Incidence, Causes, Complications, and Trends Associated with Peripartum Hysterectomy and Interventional Management for Postpartum Haemorrhage: a 14-Year Study

Menelik MH LEE MBBS, MRCOG, MHKCOG
Belinda CW YAU MBBS, MRCOG, FHKCOG, FHKAM (O&G)
Department of Obstetrics and Gynaecology, Queen Elizabeth Hospital, Jordan, Hong Kong

Objectives: To identify possible causes for peripartum hysterectomy (PH), how the mode of delivery impacts on having the procedure, and whether other interventional management reduces the likelihood of resorting to this intervention.
Methods: This was a study of patients encountered over the period 1998 to August 2012. The records of all patients who underwent a PH and those who had other non-hysterectomy interventional management (uterine and/or iliac artery embolisation, uterine and/or iliac artery ligation, uterine compression sutures, and balloon tamponade) for postpartum haemorrhage were retrospectively reviewed. Those managed by medical management alone were excluded. Causes and complications associated with a PH were identified and trends over the 14-year study period were explored. Its associations with mode of delivery were similarly reviewed. Patients were also divided into two groups, namely: those having PH and those having other interventional management. Causes, mode of delivery, complications, and management successes in the two groups were compared. Significant factors and causes were also analysed in detail for two time periods, namely: 1998-2004 and 2005-2012.
Results: During the 14-year period (1998 to 2012), a total of 76,145 mothers underwent delivery. Among these, 75 (0.099% or 1 per 1000) patients underwent a PH or other interventional management as a treatment for postpartum haemorrhage; 47 (0.062% or 0.62 per 1000) had a PH. Analysis of these 47 patient's records showed that abnormal placentation including placenta praevia and morbidly adherent placenta were the main prevailing causes (57.4%). In this group, undergoing a Caesarean section (76.6%) was more prevalent than vaginal delivery (23.4%). While morbidly adherent placenta (odds ratio [OR]=15.3; 95% confidence interval [CI], 1.9-122.8; p<0.001), classical Caesarean section (OR=2.3; 95% CI, 1.3-7.4; p=0.006), and previous Caesarean section (OR=4.4; 95% CI, 1.3-14.8; p=0.01) were significantly associated with having a PH when compared to mothers who underwent other interventional management. Among those who had Caesarean section as the mode of delivery, elective operations (OR=4.8; 95% CI, 1.0-24.2; p=0.04) and those having repeat Caesarean sections (OR=4.1; 95% CI, 1.2-15.1; p=0.02) were also more likely to have a PH. There were also significance in the amount of packed cells (PH vs. non-PH: 16.4 units vs. 10.2 units; p=0.037) and fresh frozen plasma (9.0 units vs. 5.2 units; p=0.046) transfused. Those patients who had a uterine or internal iliac artery embolisation (OR= –3.3; 95% CI, -1.2 to -9.0; p=0.018), and/or uterine compression sutures (OR = –3.7; 95% CI, -1.1 to -4.3; p=0.014) were less likely to need a PH, particularly those caused by uterine atony. In the past 14 years, PHs have a 3.0-fold increase after adjustment for the rise of total delivery numbers. Among those who had a PH, Caesarean section (4.3-fold, p<0.001), previous Caesarean section (6.4-fold, p<0.001), and abnormal placentation (6.0-fold, p<0.001) were the main contributing causes and factors for such increase.
Conclusions: This paper reinforces the need for obstetricians to be made aware of the seriousness of maternal morbidity and mortality associated with a PH which is on the rise. Much of this increase was due to the leading causes and factors which were Caesarean sections, previous Caesarean sections, and abnormal placentation. As most of these causes are known factors associated with a Caesarean section, these data provide further impetus to control the rapidly increasing Caesarean section rate including those on request alone. In addition, when interventional management for postpartum haemorrhage is inevitable, methods such as uterine compression sutures and arterial embolisation should be used at an earlier stage especially if the cause was due to uterine atony.
Hong Kong J Gynaecol Obstet Midwifery 2013; 13(1):52-60

Keywords: Hysterectomy; Peripartum period; Postpartum hemorrhage; Uterine rupture

Correspondence to: Dr. Menelik MH Lee
Email: menelik.lee@gmail.com

Introduction

Postpartum haemorrhage (PPH) is a leading cause of maternal morbidity and mortality worldwide[1]. When severe and all methods fail to control the bleeding, peripartum hysterectomy (PH) is usually performed[2]. Literature suggested the overall point prevalence of PH ranges from 0.3 to 2.7 per 1000 deliveries (0.0003 to 0.0027%)[3-8] and 1.05 to 8.9 per 1000 Caesarean deliveries (0.001 to 0.0089%)[2]. Recent studies have shown that Caesarean section in particular, is highly associated with a PH[9]. It is believed that with an increasing number of Caesarean sections worldwide, the rate of PH is also expected to increase[10].

