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Checklists and multidisciplinary team performance during simulated obstetric hemorrhage

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Abstract

Background—Checklists can optimize team performance during medical crises. However, there has been limited examination of checklist use during obstetric crises. In this simulation study we exposed multidisciplinary teams to checklist training to evaluate checklist use and team performance during a severe postpartum hemorrhage.

Methods—Fourteen multidisciplinary teams participated in a postpartum hemorrhage simulation occurring after vaginal delivery. Before participating, each team received checklist training. The primary study outcome was whether each team used the checklist during the simulation. Secondary outcomes were the times taken to activate our institution-specific massive transfusion protocol and commence red blood cell transfusion, and whether a designated checklist reader was used.

Results—The majority of teams (12/14 (86%)) used the checklist. Red blood cell transfusion was administered by all teams. The median [IQR] times taken to activate the massive transfusion protocol and transfuse red blood cells were 5 min 14 s [3:23–6:43] and 14 min 40 s [12:56–17:28], respectively. A designated checklist reader was used by 7/12 (58%) teams that used the checklist. Among teams that used a checklist with versus without a designated reader, we observed no differences in the times to activate the massive transfusion protocol or to commence red blood cell transfusion ($P>0.05$).

Conclusions—Although checklist training was effective in promoting checklist use, multidisciplinary teams varied in their scope of checklist use during a postpartum hemorrhage simulation. Future studies are required to determine whether structured checklist training can result in more standardized checklist use during a postpartum hemorrhage.

Keywords

Checklist; Multidisciplinary; Obstetrics; Postpartum hemorrhage; Simulation

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijoa.2015.08.011.

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Introduction

Postpartum hemorrhage (PPH) remains a leading cause of maternal morbidity and mortality.[1–3] Despite advances in medical and obstetric management, rates of PPH in the USA and other well-resourced countries have increased in recent years.[4–6] Consequently, system-wide approaches and protocols have been recommended to improve how obstetric care providers identify and manage PPH.[7]

There is growing awareness of the importance of checklists for assisting providers during medical crises. Studies have shown that providers are more likely to adhere to recommended procedures during critical phases of medical emergencies when using checklists or cognitive aids.[8–12] Simulation training and checklist use offer the prospect of improving how multidisciplinary teams manage obstetric crises. However, the impact of checklists on multidisciplinary team performance during simulations of PPH has not been investigated.

In this prospective observational study, we exposed 14 multidisciplinary teams to checklist training to evaluate checklist use and team performance during a simulation of major PPH post-vaginal delivery.

Methods

This prospective observational study was approved as exempt by Stanford University Institutional Review Board. The study was performed on the labor and delivery unit at a tertiary obstetric center (Lucile Packard Children's Hospital, Stanford, California) over a four-month period in 2013. Fourteen multidisciplinary teams were studied: each team consisted of seven to 10 participants which included two obstetricians (attendings, fellows, and residents), one anesthesiologist (resident), three to five labor and delivery nurses and one to two operating room (OR) technicians. The teams encountered the same scenario of a patient with atonic PPH following vaginal delivery. Participants were naïve to the scenario before performing each simulation.

For the design of the checklist the authors reviewed PPH guidelines from recognized obstetric bodies (American College of Obstetricians and Gynecologists (ACOG) and the Royal College of Obstetricians and Gynaecologists), relevant papers from the literature and our institutional PPH protocol.[13–15] The final action items for the checklist were selected by consensus by all authors. The checklist was available for participants' use during simulations (Fig. 1). Fifteen key tasks were identified for inclusion on the PPH checklist which included clinical, communication, and systems-based aspects of management. The items were separated into three boxes to enable easier use of the checklist, which is a common challenge in checklist design. At the time of the study PPH checklists were not being used for clinical care on our labor and delivery unit. Anesthesia residents had prior experience with checklists in other anesthesia domains; however, other participants had minimal or zero experience using checklists.

All 14 teams underwent standardized educational training immediately before each simulation. Each training session lasted 15 min and comprised two parts. Each simulation was overseen by an expert in obstetric simulation (GH, KD, SL) with at least 10 years of

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experience in simulation training. The first part was didactic training in which participants viewed a slide presentation with an oral presentation by an expert in obstetric simulation training (GH, SL). During the oral presentation, the benefits of using a checklist were discussed. It was explained to each team that a checklist could be used to initiate tasks (in a prospective manner) or verify task completion (in a retrospective manner). Teams were able to use either approach. Trainers advised teams to designate a participant to be a checklist reader who assisted the team leader by reading out-loud tasks on the checklist and verifying completion of each.[9] The second part of the training session was hands-on checklist training. For training purposes, a checklist for managing shoulder dystocia was used which was formatted in a similar style to the PPH checklist.

