AOGS MAIN RESEARCH ARTICLE

Contribution of antepartum and intrapartum hemorrhage to the burden of maternal near miss and death in a national surveillance study

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Abstract

Objective. To evaluate the occurrence of severe obstetric complications associated with antepartum and intrapartum hemorrhage among women from the Brazilian Network for Surveillance of Severe Maternal Morbidity. *Design.* Multicenter cross-sectional study. *Setting.* Twenty-seven obstetric referral units in Brazil between July 2009 and June 2010. *Population.* A total of 9555 women categorized as having obstetric complications. *Methods.* The occurrence of potentially life-threatening conditions, maternal near miss and maternal deaths associated with antepartum and intrapartum hemorrhage was evaluated. Sociodemographic and obstetric characteristics and the use of criteria for management of severe bleeding were also assessed in these women. *Main outcome measures.* The prevalence ratios with their respective 95% confidence intervals adjusted for the cluster effect of the design, and multiple logistic regression analysis were performed to identify factors independently associated with the occurrence of severe maternal outcome. *Results.* Antepartum and intrapartum hemorrhage occurred in only 8% (767) of women experiencing any type of obstetric complication. However, it was responsible for 18.2% (140) of maternal near miss and 10% (14) of maternal death cases. On multivariate analysis, maternal age and previous cesarean section were shown to be independently associated with an increased risk of severe maternal outcome (near miss or death). *Conclusion.* Severe maternal outcome due to antepartum and intrapartum hemorrhage was highly prevalent among Brazilian women. Certain risk factors, maternal age and previous cesarean delivery in particular, were associated with the occurrence of bleeding.

Abbreviations: AIH, antepartum and intrapartum hemorrhage; CI, confidence interval; MD, maternal death; MNM, maternal near miss; PLTC, potentially life-threatening conditions; PR, prevalence ratio; SMO, severe maternal outcome; WHO, World Health Organization.

Key Message

Knowledge on hemorrhage as a cause of maternal morbidity and mortality is widespread; however, mainly for postpartum and not for antepartum and intrapartum conditions. We targeted their occurrence, risk factors and potential for preventability.

Introduction

Maternal mortality is directly related to maternal health conditions and maternal care in a region. Maternal mortality ratio is an important indicator of the quality of

obstetric care. The situation is still critical in many populations worldwide, especially Southern Asia and sub-Saharan Africa. In these under-resourced regions, people have chronically lived with very high maternal mortality ratios that contribute to the elevated global rate of maternal deaths (MD) (1).

The aim of the fifth Millennium Development Goal is to decrease by 75% the maternal mortality ratio from 1990 to 2015 (2). Despite notable advances towards the improvement in mortality, it seems unlikely that this goal will be achieved. Although there has been a significant decrease in the number of MDs – from virtually 47% between 1990 and 2010 – the declining rate is less than half of the rate necessary to attain such a goal. To make this possible, urgent interventions are required, including improved access to emergency obstetric services with staff qualified in labor care (1,2).

Advances in obstetrics have significantly reduced MDs resulting from hemorrhagic syndromes. Nevertheless, hemorrhage remains the leading cause of MDs worldwide, accounting for around 50% of deaths in some low-income and middle-income countries. The reason for this high death rate is the lack of either adequate medical care or basic life support, despite the existence of well-defined protocols for prevention (3–5).

Antepartum and intrapartum hemorrhage (AIH) affects about 1% of all pregnancies and remains one of the leading causes of maternal and perinatal morbidity/mortality worldwide (6,7). About half of the cases are caused by placental abruption or placenta previa. Uterine rupture, placental anomalies and local genital tract disorders, such as cervicitis and neoplasms, are other causes of bleeding. No definitive cause is diagnosed in some patients (8). AIH poses a great risk to the fetus, representing a major cause of perinatal mortality (9).

Intrapartum hemorrhage has various predisposing causes, such as vaginal laceration, uterine laceration during cesarean section and abnormally invasive placenta. Up to 90% of patients with placenta accreta variations require transfusion therapy and maternal mortality is elevated (10). An increased risk of bleeding due to placenta accreta during delivery has been observed even in high-income countries and is related to the increase in cesarean deliveries (11–13).

