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The Haemostasis Traffic Light, a user-centred coagulation management tool for acute bleeding situations: a simulation-based randomised dual-centre trial

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Abstract: The Haemostasis Traffic Light is a cognitive aid with a user-centred design to enhance and simplify situation awareness and decision-making during peri-operative bleeding. Its structure helps to prioritise therapeutic interventions according to the pathophysiology and the severity of the bleeding. This investigator-initiated, randomised, prospective, international, dual-centre study aimed to validate the Haemostasis Traffic Light by adapting it to the local coagulation protocols of two university hospitals. Between 9 January and 12 May 2020, we recruited 84 participants at the University Hospital Zurich, Switzerland, and the Italian Hospital of Buenos Aires, Argentina. Each centre included 21 resident and 21 staff anaesthetists. Participants were randomly allocated to either the text-based algorithm or the Haemostasis Traffic Light. All participants managed six bleeding scenarios using the same algorithm. In simulated bleeding scenarios, the design of the Haemostasis Traffic Light algorithm enabled more correctly solved cases, OR (95%CI) 7.23 (3.82–13.68), $p < 0.001$, and faster therapeutic decisions, HR (95%CI) 1.97 (1.18–3.29, $p = 0.010$). In addition, the tool improved therapeutic confidence, OR (95%CI) 4.31 (1.67–11.11, $p = 0.003$), and reduced perceived work-load coefficient (95%CI) -6.1 (-10.98 to -1.22), $p = 0.020$). This study provides empirical evidence for the importance of user-centred design in the development of haemostatic management protocols.

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The Haemostasis Traffic Light – a user-centred coagulation management tool for acute bleeding situations: a simulation-based randomised dual-centre trial

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Summary

The Haemostasis Traffic Light is a cognitive aid with a user-centred design to enhance and simplify situation awareness and decision making during perioperative bleeding. Its structure helps to prioritise therapeutic interventions according to the pathophysiology and the severity of the bleeding. This investigator-initiated, randomised, prospective, international, dual-centre study aimed to validate the Haemostasis Traffic Light by adapting it to the local coagulation protocols of two University hospitals in different parts of the world. Between January 9 and May 12, 2020, we recruited a total of 84 participants at the University Hospital Zurich in Switzerland and the Italian Hospital of Buenos Aires in Argentina. Each centre included 21 resident and 21 staff anaesthesiologists. Participants were 1:1 randomised to either the text-based algorithm or the Haemostasis Traffic Light. All participants managed six bleeding scenarios using the same algorithm. In simulated bleeding scenarios, the design of the Haemostasis Traffic Light algorithm facilitated more correct (odds ratio 7.23, 95% CI 3.82 to 13.68, $p < 0.001$) and faster (hazard ratio 1.97, 95% CI 1.18 to 3.29, $p = 0.010$) therapeutic decisions. In addition, the tool improved therapeutic confidence (OR 4.31, 95% CI 1.67 to 11.11, $p = 0.003$) and reduced perceived workload (coefficient -6.1, 9% CI -10.98 to -1.22, $p = 0.020$). This study provides empirical evidence for the importance of user-centred design in the development of haemostatic management protocols.

Introduction

Acute haemorrhage during surgery increases postoperative morbidity and mortality [1] and remains the leading cause of death worldwide after trauma [2]. Its successful management is challenging for the physicians involved [3]. Understanding causes of bleeding can be complicated, as they are often multifactorial. There are different methods to diagnose the coagulation disorders and different ways to treat them. The best haemostatic management approach is still a matter of highly controversial debate [4]. Both the Helsinki Declaration on Patient Safety and the European guideline on management of major bleeding following trauma encourage institutions to establish local, evidence-based protocols for the treatment of massive haemorrhage [5,6]. Recent treatment guidelines for actively bleeding patients include laboratory values and viscoelastic tests [6,7]. There is evidence that human factor aspects influence the outcome of the bleeding patient [8,9]. Hence, we aim to focus our efforts on developing strategies to enable care providers to achieve their best performance in such critical situations.

In this paper, we evaluate a coagulation algorithm concept called “The Haemostasis Traffic Light” [10]. This tool intends to simplify coagulation management through situational awareness-oriented presentation of essential information. This structured algorithm integrates a clinical classification system that categorises the bleeding patient’s current condition according to the model of a traffic light – a simple and ubiquitous symbol. This study aimed to validate the Haemostasis Traffic Light by adapting it to the local coagulation protocols of two University hospitals in different parts of the world. We evaluated how physicians perform using the assigned algorithm in simulated bleeding scenarios. We hypothesised that the Haemostasis Traffic Light increases physicians’ performance and their confidence in solving a given coagulation management task. Furthermore, we assumed that it would reduce the perceived workload.

