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Article

Crisis Resource Management in the Delivery Room. Development of Behavioral Markers for Team Performance in Emergency Simulation

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Abstract: Human factors are the most relevant issues contributing to adverse events in obstetrics. Specific training of Crisis Resource Management (CRM) skills (i.e., problem solving and team management, resource allocation, awareness of environment, and dynamic decision-making) are now widespread and are often based on High Fidelity Simulation. In order to be used as a guideline in simulated scenarios, they need to be translated into specific and observable behavioral markers. To this purpose, we developed a set of observable behaviors related to the main elements of CRM in the delivery room. The observational tool was then adopted in a two-days seminar on obstetric hemorrhage where teams working in obstetric wards of six Italian hospitals took part to simulations. The tool was used as guide for the Io and as a peer-to-peer feedback. It was then rated for its usefulness in facilitating the reflection upon one's own behavior, its ease of use, and its usefulness for the peer-to-peer feedback. The ratings were highly positive, around 4 in a 5-point scale. The CRM observational tool is therefore a useful, quick and easy solution to facilitate the debriefing, the peer-to-peer feedback and, most of all, the transfer of safe behavior from simulation to everyday practice.

Keywords: Crisis Resource Management; obstetric hemorrhage; non-technical skills; High Fidelity Simulation; delivery room

1. Introduction

The number of adverse events in obstetrics is dramatically high due to the complexity of the operational environment. Up to 10% of obstetric cases are characterized by injuries or even death of the patient due to factors that could have been prevented or mitigated [1, 2]. Among these contributing factors, poor communication and ineffective teamwork account for the vast majority of adverse outcomes [3]. Since the seminal book *To err is human* [4], we know that clinical errors are mainly due to team, system or process failure, rather than individual mistakes; as a consequence, any training oriented to reduce clinical errors should address interprofessional teams [5]. Working as a team requires, probably more than working at the individual level, the proper integration of three kinds of skills: (i) professional skills, i.e. the set of technical knowledge and competencies that are typical of each profession; (ii) cognitive skills, i.e., the capacity to understand the situation and decide accordingly; (iii) interpersonal skills, i.e., the capacity to communicate, coordinate, and cooperate as a team. These three skills are mutually interdependent for a safe management of the clinical situation: a lack in one or two of them will result in poor management and a high potential for error and adverse outcomes.

In recent years, a growing body of evidence has demonstrated the importance of the cognitive and interpersonal skills for the clinical practice and how a structured intervention in the training and analysis of clinical processes in terms of cognitive and interpersonal skills can lead to better teamwork and a reduction of adverse patient outcomes [6, 7, 9]. This structured approach has been labeled Crisis Resource Management (CRM) and has been initially developed in aviation as Crew resource Management, it has been recently adapted for Anesthesiology [10, 11], and has then been applied to many other medical domains [7]. Key CRM skills embrace problem solving and team management, resource allocation, awareness of environment, and dynamic decision-making [12]. These areas encompass a more detailed range of skills that vary in their number, according to specific domain they are applied to and their level of generality. One common and widely cited list of key CRM skills is the following [13]:

1. Know the environment
2. Anticipate and plan
3. Call for help early
4. Exercise leadership and followership with assertiveness
5. Distribute the workload
6. Mobilize all available resources
7. Communicate effectively —speak up
8. Use all available information
9. Prevent and manage fixation errors
10. Crosscheck and double-check (never assume anything)
11. Use cognitive aids
12. Re-evaluate repeatedly
13. Use good teamwork—coordinate with and support others
14. Allocate attention wisely
15. Set priorities dynamically

High Fidelity Simulation (HFS) is one of the most effective methods to train CRM skills [14, 15]. It can reproduce critical situations upon which practitioners can have a proper debriefing aimed at fostering metacognition on technical, cognitive, and interpersonal skills that are implicitly performed during everyday activity but that need a clear and conscious focus in order to be trained and promoted [5]. The real challenge in training CRM principles with HFS is to address specific and observable behavior, setting clear criteria for what is considered a good or poor performance [15, 16]. For this reason, each skill has to be described in terms of a specific behavioral marker representing what can be observed in a simulated scenario or in real life.