Despite a global improvement in maternal mortality ratios, antepartum/intrapartum hemorrhage remains an important cause of maternal near miss (MNM). For every woman who dies, many more will survive but suffer from disabilities of any nature. Some of these conditions are less severe and may be characterized as potentially life-threatening conditions (PLTC). However, other conditions are severe and life-threatening, with characteristics very similar to cases that result in MD (14,15). MNM is

defined by the World Health Organization (WHO) as an event in which a woman almost died, but survived the complication during pregnancy, childbirth or within 42 days of termination of pregnancy. The woman had to present at least one criterion of severity with regard to organ dysfunction or failure. For this purpose, standardized criteria were defined (clinical signs, laboratory-based or management-based) to identify near-miss cases. These criteria were previously validated in a Brazilian obstetric population (16). The WHO also recommends that this approach should be used to evaluate the quality of obstetric care (17).

Characterization of MNM morbidity is valuable for monitoring the quality of obstetric care. The use of MNM as a model for the study of MD still offers considerable advantages. It allows the identification of risk factors and early signs of maternal life-threatening conditions. Furthermore, it has greater acceptance than MDs with better performance of data analysis, since the near-miss rate is higher than the death rate (16,18,19).

The present analysis proposed to evaluate the occurrence of factors associated with maternal complications (potentially life-threatening condition, MNM and MD) attributed to AIH in a group of pregnant and postpartum women, included in the Brazilian Network for Surveillance of Severe Maternal Morbidity Study (16,20). The study was also aimed at identifying the sociodemographic and obstetric characteristics of women associated with a worse progression for severe maternal outcome (SMO; death or near miss), as well as the frequency of criteria for management of near-miss cases among these women.

Material and methods

The current study analyzed all hospital admissions for deliveries and postpartum care that occurred from July 2009 to June 2010 in 27 obstetric referral centers distributed in the five geographical Brazilian regions. Data were collected from the Brazilian Network for the Surveillance of Severe Maternal Morbidity (16,20) in a cross-sectional cohort study by prospective surveillance of patient charts at the time of hospital discharge. At each center, a local research coordinator collected data using manual forms. Data were then entered into an electronic on-line platform (OpenClinica® version 3.0; Akaza Research, Waltham, MA, USA). Subsequently, data were checked and validated by the local investigator. Data quality control was performed at each participating center. Health professionals trained by the coordinating center made follow-up visits and analyzed randomly selected cases (about 5% of cases from each center). More detailed information about the methodological aspects of the study can be found in other publications (16,20).

Sample size was estimated at 75 000 deliveries that should be screened to obtain a sufficient number of maternal complications of diverse causes. Covering a total of 82 144 live births, the presence of any potentially life-threatening condition, MNM and MD was observed, according to new WHO definition and criteria, which are summarized in Table 1 (13). The sociodemographic, clinical, obstetric and prenatal characteristics, complications during labor and/or postpartum period, data on patient care and newborn conditions were analyzed in all the included cases. The study was approved by the Institutional Review Board of the study coordinating center, by the respective Institutional Review Boards of each participating center, and finally by the National Research Ethics Council. The prevalence of different types of bleeding complications among women with PLTC, MNM and MD was calculated. The presence of criteria for management of severe bleeding was also evaluated among women with any type of antepartum or intrapartum hemorrhage and women who had some other complication, estimating the prevalence ratio (PR) and its respective confidence interval (95% CI). Similarly, the sociodemographic and obstetric characteristics of women with antepartum or intrapartum complications were analyzed, estimating the risk of SMO (near miss or death). The presence of WHO criteria for near miss among women with antepartum or intrapartum hemorrhagic complications was observed. The presence of factors associated with SMO (SMO = MD + MNM) was also analyzed. Finally, multiple logistic regression analysis was carried out to identify factors independently associated with more severe complications due to antepartum or intrapartum hemorrhage.

The results were analyzed using SPSS® (IBM Corp, Armonk, NY, USA) and Epi Info® 3.5.3 (http://epi-info. software.informer.com/3.5/) software packages. Values of $p < 0.05$ were considered significant. On bivariate analysis, a Fisher's exact or a chi-squared test was used, estimating the PR with 95% CI adjusted for cluster effect of study design. For multivariate analysis, multiple Poisson regression including all the predictive variables in the model was used.