Methods

The Haemostasis Traffic Light concept serves as a cognitive aid with a user-centred design. It aims to enhance situation awareness and simplify decision making during perioperative bleeding. Its structure helps to prioritise therapeutic interventions according to the pathophysiology and the severity of the bleeding. The user makes decisions based on clinical judgement, as well as predefined laboratory and point of care testing (i.e., rotational thromboelastometry) thresholds. At an early stage, the physician classifies the bleeding situation based on its clinical severity into one of the three traffic light colours being red, yellow, and green. Within the line of the selected light, the algorithm is read from left to right, following four specific steps with different therapeutic priorities. The content of each line adheres to the local coagulation algorithm of the respective University hospital.

The first step includes therapeutic interventions that must be carried out without delay. Examples are interventions that address haemostatic preconditions such as patient warming and normalising serum calcium levels. The second step asks the care provider about the presence of any drugs that could impair haemostasis and the need for reversal. The third step contains interventions that care providers may perform simultaneously and as needed to support clot formation and stability. The final fourth step is only present in yellow and green light situations and refers to therapeutic interventions that one should only perform if the patient continues to bleed after completing the previous steps. All lights initially seek to optimise haemostatic preconditions and to reverse anticoagulation if needed. In a red-light situation, which is clinically regarded as severe, i.e., at risk of or in cardiac arrest, the operator manages the clot properties (stability, strength, and thrombin generation) simultaneously. The yellow light focuses first on clot stability and strength, while the green light prioritises stability and fibrinogen contribution to clot strength (Fig. 1).

This was an investigator-initiated, randomised, prospective, international, dual-centre study comparing two different algorithm designs for perioperative bleeding management in hypothetical situations. We conducted this study between January 2020 and May 2020 simultaneously at the University Hospital Zurich in Switzerland and the Italian Hospital of Buenos Aires in Argentina. Both centres are tertiary care facilities with vast experience in acute bleeding management. The leading ethics committee in Zurich waived ethical approval as the study does not fall within the scope of the human research act. The ethics committee responsible for the centre in Buenos Aires issued a separate statement and approved the study protocol. Each participant gave written informed consent for data collection prior to participation in the study.

Each centre included 21 resident and 21 staff anaesthesiologists, making a total of 42 participants per centre and 84 in total. We selected them randomly according to their availability in daily clinical practice, regardless of gender, age, or knowledge in coagulation management. For this study, we excluded all physicians who had already participated in a pilot study, which we conducted during October 2019 in Zurich.

The participants were required to manage simulated bleeding scenarios using either their own institutional, text-based coagulation management protocol or the respective Haemostasis Traffic Light algorithm. We adapted the content of the Haemostasis Traffic Light to match the local text-based algorithms. This procedure allowed us to investigate the concept without having differences in therapeutic options. In Supporting Information 1, we provide all used coagulation management protocols. We performed a balanced randomisation scheme of 1:1 (text-based group versus Haemostasis Traffic Light group) in each centre. Further, we stratified the randomisation by job description (staff or resident anaesthesiologist) using a computerised number generator (Randomizer.org). We prepared six different intraoperative bleeding scenarios, each with a case description, corresponding laboratory values and ROTEM result outputs. The randomisation also

included the scenario order. To conceal the allocation sequence from those who recruited the participants, an independent third party prepared numbered envelopes containing all the study information. In Supporting Information 2, we provide all scenarios including their correct answers.

At the beginning of the study, we conducted a brief demographic survey. Each participant stated their professional experience in anaesthesia, and the number of ROTEM interpreted per year on a continuous rating scale from 0 to more than 100. Further, the participants rated their skills in handling ROTEM results on a continuous rating scale from 0, labelled “novice”, to 100, labelled “expert.” We then gave the participants an envelope containing the randomly assigned algorithm and the six cases in paper form and in a randomised order. Before starting to manage those cases, we showed the participants a video explaining the structure of the assigned algorithm. We provide both instructional videos in Supporting Information 3. The participants had to manage each of the six cases using the same assigned coagulation algorithm. We gave a maximum time limit of three minutes per scenario and asked them to enter their therapeutic recommendations into an iPad (Apple Inc., Cupertino, CA, USA) as quickly and precisely as possible. We collected data using the app iSurvey (Harvest Your Data, Wellington, NZ) [11]. All scenarios required multiple therapeutic interventions. We presented the given answer options as checkboxes in multiple choice format. After managing each case, the participants had to rate their therapeutic confidence. Furthermore, we evaluated perceived workload after each scenario using a modified version of the raw NASA (National Aeronautics and Space Administration) Task Load Index questionnaire. This subjective tool asks the user to rate six different, workload associated sub dimensions ranging from 0 (very low workload) to 100 (very high workload). In the validated raw NASA Task Load Index questionnaire, the overall score constitutes the arithmetic mean of all six sub scores [12-15]. In this study, we removed the physical demand question on the workload questionnaire as given tasks did not require physical effort.