The scenario consisted of a severe PPH (1500 mL blood loss) due to refractory uterine atony in a primiparous 18-year-old patient who had undergone a spontaneous vaginal delivery. The patient became tachycardic and hypotensive consistent with hemorrhagic shock. All simulations were performed on the labor and delivery unit. We used a hybrid mannequin (MamaNatalie Birthing Simulator; Laerdal, Wappingers Falls, NY, USA) for simulations in the labor room. A high-fidelity mannequin (NOELLE Maternal and Neonatal Birthing Simulator S550; Gaumard Scientific, Miami, FL, USA) was used for simulations in the OR. All simulations were videotaped. None of the teams received information about the PPH simulation before starting the simulation.

Before each simulation, instructors informed each team that a checklist would be available in the labor room. However, none of the teams received or viewed the actual PPH checklist before the simulation. After being introduced to the scenario, teams were expected to manage ongoing blood loss in a hemodynamically unstable patient. Key management tasks were: activation of the institutional massive transfusion protocol (MTP) and transfusion of red blood cells (RBC) via a rapid infuser (Belmont Rapid Infuser; Belmont Instrument Corp., Billerica, MA, USA). The simulation was stopped when each team completed all 15 tasks on the checklist, or when 20 min had elapsed (if <15 tasks were completed). During each simulation checklist use was not enforced and the choice to use the checklist was at the discretion of each team. A study investigator not involved in the simulation recorded the times to complete key events. Before each simulation, participants were not informed that key events were timed. These times were verified by a second investigator who reviewed videos of each simulation. After each simulation all participants were asked to complete a survey related to the use of checklists. Questions required a yes/no answer or an answer based on an ordinal scale (1=poor, 5=excellent). Survey questions are presented in the Appendix.

The primary study outcome was the use of the PPH checklist (yes/no). Secondary outcomes included: times to administer a second-line uterotonic, activate the MTP, and commence RBC transfusion; and the order and number of checklist tasks completed. Time zero for these interventions was taken from the end of the third stage of labor. If teams completed all 15 checklist tasks, the time to complete all tasks was recorded. We also evaluated whether each team used the checklist intermittently or continuously (determined by the study investigator), the location (labor room or OR) when the checklist was first used, and if a checklist reader was used by each team. A reader is a designated person who reads tasks out-

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loud from the checklist to the team leader. A reader can decrease task saturation experienced by the team leader thereby increasing the likelihood that all critical tasks are completed.[9]

Statistical analysis

For this observational study, we used a convenience sample size comprising 14 teams. Continuous data are presented as mean ± standard deviation (SD) or median [interquartile range] and categorical data are presented as percentages. For groups that used and did not use a checklist reader, we compared the times to administer a second-line uterotonic, activate the MTP, and administer RBC using the Mann–Whitney U test. Statistical analyses were performed using IBM SPSS Version 20.0 for Windows statistical package (IBM, Armonk, NY, USA).

Results

Data on checklist use are presented in Table 1. The majority of teams (12/14 (86%)) used the checklist during the simulation (50% intermittently and 50% continuously). Secondary outcomes are presented in Table 1. All teams administered a second-line uterotonic medication with a median time of 3 min 28 s [IQR 2:45–3:42]. The median time taken to activate the MTP was 5 min 14 s [IQR 3:23–6:43]. Red blood cell transfusions were administered by all teams and the median time to commence RBC transfusion was 14 min 40 s [IQR 12:56–17:28]. The time to commence transfusion included a 5 min period designated for transportation of the MTP blood products from the transfusion department to the labor and delivery unit. Eight teams completed all 15 tasks on the checklist within 20 min; all eight of these teams used the checklist (four teams with and four teams without a checklist reader).

