**Implementing military aviation debriefing methods to improve outcome of peripartum interventional procedures**

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**Abstract**

**Objective**

Debriefing is widely used as a means to improve motivation, learning, and performance. We examined trends in maternal and perinatal outcomes over time following the implementation of the Israeli Air Force's (IAF's) debriefing methods.

**Methods**

Following the training period, an online mobile application was developed to investigate two peripartum interventions: vacuum deliveries and genital tract examinations performed in cases of postpartum hemorrhage (PPH) or retained placental products. The application was downloaded to the smartphones of all ward physicians during the study period. After each procedure, regardless of outcome, physicians were prompted to answer the following three questions within 24 hours of the procedure: What happened? Why did it happen? How can I improve? A similar form was completed regarding equipment used. Outcomes examined included trends over time in maternal and neonatal outcomes related to the two interventions examined, as well as the rate of equipment faults. The Cochran-Armitage test for trend and Spearman’s correlation test were utilized in the case of dichotomous and continuous variables, respectively.

**Results**

Between November 2016 and May 2018, 308 vacuum deliveries and 219 genital tract examinations were performed. The results of the time-trend analysis revealed that the military aviation debriefing methods led to a reduction in the number of errors relating to process of care, inappropriate procedure performance, and equipment malfunctions within the delivery ward.

**Conclusion**

Using IAF's debriefing method in the delivery ward led to improved maternal and neonatal outcomes for the two interventional procedures examined.

**Introduction**

An analysis of adverse events involving hospitalized patients showed that about 70% of all accidental injuries are caused by errors or failure to follow accepted practices (1-3). Additionally, half of all surgical complications are thought to be avoidable, and most are the result of communication failures (4).

Debriefing is used in medical environments as a means of learning from daily practice and is widely used to improve performance (1). Furthermore, a growing body of evidence links surgical debriefing and teamwork to improved outcomes and reduced rates of adverse events (5-17). A meta-analysis showed that organizations can improve individual and team performance by approximately 25% by implementing properly conducted debriefs (1).

Much of what is known about debriefing and teamwork has been generated from many years of research in aviation and military settings (18). Aviation debriefing allows team members to discuss the decisions made, what could have been done differently, if there is any potential need for rehabilitation or training, and what was successfully accomplished (18). Aviation debriefing concepts have been found to be simple, inexpensive and suitable for adaptation to hospital emergency departments and operating rooms (2,19).

Delivery wards are complex, multifaceted settings in which effective communication and the coordination of team members is vital for safe and robust functioning. Team members need to quickly share information when they are responding to expected and unexpected events. In this study we examined the impact of implementing the Israeli Air Force's (IAF's) debriefing methods on maternal and neonatal outcomes for two peripartum interventions: vacuum deliveries and genital tract examinations performed immediately postpartum under anesthesia.

**Methods**

A retrospective study was conducted at a single teaching hospital using data collected between November 2016 and May 2018. In 2016, the delivery ward in Emek Medical Center was part of the "Shamayim" (or “sky,” in English) debriefing program. Shamayim is a social business organization managed by former IAF pilots. The principles of the "Shamayim" methodology are based on simplicity and efficiency in debriefing as a learning routine. The concept is based on moving from blame-based responses to taking personal responsibility, personal learning that leads to group learning, drawing conclusions and attaining quick results. The concept is based on the IAF's method of debriefing that includes three key questions: 1) What happened? Whereby the outcome of the debrief is identified; 2) why did it happen? Which pinpoints the essential reasons and system failures that led to that specific outcome; and 3) how can I improve? Which provokes team members to develop suggestions that either prevent problem reoccurrence or to promote certain behaviors, depending on the outcome. These three questions are employed in each minor and major action and procedure undertaken by IAF personnel in cases of unfavorable outcomes (in order to improve) and favorable outcomes (in order to replicate). This method includes debriefing on an individual basis and within the context of a team, since it includes all team members involved.

The "Shamayim" program began at our institution with weekly meetings of a designated medical staff group that included senior obstetricians, residents, chief, senior and junior midwifes, and was led by the chief of the delivery ward.

Each session was steered by the same instructor, a former IAF pilot. Briefing and debriefing included lectures, case studies on daily medical events and procedures that took place during the previous week, role playing, video-recorded simulation, and training in briefing and debriefing methods based on the three key questions.

This period lasted three months. After that (for the following nine months), monthly meetings aimed at transferring the stick from the "Shamayim" instructor to the medical staff.