We defined the number of correctly solved scenarios as the primary outcome. If the participants chose all correct and no wrong treatment options proposed by the coagulation algorithm, we considered a scenario correctly solved (binary as correct/incorrect). As secondary outcomes, we investigated time to decision in seconds, the number of correct and incorrect decisions, reported therapeutic confidence on a four-point Likert scale (0 = very unconfident, 1 = unconfident, 2 = confident, 3 = very confident), and perceived workload according to the raw NASA Task Load Index score.

To give a descriptive overview of the data, we presented medians and interquartile ranges (IQR) for continuous data and numbers and percentages for categorical data. We used mixed models with a random intercept for each participant to take into account that measurements from the same person are not independent. For the primary outcome regarding the correctly solved scenarios, we used a mixed logistic regression model. Further, we investigated the number of correct and incorrect answers using a mixed Poisson regression model where the maximum number of correct answers per scenario is included as an offset. The time to decision was measured in seconds and censored after 180 seconds. For the analysis, we applied a mixed Cox regression model for censored times. Regarding confidence as a secondary outcome, we generated a binary variable with the categories “confident” and “not confident”, each of which comprised the two respective answers from the original variable (very unconfident and unconfident, or, very confident and confident). We then assessed this variable using a mixed logistic regression model. To examine the perceived workload, we calculated a linear mixed regression model. We included the algorithm variable, the centre, the job variables, the respective scenario, and the case sequence as covariates for all outcomes in all models.

In a pilot study at the University Hospital Zurich, we calculated an odds ratio (OR) of 12.6 for the comparison of the Haemostasis Traffic Light with the text-based algorithm. Using a significance level of 5% and a power of 90%, this led to a calculated minimal sample size of 15 participants per group (i.e., 30 participants in total) to show a difference of this size. However, the size of this assumed odds

ratio seemed very large and might have resulted from the small sample size of the pilot study. For this reason, we decided to use a smaller and hence more conservative odds ratio of 6.0 for our final sample size calculation. Hence, for a 5% significance level and a 90% power, a sample size of 42 persons per group (i.e., 84 in total) was needed.

We analysed all data using R Version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria). A p-value of less than 0.05 was considered to indicate statistical significance. To create figures, we used GraphPad Version 8.4.3 (GraphPad Software Inc., California, USA).

Results

Between January 9 and May 12 2020, we recruited a total of 84 participants, both study centres recruited 21 residents and 21 staff anaesthesiologists. Participants were 1:1 randomised to either the text-based algorithm or the Haemostasis Traffic Light. All participants managed six bleeding scenarios using their allocated algorithm. This resulted in 252 cases solved with each algorithm. We did not exclude any data. The physicians had an overall experience median (IQR [range]) of 5.0 (2.0 – 10.0 [0.0 – 30.0]) years. We provide a more detailed description of the study and participant characteristics in Table 1.

All following models included the centre, job, scenario and case order as influencing variables. Regarding the primary outcome correctly solved scenarios, mixed logistic regression yielded 7.23 times higher odds of correctly solving a case when the Haemostasis Traffic Light algorithm was used (mean OR (95% confidence interval [CI]) of 7.23 (3.82 to 13.68), $p < 0.001$). There was no evidence for a difference between the centres ($p = 0.77$), but moderate evidence for an effect of the job description. A staff physician's odds of correctly managing a case were, on average, 2.33 times higher than a resident's (OR of 2.33 (1.29 to 4.2), $p = 0.005$). In the same model, there was strong evidence for an effect of the order of the cases, with a reported OR of 1.23 (1.07 to 1.41), $p = 0.003$. In Figure 2, we provide boxplots illustrating the decision-making analysis. Regarding the number of correct answers, mixed Poisson regression yielded very strong evidence with a 22% increase in the number of correct answers if the Haemostasis Traffic Light was used (rate ratio (95% CI) of 1.22 (1.13 to 1.31), $p < 0.001$). Further, the same model yielded a 49% reduction in the number of wrong answers when the Haemostasis Traffic Light was used (rate ratio of 0.49 (0.34 to 0.72), $p < 0.001$).