The points listed in the CRM skills are good guidelines for the effective management of a critical situation, however they do not provide enough support for the debriefing after the simulation for two main reasons. First of all, some of the points are very broad and generic (e.g., "Exercise leadership and followership with assertiveness") and they need a clear and unambiguous definition in order to be used as a criterion for performance observation. Ratings and comments may be very heterogeneous about the same behavior, if the observers do not have a clear and specific definition of assertive leadership and followership. Secondarily, some points are not easily observable because they are related to mental processes (e.g., "Allocate attention wisely"). A proper behavioral marker should explicit an observable action, the explicit result of that very mental process. For these reasons, the CRM points should be accompanied by a specific and observable set of behavioral markers.

At the best of our knowledge, in literature about CRM there is only one study where behavioral markers are applied to obstetric teams involved in emergency simulations [14]. However, this study reports the adoption of a rating form where the CRM key skills were not explicitly overlapping the list provided by Gaba and colleagues and, most of all, it reported only a checklist of actions to be achieved, without the description of a poor performance, as typical of many observational tools concerning non-technical skills. Other studies were based on the CRM principles for teamwork in

the delivery room [17-20], but we did not find evidence for the adoption of a structured observational form of specific behavioral markers. This method was adopted in [21], but the observational form, called MINTS-DR (Multi-professional Inventory for Non-Technical Skills in the Delivery Room) was concerning non-technical skills in the delivery room in general, and not explicitly focused on the CRM. In addition, the number of behavioral markers listed in MINTS-DR was quite high, resulting in a time-consuming tool to use during the debriefing. In order to fill this gap and provide a quicker tool for peer-to-peer observation, we decided to develop an observational tool with specific behavioral markers for team performance in a delivery room simulated emergency inspired by the CRM key points. We wanted this tool to be quick to administer, easy to understand also for practitioners inexperienced in human factors, useful for fostering metacognition. In addition, we wanted to use this tool not only as a guide for the debriefer after the simulation, but also as a checklist for observers taking part to the training session and observing their colleagues involved in the simulation. As demonstrated in a previous study [22], a proper debriefing after the simulation can foster CRM skills not only for those who took part to the scenario, but also for the observers. The observer will therefore become an active agent of the simulation. The learning objectives would change: not only training practitioners to technical and non-technical skills, not only training them to metacognition and reflection upon one's own actions, but also training them to peer-to-peer observation and feedback in everyday operations. We argue that a non-judgmental peer-to-peer feedback is a good opportunity to learn CRM skills, promote metacognition and reflection upon one's own practice. An observational tool based on specific and observable behavioral markers could therefore help both who took part to the simulation, and the colleagues observing the scenario. Moreover, the list of CRM skills should provide both positive and negative examples, in order to help the practitioner to have a range within locate the behavior. The list should be easy to administer, to understand, and most of all, easy to keep in mind while working or when discussing about an event.

2. Materials and Methods

The development of the observational tool followed several steps divided into two main moments: tool design and tool testing. We first listed the 15 points of CRM, as provided by Gaba and colleagues [13], together with an extensive description of each of them. For each point, we reported the behavioral markers we already developed in the MINTS-DR [20], a set of non-technical skills for anesthetists, gynecologists, midwives, and assistants working in the delivery room. We distributed across the 15 CRM points the best matching behavioral markers, accounting for skills like leadership, communication, situation awareness, decision making, task management, and teamwork.

After that, we conducted a series of meetings with anesthetists, gynecologists, midwives, and assistants in order to define the specific behavioral marker for each CRM point. Each point was first defined according to Gaba and colleagues [13], in order to help practitioners understand its core meaning. We then showed the participants videos of simulates scenarios of peripartum hemorrhage in order to familiarize them with the CRM points. Once described the simulations in terms of CRM principles, we engaged practitioners in a brainstorming to provide the best descriptive, observable, and specific behavior for each one of the 15 points, thinking about the activity in the delivery room. We tried to limit the number of items and identify the most descriptive behavioral marker for each point, because we wanted the tool to be rapid and suitable for debriefing after the scenario. We split some CRM points only when the point was double (e.g., Exercise leadership and followership with assertiveness), or was too general to be covered with only one item (e.g., Communicate effectively).

