: Estudo Multinacional Sobre Cegueira por Desatenção Entre Anestesiologistas.** Após a exposição, o discente foi arguido oralmente pelos membros da Comissão Examinadora presentes na defesa. O conceito final obtido pelo referido aluno foi "APROVADO". Nada mais havendo, foi lavrada a presente ata, que após lida e aprovada, foi assinada pela Presidente da Comissão Examinadora.

Profa. Dra. LAIS HELENA NAVARRO E LIMA

DEDICATÓRIA

Ao Senhor Deus, para quem e por meio de quem eu vivo, e que tem derramado graça e bençãos indizíveis sobre minha vida, das quais não sou merecedor. A Ele toda glória, honra e louvor!

À minha esposa, Milena, e filhas, Julia e Manuela, por quem palavras e gestos jamais conseguirão expressar o amor que sinto.

Aos meus queridos pais, Hugo e Marlene, que desde o berço me criaram nos princípios bíblicos de amor, honestidade e integridade, e que ainda hoje me inspiram como exemplos vivos de trabalho árduo e boa índole.

Ao meu irmão, amigo e conselheiro, Marcio, e sua família, por quem tenho imensa admiração e amor.

À minha irmã, Mayuli, que não obstante a distância, será sempre muito amada.

Aos meus sogros, Rodolfo e Nair, cunhados, Rodolfo e Murillo, e respectivas famílias que gentil e amorosamente me acolheram.

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Aos colegas brasileiros, canadenses, e de Hong Kong que direta ou indiretamente participaram desse projeto, permitindo que, a despeito das dificuldades impostas pela pandemia, a pequena semente plantada em 2017 viesse a germinar e frutificar, culminando na presente tese. Em especial, ao Prof. Dr. Anthony Ho, que tem diligentemente me assistido em todos os aspectos de minha vida acadêmica no Canadá, e participou ativamente no presente estudo.

Ao departamento de anestesiologia e medicina perioperatória da Universidade Queen's, por todo suporte ao longo desse projeto.

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EPÍGRAFE

"*Era desprezado e o mais rejeitado entre os homens; homem de dores e que sabe o que é padecer; e como um de quem os homens escondem o rosto, era desprezado, e dele não fizemos caso. Certamente, ele tomou sobre si as nossas enfermidades e as nossas dores levou sobre si; e nós o reputávamos por aflito, ferido de Deus e oprimido. Mas ele foi traspassado pelas nossas transgressões e moído pelas nossas iniquidades; o castigo que nos traz a paz estava sobre ele, e pelas suas pisaduras fomos sarados. Todos nós andávamos desgarrados como ovelhas; cada um se desviava pelo caminho, mas o SENHOR fez cair sobre ele a iniquidade de nós todos. Ele foi oprimido e humilhado, mas não abriu a boca; como cordeiro foi levado ao matadouro; e, como ovelha muda perante os seus tosquiadores, ele não abriu a boca... Todavia, ao SENHOR agradou moê-lo, fazendo-o enfermar; quando der ele a sua alma como oferta pelo pecado, verá a sua posteridade e prolongará os seus dias; e a vontade do SENHOR prosperará nas suas mãos. Ele verá o fruto do penoso trabalho de sua alma e ficará satisfeito; o meu Servo, o Justo, com o seu conhecimento, justificará a muitos, porque as iniquidades deles levará sobre si. Por isso, eu lhe darei muitos como a sua parte, e com os poderosos repartirá ele o despojo, porquanto derramou a sua alma na morte; foi contado com os transgressores; contudo, levou sobre si o pecado de muitos e pelos transgressores intercedeu.*"

(**Isaías 53:3-7 & 10-12**)

SUMÁRIO

RESUMO

Introdução e Objetivos: Erros médicos podem ocasionalmente ser explicados por cegueira por desatenção que é a falha em se perceber um evento e/ou um objeto que se encontra plenamente visível. O presente estudo objetivou determinar se a idade/experiência clínica, o cansaço, e a exposição prévia à educação em simulação de anestesiologistas podem afetar o fenômeno de cegueira por desatenção no ambiente anestésico-cirúrgico.