The instructor accompanied this period most of the time. During this period, medical staff implemented methods of debriefing based on the 3 key questions. Throughout this period, an online debriefing tool (smartphone application) was developed by the head of the delivery ward (R.S.) that participated in the project together with the head "Shamayim" instructor (M.P.). The application was designed to investigate two peripartum interventions: vacuum deliveries and genital tract examinations performed in cases of postpartum hemorrhage (PPH) or retained placental products under regional or general anesthesia. At our institution when instrumentalvaginal delivery is indicated, only vacuum extraction is used. These procedures are performed by the physician in charge and require multiple team members and designated equipment. The application was downloaded to the smartphones of all delivery ward physicians.

After each intervention, regardless of outcome, the physician in charge was prompted by his/her electronic device to answer the following three questions: What happened? Why did it happen? How can I improve? The same form was also completed regarding the equipment used. In order to focus on specific scenarios (ex. what happened?), a number of potential outcomes were pre-prepared. These outcomes focused on the process that led to the event, rather than it’s etiology (Table 1). For example, performing a vacuum extraction and delivery of a neonate with a cord artery pH less than 7.1 was one pre-prepared outcome that physicians could select when prompted with the first key question: "what happened?" (Table 1). The next two key questions (Why did it happen? and, how can I improve?) would focus on this issue in more detail. For example, physicians often cited delays in timing of the intervention, as well as ineffective utilization of all potential team communication as possible explanatory factors. Physicians completed the form, usually within several minutes of the prompt, and e-mailed their responses to the head of the delivery ward within 24 hours of the event. Forms were received anonymously.

Every three to four months, the received forms were presented to all obstetric team members during a staff meeting. Rates of favorable and unfavorable outcomes were presented. Conclusions were recorded and implemented as soon as possible.

Data for the present study was collected from computerized labor files, electronic medical records at discharge, and the application forms. Data included maternal demographic and obstetric variables. Outcomes examined included those that occurred before discharge and those related to the two procedures under study, including number of vacuum cup detachments, PPH, grade 3 and 4 perineal tears, and the length of maternal stay after delivery. Neonatal outcomes included shoulder dystocia, Apgar score, umbilical cord artery pH, intensive care unit (NICU) admission, photo therapy, and rate of fetal trauma including clavicular fracture, Erb's palsy and cefalohematoma. For the genital tract examination, outcomes examined also included hemoglobin (Hb) drop, systolic blood pressure (BP) <70 mmHg, and the need for a blood transfusion.

Among the equipment faults that were examined were electrical outlet faults, technical errors in activating the operating theater bed, elementary equipment not found in the designated place and equipment malfunction, as in the case of blunt blades of the episiotomy scissors.

The primary outcome was a trend in the occurrence of maternal and neonatal outcomes examined during the study period (time from application use) related to the two interventions as well as a trend in rate of equipment faults.

**Statistical analysis**

Statistical analysis was conducted using the IBM SPSS 23 program and the R programming language. Spearman's correlations were calculated to determine the presence, direction and strength of correlations between the time index and continuous variables such as BMI and gestational age, while the analogous values were tested via the Cochran-Armitage trend test in the case of dichotomous variables such as diabetes, low levels of HB, and other outcomes. Descriptive statistics and the calculation of means and standard deviations were performed via SPSS, while Spearman correlations and Cochran-Armitage tests for trend estimation were performed via R. Meta-analytic results from 46 independent samples and from other reports that showed that debriefs improved the performance of teams and individuals (1,16,17). As a result, all of the applied tests were one-tailed, as the underlining assumption was that as the treating unit improves as time goes by, the frequency of unfavorable outcomes and errors will decrease.

**Results**

Data from all 308 vacuum deliveries and 219 genital tract examinations that occurred between November 2016 and May 2018 were collected. The medical staff was comprised of fifteen attending physicians who were asked to complete the debriefing forms following the two selected procedures. The compliance rate in cases of vacuum delivery was 43.2% (133 forms were completed out of a total of 308 procedures) and 35.2% in genital tract examination (77 forms were completed out of a total of 219 procedures).