Each behavioral marker was then defined both in positive and in negative terms, i.e., mentioning the behavior representing the best implementation of the CRM skill, and the behavior representing an extremely poor or even absent skill. The two behavioral descriptions were then located at the extremes of a four-point scale. The reason for this choice is to be found in the need for observers to have a clear anchor to understand and assess the observed behavior, with the two extreme points representing the best and worst condition, and the two inner points representing an acceptable and a scarce behavior. We decided to avoid items referring to actions that may have not

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been observed and therefore not being applicable to the current scenario (e.g., "if the treatment is not effective, the team can change the therapeutic plan"), for two main reasons. First of all, in our experience, the conditional expression is not easy to understand and to observe: for instance, some could not notice that a treatment is not effective and therefore some observers would inaccurately rate the behavior while other would mark the item as "not applicable". Secondarily, we wanted to concentrate on behaviors that will certainly occur in an emergency situation.

In addition, we decided to interpret each CRM point taking into account the team as a whole. Therefore, the behavioral markers we provided could be applicable to any professional working in the delivery room. Since some of the CRM points are quite generic (e.g., "Communicate effectively"), some of them had more than one behavioral marker. The final list of items is presented in table 1.

Table 1. Sample of behavioral markers for CRM in the delivery room (for the complete list see the Supplementary material)

Stem	Positive anchor	Negative anchor
Know the environment		
Resources (tools, personnel, materials)…	are found and used when necessary	are found after looking around or after asking where they were
Anticipate and plan		
The potential clinical complications are discussed...	in advance	when they happen or are not discussed at all
Call for help early		
The request of medical and/or organizational resource supply is made...	as soon as the team members realize a problem has occurred	some after the problem has occurred
Exercise leadership and followership with assertiveness		
In the team…	someone is coordinating, assigning tasks, declaring the decisions	nobody is coordinating, assigning tasks, declaring the decisions
In the team…	the leader encourages and supports the opinions of the other colleagues	the others' opinions are ignored, trivialized or discouraged
The team members…	share opinions and personal points of view	perform silently what required and do not express any personal opinion

After the development of the behavioral markers list, we also produced a sheet with short descriptions of the 15 CRM points. We ended up with a booklet (see the supplementary material) that was given to each participant to the second stage of the research: the testing of the tool.

The tool testing involved six teams working in the obstetric ward of six different Italian hospitals (N = 52). Each team was composed by anesthetists (N = 14), gynecologists (N = 12), neonatologists (N = 1), midwives (N = 14), nurses (N = 5), and the risk manager (N = 6). All of them were informed about the research, they signed a consent form to explicitly take part to the study and allowed the researchers to video-record them during the simulations. The teams underwent a

two-days seminar about the implementation of the guidelines of the National Institute of Health about prevention and treatment of post-partum hemorrhage. Specifically, the topics treated during the seminar were:

- Guidelines about obstetric hemorrhage
- Clinical and organizational proactive approach to hemorrhage
- Clinical management of obstetric hemorrhage
- Clinical procedures for emergency management of obstetric hemorrhage
- The role or risk management for the proactive approach to risks
- The method of Significant Event Audit
- Non-technical skills and Crisis Resource Management
- Obstetric hemorrhage high fidelity simulations

The seminar took place at the CISEF Gaslini, the International Centre for Studies and Training Germana Gaslini of Genoa. The simulator was the high fidelity NOELLE® S574.100 Tetherless Maternal and Neonatal Birthing Simulator. The scenarios were designed as the cases summarized in Table 2.