Métodos: Neste estudo multicêntrico incluindo instituições brasileiras, canadenses, e de Hong Kong, 280 anestesiologistas (amostra por conveniência) assistiram um vídeo que demandava alto grau de atenção envolvendo um paciente politraumatizado sendo submetido à laparotomia de emergência. Os participantes foram solicitados a anotar de maneira *independente* e *anônima* todas as anormalidades observadas. O vídeo continha 4 anormalidades *esperadas/comuns* (hipotensão, taquicardia, hipóxia, hipotermia) e 2 anormalidades *inesperadas/raras* (paciente sob anestesia geral movendo a cabeça, e desconexão de acesso venoso central) apresentadas de maneira proeminente ao longo do vídeo. O objetivo primário foi analisar a capacidade dos participantes em perceber os eventos (tanto esperados quanto inesperados) implantados no vídeo. O objetivo secundário visou avaliar a proporção de eventos esperados/inesperados de acordo com a faixa etária, o estado "descansado/afadigado", e a exposição prévia à educação em simulação dos participantes.

Resultados: Anestesiologistas de todas as faixas etárias foram menos capazes de perceber eventos inesperados/raros do que eventos esperados/comuns. No geral, os eventos esperados/comuns passaram menos despercebidos aos anestesiologistas mais jovens quando comparado aos participantes de idade mais avançada ($P = 0.02$). Não houve associação consistente entre idade e a percepção de eventos inesperados/raros ($P = 0.28$), embora a performance da coorte mais jovem

(< 30 anos de idade) tenha sido melhor do que os demais grupos etários. Educação previa em simulação não afetou a proporção de eventos inesperados/raros que passaram despercebidos, mas esteve associada a menor número de eventos esperados/comuns que deixaram de ser notados. Por fim, o fato de os participantes se sentirem descansados ou afadigados não impactou sua percepção dos eventos em questão.

Conclusão: Anestesiologistas perceberam menos eventos inesperados/raros do que eventos esperados/comuns que foram implantados em um vídeo envolvendo um paciente traumatizado, indicando a presença de cegueira por desatenção. Educação previa em simulação esteve associada a maior habilidade dos participantes em perceber eventos esperados/comuns, mas não reduziu a cegueira por desatenção. Nossos resultados podem ter implicações na compreensão de eventos adversos na área da saúde, assim como nos esforços para se melhorar a consciência situacional, especialmente em áreas de alta acuidade como no ambiente perioperatório e medicina intensiva e emergencial.

Palavras-chave: Anestesiologia; Cegueira por desatenção; Consciência situacional; Simulação.

ABSTRACT

Purpose: Medical errors may be occasionally explained by inattentional blindness (IB), i.e., failing to notice an event/object that is in plain sight. We aimed to determine whether age/experience, restfulness/fatigue, and previous exposure to simulation education may affect IB in the anesthetic/surgical setting.

Methods: In this multicentre/multinational study, a convenience sample of 280 anesthesiologists watched an attention-demanding video of a simulated trauma patient undergoing laparotomy and (independently/anonymously) recorded the abnormalities they noticed. The video contained four *expected/common* abnormalities (hypotension, tachycardia, hypoxia, hypothermia) and two prominently displayed *unexpected*/*rare* events (patient's head movement, leaky central venous line). We analyzed the participants' ability to notice the expected/unexpected events (primary outcome) and the proportion of expected/unexpected events according to age group, self-perceived restfulness (no validated metric was used) and prior exposure to simulation education (secondary outcomes).

Results: Anesthesiologists across all ages noticed fewer unexpected/rare events than expected/common ones. Overall, younger anesthesiologists missed fewer expected/common events than older participants did ($P = 0.02$). There was no consistent association between age and perception of unexpected/rare events ($P = 0.28$), although the youngest cohort (< 30 years-old) outperformed the other age groups. Prior simulation education did not affect the proportion of misses for the unexpected/rare events but was associated with fewer misses for the expected/common events. Self-perceived restfulness did not impact perception of events.

Conclusion: Anesthesiologists noticed fewer unexpected/rare clinical events than expected/common ones in an attention-demanding video of a simulated trauma patient, in keeping with IB. Prior simulation training was associated with an improved ability to notice anticipated/expected events, but did not reduce IB. Our findings may have implications for understanding medical mishaps, and efforts to improve situational awareness, especially in acute perioperative and critical care settings.

Keywords: Anesthesiology; Inattentional blindness; Simulation; Situation awareness.

Identifying Intraoperative Events in a Simulated Laparotomy Video: A Multinational Study of Inattentional Blindness Among Anesthesiologists

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ATTESTATION TO AUTHORSHIP

Glenio B. Mizubuti: This author conceived the research idea and helped with data collection and analysis, preparing the simulation video, drafting the manuscript, participating in the revision process, and approving the final version for publication.