Maternal demographic and obstetric variables of the women who had undergone vacuum deliveries during the study period are presented in Table 2. No statistically significant correlations were detected between time (study period) and maternal demographic and obstetric variables, based on Spearman’s correlation coefficient. In vacuum deliveries, a decreasing trend over time was observed in the rates of vacuum cup detachments based on 17 (5.5%) reported cases (*p*<0.001), and in the rate of PPH, based on 28 (9.1%) cases reported following the procedure, (p=0.019). There was one case of a grade 3 or 4 tear during the study period. Regarding shoulder dystocia, while the trend was significant (p<0.001), the calculation was based only on 5 cases (1.6%) of 308 vacuum deliveries. As such, the test might not be as powerful as its significance implies. A significant decrease over time was also detected in length of maternal stay using Spearman’s correlation coefficient (p=0.003). Regarding neonatal outcome, a significant decrease was detected over time in cases of Apgar score <7 at 1 minute (p=0.006), based on 20 (6.5%) reported cases. In contrast, no significant trend was detected in the frequency of Apgar score <7 at 5 minutes (p=0.2686). Additionally, a significant and decreasing trend over time was detected in the frequency of cases where the cord artery pH was lower than 7.1 (p<0.001) based on 36 (11.7%) reported cases, and similarly, for cases where the cord artery pH was <7.0 (p=0.0064). An analysis of 13 cases (4.2%) showed a significant decrease in the frequency of NICU admission (p=0.048). A significant and decreasing trend was also detected in the frequency of photo therapy (p<0.001) based on 57 (18.5%) reported cases. In general the frequency of any of the above neonatal outcomes tended to decrease over time (p<0.001). No significant trend was detected in the frequency of cephalohematoma (p=0.426) or clavicular fracture (p=0.104). There was only one case of Erb's palsy during the study period. There was no decrease in the frequency of any neonatal trauma related to vacuum extraction (p=0.132). Additionally, no decrease was detected in the length of neonatal stay (p=0.99), (Table 2).

Maternal demographic and obstetric variables of the 219 women who had undergone genital tract examinations during the study period are presented in Table 3. No significant correlations were detected between time (study period) and maternal demographic and obstetric variables, based on Spearman’s correlation coefficient. A significant and decreasing trend was detected in the frequency of blood transfusions based on 57 (26%) reported cases (*p*<0.001). However, no significant trend was detected in the number of blood transfusions given (*p*=0.506). Based on 148 (67.6%), 122 (55.7%) and 84 (38.4%) reported cases, a decreasing trend in the frequency of HB drop >2mg%, and frequency of HB levels <9mg% and <8mg%, respectively, were detected (*p*<0.001 for the three trends). The frequency of systolic BP <70mmHg decreased over time *(p*=0.042), however, as there were only 10 observed cases of BP <70 mmHg, this decrease in trend should be interpreted with caution. No trend was detected in the length of maternal stay (*p*=0.637) (Table 3).

Regarding equipment faults, 203 forms (39% of both procedures) were completed; including 130 completed forms (42.2%) for the vacuum extraction procedure and 73 (33.3%) for the genital tract examination procedure. Based on 47 (23.2%) reported faults (23 with vacuum and 24 with genital tract examination) a decreasing trend over time was observedin the equipment faults rate *(p* <0.001) (Figure 1).

**Discussion**

The results of the current study show that the use of military aviation debriefing methods in the delivery ward for cases of vacuum deliveries and postpartum genital tract examinations resulted in improved maternal and neonatal outcomes. Identified errors were mainly related to the process of care, such as delayed intervention, problems consulting with a specialist, and inappropriate procedure performance. Additionally, errors of judgement, e.g. underestimation or failure to adequately interpret the fetal heart rate tracing were also observed.

Equipment errors found during the study period were also reduced over time. A number of issues were identified and handled, including equipment adjustments, ordering additional equipment to prevent immediate shortages, and rearranging equipment and medications in the delivery and the operative suites.

Similar results of 24% equipment errors were reported by Wolf et al, who examined the impact of debriefing on operating room team function. The authors stated that equipment issues that included delays, shortages, and malfunctions decreased significantly (from 24% to 6.8%) as a result of debriefing (6).

Data suggests that at least half of all surgical complications are avoidable (20,21). After analyzing 805 incident reports completed by general practitioners in Australia,

Bhasale et al found that 76% of events were preventable (22). There have also been a number of reports of increased safety-related practices and improved communication after team training (23), and preoperative debriefings (17,24,25), that led to improved performance (24,25). In high-risk settings other than the operating room, such as emergency departments (26), labor and delivery units (27), and neonatal suites (28), there is evidence that debriefing leads to fewer clinical errors (26) and adverse outcomes (24,25,27), as well as decreased rates of morbidity and mortality (10,25). Findings from a meta-analysis (*N* = 2,136) of team and individual level debriefs showed that organizations can improve individual and team performance by approximately 25% through the use of properly conducted debriefs. The results were similar for both teams and individuals, as well as for medical and nonmedical participants. Moreover, there was no relationship between effect size and publication year, gender mix, time spent debriefing, or team size. The authors of this study stated that an improvement of 20% or more is quite encouraging for an inexpensive intervention that requires little time to conduct (1).

