



Clinical science

Vitreoretinal surgical performance after acute alcohol consumption and hangover

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ABSTRACT

Aim Routine alcohol testing of practicing physicians remains controversial since there are no uniform guidelines or legal regulations in the medical field. Our aim was to quantitatively study the acute and next-morning effects of breath alcohol concentration (BAC)-adjusted alcohol intake on overall simulated surgical performance and microtremor among senior vitreoretinal surgeons.

Methods This prospective cohort study included 11 vitreoretinal surgeons (>10 years practice). Surgical performance was first assessed using the Eyesi surgical simulator following same-day alcohol consumption producing a BAC reading of 0.06%–0.10% (low-dose), followed by 0.11%–0.15% (high-dose). Dexterity was then evaluated after a 'night out' producing a high-dose BAC combined with a night's sleep. Changes in the total score (0–700, worst–best) and tremor (0–100, best–worst) were measured.

Results Surgeon performance declined after high-dose alcohol compared with low-dose alcohol (-8.60 ± 10.77 vs -1.21 ± 7.71 , $p=0.04$, respectively). The performance during hangover was similar to low-dose alcohol (-1.76 ± 14.47 vs -1.21 ± 7.71 , $p=1.00$, respectively). The performance during hangover tended to be better than after high-dose alcohol (-1.76 ± 14.47 vs -8.60 ± 10.77 , $p=0.09$, respectively). Tremor increased during hangover compared with low-dose alcohol (7.33 ± 21.65 vs -10.31 ± 10.73 , $p=0.03$, respectively). A trend toward greater tremor during hangover occurred compared with high-dose alcohol (7.33 ± 21.65 vs -4.12 ± 17.17 , $p=0.08$, respectively).

Conclusion Alcohol-related decline in simulated surgical dexterity among senior vitreoretinal surgeons was dose-dependent. Dexterity improved the following morning but remained comparable to after low-dose alcohol ingestion. Tremor increased during hangover compared with same-day intoxication. Further studies are needed to investigate extrapolations of these data to a real surgical environment regarding patient safety and surgeon performance.

INTRODUCTION

Alcohol's toxic, psychoactive and dependency-inducing effects are well-described and generally

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Although the negative repercussions of alcohol consumption are well-described and generally familiar to physicians, there is no legal regulation stipulating a desired level of safety regarding medical activities, so routine alcohol testing by practicing physicians remains controversial.

WHAT THIS STUDY ADDS

⇒ Alcohol consumption adjusted by breath alcohol concentration negatively impacts in a dose-dependent manner the simulated surgical dexterity among senior vitreoretinal surgeons. Although dexterity improves the next morning, surgeons' hand tremor increases during the hangover phase compared with same-day intoxication.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The findings suggest that senior vitreoretinal surgeons should consider abstaining from alcohol consumption on the same day and limiting alcohol consumption on the day before surgery to avoid a potential impact on surgical performance.

familiar to physicians.¹ Liberal use of alcohol occurs worldwide, as alcohol has become a part of business socialisation. Broad societal acceptance of alcohol may contribute to overlooking its various remote effects. Notable among these is *veisalgia*, a little-used medical term for headache, fatigue, nausea, vomiting and concentration difficulties that follow excessive alcohol use, more familiarly known as hangover.

In the USA, driving with a blood alcohol concentration (BAC) of 0.08% or higher is illegal; for drivers younger than 21, the legal limit is lower, with state limits ranging from 0.00% to 0.02% BAC.² In Brazil, the 'dry law' stipulates no tolerance (BAC=0).³ Moreover, US Federal Aviation Administration regulations require pilots to not ingest alcoholic beverages within 8 hours of joining



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a flight crew; pilots must undergo alcohol testing on request.⁴ Similar to driving or aviation, where public safety is an issue, the surgical environment is also a high-skill discipline that is unforgiving of mistakes. However, routine alcohol testing by physicians remains controversial.

Although the repercussions of alcohol consumption may be more consequential for physicians, there is no legal regulation stipulating a desired level of safety regarding medical activities.^{5,6} A large national study involving 7197 American surgeons found that 15.4% met the diagnostic criteria for alcohol abuse/dependence according to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition,⁷ a higher prevalence of alcohol-related disorders than in the general population, in which 13.9% of adults older than 18 years meet the criteria for current alcohol use disorder, according to the third National Epidemiologic Survey on Alcohol and Related Conditions.⁸ These data suggest that surgeons likely underestimate the amount of alcohol they routinely consume and the performance impairment associated with this exposure. This trend is especially true during symptomatic veisalgia, in which residual impairment remains after supposed recovery from the acute effects of drinking the previous day. In this context, the surgical simulator approach is a logical and ethical strategy to analyse performance in adverse conditions, such as after alcohol exposure, without compromising patient safety.