Table 1. The WHO criteria for potentially life-threatening conditions and maternal near miss (13).

(A) Criteria for potentially life-threatening conditions	
Hemorrhagic disorders	**Hypertensive disorders**
Placental abruption	Severe preeclampsia
Accreta/increta/percreta placenta	Eclampsia
Ectopic pregnancy	Severe hypertension
Postpartum hemorrhage	Hypertensive encephalopathy
Ruptured uterus	HELLP (hemolysis, elevated liver enzymes, low platelets) syndrome
Other systemic disorders	**Severe management indicators**
Endometritis	Blood transfusion
Pulmonary edema	Central venous access
Respiratory failure	Hysterectomy
Seizures	Intensive care unit admission
Sepsis	Prolonged hospital stay (>7 postpartum days)
Shock	Non-anesthetic intubation
Thrombocytopenia <100 000	Return to operating room
Thyroid crisis	Surgical intervention
(B) Criteria for maternal near-miss criteria	
Clinical criteria	
Acute cyanosis	Loss of consciousness lasting ≥12 h
Gasping	Loss of consciousness AND absence of pulse/heart beat
Respiratory rate >40 or <6/min	Stroke
Shock	Uncontrollable fit/total paralysis
Oliguria non-responsive to fluids or diuretics	Jaundice in the presence of pre-eclampsia
Clotting failure	
Laboratory-based criteria	
Oxygen saturation <90% for ≥60 min	pH < 7.1
$P_aO_2/F_iO_2 < 200$ mmHg	Lactate >5 mmol/L
Creatinine ≥300 mmol/L or ≥3.5 mg/dL	Acute thrombocytopenia (<50 000 platelets)
Bilirubin >100 mmol/L or >6.0 mg/dL	Loss of consciousness AND the presence of glucose and ketoacidosis in urine
Management-based criteria	
Use of continuous vasoactive drugs	Intubation and ventilation for ≥ 60 min not related to anesthesia
Hysterectomy following infection/hemorrhage	Dialysis for acute renal failure
Transfusion of ≥5 units red cell transfusion	Cardio-pulmonary resuscitation

Table 2. Prevalence of the main causes of antepartum and intrapartum hemorrhage among maternal morbidity cases classified as potentially life-threatening conditions (PLTC), maternal near miss (MNM) and maternal death (MD).

Type of maternal morbidity	PLTC (*n*)	MNM (*n*)	MD (*n*)	Total (*n*)
Complications due to hemorrhage	23.0%	43.5%	35.7%	
Antepartum and intrapartum hemorrhage	7.1 (613)	18.2 (140)	10.0 (14)	(767)
Placental abruption	5.4 (467)	9.2 (71)	5.0 (7)	(545)
Placenta previa/accreta	1.7 (147)	7.7 (59)	2.9 (4)	(210)
Uterine rupture	0.2 (17)	1.7 (13)	2.1 (3)	(33)
Other complications	77.0%	56.5%	64.3%	
Total	8645	770	140	
WHO criteria for MNM and MD for antepartum and intrapartum hemorrhage				
Clinical		(73)	(13)	(86)
Laboratory-based		(45)	(10)	(55)
Management-based		(109)	(14)	(123)
Total		140	14	154

Results

During the study 82 144 deliveries with live births were recorded in participating obstetric units. Of these, 9555 women had some complication related to pregnancy, labor or the postpartum period, respectively with 8645 (90.38%) PLTC cases, 770 (8.14%) of MNM and 140 (1.48%) of MD. Among women with PLTC, 23% had a bleeding complication, which also occurred in 43.5% of women with near-miss events and 35.7% of those who died (Table 2). Antepartum and intrapartum bleeding complications accounted for 7.1% of PLTC cases, 18.2% of MNM cases and 10% of MD cases, representing 8% of all complications identified (Figure 1), whereas postpartum hemorrhage was more frequent, representing 12.5% of all complications. Placental abruption was the most common cause of antepartum and intrapartum hemorrhage, accounting for 5.4% of PLTC cases, 9.2% of MNM cases and 5.0% of MD cases (Table 2).