Laís H. N. e Lima: This author helped with data collection, preparing the simulation video, revising the manuscript, and approving the final version for publication.

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Michael McMullen: This author helped with revising the manuscript and approving the final version for publication.

Jessica Burjorjee: This author helped prepare the simulation video, revised the manuscript, and approved the final version for publication.

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Wilma A. Hopman: This author helped with the statistical analysis and finalization of the manuscript.

Anthony M.-H. Ho: This author conceived the research idea and helped with data collection and analysis, preparing the simulation video, drafting the manuscript, participating in the revision process, and approving the final version for publication.

All authors meet all authorship criteria as indicated in the *Journal*'s instructions for authors (https://www.springer.com/journal/12630/submission-guidelines#Instructions%20for%20Authors), namely: 1) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; 2) drafting the article or revising it critically for important intellectual content; and 3) final approval of the version to be published.

IMPLICATION STATEMENT

Inattentional blindness (IB), as measured by the ability to notice unexpected/rare intraoperative adverse events in a simulated video, was prevalent among anesthesiologists in this multinational study. Subjective restfulness/fatigue did not impact IB. Prior simulation training improved participants' ability to notice anticipated/expected events, but did not reduce IB.

INTRODUCTION

Some medical errors defy logic. In a first example, in 2005, an intensive care patient had a femoral venous catheter sited using the Seldinger technique. Five days later, during insertion of an inferior vena cava filter, it was discovered that the guidewire from the femoral catheter placement had been inadvertently left inside the patient. A review of the chest *x-rays* taken daily for the previous five days, and reviewed by multiple consultants, revealed that the guidewire was plainly visible in every one of them.[1] In a second example, during a transfemoral transcatheter aortic valve replacement under fluoroscopic guidance, a previously placed aortoiliac stent was inadvertently dislodged, migrated, and was fixed behind the prosthetic aortic valve. The migrated aortoiliac stent was only discovered at a routine follow-up. A review of the fluoroscopy-guided aortic valve deployment showed that the aortoiliac stent was in plain view all along.[2] In a third example, in 2013, an experienced transplant team, following multiple checks, transplanted the heart from a patient with an incompatible blood group.[3] According to a 2006 study, wrong-site/side surgery occurs (despite surgical checklists) at a rate of 1 in every 112,994 cases.[4]

The underlying reasons for medical errors are multifactorial and complex (as are the solutions). It is important to note that, at their core, they are not necessarily a result of incompetence or negligence. In fact, errors are often made by dedicated professionals who routinely take reasonable precautions to avoid them. Some errors can be explained in part by a concept called inattentional blindness (IB), which comes from cognitive psychology. Simply put, IB is failing to notice a visible object or event that is in plain sight.[5] An example of this phenomenon is a widely viewed video of two teams passing basketballs while a man in a gorilla suit walks among them, stopping in the middle of the screen and pounding his chest. While busy counting the passes, half the viewers do not notice the gorilla.[5] Another example is provided by a similar National Geographic YouTube video.[A] Inattentional blindness occurs when attention is focused on certain stimuli in the environment at the expense of others which, in turn, never make their way into working memory or conscious thought and, therefore, are not (at all) perceived. Everyday examples of IB include automobile accidents while texting,[6] inconsistent/erroneous scenes seldom noticed in movies, and stage magic/illusions.[7]

Inattentional blindness impairs situational awareness (SA), which describes an individual's ability to maintain an adequate internal representation of the status of the environment in complex and dynamic domains.[8,9] The contributors to IB are many and intertwined, the usual suspects being cognitive overload, boredom, stress, fatigue, drugs, distractions, advanced age, preconception/expectation, and experience (too little or a lot).[8,9] Most of these contributors are prevalent in our specialty. In an earlier study, we showed that anesthesiologists performed poorly when compared with medical students (with little or no operating room experience and therefore no preconception or expectation) in noticing an unexpected but plausible intraoperative event.[10]

We hypothesized that age/experience, restfulness, and previous exposure to simulation education are some of the parameters potentially affecting IB in the anesthetic/surgical setting.

[A] *National Geographic.* Brain Games: A Double Dutch. Available from URL: https://www.youtube.com/watch?v=iiEzf3J4iFk (accessed May 2024).