Identification of such associations and causes of PH are important as the operation may result in substantial maternal morbidity and mortality, as well as loss of fertility. By understanding the trends of relevant associated factors, there may be scope for improving patient safety and preserving fertility.

In recent years, other forms of interventional management have been shown to be effective in preventing PHs. Recourse to arterial embolisation, uterine compression sutures, iliac artery ligation, and balloon tamponade have all been shown to be successful, with success rates ranging between 84 and 92%[11]. It is therefore important to identify the type of interventions used and the associated likelihood of reducing PHs. Similar previous studies performed in the United States and Taiwan showed that morbidly adherent placentas were the leading cause of PH[3], while uterine atony was also a major cause[12]. However, there was no similar study in the Hong Kong population and no local reports addressed other interventional management as possible PH-prevention strategies.

Thus, the aim of this study was to review Hong Kong's population to identify possible causes for PH and how the mode of delivery affects having such an operation. This entailed analysis of putative causes/associations over the 14-year study period and assessing whether other interventional management was likely to reduce the likelihood of PH.

Methods

Queen Elizabeth hospital is one of the largest hospitals within the Hong Kong public hospital system and provides high-risk obstetric services. In this retrospective study, all patients who underwent a PH and those who had other interventional management for primary PPH were included. The latter interventions included uterine and/or iliac artery embolisation, uterine and/or iliac artery ligation, uterine compression sutures, and balloon tamponade (either via a foley balloon, a Sengstaken Blakemore tube or a Bakri balloon). Patients managed by medical management alone were excluded. In our hospital, primary PPH was defined as >500 ml blood loss within 24 hours of delivery after a vaginal delivery and 1000 ml after a Caesarean section. The duration of the study was taken from 1998 (when the Clinical Management System [CMS] computerised record system was initiated) until the most recent month of August 2012 to ensure a maximal number of available cases.

Hospital delivery rates and Caesarean section rates were first identified through the hospital database. Patient identifications were then performed via the CMS. All obstetrics patients who had a PH or other interventional management would have had their episodes documented in the Health Authority's CMS within 28 days, with different procedures being identifiable by a specific code. Patients having these various procedures could therefore be readily identified, and relevant information could then be retrieved via the Clinical Data Analysis and Reporting System.

The admission records of identified patients were traced and reviewed. Using a specially designed in-house proforma, necessary information was retrieved from the patients' hospital notes, and included demographic data such as age, gravidity, parity, and gestational age. Total PH rates over the 14-year study period were derived. Analyses of the causes and complications of the procedure were also carried out. Causes were categorised as placental (placenta praevia, placenta accreta, or morbidly adherent placenta); uterine (uterine atony, uterine rupture, uterine wound tear, uterine inversion); and other (e.g. disseminated intravascular coagulopathy [DIC], vulval haematoma, and perineal tears).

Mode of delivery, which in itself is highly associated with PH[9], was also examined in detail. Normal vaginal delivery and instrumental delivery were categorised as vaginal, since collectively these are not believed to influence the risk to PH[9]; Caesarean sections will be categorised separately.

Patients who ultimately underwent a hysterectomy in the peripartal period were categorised as being in the PH group, regardless of any other additional interventions (e.g. compression sutures or balloon prior to their hysterectomy). In the other group, patients who had other interventional management without undergoing PH were referred to as the non-hysterectomy (NH) group. Patients in both groups

could have received mechanical and medical methods to treat PPH (e.g. uterine massage, syntocinon infusion, misoprostol, carboprost and/or nalador administered).

Causes, mode of delivery, and complications were compared in the two groups. The aim was to identify causes that best predicted having a PH, but also to identify other interventional methods that failed. Regarding the PH group, all causes identified as significant were also assessed separately in two time periods (between 1998 – 2004 and between 2005 – August 2012). The aim of such separate time-dependent assessments was to evaluate possible trends with respect to the point prevalence of PH as well as putative causes. Other interventional management strategies used in the PH and NH groups were also reviewed to determine whether they could have had an influence on PH and NH rates. Interventions significantly associated with avoidance of PH were then carefully evaluated as possibly indicated for peripartal patients at risk.