Vitreoretinal surgery is among the most demanding disciplines regarding dexterity and cognitive skills in the microsurgical arena and is a suitable setting to study the potentially deleterious effects of acute alcohol ingestion and hangover on microsurgical performance. We reported previously that surgical dexterity diminished dose-dependently after acute alcohol intake among novice vitreoretinal surgeons compared with other external exposures.⁹ This result raised the question of whether our findings can be extrapolated to expert surgeons and if the alcohol-deleterious effects persist the day after exposure. The current study used a vitreoretinal surgical simulator to objectively analyse the overall performance and microtremor of senior vitreoretinal surgeons exposed to acute BAC-adjusted alcohol consumption and the potential persistent next-day effects.

MATERIALS AND METHODS

Design and participants

In this prospective cohort study, 11 senior surgeons with more than 10 years of surgical experience were recruited from July to September 2022 among the staff members of the Retina Division from the Universidade Federal de São Paulo, Brazil. This was a self-controlled study in which each participant underwent an initial surgical simulation to establish a personal baseline performance that subsequently was compared with their own results following alcohol consumption. To mitigate the influence of the intrinsic learning curve on the simulator performance, participants must have had previous experience with the Eyesi posterior segment module for at least 12 hours within the month preceding the initiation of data collection. This ensured proficiency and allowed a focused evaluation of the primary variables related to alcohol intake rather than the learning process. Exclusion criteria included long-term medication use, any medical condition, a daily alcohol intake exceeding three standard drinks¹⁰ or a habitual daily caffeine consumption exceeding two 8-ounce cups. Furthermore, caffeine or propranolol intake was not allowed on the days of the study protocol. Pregnant women were excluded.

Study protocol

The Eyesi simulator V.3.4.2 (Haag-Streit Group, Koeniz, Switzerland) evaluated microsurgical skills. This high-fidelity virtual-reality tool replicates real intraocular surgical environments with familiar sensory perceptions. It offers a vitreoretinal module with tasks from basic to entire procedures. Abstract tasks use geometric objects for training aspects, while surgical modules show realistic interactions with tissues. A course consisting of four abstract exercises and three surgical procedures was created, which included a navigation module (level 3/4), anti-tremor module (level 5/7), bimanual standard (level 1/5), bimanual scissors (level 1/5), posterior hyaloid detachment (level 1/6), epiretinal membrane (level 1/6) and inner limiting membrane peeling (level 2/6). The evidence of validity for all selected modules and metrics used had been previously investigated in the published literature to measure outcomes central to the objectives of our study.^{9, 11–16} By the end of the course, the performance metrics included the Eyesi-generated total surgical score (range, 0–700, worst–best), and tremor amount (range, 0–100, best–worst).

A calibrated Food and Drug Administration-approved AT6000 Professional Breathalyzer (Greenwon Technology, Taiwan) was used to determine the BAC, assuming a blood:breath ratio of 2 300:1,¹⁷ and alcohol ingestion was guided prospectively by applications of the Widmark model¹⁸ to calculate the BAC. Participants were instructed not to drink alcohol for 24 hours before each day of data collection and to eat regular meals throughout the day. During the study, one or more of the investigators observed subjects at all times and were responsible for repeatedly quantifying the participants' BAC.

Regarding the relationship between BAC and physiological and behavioural effects, sociability, judgement, attention, memory, motor coordination and reaction time tend to decrease from 0.06% to 0.10% BAC; while drowsiness, deterioration of some visual functions and impaired balance can occur at 0.11% to 0.15% BAC.¹⁹ The above-mentioned alcohol ranges were adopted for the present protocol. The Widmark modelling formula¹² was applied prospectively for BAC determination. The constant was calculated using the average of the approaches presented by Forrest²⁰ and Seidl *et al.*²¹ A final alcoholic titration with additional wine intake or increased time before the surgical simulation test was adopted whenever necessary to reach the target BAC.