The order of checklist task completion varied considerably among teams (Table 2). Of the 12 teams that used the checklist, a checklist reader was used by seven (58%) teams. Among teams that used a checklist with versus without a checklist reader, we observed no significant differences in the times to administer a second-line uterotonic (P=0.94), activate the MTP (P=0.81), and commence RBC transfusion (P=0.81) between teams (data not presented). Requests to use the checklist were made by the obstetrician in 3/12 (25%) teams and by nursing staff in 9/12 (75%) teams. Most teams (10/12 (83%)) requested the checklist whilst in the labor room. Only 2/12 (17%) teams requested the checklist after transfer to the OR. Six teams used the checklist in a prospective manner to complete tasks in the order presented on the checklist. Six teams used it in a retrospective manner to verify completion of tasks performed by the team.

All 114 participants completed the checklist survey. Data from the survey are presented in Tables 3 and 4.

Discussion

In this prospective observational study we examined multidisciplinary team performance after checklist training during a simulation of severe PPH post-vaginal delivery. The majority of teams used the checklist and all teams initiated RBC transfusion within 20 min

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of PPH onset. Despite pre-simulation checklist training, teams varied in how they used the checklists during the actual simulations. The findings of this simulation study suggest that multidisciplinary teams are receptive to using checklists for PPH management; however, further research is needed to examine how teams can effectively use checklists during a PPH.

In obstetrics, patient safety checklists have been promoted as an important tool for improving perinatal care and reducing maternal and neonatal mortality. The World Health Organization has developed a 29-item checklist to promote the delivery of key maternal and perinatal care practices.[16] Furthermore, ACOG has developed a number of patient safety checklists in obstetrics including a checklist for managing PPH post-vaginal delivery.[13] With efforts being focused on system-wide approaches to lower rates of maternal morbidity and mortality in the USA, it is likely that hospital administrators and physicians will be expected to integrate checklists into institutional protocols.[17] However, it has been unclear whether obstetric care providers are receptive to checklist training and whether they are able to use checklists in a consistent, effective and time-efficient manner.

In our study, checklists were used by the majority of teams in the management of PPH. As checklists were not in clinical use at the time of the study, this finding suggests that, after checklist training, care providers are receptive to modifying established team-based approaches to PPH management. This finding has clinical relevance as there is growing appreciation that physicians' use of checklists can improve standardization of care and teamwork during crisis scenarios. In simulation studies of intraoperative emergencies, failure to adhere to lifesaving procedures was less common among teams using crisis checklists compared to teams without access to checklists.[8,18] Other simulation studies in anesthesia indicate that checklists or cognitive aids can improve how trainees manage rare but life-threatening anesthetic emergencies, such as local anesthetic systemic toxicity and malignant hyperthermia.[11,12]

Despite the high rate of checklist use in our study, 2/14 teams did not use the checklist. In the post-simulation survey the most common explanations for not using the checklist were: "no-one mentioned it during the drill" and "it was not requested by the team leader". These observations suggest that, despite training, a minority of providers have entrenched opinions and approaches to obstetric crises management. It is likely that a shift in medical culture would be needed to encourage all providers to use checklists during obstetric crises.[8]

Despite pre-simulation checklist training, the use of a checklist reader by teams was inconsistent. Based on recent literature, a designated checklist reader can improve team performance during medical events.[9,19] Ideally, a checklist reader should be an experienced member of medical or nursing staff who is familiar with the tasks and task-order on the checklist.[10] However, we did not observe differences in the times for second-line uterotonic use, MTP activation, and RBC transfusion between teams with versus without a checklist reader. These subgroups were small which limits data inference; thus, more research is needed to evaluate how obstetric teams use checklist readers during obstetric crises. We also observed other variations in how teams used checklists. Half the teams used the checklist prospectively (in a "call/do" manner) with the remaining half using it retrospectively (in a

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"do/verify" manner). The order of task completion varied markedly between teams. Overall, these findings suggest that regular checklist training may be needed to standardize how teams use checklists during obstetric crises.

Task completion also varied between teams. Despite all teams activating the MTP and transfusing RBC, 14% of teams did not administer oxygen/vasopressors or discuss the management plan. Poor team organization and task assignment have also been reported in a previous simulation study of how physicians perform during simulated obstetric emergencies, including PPH.[20] These observations exemplify the importance of effective communication among care providers during obstetric crises. With communication failure recognized as the root cause of many sentinel events on the labor unit,[21] periodic training to improve and maintain effective communication between providers should be encouraged.[22]

The results of our post-course survey suggest that participants highly rated the checklist training. Participants also indicated that the checklist improved team performance. More research is needed to determine the best educational approaches for effective training of interdisciplinary teams, taking into account both subjective and objective measures of team performance. Goldhaber-Fiebert et al. have recommended a four-element framework for implementing crisis checklists.[23] The four elements are: (1) create (or customize) the checklist; (2) familiarize providers in using checklists effectively; (3) use checklists in clinical practice; and (4) integrate into a hospital's safety culture. In keeping with these elements and subsequent to the drill, we have created a simplified checklist for our labor and delivery unit which incorporates fundamental tasks that require completion during the early stages of PPH (Fig. 2). This simplified checklist is currently in clinical use on our labor and delivery unit.