Statistical analyses were performed using the Statistical Package for the Social Sciences (Windows version 19.0; SPSS Inc, Chicago [IL], US). Baseline characteristics of the study were compared using percentages and a variety of statistical tests. The independent *t*-test was used to analyse continuous data, such as blood loss and units of blood transfused. Categorical data (causes, blood loss, blood product use, management strategies) in the two groups were analysed using backward logistic regression. The frequencies of significant causes throughout the 14 years were analysed using the hypothesis test. All statistical tests were two tailed, and p values of <0.05 were considered statistically significant.

The entire research protocol was approved by the Ethics Committee of the study hospital. No patients underwent additional tests or visits, and therefore consent from the patients was not obtained.

Results

During the 14-year period from 1998 to August 2012, a total of 76,145 mothers delivered their babies in our hospital. Of these, 16,952 (22.3%) were by Caesarean section. Delivery frequencies and Caesarean section rates increased steadily during this period. In all, 75 of these mothers had a PH or NH as a treatment for PPH, which amounts to 0.099% or approximately 1 per 1000 mothers; ultimately, 47 patients (0.062% or 0.62 per 1000 deliveries) underwent PH (Table 1).

Among the reasons for PH, abnormal placentation was the most common (57.4%); 36.2% being due to a morbidly adherent placenta and 21.3% being due to placenta praevia. Uterine atony continues to be an important cause (29.8%). Regarding the mode of delivery in PH patients, 76.6% had undergone a Caesarean section and 23.4% had undergone vaginal delivery (Table 2). Backward logistic regression showed that a morbidly adherent placenta (odds ratio [OR]=15.3; 95% confidence interval [CI], 1.9-122.8; p<0.001) was the cause more associated with the PH than NH group. Having a classical Caesarean section (OR=2.3; 95% CI 1.3-7.4, p=0.006) and having had a previous Caesarean section (OR=4.4; 95% CI, 1.3-14.8; p=0.01) were also more likely in the PH than NH group. Patients with uterine atony (OR= –8.6; 95% CI, -2.9 to -25.6; p<0.001) were more associated with the NH than PH group (Table 3).

Using backward logistic regression in patients having a Caesarean section (n=36), it was evident that PH was significantly associated with having the Caesarean as an elective (rather than emergency procedure) [OR=4.8; 95% CI, 1.0-24.2; p=0.04], and having had a prior Caesarean section (OR=4.1; 95% CI, 1.2-15.1; p=0.02) [Table 3].

The most common complications we encountered after PH and NH are shown in Table 4. In the PH group,

Table 1. Total numbers of deliveries between 1998 and August 2012

	Total (1998-2012 Aug)	1998-2004	2005-2012 August
Total No. of delivery	76,145	31,712	44,433
No. (%) of Caesarean sections	16,952 (22.3%)	6206 (19.6%)	10,746 (24.2%)
Total Nos. having interventional management* or peripartum hysterectomy	75 (0.099%)	11	64
Total Nos. having peripartum hysterectomy only	47	9	38
Total rate of peripartum hysterectomy	0.062%	0.028%	0.086%

* Interventional management defined as either: balloon tamponade, uterine/internal iliac embolisation, uterine compression sutures, or uterine/internal iliac ligation after failure using medical and mechanical management

Table 2. Most common causes and mode of delivery found among those who had a peripartum hysterectomy (PH)

Cause/mode of delivery	PH group (n=47)
Causes	
Abnormal placentation	27 (57.4)
Placenta praevia	10 (21.3)
Morbidly adherent placenta	17 (36.2)
Uterine atony	14 (29.8)
Uterine rupture	2 (4.3)
Haematoma	2 (4.3)
Uterine wound tear	1 (2.1)
Disseminated intravascular coagulopathy	1 (2.1)
Mode of delivery	
Caesarean section (all)	36 (76.6)
Repeat Caesarean section	19 (40.4)
Primary Caesarean section	17 (36.2)
Vaginal delivery (including instrumental delivery)	11 (23.4)
Classical Caesarean section	11 (23.4)

they were: DIC (44.7%), surgical re-exploration (38.3%), and postoperative fever (23.4%). Notably, eight (17.0%) of PH patients sustained cardiovascular injuries; half (n=4) of these had a cardiac arrest, two of whom did not survive. Thus, the overall death rate in the PH group was 4.3%. On comparing the complication rates in the PH and NH groups, only surgical re-exploration was significantly more likely in the former.