Still, evidence for the effectiveness of peripartum debriefing programs in improving women’s safety, and their impact on overall delivery ward function (delays in action, misjudgment, and equipment errors) has not been thoroughly studied. In the current study, we adopted military aviation debriefing methods that were established among fighter pilots several decades ago (29). Aviation teamwork concepts have been found suitable for adaptation to hospital emergency departments and operating rooms (10). Additionally, the educational and implementation process employed in this study was based on 3 questions used to brief and debrief events in the IFA. In order to implement this simple and inexpensive intervention in the delivery ward, we used a smartphone application, an easy and cheap electronic modality, as a means for the process of debriefing. Electronic integration has been shown to increase compliance in debriefing implementation and has the potential to drastically improve practice (10,30). Additionally, participant discomfort was minimized through the use of anonymous methods of data sharing. As in the case of the IFA’s debriefing method, the focus of this research was on learning and improving performance.

**Limitations**

This study has a number of limitations. The design, which involved the comparison of data over time, led to the lack of a control group. Another study limitation stemmed from the fact that our program was designed to meet the needs of the medical staff operating within the delivery ward and, as a result, may not be applicable “as is” to other healthcare providers and settings. However, major elements of the approach could be generalized to other hospital wards. Additionally, our findings may be related, at least in part, to the Hawthorne effect, i.e. an improvement in performance due to subjects’ knowledge of being observed (31). Moreover, the compliance rate for briefings/debriefings was not monitored on a regular basis for each procedure and not all procedures in the study period were followed by a debriefing form. Nevertheless, with increased awareness a gradual change took place. We decided to include data from all procedures undertaken during the study period since all physicians attended the feedback meetings and had the opportunity to learn and improve from the debriefing process. Compliance with debriefing has been reported to be difficult by others who, at the same times, reported improved outcomes regardless of the compliance rate (1,2,32-34).

**Conclusion**

Intrapartum complications are a substantial cause of morbidity and, occasionally, mortality. They may be devastating to a woman and her child and costly to health care systems. Some of these complications are preventable. However, their prevention may require a change in systems and individual behavior. The aviation debriefing concept, and the three questions presented via a smartphone application have the potential to be successfully adapted to other delivery wards. This is because they not only decrease errors, but these tools have also been shown to be cost-effective, efficient and easily generalizable to other clinical settings.

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**Table 1:** Application for post-procedure debriefing.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Vacuum delivery debriefing form** | | | | | | | | | | | | | |
| 1. What happened? (mark the relevant space) | | | | | | | | | | | | | |
| other | Uneventful | | Failed | | Tear grade 3/4 | | PPH | Shoulder dystocia | | Cord pH<7.1 | Neonatal trauma | |  |
|  |  | |  | |  | |  |  | |  |  | | NRFHR |
|  |  | |  | |  | |  |  | |  |  | | Prolonged second stage |
|  |  | |  | |  | |  |  | |  |  | | Woman exhaustion |
|  |  | |  | |  | |  |  | |  |  | | NRHFR + Prolonged second stage |
| **Uterine revision debriefing form** | | | | | | | | | | | | | |
| 1. What happened? (mark the relevant space) | | | | | | | | | | | | | |
|  | |  | |  | Other | Uneventful | | | Systolic blood pressure < 70 mmHg | | | PPH |  |
|  | |  | |  |  |  | | |  | | |  | Retained placenta |
|  | |  | |  |  |  | | |  | | |  | Retained membranes |
|  | |  | |  |  |  | | |  | | |  | Retained cotyledon |
|  | |  | |  |  |  | | |  | | |  | PPH |
|  | |  | |  |  |  | | |  | | |  | Complicated suturing |