There are a number of study limitations. Our study did not include a control group and therefore it is unclear whether team performance and checklist use would have differed for teams not exposed to checklist training or access. We did not collect data on the total number of prior obstetric simulations or the degree of simulation training that each participant had experienced. We did not assess whether all participants had participated in simulation with other members of the same team. Due to the short time-window (four months) for scheduling the simulations, in tandem with the restricted availability of all participants and trainers, it was not possible to construct teams with similar levels of simulation training or experience. Therefore, variations in team performance may have been influenced by these factors. However, the different levels of clinical experience and simulation training of participants in each team may reflect those of staff members on any given shift on our labor and delivery unit. We were unable to compare provider-level performances within teams, but the provider mix (obstetrician, anesthesiologist, nurses and technicians) in each team was deemed to be similar to a team that typically responds to a major PPH at our hospital. We cannot rule out a Hawthorne effect, therefore our data may not accurately reflect true multidisciplinary team performance during obstetric crises. Despite these limitations, high-fidelity simulation has become an accepted part of medical practice for training providers to deal with medical emergencies,[24] and simulation studies have demonstrated face validity and initial construct validity.[25–29] We believe that our findings may be comparable to other tertiary care obstetric centers. Although a team of

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experienced physicians developed the checklist, the checklist did not undergo validation testing. Nonetheless, we believe that the components of our checklist may be applicable to current obstetric and anesthetic practices for managing severe PPH post-vaginal delivery in tertiary care obstetric centers. Lastly, our outcomes were based on surrogate measures; therefore, we cannot comment on whether simulation training with checklists improves perinatal outcomes. However, prior research has shown improvements in neonatal and maternal outcomes through the use of simulation training for obstetric emergencies, including PPH.[30]

Our findings suggest that multidisciplinary teams are receptive to checklist training and may adopt checklists whilst managing patients with severe PPH. However, there may be marked variability in how teams use checklists during these events. Future studies are required to determine whether regular structured training can result in more standardized checklist use during obstetric crises. Furthermore comparative-effectiveness research is needed to evaluate whether the availability and use of checklists and simulation training can improve maternal and perinatal outcomes compared to current standard-of-care approaches.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Disclosure