We assessed time to decision-making using mixed Cox regression models, which showed moderate to strong evidence for an effect of the Traffic Light algorithm with an estimated hazard ratio (HR) (95% CI) of 1.97 (1.18 to 3.29), $p = 0.010$. Also, there was weak evidence for the effect of the centre with a

HR of 0.64 (0.39 to 1.07), $p = 0.090$] and no evidence for an effect of the job description ($p = 0.67$). Furthermore, with each additional scenario the probability of doing everything in time was 35% higher (HR of 1.35 (1.26 to 1.43), $p = 0.001$).

Confidence was assessed using a mixed logistic regression model. There was very strong evidence for an effect of the Haemostasis Traffic Light with an OR of 4.31 (1.67 to 11.11), $p = 0.003$ compared with the text-based algorithm (Fig. 2). There was no evidence between the centres regarding the confidence ratings ($p = 0.31$), but moderate to strong evidence for an effect of the job description. A staff physician's odds of being confident was 3.32 times as high as a resident's, with a reported OR of 3.32 (1.3 to 8.53), $p = 0.010$. Further, there was strong evidence for an effect of the order of the cases. With each additional case, the odds of being confident increased by a factor of 1.34, with an OR of 1.34 (1.11 to 1.61), $p = 0.002$.

In the analysis of the perceived workload, mixed linear regression yielded a moderate effect of the Haemostasis Traffic Light with a coefficient (95% CI) of -6.1 (-10.98 to -1.22), $p = 0.020$ (Fig. 2). There was a strong evidence for a difference between the centres. The Italian Hospital of Buenos Aires reported a mean overall workload score of 8.38 points lower than the University Hospital Zurich (coefficient of -8.38 (-13.27 to -3.5), $p = 0.001$). There was no difference in perceived workload between both job descriptions ($p = 0.38$). Each additional case reduced the raw NASA Task Load Index scores by 0.93 points (coefficient of -0.93 (-1.39 to -0.47), $p < 0.001$).

Discussion

This study analysed the therapeutic decisions of 84 physicians on coagulation management after solving six simulated bleeding scenarios. We found that participants assigned to the Haemostasis Traffic Light algorithm solved more cases correctly and had fewer incorrect answers than physicians using the local, text-based algorithm. Further, the participants reported higher confidence in their therapeutic recommendation and less perceived workload with a higher probability of solving a case in time when using the Haemostasis Traffic Light. In all analyses, we used different mixed models adjusted for possible confounding factors.

The odds of correctly solving a simulated bleeding case were around seven times higher if using the Haemostasis Traffic Light compared with a text-based algorithm. At the same time, the number of correct answers increased by 22%, and the incorrect ones decreased by almost 50% without a significant difference between both study centres. The Haemostasis Traffic Light effect was maintained despite the participant's job and centre. This indicates that regardless of the clinical experience both staff and residents benefited from using the Haemostasis Traffic Light. It seems especially noteworthy in this regard that none of the participants had seen the Haemostasis Traffic Light algorithm before attending the study. These results underline the importance of the design of institutional protocols. In developing the Haemostasis Traffic Light, we incorporated principles of situational awareness-oriented, user-centred design, aiming to transfer the required information to the decision-makers as quickly as possible and with the lowest possible cognitive demand [16]. In the field of anaesthesiology, such user-centred aids have already demonstrated that they can help improve situational awareness and performance [17-21]. Our results now further support these findings. As they were not related to local phenomena, this emphasises the usefulness of the Haemostasis Traffic Light concept as a generalisable tool.

The Haemostasis Traffic Light applies the nearly universally used triple colour code familiar to most people [22,23]. The colour scheme of green, yellow, and red reflects the clinical classification system regarding the severity of the bleeding situation. The icons used in the Haemostasis Traffic Light have the same colours as the ones presented by the diagnostic tests (for example, EXTEM CT, INTEM CT, etc.), aimed to facilitate the identification of diagnostic criteria in it. With its drop-down menu-like style of therapeutic interventions in the form of a checklist, the Haemostasis Traffic Light design aims to reduce fixation errors in these stressful bleeding situations by providing a graphical overview of the available choices. Our results support that this design not only helps perform the appropriate haemostatic procedures but also reduces the implementation of inappropriate ones. The Haemostasis Traffic Light provides caregivers with a graphical mental model of the interventions that one should apply in a given situation. Using a text-based algorithm, each physician must create the mental model required to successfully resolve a situation in their mind, assembling it from text fragments.