Based on independent sample *t*-tests, there were statistically significant differences between the PH and NH groups with respect to mean values for soft/surrogate end-points (Table 4). The respective mean values were as follows: estimated blood losses, 6351 ml vs. 3131 ml (p=0.001); packed cell units transfused, 16.4 vs. 10.2 (p=0.037); fresh frozen plasma units transfused, 9.0 vs. 5.2 (p=0.046). Respective mean fetal Apgar scores at 1 minute were 6.40 and 6.96 (p=0.305) and at 5 minutes were 7.78 and 8.0 (p=0.188).

Using backward logistic regression to compare other interventional managements in the PH and NH

Table 3. Frequencies of causes and mode of delivery in peripartum hysterectomy (PH) and non-hysterectomy (NH) groups

	No. (%)		OR	95% CI	p Value
	PH group (n=47)	NH group (n=28)			
Causes					
Morbidly adherent placenta	17 (36.2)	1 (3.6)	15.3	1.9 to 122.8	<0.001
Placenta praevia	10 (21.3)	3 (10.7)	2.5	0.5 to 9.0	0.242
Uterine atony	14 (29.8)	23 (82.1)	-8.6	-2.9 to -25.6	<0.001
Uterine rupture	2 (4.3)	0 (0)	1.6	1.4 to 1.9	0.269
Haematoma	2 (4.3)	0 (0)	1.6	1.4 to 1.9	0.269
Uterine wound tear	1 (2.1)	0 (0)	1.6	1.3 to 1.9	0.437
Disseminated intravascular coagulopathy	1 (2.1)	0 (0)	1.6	1.3 to 1.9	0.437
Perineal tear	0 (0)	1 (3.6)	-1.6	-1.3 to 1.9	0.437
Causes and risk factors					
Mode of delivery					
CS: all	36 (76.6)	19 (67.9)	1.5	0.5 to 4.4	0.95
Vaginal (including instrumental)	11 (23.4)	9 (32.1)			
Primary vs. repeat CS					
Repeat CS	19 (40.4)	4 (14.3)	4.4	1.3 to 14.8	0.01
Primary CS	17 (36.2)	15 (53.6)			
Classical CS	11 (23.4)	0 (0)	2.3	1.3 to 7.4	0.006
Among those who had CS	(n=36)	(n=19)			
Previous CS (compared to primary CS)	19 (52.8)	4 (21.1)	4.1	1.2 to 15.1	0.02
Elective CS (compared to emergency CS)	14 (38.9)	2 (10.5)	4.8	1.0 to 24.2	0.04

Abbreviations: OR = odds ratio; CI = confidence interval; CS = Caesarean section

Table 4. Complications and blood requirements associated with a peripartum hysterectomy (PH) or non-hysterectomy (NH)

Type of complications	Total No. (%) of complications	No. (%) of complications in PH group (n=47)*	No. (%) of complications in NH group (n=28)*	p Value between 2 groups
DIC	32 (42.7)	21 (44.7)	11 (39.3)	0.840
Surgical re-exploration	21 (28.0)	18 (38.3)	3 (10.7)	0.026
Postoperative fever	23 (30.7)	11 (23.4)	12 (42.9)	0.051
CVS injury	10 (13.3)	8 (17.0)	2 (7.1)	0.996
Urinary injury	4 (5.3)	4 (8.5)	0	0.090
Cardiac arrest	4 (5.3)	4 (8.5)	0	0.090
Depression	2 (2.7)	2 (4.3)	0	0.447
Maternal death	2 (2.7)	2 (4.3)	0	0.346
Bowel injury	1 (1.3)	1 (2.1)	0	0.405
Mean (range) blood loss (ml)	5149 (500-29,400)	6351 (1500-29,400)	3131 (500-7400)	0.001
Mean blood transfused (units)	14.1	16.4	10.2	0.037
Mean FFP transfused (units)	7.6	9.0	5.2	0.046
Mean platelets transfused (units)	9.5	11.0	6.8	0.065
Mean cryoprecipitate transfused (units)	1.0	1.4	0.3	0.074
ICU admission	71 (94.7) 2 postnatal, 2 deceased	45 (95.7) 2 deceased	26 (92.9)	-

Abbreviations: DIC = disseminated intravascular coagulopathy; CVS = cardiovascular system, FFP = fresh frozen plasma; ICU = intensive care unit

* Unless otherwise stated

Table 5. Interventional management options comparing peripartum hysterectomy (PH) or non-hysterectomy (NH) groups