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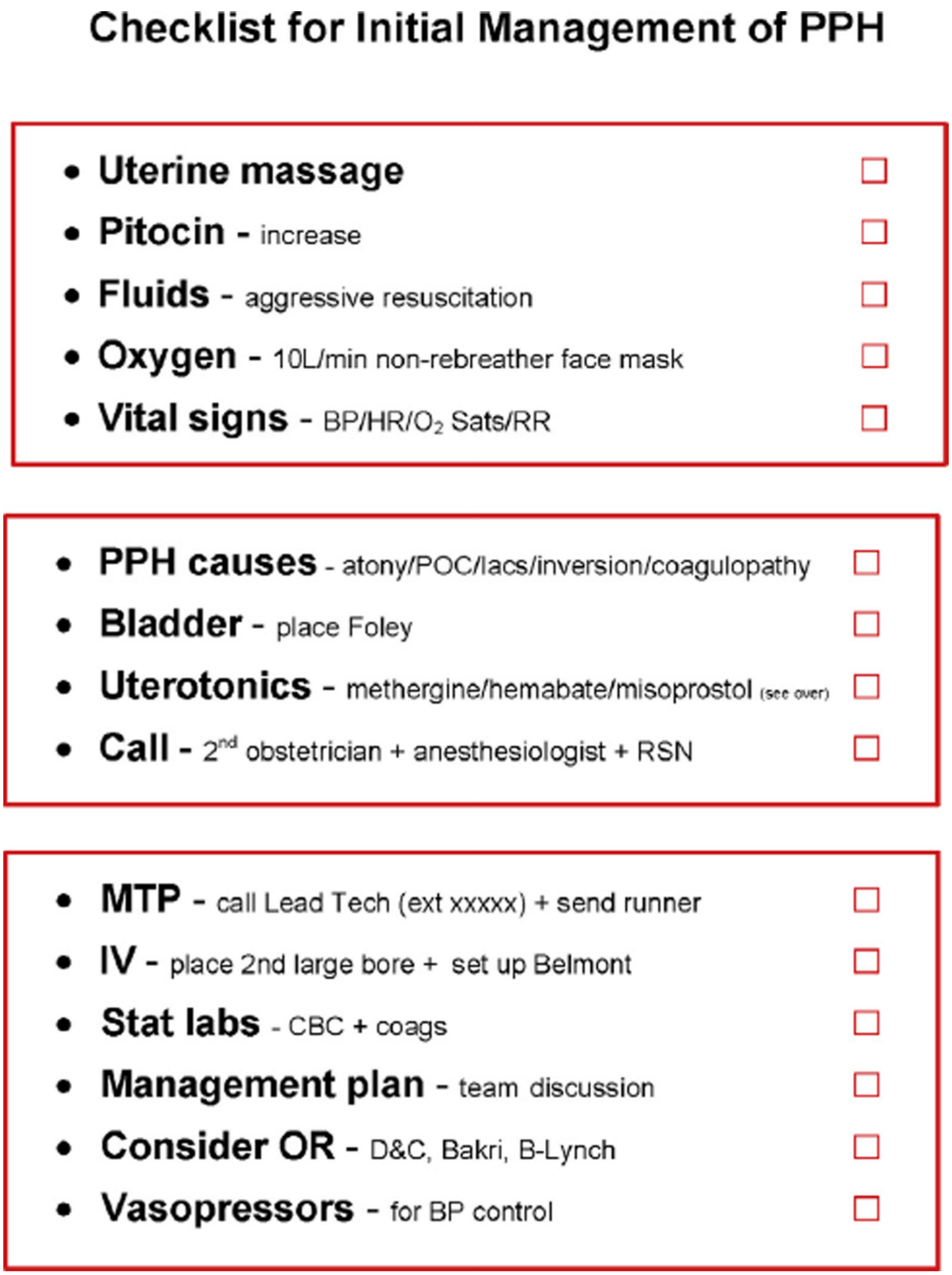

Checklist for Initial Management of PPH

- **Uterine massage** ☐
- **Pitocin** - increase ☐
- **Fluids** - aggressive resuscitation ☐
- **Oxygen** - 10L/min non-rebreather face mask ☐
- **Vital signs** - BP/HR/O_2 Sats/RR ☐

- **PPH causes** - atony/POC/lacs/inversion/coagulopathy ☐
- **Bladder** - place Foley ☐
- **Uterotonics** - methergine/hemabate/misoprostol (see over) ☐
- **Call** - 2^{nd} obstetrician + anesthesiologist + RSN ☐

- **MTP** - call Lead Tech (ext xxxxx) + send runner ☐
- **IV** - place 2nd large bore + set up Belmont ☐
- **Stat labs** - CBC + coags ☐
- **Management plan** - team discussion ☐
- **Consider OR** - D&C, Bakri, B-Lynch ☐
- **Vasopressors** - for BP control ☐

Fig. 1.

Postpartum hemorrhage checklist used during the drill. BP: blood pressure; HR: heart rate; Sats: oxygen saturation; RR: respiratory rate; PPH: postpartum hemorrhage; POC: products of conception; RSN: resource staff nurse; MTP: massive transfusion protocol; IV: intravenous; CBC: complete blood count; OR: operating room; D+C: dilation and curettage