Participants who used the Haemostasis Traffic Light not only managed more cases correctly but also managed them faster. Our analyses showed moderate to strong evidence that Haemostasis Traffic Light users had twice the chance in solving a case in time compared to the text-based users, independent of their job. Studies have repeatedly shown that timely administration of coagulation management improves time to effective haemostasis control and patient outcomes in the clinical setting [24-26].

Mixed logistic regression yielded very strong evidence with around four times higher odds of being confident solving the bleeding cases using the Haemostasis Traffic Light compared with the text-based algorithm. There is evidence that a person with high confidence in their situational awareness will more likely achieve a good result than a person with equal understanding but less confidence [16,27]. The unconfident individual will more likely behave protectively and choose to gather more information. He will be less likely to react and therefore be less effective. Further, our analysis yielded no significant difference between centres but moderate to strong evidence when comparing jobs. Staff

physicians reported significantly higher odds of therapeutic confidence compared to the residents. Furthermore, with each additional case, the odds of being confident also significantly increased. This is all in line with our expectations. Previous studies provided evidence that training in critical incident management improves both confidence and decision-making ability [28]. More professional experience allows grouping signs and symptoms into patterns through acquired knowledge and skills [29]. This results in subconscious decisions and learned automatic behaviours that ultimately lead to efficient evaluation and management of crises [30,31]. However, overconfidence can lead to physicians not considering other possible diagnoses and thus impair their ability to make decisions [32]. By improving the therapeutic confidence of resident physicians, the Haemostasis Traffic Light may enhance their ability to effectively challenge erroneous decisions and eventually prevent harm to the patient [33].

Acute bleeding situations represent a highly stressful environment requiring many rapid and complex decisions in a short time. The physician in charge should endeavour to maintain a high level of understanding of the situation, and tailor specific tasks for appropriate personnel. In this environment, having a resource that keeps workload low and frees cognitive resources for other tasks is essential. The NASA Task Load Index represents the most widely accepted questionnaire to measure subjective workload [34,35]. Many areas, including the health care sector, have validated its results [15,36-40]. In this study, both staff and resident physicians reported significantly less workload when solving the simulated bleeding scenarios while using the Haemostasis Traffic Light compared to the respective text-based algorithm. We assume that the user-friendly design of the Haemostasis Traffic Light facilitated cognitive processing [41]. The clearly arranged presentation of the same information may have led to the lower perceived workload. Psychological stress reduces cognitive capacity and impairs the ability to make decisions [16,42]. Further, a convenient design leads to cognitive ease, which ultimately increases user acceptance of the application [43]. In stressful bleeding situations, any aid that spares mental resources should be encouraged.

In this study, our clinical scenarios included various medical specialties, such as trauma, cardiovascular surgery, obstetrics, and major visceral surgery. This posed a particular challenge for the participants, who may not be familiar with each specialty's nuances of the individual bleeding setting. Nonetheless, the effect of the Haemostasis Traffic Light algorithm persisted across all scenarios. Hence, we have reason to believe this concept can be successfully adapted across different surgical specialties and bleeding severities.

This study has limitations. We prepared all simulated, intraoperative bleeding cases in paper format adapted directly from real clinical practice with particular laboratory values and ROTEM outputs. This may not reflect the temporal relations, complexity, and severity of a real-life haemorrhage situation. Further studies in a high-fidelity simulation or a real clinical environment setting are required to investigate whether the benefits associated with the Haemostasis Traffic Light persist in these environments. Moreover, we provided the participants with a multiple-choice list of possible therapeutic interventions. This might have simplified the decision-making process and influence our results underestimating the Haemostasis Traffic Light effect. Finally, we investigated coagulation management performance in large tertiary care facilities with considerable experience in haemostatic resuscitation. Performance might differ in smaller health care facilities.

However, this study also possessed particular strengths. Sample size calculation adequately powered all analyses. The international, dual-centre design reduced local bias and emphasised the universality of the Haemostasis Traffic Light concept. Further, the between-subjects comparisons reduced the chance of cross-contamination between algorithms, and the randomisation with allocation concealment decreased selection bias. Hence, this allowed for a better comparison of the two coagulation management algorithms.