The study protocol was conducted over two non-sequential days of analysis. A safe place in the laboratory was provided for participants to rest after each protocol day, and subjects were allowed to leave only after regaining sobriety. Moreover, no volunteers participated in patient care on the study night or the following day. During study period 1, to mitigate potential bias due to unquantifiable personal factors that could be potentially associated with performance variations, each surgeon underwent a baseline surgical simulation to establish a baseline for self-comparison with their post-alcohol performance data. Subsequently, surgeons ingested an increasing BAC-adjusted dose of red wine, followed by a breathalyser reading 30 min after beverage ingestion to guarantee sufficient time for alcohol to reach peak plasma concentration of 0.06%–0.10% (low-dose alcohol).²² On achieving the desired BAC, each participant underwent the first performance assessment using the predefined simulator course. An increasing weight-adjusted alcohol intake was administered to achieve a BAC of 0.11%–0.15% (high-dose alcohol). Similarly, the BAC was assessed after a 30-minute interval, and the second simulator sequence was performed (figure 1).

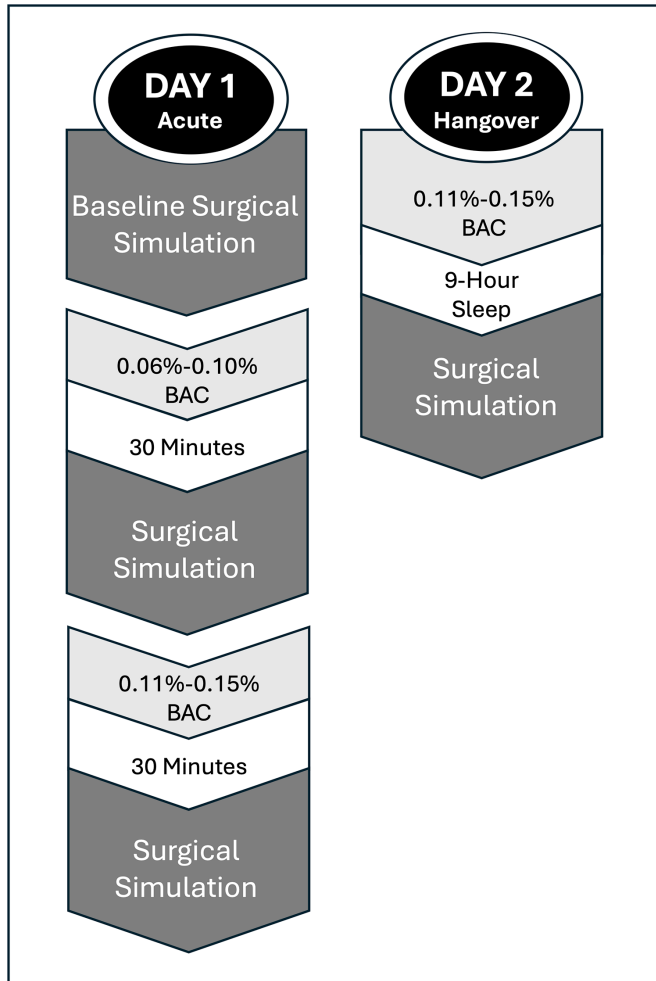


Figure 1 Study flowchart illustrating the order of interventions. BAC, breath alcohol concentration.

During study period 2, participants' surgical performance was evaluated the next morning after a supervised night of alcohol consumption. To closely replicate real-life night-out conditions, senior surgeons were invited to a restaurant dinner and required to drink a set amount of alcohol to reach a BAC of 0.11%–0.15%. All subjects were then transported to a private room in the dry laboratory, where they were allowed to start sleeping at midnight and awakened at 06:00. Surgical simulations were performed the following morning beginning at 07:00 to achieve a 9-hour interval between alcohol intake and testing (figure 1). The total time in bed and the interval between alcohol consumption and performance assessment agreed with previously published studies.^{23–26} A breathalyser measured the BAC immediately before the 09:00 assessment.