Table 2. The three scenarios used in the simulation

Main clinical issue	Participants	CRM points addressed
Post-partum hemorrhage due to cotyledon retention	• 2 Midwives • Gynecologist • Nurse anesthetist • Anesthetist • Relative (confederate)	• Anticipate and plan • Call for help early • Use good teamwork • Distribute the workload
Post-partum hemorrhage due to uterine atony	• 2 Midwives • Gynecologist • Nurse anesthetist • Anesthetist • Husband (confederate)	• Anticipate and plan • Use good teamwork • Set priorities dynamically • Re-evaluate repeatedly • Crosscheck and double-check
Uterotonic drug management during peripartum hemorrhage	• 3 Midwives • Gynecologist • Anesthetist • Midwife handing-over (confederate) • Relative (confederate)	• Anticipate and plan • Call for help early • Use good teamwork • Distribute the workload • Mobilize all available resources • Use all available information • Prevent and manage fixation error

Each scenario lasted from 10 to 15 minutes and all the six teams took part to at least one of the simulations. All the participants (except the risk managers) were involved in at least one scenario. While the team was performing the simulation, the other teams observed the scenario using the CRM observational tool. The observers followed the scenario on wide screen in a separate room, in order to not disturb the simulation. The screen displayed the scene from two points of view (a distant camera capturing the whole team, and a close-up camera capturing the woman's body, to see the details of maneuvers and actins performed on the simulator). The screen also and reported the clinical parameters of the woman and the foetus (heartbeat, oxygen peripheral saturation, non-invasive blood pressure). A team of simulation experts composed by nurses, anesthetists, midwives, gynecologists, and simulator technical support remotely controlled the simulator, both controlling the physiological parameters and the woman's voice. In some scenarios a confederate

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played the role of the woman's parent or partner attending the delivery. After the simulation, the debriefing was conducted by a practitioner with certified experience in simulation training and by a psychologist. They asked each participant to share what he/she had done in the scenario and reflect on the strengths and weaknesses of his/her behavior. The team risk manager was than involved in the debriefing in order to discuss procedural and organizational issues that emerged from the simulation. After that, the observers were asked to provide a peer-to-peer feedback using the CRM observational tool and explicitly referring to specific behavioral markers that were notable for the current scenario. The goal of the debriefing was to foster a proper metacognition about what they thought and why the decided that specific course of actions. Each observer, after the debriefing, rated the CRM observational tool about: (i) its usefulness in facilitating a reflection about one's own behavior; (ii) its usefulness in helping the observation during the simulation and the peer-to-peer feedback, and (iii) it's ease of use. All the ratings were on a 5-point rating scale (1 = "scarce"; 2 = "poor"; 3 = "average"; 4 ="moderate"; 5 = "extreme").

3. Results

We administered 101 observational tools. Descriptive statistics about the three usefulness and usability questions are presented in Table 3.

Table 3. Descriptive statistics about usefulness and usability of the tool (N=101).

Question	Mean score [1]	S.D.
Usefulness for metacognition	3,96	0,74
Usefulness for peer-to-peer feedback	4,01	0,68
Ease of use	3,79	0,79

[1] (1 = "scarce"; 2 = "poor"; 3 = "average"; 4 ="moderate"; 5 = "extreme").

In Figure 1 we reported the distribution of the ratings the three questions.