METHODS

Based on previous work by our group,[10] we asked anesthesiologists to watch an attention-demanding four-minute video (Electronic Supplementary Material eVideo) of a simulated trauma patient undergoing an emergency exploratory laparotomy for intra-abdominal hemorrhage under general anesthesia. We told participants that it was a test of vigilance and, without the term IB ever mentioned, we asked them to record "each and all" abnormalities they noticed in the video. We specifically instructed participants not to communicate (by any means, including sharing notes) among themselves and at any time during the video. The Figure shows a still frame of the video depicting the operating room environment with the anesthetized patient at the centre, as well as standard monitors showing parameters typically monitored intraoperatively, i.e., ventilation parameters (top monitor: peak airway pressure, positive end-expiratory pressure, minute volume, tidal volume, sevoflurane concentration, inspired fraction of oxygen, respiratory rate, etc.) and vital signs (bottom monitor: electrocardiogram, heart rate, invasive and non-invasive blood pressure, central venous pressure, oxygen saturation, end-tidal carbon dioxide, and esophageal temperature). The conversation between the surgeon, anesthesiologist, and operating room nurse was typical during the simulated video, which also included discussion around excessive blood loss requiring blood transfusion. Notably, we appropriately translated the video so that all participants watched it in their native language. The *expected/common* events during the simulated scenario included several vital parameters that trended down to a nadir or up to a peak and stayed there until the end of the video: hypotension (blood pressure nadir of 64/35 mm Hg), tachycardia (heart rate peak of 156/min), hypoxia (oxygen saturation nadir of 87%), and hypothermia (temperature nadir of 34.1 °C). There were two *unexpected*/*rare* events: the patient turning their head (which was plausible due to the low depth of anesthesia in a patient with hypotension) over a ~45° range and back over a 25-second interval at the second minute and once again at the third minute; and a loosely connected central venous pressure line continuously leaking a small amount of blood starting at two minutes 18 seconds and continuing until the end of the video (lasting one minute 42 seconds). Both unexpected events were displayed prominently in the foreground. Participants *anonymously* and *independently* recorded the abnormal events noticed using a blank sheet of paper (as opposed to having items for participants to check off). Our primary outcome was the comparative proportion of participants noticing the expected *vs* unexpected events. Secondary outcomes were the proportions of expected and unexpected events according to age group, self-perceived restfulness (no specific restfulness scale was used; instead, restfulness was measured based on the participants' subjective feeling of whether [yes/no] they felt rested that day, regardless of the cause), and prior exposure to simulation education.

With institutional ethics committee approval from all participating centres (Queen's University, Kingston, ON, Canada; McMaster University, Hamilton, ON, Canada; University of Toronto, Toronto, ON, Canada; Pamela Youde Nethersole Eastern Hospital, Hong Kong; and São Paulo Federal University, São Paulo, Brazil), we recruited a convenience sample of 288 consenting participants during scheduled events. We performed no *a priori* sample size calculations. All participants viewed the video *once* before a regularly scheduled weekly teaching round session (Kingston, Hamilton, Toronto, and Hong Kong) or before several sessions in a paid simulation course (São Paulo; each participant attended one session). The time of the day when such rounds took place was not controlled or recorded. Non-anesthesiologists were excluded from the analysis.

We analyzed the data (noticing or not noticing the events) using the Chi square or Fisher's exact test as appropriate depending on cell sizes. We pre-specified a *P* value of 0.05 as the cut-off point for statistical significance. Nevertheless, since we performed a substantial number of comparisons, a Bonferroni correction should be applied. For approximately 35 comparisons, the criterion for statistical significance would be $P < 0.0014$. Nevertheless, this can be overly conservative within the context of smaller studies and can lead to a higher rate of false negatives. For this reason, we chose not only to note this but also to provide the actual *P* values to allow the reader to interpret them accordingly.

The protocol of this project had not been preregistered, and the data analysis and statistical plan were written after accessing the collected data.

This report adheres to the Strengthening the Reporting of Observational Studies in Epidemiology Statement guidelines for cohort studies.

RESULTS

There were 288 participants, of which eight were excluded after data collection as these individuals were non-anesthesiologists, leaving 280 sets of data for analysis. All participating anesthesiologists submitted their data sheets. Table 1 shows the geographic distribution of the participants and their age statistics. The gender distributions were male:female:not stated = 154:122:4. The cohort was relatively young, with the largest group (47%) being between 30 and 39 years of age (Table 2).

Significantly fewer participating anesthesiologists across all ages noticed either or both of the two unexpected/rare events when compared with the four expected/common events (Tables 2, 3, and 4).