Statistical analysis

The sample size calculation was performed using PASS V.14 (NCSS Statistical Software, Kaysville, Utah, USA). With a sample size of 11 participants and a 30-point modification in the Eyesi-generated score, we calculated a power of 80% at a 5% significance level. Data were analysed with SPSS V.22 (IBM Corp., Armonk, New York, USA) and STATA V.17 (StataCorp LLC, College Station, Texas, USA), and the tests were two-sided, with $p < 0.05$ indicating significance. Comparisons of simulation performance data between the self-controlled baseline and post-alcohol consumption at different times of the study day were

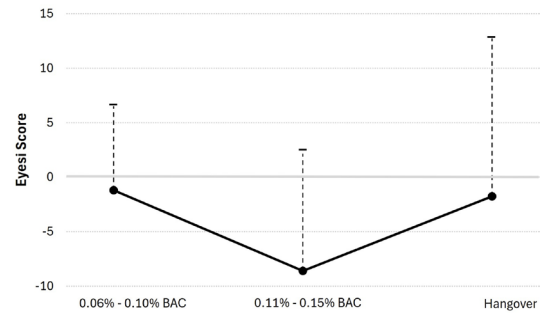


Figure 2 Eyesi-generated score after breath alcohol concentration (BAC)-adjusted dose of alcohol, self-controlled by the baseline performance before alcohol intake (bullet: mean, dotted line bars: SD). Performance declined following ingestion of high-dose alcohol (0.11%–0.15% BAC) compared with low-dose alcohol (0.06%–0.10% BAC) (-8.60 ± 10.77 vs -1.21 ± 7.71 , $p = 0.04$). While surgeons exhibited improved performance the morning after alcohol consumption (hangover) compared with exposure to high-dose alcohol, this trend did not reach statistical significance (-1.76 ± 14.47 vs -8.60 ± 10.77 , $p = 0.09$).

conducted, and the relative delta was calculated as the difference between the Eyesi-generated data before and after weight-adjusted alcohol ingestion; the value obtained was divided by the data obtained before alcohol intake (baseline), allowing for positive or negative relative delta results. Linear regression with random effects was performed to analyse the time-dependent variable, followed by Bonferroni's multiple comparison test. Quantitative variables are expressed as the means \pm SD.

RESULTS

Eleven surgically active senior vitreoretinal surgeons (73% men; mean age, 45.73 ± 5.33 ; mean body mass index, 24.90 ± 2.89 kg/m²; surgical practice time, 15.45 ± 4.48 years; number of pars plana vitrectomies performed per month, 16.27 ± 12.37) were recruited, all of whom were right-handed; none was excluded. All individuals consumed alcohol socially less than once weekly and always less than three standard drinks/day. No unexpected adverse effects were reported or observed for any surgeon after alcohol ingestion. All surgeons reported an uninterrupted night's sleep for the hangover protocol (study period 2) the morning after the night out. At the time of the testing period the following day, 9 hours later, all participants had a BAC of zero measured by the breathalyser.

The Eyesi-generated score indicated impairment as senior surgeons ingested a progressively higher BAC-adjusted dose of alcohol; the experts performed worse after ingesting high-dose alcohol compared with low-dose alcohol (-8.60 ± 10.77 vs -1.21 ± 7.71 , $p = 0.04$, respectively) (figure 2). We detected no difference in simulated surgical dexterity delta in the comparison between the hangover scenario with low-dose alcohol intake (-1.76 ± 14.47 vs -1.21 ± 7.71 , $p = 1.00$, respectively). Furthermore, although surgeons performed better the morning after alcohol consumption compared with high-dose alcohol exposure, the study was not powered to detect this emerging trend (-1.76 ± 14.47 vs -8.60 ± 10.77 , $p = 0.09$, respectively).

Regarding delta tremor, we observed a higher tremor rate during the hangover period compared with after low-dose alcohol ingestion (7.33 ± 21.65 vs -10.31 ± 10.73 , $p = 0.03$, respectively) (figure 3). A trend toward greater tremor during hangover was seen compared with acute high-dose alcohol intake (7.33 ± 21.65 vs -4.12 ± 17.17 , $p = 0.08$, respectively).