Among the 140 women with near-miss events and antepartum/intrapartum hemorrhage, 73 had some clinical criteria, 45 had some laboratory-based criteria and 109 had some management-based criteria for near miss. In contrast, among the 14 deaths due to bleeding, 13 had some clinical criteria, 10 had some laboratory-based criteria and all 14 had some management-based criteria (Table 2). Among the cases of death from this specific cause, seven (50%) were due to placental abruption, four to placenta accreta and three to uterine rupture. The great majority of them were associated with important delays and/or substandard care related to the characteristics and professionals of the facilities where the deaths occurred.

Concerning criteria used for management of severe bleeding in women with AIH compared with those with any other complications, a significantly higher risk was
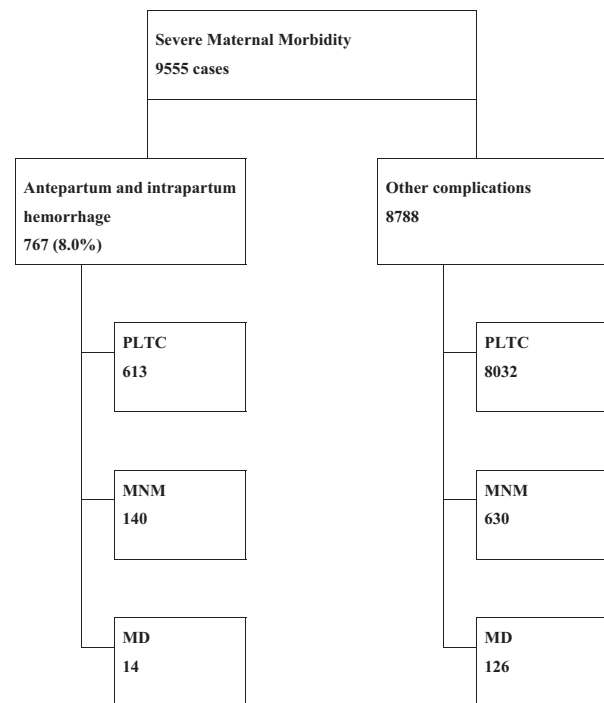
Figure 1. Flowchart of women with severe maternal morbidity due to antepartum and intrapartum hemorrhage or other causes according to the final outcome in potentially life-threatening condition (PLTC), maternal near miss (MNM) or maternal death (MD).

observed in this group for transfusion therapy (PR = 2.62), use of central venous access (PR = 1.62), return to the operating room (PR = 1.57), and laparotomy or hysterectomy (PR = 2.18). A lower risk of using magnesium sulfate was also observed (PR = 0.51) (Table 3).

The risk of SMO (MNM or MD) was estimated among women with antepartum or intrapartum hemorrhage, in comparison to those presenting with any other obstetric

Table 3. Estimated risk of antepartum and intrapartum hemorrhage in several criteria for management of severe bleeding in women with obstetric complications.

Criteria for severity	Antepartum and intrapartum hemorrhage	Other complications	PR	95% CI
Blood transfusion	37.9	14.5	**2.62**	**2.01–3.40**
Central venous access	5.9	3.6	**1.62**	**1.01–2.60**
Admission to intensive care unit	21.5	22.2	0.97	0.74–1.28
Prolonged hospital stay (>7 days)	31.6	29.9	1.06	0.94–1.19
Intubation unrelated to anesthesia	3.8	3.0	1.24	0.85–1.81
Return to operating room	5.0	3.2	**1.57**	**1.06–2.30**
Hysterectomy/laparotomy	12.3	5.6	**2.18**	**1.39–3.41**
Use of magnesium sulfate	25.8	50.3	**0.51**	**0.41–0.64**
Other major surgical procedure	1.2	0.7	1.61	0.83–3.13
Total	767	8788		

PR, prevalence ratio adjusted for cluster effect; 95% CI, 95% confidence interval for prevalence ratio.

Values in bold type are statistically significant.

complications, according to sociodemographic characteristics. The risk of SMO was higher in women from 30 to 39 years old (PR = 1.86) and in married women or those with a partner (PR = 1.57) (Table 4). Among obstetric characteristics, the estimated risk of SMO was higher among women with a history of two or more previous cesarean deliveries (PR = 3.23), increasing parity

Table 4. Estimated risk of severe maternal outcome (maternal near miss + maternal death) among women with antepartum and intrapartum hemorrhage according to some sociodemographic characteristics.