NRFHR, non-reassuring fetal heart rate; PPH Postpartum Hemorrhage

2. Why did it happen? ...................................

3. How can I improve? ..................................

**Equipment faults related to the distinctive procedure**

1. Were there equipment problems? Yes/No

2. Why did it happen? .................................

3. How can I improve? .................................

**Table 2. Maternal demographic and obstetric variables and outcomes of vacuum delivery over time**

|  |  |  |  |
| --- | --- | --- | --- |
| **Demographic and obstetric variables** | | **Maternal outcomes** | |
| **Variables** **(N=308)** | **Mean ± SD or N (%)** | **Outcome** | ***P*-value** |
| Maternal age, years | 28.3±5.4 | Tear grade 3 or 4\* | ….. |
| Maternal age >35 years | 30 (9.7) | Vacuum cup detachments | <0.001 |
| Smoking status | 21 (6.8) | Shoulder dystocia | <0.001 |
| Ethnicity  Arabs  Jews | 128 (41.6) 180 (58.4) | PPH | 0.019 |
| Pregestational BMI (kg/m2) | 23.0±4.3) | Length of stay, days | 0.003 |
| Pregestational BMI >30 (kg/m2) | 20 (6.5) | **Neonatal outcomes** | |
| Primiparous (1st birth) | 223 (72.4) | **Outcome** | ***P*-value** |
| Maternal diseases | 39 (12.7) | Apgar<7 at 1 min | 0.006 |
| Diabetes in pregnancy | 28(9.1) | Apgar<7 at 5 min | 0.2686 |
| Hypertension | 5 (1.6) | Cord artery PH<7.1 | <0.001 |
| Gestational age at delivery | 39.5±1.0 | Cord artery PH<7.0 | 0.0064 |
| Reason for vacuum  Prolonged second stage Non-reassuring fetal FHR Combined | 103 (33.4) 187 (60.7) 18 (5.8) | Photo therapy | <0.001 |
| **Neonatal variables during the study period** | | NICU admission | 0.048 |
| **Variables** **(N=308)** | **Mean ± SD or N (%)** | Any of the above | <0.001 |
| Neonatal birthweight, grams | 3188.7±421.2 | Neonatal trauma  Cefalohematoma  Clavicular fracture  Erb's palsy\*  Any | 0.426  0.104  …..  0.132 |
| Neonatal gender (male) | 154 (50) | Length of stay | 0.99 |

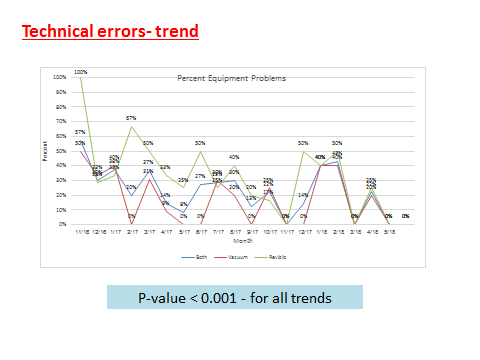
\*Only one case was identified during the study period

**Table 3. Maternal demographic and obstetric variables and outcomes of genital tract examination over time**

|  |  |  |  |
| --- | --- | --- | --- |
| **Demographic and obstetric variables** | | **Maternal outcomes** | |
| **Variables** **(N=219)** | **Mean ± SD or N (%)** | **Outcome** | ***P*-value** |
| Maternal age, years | 28.88±5.93 | Blood transfusion | >0.001 |
| Maternal age >35 years | 32 (14.6) | Number of blood units transfused | 0.506 |
| Ethnicity  Arabs  Jews | 105 (47.9) 114 (52.1) | Postpartum hemoglobin drop >2 gr% | >0.001 |
| Pregestational BMI (kg/m2) | 24.066±4.53 | Postpartum hemoglobin <9 gr% | >0.001 |
| Pregestational BMI >30 (kg/m2) | 33.150 (2.58) | Postpartum hemoglobin <8 gr% | >0.001 |
| Smoking | 11 (5.0) | Systolic blood pressure <70 mmHg | 0.042 |
| Primiparous (1st birth) | 86 (39.3) | Length of stay, days | 0.637 |
| Maternal diseases | 29 (13.2) |  |  |
| Diabetes in pregnancy | 12 (5.5%) |  |  |
| Hypertension | 10 (4.6) |  |  |
| Gestational age at delivery | 39.229±2.01 |  |  |
| Mode of delivery  Spontaneous vaginal  Vacuum extraction | 208 (95.0) 11 (5.0) |  |  |
| Reasons for revision\*  PPH  Retained placental products  Complicated tears\*\* | 108 (48.2) 44 (19.6) 72 (32.1) |  |  |
| Tear grade 3 or 4 | 1 (0.5) |  |  |

\*N=224, due to overlap reasons.

\*\*Complicated tears were those who required general or regional anesthesia for repair and included tears in the cervix, proximal part of the vagina, grade 3 or 4 and tears that were repaired under anesthesia upon women request.



**Figure 1**