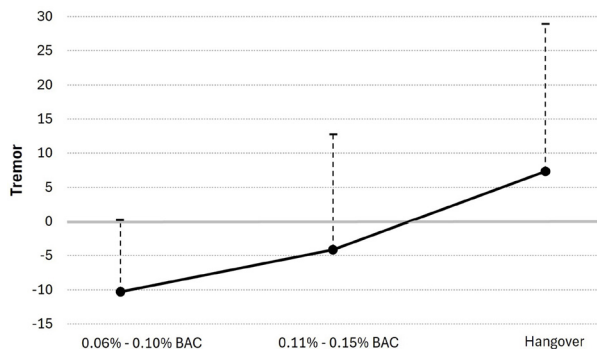


Figure 3 Eyesi-generated tremor data after breath alcohol concentration (BAC)-adjusted dose of alcohol, self-controlled by the baseline performance before alcohol intake (bullet: mean, dotted line bars: SD). A higher tremor rate was demonstrated during the hangover phase compared with low-dose alcohol ingestion (0.06%–0.10% BAC) (7.33 ± 21.65 vs -10.31 ± 10.73 , $p=0.03$, respectively), with a tendency towards increased tremor observed during hangover compared with acute high-dose alcohol consumption (7.33 ± 21.65 vs -4.12 ± 17.17 , $p=0.08$, respectively). Notably, expert surgeons exhibited no statistically significant variation in delta tremor assessment between low and high alcohol doses (-10.31 ± 10.73 vs -4.12 ± 17.17 , $p=0.77$, respectively).

Finally, the expert surgeons showed no significant change in delta tremor assessment when the low and high-alcohol doses were compared (-10.31 ± 10.73 vs -4.12 ± 17.17 , $p=0.77$, respectively).

DISCUSSION

This self-controlled, prospective cohort study demonstrated progressive impairment in overall simulated surgical dexterity among senior vitreoretinal surgeons after increasing BAC-adjusted acute alcohol intake. Simulated surgical performance the day after consumption of high-dose alcoholic beverages showed improved surgical dexterity compared with acute high-dose intoxication. However, the dexterity remained impaired at a level not significantly different from acute low-dose alcohol ingestion. Notably, the tremor rate increased during the hangover period compared with tremor during BAC-adjusted same-day alcohol intoxication.

Alcohol is a central nervous system depressant that reduces cognitive and motor performance. It is widely consumed as part of social activity or to modulate stress. In excess, alcohol-related disorder is a leading risk factor in disease burden worldwide.¹ Acute alcohol intoxication may result in fatal and nonfatal injuries; chronic alcohol consumption is linked to hypertensive heart disease, cirrhosis and several cancers.²⁷ The current literature lacks a comprehensive quantitative measurement of alcohol's indirect effect on patient health, such as that occurring as a result of its impact on surgeon dexterity, both during intoxication and the hangover period, in the ophthalmology field.

Adatia *et al*²⁸ conducted a study using a similar protocol in which they correlated simulated surgical scores on a virtual retina simulator and the effects of acute alcohol intake in a population of ophthalmology residents, retina fellows and surgical retina staff. However, they did not extend the data collection and analysis to the next-day alcohol-related (hangover period) impact on performance. The group found a non-significant 5.2% decrease in performance ($p=0.5$) 45 min after two tequila shots. Our study corroborates these earlier observations. Kirby *et al*²⁹ published a similar study in the ear, nose and throat surgical field; they also used increasing doses for acute alcohol exposure

and found a reduction in the simulated surgical ability of 7.25% after three glasses of wine and 19.25% after six glasses among participants of varying surgical experience. The absence of BAC standardisation and the heterogeneity of recruited participants were limitations of those studies. By addressing those considerations, we aimed to contribute data to support safety guidelines for surgeons on alcohol consumption according to individual metabolic differences.

Huizinga *et al*³⁰ conducted a BAC-adjusted study and reported a decreased tendency in laparoscopic performance in dexterity, force and motion with a 0.06% BAC; however, a significant effect was detected only for the distance traversed by the left instrument. Our results agreed with those findings, and statistical significance could potentially have been achieved if they had used a higher alcohol intake in their protocol. Following this idea, also in the laparoscopic field, Mohtashami *et al*³¹ and Dorafshar *et al*²⁴ adopted the legal intoxication rate (BAC $\geq 0.08\%$) to assess simulated skills. Both found acute alcohol-induced impairment of simulated laparoscopic surgery. Our study was further standardised, because it assessed the impact on fine motor skills after weight-adjusted low- and high-dose alcohol consumption and established a specific BAC range, rather than just a minimal intoxication cut-off point to be hit. Dorafshar *et al*,²⁴ in particular, extrapolated their analysis to a 10-hour period after drinking started, following a night's sleep and found no hangover effect on performance the next morning.