Characteristics	SMO	PLTC	PR	95% CI
Age (years)				
10–19	7.1	12.7	0.78	0.53–1.16
20–29	36.4	48.8	(ref.)	
30–39	51.9	31.5	**1.86**	**1.48–2.34**
40–49	4.5	7.0	0.89	0.48–1.63
n	154	613		
Marital status[a]				
Married/with partner	66.7	53.4	**1.57**	**1.02–2.42**
Single/no partner/widow	33.3	46.6	(ref.)	
n	123	500		
Education[b]				
Primary	52.0	51.0	(ref.)	
High	37.8	44.0	0.87	0.64–1.18
University	10.2	5.0	1.67	0.80–3.52
n	98	402		
Ethnicity[c]				
White	49.6	43.1	(ref.)	
Non white	50.4	56.9	0.81	0.40–1.64
n	121	448		

95% CI, 95% confidence interval for prevalence ratio adjusted for cluster effect; PLTC: potentially life-threatening condition; PR: prevalence ratio; SMO, severe maternal outcome.

Values in bold mean they are statistically significant.

Missing values for: [a]144 cases; [b]267; [c]198.

(PR = 2.87), hospital admission at a gestational age lower than 28 weeks (PR = 1.74) or in the postpartum period (PR = 4.69). The identification of any delay was only marginally associated with SMO (odds ratio 1.55, 95% CI 1.00–2.42) (Table 5).

Among all the factors evaluated together, multivariate analysis (Table 6) showed that greater age (PR = 1.03) and a previous history of cesarean section (PR = 1.85) were independently associated with the occurrence of a more severe condition (near miss or death), due to complications resulting from AIH.

Discussion

Despite advances in obstetrics and intensive-care medicine, hemorrhage persists as the leading cause of MD. The important role of this condition in severe maternal morbidity and mortality was clearly evident in the current study. Bleeding complications were present in 23% of women who had any potentially life-threatening condition. However, when the most severe cases were analyzed – outcome categorized as near miss or death – hemorrhage was increasingly frequent (43.5% of near-miss cases and 35.7% of deaths). Therefore, when a bleeding complication was present, clinical course tended to be more severe. Previous studies have already shown such an association (21,22).

Specifically, hemorrhage in the antepartum and intrapartum period was shown to be less frequent than postpartum hemorrhage, occurring in about 1% of all live births, whereas postpartum hemorrhage was almost twice as frequent (7). However, when the most severe cases were analyzed, its importance became more evident. Around 18% of all MNM cases and 10% of all MDs were due to these bleeding complications. Owing to their frequency, potential for preventability and crucial

Table 5. Estimated risk of severe maternal outcome (maternal near miss + maternal death) among women with antepartum and intrapartum hemorrhage according to some obstetric characteristics.

Characteristics	SMO	PLTC	PR	95% CI
Previous abortions[a]				
None	71.7	75.7	(ref.)	
1 or higher	28.3	24.3	1.18	0.77–1.80
n	152	609		
Previous cesarean sections[b]				
None	53.5	74.0	(ref.)	
1	16.7	18.2	1.22	0.79–1.88
2 or higher	29.9	7.8	**3.23**	**2.12–4.90**
n	144	599		
Parity[a]				
0	19.1	38.9	(ref.)	
1–2	43.4	40.6	**1.93**	**1.31–2.85**
≥3	37.5	20.5	**2.87**	**1.93–4.27**
n	152	609		
A previous uterine scar[c]				
Yes	2.7	2.2	1.18	0.29–4.69
No	97.3	97.8	(ref.)	
n	111	496		
Number of prenatal visits[d]				
None	9.2	7.2	1.35	0.62–2.93
1–5	54.1	51.3	1.16	0.81–1.66
6 or more	36.7	41.6	(ref.)	
n	98	433		
Gestational age at admission[e]				
<28 weeks	12.9	11.3	**1.74**	**1.01–2.99**
28–33	30.6	34.8	1.40	0.77–2.54
34–36	21.1	23.1	1.44	0.81–2.58
≥37	16.3	27.6	(ref.)	
Admission in postpartum	19.0	3.2	**4.69**	**2.59–8.48**
n	147	597		
Previous clinical condition[f]				
Yes	46.3	39.4	1.25	0.78–1.99
No	53.7	60.6	(ref.)	
n	121	482		
Mode of delivery or pregnancy termination[g]				
Vaginal delivery	14.4	8.5	1.19	0.45–3.11
Cesarean section	83.0	89.5	0.75	0.27–2.14
Still pregnant/abortion/ectopic pregnancy	2.7	2.0	(ref.)	
n	153	611		
Onset of labor[h]				
Spontaneous	28.4	26.1	1.13	0.67–1.91
Induced	7.4	5.3	1.38	0.71–2.68
No labor/abortion/still pregnant	64.2	68.7	(ref.)	
n	148	609		
Coverage for prenatal care[i]				
Public	86.6	89.7	(ref.)	
Private	1.6	1.8	0.94	0.34–2.58
Health insurance	6.3	3.1	1.71	0.90–3.27
No prenatal care	5.5	5.5	1.03	0.49–2.16
n	127	455		