In simulated bleeding scenarios, the design of the Haemostasis Traffic Light algorithm improved the correctness and duration of the therapeutic decision making of physicians in two hospitals located in different parts of the world. In addition, the tool improved therapeutic confidence and reduced perceived workload. This study provides empirical evidence for the importance of user-centred design in the development of haemostatic management protocols. Further studies may test this concept in a clinical setting and is the usefulness of the tool for medical education.

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Competing Interests

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Germany, Pharmacosmos A/S, Holbaek, Denmark, Photonics Healthcare B.V., Utrecht, Netherlands, Pierre Fabre Pharma, Alschwil, Switzerland, Roche Diagnostics International Ltd, Reinach, Switzerland, Roche Pharma AG, Reinach, Switzerland, Sarstedt AG & Co., Sevelen, Switzerland and Nümbrecht, Germany, Schering-Plough International, Inc., Kenilworth, New Jersey, USA, Tem International GmbH, Munich, Germany, Verum Diagnostica GmbH, Munich, Germany, Vifor Pharma, Munich, Germany, Vienna, Austria and Villars-sur-Glâne, Switzerland, Vifor (International) AG, St. Gallen, Switzerland, Zuellig Pharma Holdings, Singapore, Singapore. DWT is one of the designated inventors of the technologies Visual Patient and Visual Clot, for which the University of Zurich holds various patents and trademarks. There are cooperation and licensing agreements with Philips Medizin Systeme Böblingen GmbH, Böblingen, Germany, Koninklijke Philips N.V., Amsterdam, The Netherlands, Philips Research/Philips Electronics Nederland B.V., Eindhoven, The Netherlands and Instrumentation Laboratory Company/Werfen Corporation, Bedford, MA, U.S.A / Barcelona, Spain. Under these agreements, DWT receives royalties. DWT also received travel support for consulting Instrumentation Laboratory, Bedford, MA, U.S.A. DWT declares a substantial financial interest in the success of the technologies he co-invented, as well as in the success of Koninklijke Philips N.V., Amsterdam, The Netherlands, and its subsidiaries and Instrumentation Laboratory Company/Werfen Corporation, Bedford, MA, U.S.A., and its subsidiaries. Author AK received honoraria for lecturing from Bayer AG Switzerland. The other authors do not have any conflicts of interests.

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Tables and Figures

Table 1: Study and participant characteristics. Values are number (proportion) or median (IQR [range]).

USZ, University Hospital Zurich; HIBA, Hospital Italiano de Buenos Aires.

Total of participants; n	84	
Different bleeding scenarios; n	6	
Total of simulated cases; n	524	
	Text-based algorithm	Haemostasis Traffic Light
Anaesthesia experience; y	5.5 (3.0 – 9.8 [0.0 – 27.0])	5.0 (2.0 – 9.8 [0.0 – 30.0])
ROTEM interpreted per year; n	35.0 (5.8 – 53.5 [0.0 – 100.0])	24.0 (6.2 – 48.2 [0.0 – 100.0])
Self-rated ROTEM skills (0 = novice to 100 = expert)	37.5 (15.0 – 57.8 [0.0 – 100.0])	40.0 (18.5 – 64.8 [0.0 – 100.0])
Staff anaesthesiologist; n	21 of 42 (50%)	21 of 42 (50%)
Resident anaesthesiologist; n	21 of 42 (50%)	21 of 42 (50%)
Gender; female	19 of 42 (45.2%)	15 of 42 (35.7%)
USZ; number of cases	120 of 252 (47.6%)	132 of 252 (52.4%)
HIBA; number of cases	132 of 252 (52.4%)	120 of 252 (47.6%)

Figure 1: Design of the Haemostasis Traffic Light. The five steps are described (0 to 4) from left to right.

Each step has its rationale and an example of an intervention (dotted line) to show how the Haemostasis Traffic Light concept may be adapted to institutional coagulation management protocols.

Figure 2: Comparison of the decision making, time to decision, diagnostic certainty and perceived workload using the Haemostasis Traffic Light versus the text-based coagulation algorithm. The box plots represent medians with interquartile range. The whiskers are 95% confidence interval and the points are the respective data points. TLX, Task Load Index.

Supporting information

Supporting Information 1: Coagulation management protocols in each centre.

Supporting Information 2: All coagulation scenarios including their correct answers.

Supporting Information 3: Instructional videos for the coagulation management algorithms.