When we examined the overall cohort for differences between age groups in noticing expected/common events, the P value for the overall Chi square test was 0.02. The < 30-years-old cohort had the lowest proportion of failure to notice these events when compared with all the other age groups ($P = 0.006$, 0.002, 0.03, and 0.02 when compared with the 30–39, 40–49, 50–59, and 60–69-years-old groups, respectively). All other comparisons were $P > 0.3$. For the unexpected/rare events, the P value for the overall Chi square test was 0.28. The < 30-years-old cohort performed better at noticing these events than the 40–49-years-old age group did ($P = 0.04$). All other comparisons were $P > 0.2$. Nevertheless, because multiple comparisons were used, as per *post hoc* Bonferroni correction for 35 comparisons, only P values < 0.0014 should be considered statistically significant for the intergroup comparisons (*cf*. Methods).

Regarding the effect of simulation training, ten participants were excluded as they did not state whether they had had prior exposure to simulation education, leaving 270 participants for analysis. Prior simulation education did not affect the proportion of misses for the unexpected/rare events but was associated with statistically significantly fewer misses for the expected/common events (Table 3).

For restfulness, eight participants were excluded as they did not state whether they were well rested or not, leaving 272 participants for analysis. There were no differences between those who felt rested and those who did not feel well rested (Table 4).

DISCUSSION

Our results show that anesthesiologists of all ages may be less capable of noticing unexpected/rare events, even when in plain view—a hallmark of IB. The alternative (expected) stimuli included parameters in the context of emergency surgery with significant blood loss. Participating anesthesiologists were likely primed to anticipate the expected (tachycardia, hypotension, hypoxia, and hypothermia) events.

It is possible that in our simulation younger participants were more eager and compliant. While the gradual upward bias (Table 2) in missing unexpected/rare and expected/common events with increasing age was not a surprise, the improvement in performance in the highest age group in noticing the two unexpected/rare events was unexpected. Reasons for aging physicians to underperform include being less up-to-date, having a slower reaction time, and having less endurance,[11–13] none of which were realistically tested in our setting, during which relaxed participants gathered to complete an anonymous test while watching a four-minute simulation video. Furthermore, the video included no controversial issues and did not require up-to-date knowledge. Increased experience, on the other hand, might have meant that older anesthesiologists had "seen it all" and were less likely to miss unexpected/rare events. Alternatively, having familiarity with trauma laparotomy and the expected changes in vital signs may have allowed them to look for other abnormalities. In previous psychology experiments, such as the one involving basketball passing,[7] older participants missed the gorilla more. Nevertheless, age did not influence susceptibility to IB in simulated distracted driving.[6] A meta-analysis on expertise (a surrogate marker for age) and IB found only a weak correlation.[14]

Our finding that prior simulation training was associated with improved performance (Table 3) must not be invoked as proof that simulation reduced IB. Indeed, as far as noticing the two unexpected/rare events, it had no effect. Perhaps most simulations do not incorporate rare events such as the ones we used. Moreover, watching a video and completing a questionnaire anonymously is less stressful than performing during hands-on simulation exercises, making previous practices less relevant. Furthermore, simulation may be merely a surrogate marker for age, as the youngest anesthesiologists may be the most likely to have had simulation experience.

Our finding that the restful state had no bearing on performance is not surprising. Watching a four-minute simulation video and providing answers anonymously was unlikely to have unmasked the effects of fatigue.

We did not compare performances between trainees and certified specialist anesthesiologists. Instead, we used age because we felt that performance and cognition do not make a quantum change before and after certification but, rather, are a continuum.

Data on IB in the anesthesiology literature is scant. Apart from our own previous work,[10] 70% of anesthesiologists failed to notice a high N_2O visual alarm in a simulated N_2O–O_2 pipeline supply cross-over study.[15] In an online survey, 699 anesthesiologists were asked to assess hypothetical day-surgery patients, including their chest *x-rays*, 665 of whom failed to notice the large gorilla head digitally added onto those *x-rays*.[16] In other health disciplines, 76.7% and 69.8% of advanced life support trainees and providers, respectively, failed to identify an O_2 line disconnect in a simulated cardiac arrest.[17] Drew *et al*. found that 20 of 24 radiologists did not see a large inserted image of a gorilla in computed tomography lung scans.[18] In a simulated laparoscopic nephrectomy, 54 of 73 surgeons failed to notice a sponge while seven failed to see a needle with suture that were digitally planted in the surgical field.[19] A 2016 study involving 71 nurses highlighted that IB was a salient but overlooked factor in failure-to-rescue events across the critical care spectrum.[20] In a study involving chiropractic students, 65% of fourth year students and 96% of second year students failed to see a gorilla head digitally implanted into a pelvic *x-ray*.[21]