Table 5. Continued

Characteristics	SMO	PLTC	PR	95% CI
Occurrence of delays[j]				
Yes	32.2	21.1	1.55	1.00–2.42
No	67.8	78.9	(ref.)	
n	146	554		
Previous maternal conditions[k]				
Chronic hypertension	14.0	11.2	1.22	0.77–1.94
Smoking	11.6	9.5	1.18	0.54–2.62
Obesity	11.6	16.4	0.72	0.41–1.25
Drug addiction	4.1	1.9	1.81	0.90–3.67
n	121	482		

95% CI, 95% confidence interval for prevalence ratio adjusted for cluster effect; PLTC: potentially life-threatening condition; PR: prevalence ratio; SMO, severe maternal outcome.
Values in bold mean they are statistically significant.
Missing values for: [a]6 cases; [b]24; [c]160; [d]236; [e]23; [f]164; [g]3; [h]10; [i]185; [j]67; [k]164 cases.

importance in maternal morbidity and mortality, healthcare protocols and prevention policies are common in the prevention and treatment of postpartum hemorrhage. Nevertheless, the same does not occur for AIH. Many cases of antepartum and intrapartum bleeding episodes occur in women with identifiable risk factors and can

Table 6. Factors independently associated with severe maternal outcome (maternal near miss + maternal death) among women with antepartum and intrapartum hemorrhage (n = 743).

Variable	Coefficient	SE coefficient	p	PR_adj (95% CI)
Age (years)	0.03	0.01	0.001	1.03 (1.01–1.04)
Previous cesarean sections (≥1)	0.61	0.18	0.002	1.85 (1.28–2.66)
Constant	−2.67	0.22	0.001	

95% CI, 95% confidence interval; PR_{adj}, prevalence ratio adjusted for cluster effect and other significant predictive factors.
Multiple Poisson regression, controlled by: age (years); marital status (married/with partner: 1; others: 0); schooling (up to high school: 0; university: 1); ethnicity (White: 0; non-White: 1); body mass index (underweight/adequate: 0; overweight/obese: 1); previous abortion (0; ≥1: 1); previous cesarean sections (0; ≥1: 1); parity (0; ≥1: 1); previous uterine scar (yes: 1; no: 0); number of prenatal visits (up to 5: 1; ≥6: 1); gestational age at admission (<37 or still pregnant: 1; ≥37: 0); risk previous to pregnancy (yes: 1; no: 0); mode of delivery (vaginal, cesarean: 1; still pregnant/abortion/ectopic pregnancy: 0); onset of labor (spontaneous/induced: 1; no labor/abortion/still pregnant: 0); coverage for prenatal care (public: 0/other: 1); occurrence of delays) (yes: 1; no: 0); previous maternal conditions: chronic hypertension (yes: 1; no: 0); smoking (yes: 1; no: 0); obesity (yes: 1; no: 0); drug addiction (yes: 1; no: 0).

therefore be oriented towards an appropriate level of care and adequate planning in such institutions. Avoiding unnecessary cesarean sections would for instance probably be effective in reducing the occurrence of antepartum and postpartum hemorrhage. Due to its potential severity, special attention is required in this specific type of bleeding complication (1,3,23).