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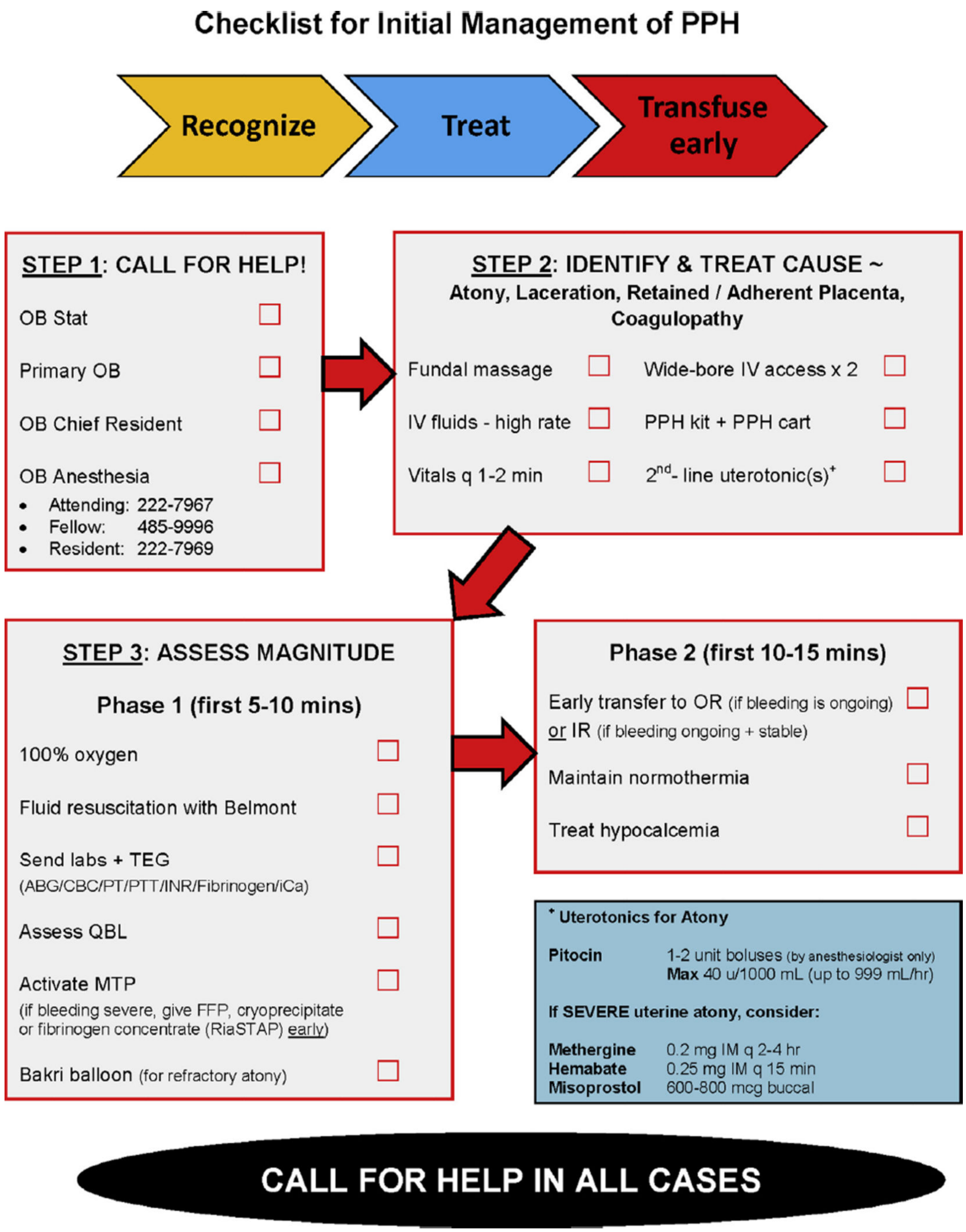

Fig. 2.

Checklist for initial management of postpartum hemorrhage (in current clinical use, at the time of manuscript preparation). PPH: postpartum hemorrhage; OB: obstetric; IV: intravenous; OR: operating room; IR: interventional radiology; TEG: thromboelastography; ABG: arterial blood gas; CBC: complete blood count; PT: prothrombin time; PTT: partial thromboplastin time; INR: international normalized ratio; Ca: calcium; QBL: quantification of blood loss; MTP: massive transfusion protocol; FFP: fresh frozen plasma

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Table 1

Data for critical task completion during the postpartum hemorrhage simulation

Critical Tasks	Time (min:s)	Teams Completing Task
Use of checklist during simulation		12 (86%)
Administration of a 2nd-line uterotonic	3:28 [2:45–3:42; 0:54–4:10]	14 (100%)
Time to activation of the MTP	5:14 [3:23–6:43; 1:44–9:55]	14 (100%)
Time to RBC transfusion	14:40 [12:56–17:28; 10:48–19:20]	14 (100%)
Completion of 15-point checklist*	14:30 [12:01–17:52; 10:20–19:08]	8/12 (67%)

Data are median [IQR; range] and number (%).

MTP: massive transfusion protocol; RBC: red blood cells.

*Within 20 min of scenario start.