Inattentional blindness studies in the field of psychology have relied heavily on simulation. We have likewise used simulation as it is exceedingly difficult to observe and quantify IB in the raw clinical setting. Our study therefore has a number of limitations. First, a simulated video inherently cannot fully duplicate real-life clinical situations. Insufficient realism might explain why there were such high misses even for such obvious problems of hypotension, tachycardia, hypoxia, and hypothermia. To improve realism, instead of having a gorilla walk through the operating room or digitally implanting a gorilla image, we chose two unexpected/rare but realistic events. Second, although we had requested for full attentiveness/participation of the participants immediately prior to rounds/courses, we could not monitor for strict adherence to the rules of no interpersonal communication. Third, there was also the possibility that some participants might have already read our previous article on IB.[10] Fourth, we did not use any restfulness/fatigue scale and did not quantify any previous simulation training as we wanted to not excessively delay rounds or the paid courses (and exhaust the goodwill of the organizers, presenters, and participants). Fifth, our convenience sample had a relatively young group of anesthesiologists, raising doubts about generalizability. That said, we found evidence for IB across all ages. Sixth, the sample size also might not have been powered to show the effect of age/experience on IB susceptibility. Last, we did not pre-register this observational study. Nevertheless, the main objectives of showing IB and the effect of age/experience on IB were adhered to.

CONCLUSION AND COMMENTS

Safe anesthesia requires SA, which is "the perception of elements of the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future."[22] This concept is incorporated in the crisis resource management objectives of the "National Curriculum for Canadian Anesthesiology Residency"[23] and the Canadian Anesthesiologists' Society "Guidelines to the Practice of Anesthesia,"[24] and is part of the CanMEDS 2015 medical expert competencies and milestones.[25] Inattentional blindness may compromise SA but is not mentioned in reports on SA in anesthesiology.[8,26] Most anesthesiologists have experienced IB (e.g., picking up the wrong drug even after reading the label; performing intraoperative echocardiography and not reacting to visual and/or audible (inattentional deafness) alarms).[27] Recognizing IB is the first step towards mitigating it, and inclusion of the term into the anesthesiology-SA lexicon among terms such as vigilance and distractions should help. As mentioned in the Introduction, the contributors to IB are numerous, and strategies to mitigate them should be explored. Some of these strategies are already in place. For example, having a second anesthesiologist in complex cases, multiple checks prior to transfusion and transplantation, pre-procedure checklist, avoiding fatigue and excessive multitasking, avoiding wherever feasible placement of drugs that look too similar near to one another, checking the labels before *and* after drawing drugs, labelled regional anesthesia lines, multiple monitor screens in the cardiac room, changing alarm tones (e.g., SpO_2), electronic charting, and less-complicated cases and fewer hours for aging anesthesiologists.

Our study is one of a few to introduce the concept of IB to the anesthesiology setting. In a simulated setting, we found that anesthesiologists missed a higher proportion of two unexpected/rare clinical events than four expected/common events, in keeping with the phenomenon of IB. An effect of age/experience on IB was not apparent in our relatively small and possibly underpowered study and deserves further investigation. Given the abundance of psychology literature strongly showing human susceptibility to IB, we have no reason to argue that our findings of anesthesiologists' susceptibility cannot be generalized. We hope readers will reflect upon their own medical errors and make the necessary adjustments to prevent them in the future. Being mindful of IB will help understand errors made, learn how to avoid them, and facilitate their future prevention through teaching and simulations that incorporate the concept.

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Table 1. Number of participants by centre and participant age.

	Hamilton	Hong Kong	Kingston	São Paulo	Toronto
Participants, *n*/total *N* (%)	38/280 (14%)	12/280 (4%)	23/280 (8%)	158/280 (56%)	49/280 (18%)
Age (years), mean (SD)	43 (14)	37 (11)	36 (9)	34 (8)	35 (6)

SD = standard deviation

Table 2. Participants missing unexpected/rare *versus* expected/common events.