Veisalgia, commonly known as 'hangover', is defined as a feeling of malaise that occurs when the BAC returns to zero. Despite the widely held belief that an alcohol hangover might adversely impact professional behaviour, surprisingly little is known about this relationship.³² In contrast to our results, Van Dyken *et al*²⁵ reported worse accuracy during intracorporeal suturing using a laparoscopic model the morning after 0.076% BAC mean alcohol intake. However, the outcomes might have been biased due to a subjective performance analysis, which classified data results as accurate versus inaccurate according to whether the needle passed through a black dot drawn on the vessel model. Gallagher *et al*²³ also found a decrease in the error score the morning following a supervised alcohol-exposure dinner. However, because the subjects were not required to drink a set alcohol amount but were instead instructed to drink freely until they felt intoxicated, their hangover outcomes were not standardised and not comparable to our study. The current study has outcomes that parallel the findings of Guillaume,²⁶ who detected no difference in next-morning performance using a neurosurgical simulator in a group of trainees and faculty following a social gathering where an average BAC of 0.14% was measured.

Alcohol withdrawal is characterised by a constellation of unpleasant physical and psychological symptoms that can occur several hours or a few days after the last drink when ethanol is absent in plasma. Tremor is a classic physical withdrawal symptom.³³ It occurs due to an unbalanced overdrive state that stimulates sympathetic nervous system activity while alcohol is metabolised.³⁴ Tremor is seen in both hangover and withdrawal syndromes, and the current thinking suggests that hangovers may be a mild manifestation of withdrawal syndrome in occasional alcohol users.³⁵

Kruisselbrink *et al*³⁶ specifically examined a population of 12 non-physician female university students to assess the effect of six bottles of beer (mean BAC=0.106%, minimal BAC=0.087%, maximal BAC=0.131%), which is equivalent to the BAC-adjusted alcohol exposure in our protocol. The results indicated that, compared with a control condition, alcohol did

not significantly compromise physiological/physical functioning but triggered morning-after hangover symptoms, including self-reported hand tremor. Given the collective background reported here, we were motivated to explore the possibility further and conduct a hangover study among surgeons to objectively quantify intraoperative hand tremor using a virtual-reality simulator that mimics real-life experience. Surprisingly, even though the hangover did not impact the performance score in our study, surgeons' hand tremor was objectively higher the next morning, as quantified by the Eyesi simulator. It is noteworthy that the present study showed measurable impairment in the next-morning surgical performance caused by a night out, raising the troubling fact that surgical performance can be adversely affected despite a null BAC. However, the impact of greater tremor, secondary to alcohol ingestion the night before, on overall surgical skills appears to be partly offset when occurring in experienced surgeons.

To our knowledge, this is the first study to evaluate the effects of BAC-adjusted alcohol consumption on simulated surgical dexterity in a homogeneous sample of ophthalmologists. This study had some limitations. First, the findings were obtained in a homogenous population of senior vitreoretinal surgeons with more than 10 years surgical practice. Further protocols should assess whether these outcomes translate to surgeons of other experience levels. Second, there were restrictions in extrapolating our results to a real operating-room scenario. In this context, while there are obvious ethical and safety issues inherent in performing procedures by surgeons who are acutely intoxicated, we are not providing guidance here. This work suggests that significant alcohol consumption the night before surgery may have measurable negative effects on parameters of surgical performance, such as tremor. Finally, the total score improved the next morning compared with performance after consuming high doses of alcohol the same day. The opposite phenomenon occurred regarding tremor compared with the same two moments, so that tremor increased in hangover in relation to high-dose alcohol intake. Although this study was adequately powered to detect the immediate performance change and persistent next-day impact of BAC-adjusted acute alcohol ingestion among senior vitreoretinal surgeons, the significance of these findings may require future studies with a larger sample.

In conclusion, we showed that the overall simulated surgical performance of senior vitreoretinal surgeons is dose-dependently impaired during BAC-adjusted progressive alcohol exposure and improves the next morning. One aspect generally considered important to microsurgical performance in vitreoretinal surgery is tremor, which increases during the next-day hangover period. At this time, our findings might provide guidance for microsurgeons who consume alcohol on a schedule that would put them in the operating theatre during that period when hangover symptoms are present. BAC-adjusted alcohol intake levels and exposure time before the surgical procedure may be used to avoid surgery during hangovers. Further work is required to validate these findings and to understand important parameters that may impact future guidance on alcohol and the performance of surgery.

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Competing interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Review board at the Universidade Federal de São Paulo (Reference number: 0464/2017) and the study adhered to the Declaration of Helsinki. Participants gave informed consent to participate in the study before taking part.

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Data availability statement Data are available upon reasonable request. All data relevant to the study are included in the article or uploaded as supplementary information.

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