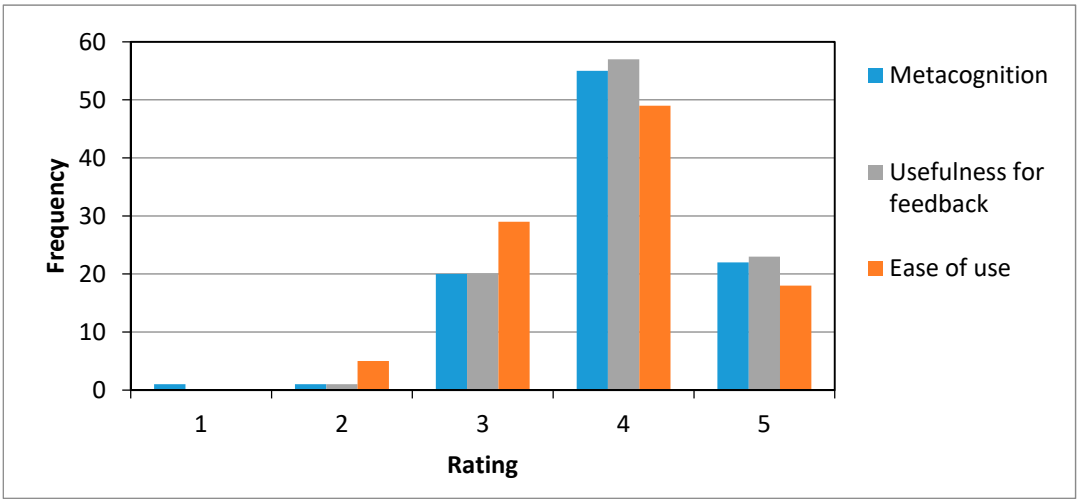

Figure 1. The distribution of the usefulness and usability ratings.

Al the rating were significantly different form the average point of the scale (3). A one-sample t test was performed with 3 as a test value: Usefulness for metacognition, t(98) = 12,89; p = ,000;

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Usefulness for feedback, t(100) = 14,80; p = ,000; Usability, t(100) = 10,58; p = ,000. We considered mean ratings of no less than 4 on either characteristic as a satisfactory result [23]. Setting 4 as a test value, the one-sample t test reported that only the rating of Usability was significantly different than 4: t(100) = -2,60; p = ,010.

In order to investigate significant differences among the scores, we performed a paired samples t test. The only significant difference between scores is that between the rating of usefulness for a peer-to-peer feedback and the rating about the ease of use of the tool, t(100) = 3,256; p = ,002.4.

4. Discussion

The ratings for usefulness and usability are skewed toward the upper part of the rating scale, which implies that the opinions of the participants were positive towards the tool. The CRM observational form was therefore considered a useful tool to trigger a reflection upon one's own behavior (metacognition), a useful tool to provide a non-judgmental and specific feedback to the colleagues involved in the simulation, and a usable tool in general. The usability rating was the lowest among the rating, yet significantly higher than the average point (3). However, taking into account a high criterion for usability rating as suggested by [23], setting 4 as the acceptable rating for usability, we see that usability rating in our sample is significantly lower (mean value = 3,79) than four. The reason for this slightly lower rating could be due to the high number of data to be processed (reading all the items) in a short time (the return of the colleagues from the simulation site to the debriefing room). The usability of the tool could be therefore improved letting the observers familiarize more with the items and providing them with more time to fill it in. In addition, the tool and the description of the CRM points had been provided as a booklet, for space reasons. We could find a better layout to fit the relevant information on a single page. However, we want to stress the fact that the participants had a short introduction to the CRM and the observation form prior to the simulation sessions. On average, they had been briefed in about 30 minutes. Notwithstanding this short time, the usability was nonetheless higher than the average point and we consider this a promising aspect of the tool, since it does not require a specific psychological expertise to be used and can become a suitable instrument for simulation-based training.

On the other hand, the high ratings of usefulness both for self-reflection and for peer-to-peer feedback are a promising sign that the tool can increase the learning potential of simulation. First of all, let us consider the CRM observational tool for peer-to-peer feedback. As argued by [24], the debriefing should focus on relevant actions observed in the scenario and help practitioners to elicit the background and often implicit cognitive and emotional processes that led to that action. By "relevant" we mean crucial for the explanation of the events, both effective and ineffective mental processes. A traditional attitude in training is to focus on what went wrong, pointing at the operators' errors and teaching them the desired behavior or knowledge. However, this approach is limited for many reasons. First of all it is judgmental and could threat the learning potential of simulation because of defensive reactions of the operators involved, which could justify their poor performance with the ecological limits and constraints of the simulator (e.g., "I don't usually talk like that to a woman, this is a mannequin…"), the devices (e.g., "I did not know if the monitor was really working"), or the scene (e.g., "our delivery room has a different arrangement"). The CRM observational tool reports both effective and ineffective behaviors for each item of the CRM, therefore the observers are guided in their feedback towards the relevant actions of both sides of the performance continuum. Without the tool, the observers could be biased by the recollection of actions that fit with the judgmental attitude to search for the weaknesses of the practitioners. In addition, pointing at the mistakes is limited because safe performance is not just based on the reduction of mistakes, but in the increase and empowerment of the processes that led to good performance. The debriefing should not be focused on explaining what went wrong in the scenario, but on the process that let the team adapt to the critical situation, which skills were involved. Eliciting often latent and implicit dynamics, we can highlight the potential for safety and resilience of the team. Again, the CRM observational tool can help to this purpose, because the debriefer can