Age (years) $N = 280$[a]	Unexpected/rare events Proportion missed (95% CI)[b]	Expected/common events Proportion missed (95% CI)[c]	P value[d]
< 30 (n = 79, 28%)	0.41 (0.33 to 0.48)	0.10 (0.07 to 0.13)	< 0.001
30–39 (n = 132, 47%)	0.49 (0.40 to 0.52)	0.26 (0.22 to 0.31)	< 0.001
40–49 (n = 38, 14%)	0.61 (0.50 to 0.72)	0.34 (0.26 to 0.41)	< 0.001
50–59 (n = 16, 6%)	0.56 (0.40 to 0.73)	0.34 (0.23 to 0.46)	0.04[f]
60–69 (n = 15, 5%)	0.43 (0.26 to 0.61)	0.35 (0.23 to 0.47)	0.44
P value[e]	0.28	0.02[f]	

Shown are the proportions, stratified by age, of 280 anesthesiologists who missed at least one of two unexpected/rare events (patient's head turning and/or central venous catheter leaking blood) and who missed at least one of four expected/common events (tachycardia, hypotension, hypoxemia, and/or hypothermia) in a video of a simulated trauma patient undergoing exploratory laparotomy for intra-abdominal hemorrhage. The reason why the denominators are 2 × n for unexpected/rare events is because each participant was counted twice, one for noticing the patient's head turning and one for noticing the catheter leaking blood. The same goes for the four expected/common events. Between-group P values for the unexpected/rare events ranged from 0.04 (< 30 *vs* 40–49 years-old) to 0.97 (< 30 *vs* 60–69 years-old); for the expected/common events, P values ranged from 0.002 (< 30 *vs* 30–39 years-old) to 0.95 (40–49 *vs* 60–69 years-old).

[a]Of the 288 individuals who participated, data from n = 8 participants were excluded as they were non-anesthesiologists.

[b]Based on a denominator of 2 × n.

[c]Based on a denominator of 4 × n.

[d]Chi square test for differences between unexpected/rare events and expected/common events.

[e]Chi square test for differences between age groups.

[f]While we pre-specified a *P* value of 0.05 as the cut-off point for statistical significance, a *post hoc* Bonferroni correction for 35 comparisons indicated a cut-off *P* value of 0.0014 (*cf*. Methods).

CI = confidence interval

Table 3. Association between participants' previous simulation training and missing notable events.

N = 280[a]	Unexpected/rare events Proportion missed (95% CI)[b]	Expected/common events Proportion missed (95% CI)[c]	P value[d]
Previous simulation training (n = 145, 52%)	0.47 (0.41–0.53)	0.20 (0.17–0.24)	< 0.001
No simulation training (n = 125, 45%)	0.48 (0.42–0.53)	0.26 (0.22–0.32)	< 0.001
P value[e]	0.50	0.03[f]	

Shown are proportions of anesthesiologists who missed at least one unexpected/rare event and at least one common event, stratified by presence/absence of previous simulation training. Unexpected/rare events were patient's head turning and/or central venous catheter leaking blood. Expected/common events were hypotension, tachycardia, hypoxemia, and/or hypothermia. Overall, the unexpected/rare events were missed more frequently than the common events. Simulation training had no effect on how often the unexpected/rare events were missed but was associated with fewer misses for the expected/common events.

[a]Of the 280 anesthesiologists who participated, n = 10 did not answer whether they had had prior simulation training.

[b]Based on a denominator of $2 \times n$.

[c]Based on a denominator of $4 \times n$.

[d]Chi square test for differences between unexpected/rare events and expected/common events.

[e]Chi square test for differences between previous simulation training *vs* no previous simulation training cohorts.

[f]While we pre-specified a *P* value of 0.05 as the cut-off point for statistical significance, a *post hoc* Bonferroni correction for all 35 comparisons in this study indicated a cut-off *P* value of 0.0014 (*cf*. Methods).

CI = confidence interval

Table 4. Association between participants' restfulness and missing notable events.

$N = 280$[a]	Unexpected/rare events Proportion missed (95% CI)[b]	Expected/common events Proportion missed (95% CI)[c]	*P* value[d]
Rested ($n = 173$, 62%)	0.47 (0.42–0.53)	0.23 (0.20–0.26)	< 0.001
Not rested ($n = 99$, 35%)	0.44 (0.37–0.51)	0.27 (0.23–0.31)	< 0.001
P value[e]	0.44	0.12	

Shown are proportions of anesthesiologists who missed at least one unexpected/rare event and at least one common event, stratified by whether they were rested or not. Unexpected/rare events were patient's head turning and/or central venous catheter leaking blood; expected/common events were hypotension, tachycardia, hypoxemia, and/or hypothermia. Overall, the unexpected/rare events were missed more frequently than the common events. A rested state had no effect on how often the rare and common events were missed.