Placental abruption is the single most significant cause of antepartum hemorrhage. Although there are various known risk factors, the etiology and pathogenesis of the condition is multifactorial and not fully understood. Placental abruption is strongly associated with preeclampsia and this complication may account for up to 50% of cases. However, it may also be related to other causes, such as smoking and trauma (24–27). In this study, the high incidence and severity of this bleeding condition were shown. It was the leading cause of AIH, accounting for 7.1% of near-miss cases and 10% of all MDs in the study. Placental abruption remains one of the most important causes of perinatal morbidity and mortality, although its rate is decreasing in some countries (7).

None of the 140 near-misses or the 14 deaths presented all the WHO criteria for near misses, something that highlights the importance of systematically investigating these three types of criteria (clinical, laboratory-based and management-based) in any surveillance proposal, as none of them alone is able to identify all SMOs.

It was not surprising that blood transfusion was used more frequently in women with AIH than in the remaining complications. Transfusion therapy is expected in a hemorrhagic syndrome, because it is part of the treatment for this condition (28,29). However, this reinforces the importance of obstetric referral centers that are equipped with blood banks or blood centers. These blood units should be situated at a short distance from the delivery room and have the capacity to provide blood products quickly. As this is one of the main lines of treatment in cases of severe complications, the lack or reduced availability of such blood banks, especially in locations far from large urban centers, may be related to the persistently high rates of negative outcome related to hemorrhage. This could also be related to the marginal trend found of delays in obtaining care for the complication.

In addition to a greater need for central venous access, indicating the severity of the case, there was also a higher risk of returning to the operating room for more invasive surgical procedures, such as laparotomy or hysterectomy. The potential severity of AIH was shown and contributed to explain the large amount of worse outcomes, such as MNM and MDs, because these procedures potentiate the risk. Furthermore, maternity hospitals equipped with blood banks and trained staff members are required to perform these procedures, when necessary.

The increased risk of SMO with increasing maternal age and parity is well-known. It is known that age and multiparity are also strongly associated with the occurrence of placental abruption and abnormally invasive placenta, along with various other morbid conditions during pregnancy and labor (24–26). The association between previous cesarean sections and hemorrhage is also known. Among the possible explanations for this association are previous uterine scars that increase the risk of abnormal placentation and uterine rupture (12,13,30). In this study, a strong association was confirmed between previous cesarean deliveries and bleeding. The risk of a worse outcome (near miss or death) due to AIH was threefold, when there was a history of two or more previous cesarean deliveries.

Women with gestational age <28 weeks at hospital admission also had a higher risk of developing more severe outcomes (death or near miss) related to AIH. Placental abruption and placenta percreta are major conditions responsible for these types of bleeding. These conditions are usually manifested at an early gestational age, which contributes to explain the increased risk found. Women in the postpartum period at the time of hospital admission also had a very high risk of developing a negative outcome. Because the study centers were obstetric referral centers, it was understood that these centers received patients who delivered in other healthcare services of lower complexity and had severe complications. An important reason for patient transfer is hemorrhage, due to the lack of blood banks in these services or the capacity to perform major surgery.

Of all factors related to AIH presenting a high risk for more severe outcomes (near miss or death), multivariate analysis showed that maternal age and previous cesarean section were independently significant. The importance of both factors in these bleeding complications was highlighted.

The current study has some limitations or weaknesses that could be addressed. For instance, some differences in results found in comparison with other studies could be due to the classification of hemorrhage used. Some of the conditions included are sometimes classified as trauma instead of hemorrhage. We tried to standardize these concepts using the WHO recommendations exactly with the purpose of making possible future comparisons for those using the same approach. On the other hand, there are of course some strengths as well, including the fact that this was the first national multicenter study to use the new WHO concepts and criteria for MNM, showing the power of combining efforts of a network of health facilities working together to generate data on maternal health that could be of importance for guiding public health policies in the field. This would be the

embryo for the proposal and development of the much desired routine system of surveillance for severe maternal morbidity to be implemented in settings where it is most needed, which could direct new challenges for research in the future.

Conclusion

Antepartum and intrapartum hemorrhages were frequent causes of obstetric complications that had a direct relationship with more severe clinical outcomes (near miss or death). The presence of bleeding increased the risk of transfusion therapy significantly, along with the need for central venous access, return to the operating room and need to undergo puerperal hysterectomy. Advanced maternal age and a history of previous cesarean section were independently related to worse maternal outcomes associated with AIH.

Funding

Acknowledgments

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