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decide to focus on the strengths of the team investigating the mental and social processes that led to the top rated items in the list.

Taking into account the high ratings of the tool as a good opportunity to reflect on one's own behavior, we argue that the tool could increase the learning effect of observers and not only of the operators involved in the scenario, as demonstrated by [22]. The tool could enhance metacognition and a critically reflective attitude towards one's own practice since it is based on specific behaviors that can be recollected from one's memory to evaluate past activities, and can be kept in mind for the future. One typical characteristic of experts' knowledge is that it is largely tacit, that is not easy to explicit verbally, nor to be fully aware of [25]. The debriefing aims at eliciting metacognition, critical reasoning, and self-reflective practice [26], and we argue that the observational tool based on observable and specific actions is a good trigger for these processes because it helps the user to focus on a specific behavior and to link it to inner mental states.

5. Conclusions

This research aimed at developing an observational tool based on the CRM points developed by Gaba and colleagues [10], adapted for the delivery room. One of the main goals of the present research was to fill in a gap in literature about CRM in simulation, where either CRM points are used as a guideline for the debriefing, but are often too general, or they are specified in terms of behavioral markers, but are not linked to the 15 points of CRM and are based on the non-technical skills frame of cognitive and social skills [6].

After a in-depth discussion with delivery room practitioners (anesthetists, gynecologists, midwives, and nurses) of the 15 items of the CRM list, we developed an observational tool inspired by the existing tools already in use both in aviation and in healthcare simulation for the debriefing about non-technical skills. The most relevant characteristics of these tools are the description of specific and observable behavioral markers, and their declination with examples of both an effective and an ineffective performance, placed along a rating scale. The observational tool for CRM in the delivery room was then composed by 19 items, because some of the CRM points had to be split to be described as behavioral markers. The tool was then administered to 52 practitioners (anesthetists, gynecologists, midwives, nurses, neonatologists, and risk managers) working in six mid and large hospitals in Italy who underwent a 2-day seminar about hemorrhage emergency management in the delivery room. The seminar was designed to provide both technical and non-technical skills in crisis management and it was based on several simulation sessions during which all the teams were involved in crisis scenarios. The observational tool was then used by their colleagues and the debriefer to run the debriefing in terms of specific actions (both effective and ineffective) and the mental and social processes underneath them. The toll was rated in terms of usefulness to trigger reflection on one's own actions during everyday practice, usefulness to provide a peer-to-peer feedback after the simulation, and in terms of usability. All the three items received higher-than-average ratings, in particular the two items about the tool's usefulness.

Some of the limits of the present research concern the relatively lower rating of usability of the tool, probably due to the high cognitive load imposed to raters to fill the form in, which required a rapid thought about non-technical behaviors, a rather unusual task form many of them. Another limit of this study is that it was focused on self-reported ratings, but the validation of the tool will need further investigation in terms of inter-raters agreement, sensitivity, and coherence of the tool.

A promising aspect of this tool concerns the involvement of the peers during the debriefing. As a consequence, the simulation becomes a learning activity not only for those involved in the scenario, but also for the colleagues watching the simulation. Training the simulation participants to use the tool could have the positive drawback of favoring a non-judgmental peer-to-peer feedback and, most of all, provide them with a take-home message based on a concrete, specific set of actions that will make their delivery room safer.

Supplementary Materials: CRM Observational Tool.

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