[a]Of the 280 anesthesiologists who participated, $n = 8$ did not answer whether they were rested or not.

[b]Based on a denominator of $2 \times n$.

[c]Based on a denominator of $4 \times n$.

[d]Chi square test for differences between unexpected/rare events and expected/common events.

[e]Chi square test for differences between rested *vs* not rested cohorts.

CI = confidence interval

LEGENDS

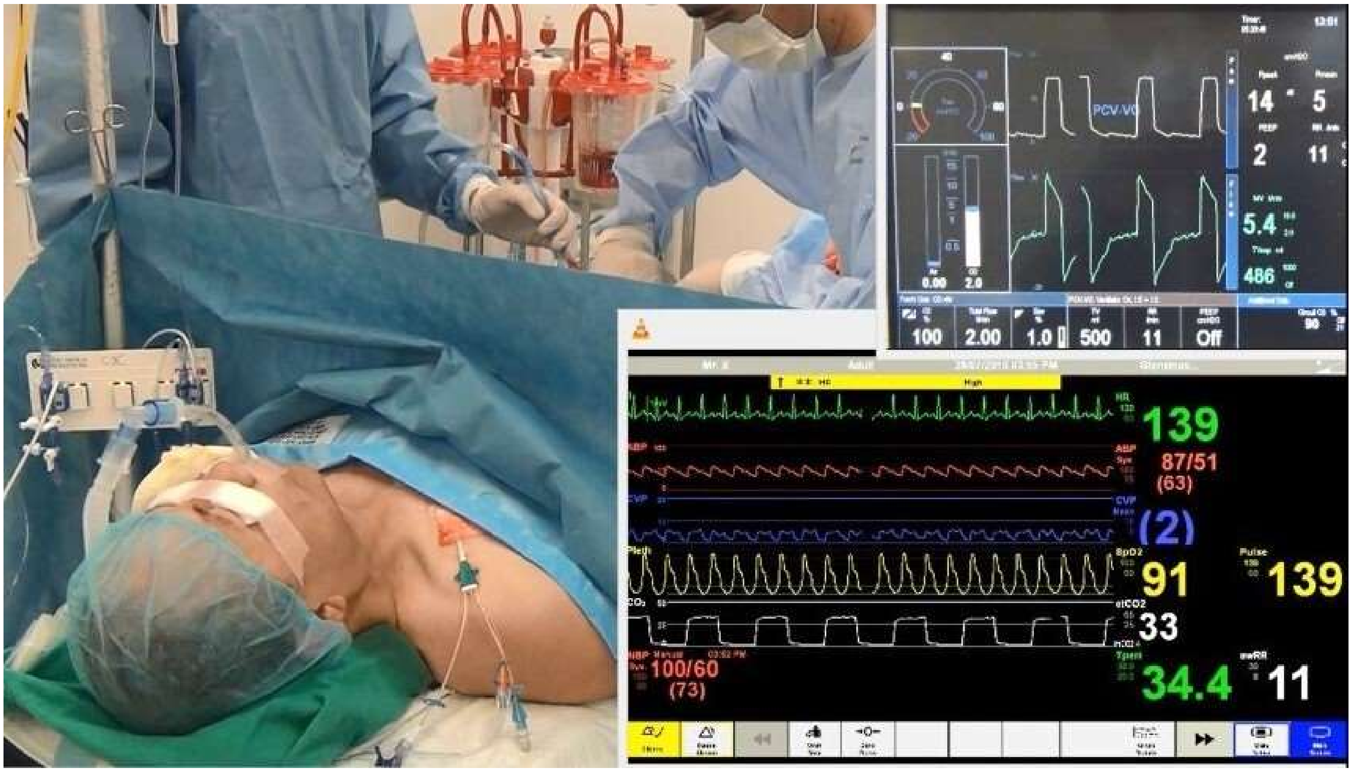

Figure. Still frame of the simulated video depicting the operating room environment with the anesthetized patient at the centre, and standard monitors showing parameters typically monitored intraoperatively, i.e., ventilation parameters (top monitor) and vital signs (bottom monitor).

Electronic Supplementary Material

eVideo. Video of a simulated trauma patient undergoing an emergency exploratory laparotomy under general anesthesia showing parameters typically monitored intraoperatively (ventilation parameters and vital signs) and containing four expected/common abnormalities (hypotension, tachycardia, hypoxia, hypothermia) and two prominently displayed unexpected/rare events (patient head movement and central venous catheter leaking blood).