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Table 2

Management tasks completed by teams during the postpartum hemorrhage simulation

Management Task	Order of task completion															
	1st	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**	**13th**	**14th**	**15th**	**Not done**
Uterine massage	14 (100%)															
Increase oxytocin administration		6 (43%)	4 (29%)	2 (14%)												2 (14%)
Increase rate of intravenous fluids							1 (7%)	5 (36%)	1 (7%)	1 (7%)	2 (14%)	3 (22%)				1 (7%)
High-flow oxygen			2 (14%)		3 (21%)	1 (7%)			2 (14%)	2 (14%)			1 (7%)			3 (21%)
Check vital signs		5 (36%)	1 (7%)		1 (7%)	2 (14%)	2 (14%)	1 (7%)		1 (7%)						1 (7%)
Consider PPH causes		2 (14%)		2 (14%)	2 (14%)				2 (14%)			2 (14%)	2 (14%)			2 (14%)
Empty bladder			1 (7%)			1 (7%)	1 (7%)			1 (7%)	4 (29%)	1 (7%)	3 (21%)			2 (14%)
Administer second-line uterotonic		1 (7%)	2 (14%)	4 (29%)	2 (14%)		3 (21%)		2 (14%)							
Call for help			1 (7%)	3 (21%)	2 (14%)	3 (21%)	1 (7%)	1 (7%)	1 (7%)		1 (7%)					1 (7%)
Activate MTP			1 (7%)	1 (7%)	1 (7%)	2 (14%)	1 (7%)	2 (14%)		1 (7%)		3 (21%)	2 (14%)			
Place second large-bore intravenous catheter			2 (14%)		1 (7%)	4 (29%)	1 (7%)	2 (14%)	2 (14%)	1 (7%)	1 (7%)					
Send laboratory tests						1 (7%)	2 (14%)		2 (14%)		2 (14%)			4 (29%)	3 (21%)	
Discuss management plan with team							1 (7%)	1 (7%)			1 (7%)	1 (7%)	1 (7%)	4 (29%)	3 (21%)	2 (14%)
Consider transfer to operating room				2 (14%)	2 (14%)		1 (7%)	1 (7%)		4 (29%)	2 (14%)	2 (14%)				
Administer vasopressors									1 (7%)	2 (14%)		1 (7%)	4 (29%)	2 (14%)	2 (14%)	2 (14%)

Data are mean (%) PPH: postpartum hemorrhage; MTP: massive transfusion protocol.

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Table 3

Participants' responses to post-simulation survey

	Number of responses	5-point Likert scores
The checklist training that I received before the simulation helped me understand how to effectively use a checklist	91	4 [4–5]
For the simulation I just experienced, the checklist was useful	88	4 [4–4.5]
Having someone reading the checklist aloud is helpful	80	4 [4–5]
Using the checklist helped our team accomplish the tasks that needed to be done	88	4 [4–5]
The layout of the checklist was easy to follow	83	4 [4–5]
I found the checklist helped our team organize and more rapidly treat the clinical problem	87	4 [3–5]

Data are number and median [IQR].

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Table 4

Participants' responses to checklist use

What were the barriers to more effective checklist use by your team?	(*n*=114)
Unfamiliarity with the checklist or practice using it	55 (48%)
It would have been helpful if an extra person were pre-assigned as the 'reader'	51 (45%)
Remembering to use it to double-check after we did everything that we could remember	24 (21%)
None, we used the checklist without any barriers	14 (12%)
Location	14 (12%)
Time taken to read the relevant information	13 (11%)
Layout or design	3 (3%)
Concern for what others might think about using it	0
If your team did not use the checklist, this was because:	(*n*=16)
No one mentioned it	9 (56%)
It was not requested by the team leader	8 (50%)
No one was available to read it	6 (38%)
Other: a) forgot, b) who to initiate it, c) availability	6 (38%)
We felt comfortable enough that a checklist was not needed	1 (6%)
We felt a checklist would distract or slow us down	1 (6%)
We were not able to access the information quickly enough	1 (6%)
A checklist would be useful for the following obstetric event(s):	(*n*=114)
Maternal cardiac arrest	106 (93%)
Eclamptic seizure	101 (89%)
Local anesthetic systemic toxicity	88 (77%)
Shoulder dystocia	86 (75%)
Uterine inversion	84 (74%)
Operative vaginal delivery	78 (68%)
Emergency cesarean delivery	71 (62%)
Cord prolapse	71 (62%)

Data are number (%).