Type of interventional management	PH group (n=47)	NH group (n=28)	OR	CI	p Value
Uterine compression sutures	8 (17.0%)	12 (42.9%)	-3.7	-1.1 to -4.3	0.014
Arterial embolisation (uterine and/or internal iliac artery)	12 (25.5%)	14 (50.0%)	-3.3	-1.2 to -9.0	0.018
Arterial ligation (uterine and/or internal iliac artery)	10 (21.3%)	1 (3.6%)	7.3	0.9 to 60.5	0.036
Balloon tamponade	1 (2.1%)	1 (3.6%)	-1.7	-0.1 to 2.9	0.712

Abbreviations: OR = odds ratio; CI = confidence interval

patients, those who had had uterine or internal iliac artery embolisation, and/or uterine compression sutures were more likely in the NH group (respective ORs being -3.3; 95% CI, -1.2 to -9.0; p=0.018 and -3.7; 95% CI, -1.1 to -4.3; p=0.014). Whereas those who had uterine or internal iliac artery ligation were more associated with the PH group (OR=7.3; 95% CI, 0.9 to 60.5; p=0.036) [Table 5].

Given that both arterial embolisation and uterine compression sutures being significantly associated with the avoidance of PH, these strategies were looked into detail regarding their indications and their successes (Table 6). A total of 20 patients had uterine compression sutures, of which 70% (14/20) were for uterine atony, and among them 9 (64%) avoided PH. Only four patients had the compression sutures for abnormal placentation (placenta praevia, morbidly adherent placenta, or both) and the success rate was 50%. In eight of the 14 patients with uterine atony, the Hayman suturing technique was used and hysterectomy was avoided in four of them. In nine patients, B-lynch or modified B-lynch sutures were used; 6 for atony (of which 5 [83.3%] were successful) and 3 for abnormal placentation (of which only 1 [33.3%] was successful).

Among those who had arterial embolisation to treat PPH, 15 did so for uterine atony, and in 11 (73.3%) it was successful. In contrast, only one (14.3%) of seven patients was managed successfully with the use of

Table 6. Compare the indications and success among effective interventional management used

	Total	No. (%) successful
Total compression sutures used	20	12 (60.0)
Compression sutures for uterine atony	14	9 (64.3)
Compression sutures for abnormal placentation	4	2 (50.0)
B-lynch suture	9	7 (77.8)
For uterine atony	6	5 (83.3)
For abnormal placentation	3	1 (33.3)
Hayman's suture	11	5 (45.5)
Hayman's suture for uterine atony	8	4 (50.0)
Hayman's suture for abnormal placentation	1	1 (100.0)
Total artery embolisation used	25	13 (52.0)
Embolisation used for uterine atony	15	11 (73.3)
Embolisation for abnormal placentation	7	1 (14.3)

Table 7. Rates between 1998-2004 and 2005-2012 August

Risk	No. (%)		Adjusted increase	p Value (adjusting to total delivery
	1998-2004	2005-2012 Aug		
Data from Annual Obstetrics report via Hospital Authority				
Total No. of deliveries	257,276 (100)	244,417 (100)*	0	-
Total No. of CS	54,118 (21)	59,807 (24.5)*	1.2-fold	<0.001
Total vaginal deliveries (including instrumental delivery)	202,465 (79)	184,610 (75.5)*	0.9-fold	-
PH rate	143 (0.056)	153 (0.063)*	1.1-fold	-
Total hospital data				
Total No. of deliveries	31,712 (100)	44,433 (100)	0	-
Total No. of CS	6206 (19.6)	10,746 (24.2)	1.2-fold	-
Total vaginal deliveries (including instrumental delivery)	25,506 (80.4)	33,687 (75.8)	0.9-fold	-
PH rate	9 (0.028)	38 (0.086)	3.0-fold	<0.001
Among all PHs				
Total No. of PH	9 (0.028)	38 (0.086)	3.0-fold	<0.001
Vaginal delivery (including instrumental delivery)	4 (0.013)	7 (0.016)	1.2-fold	0.726
CS	5 (0.016)	31 (0.070)	4.3-fold	<0.001
Previous CS	2 (0.006)	17 (0.038)	6.4-fold	<0.001
Abnormal placentation	3 (0.009)	24 (0.054)	6.0-fold	<0.001
Atony	5 (0.016)	9 (0.020)	1.3-fold	0.726
Atony + primary CS	2 (0.006)	6 (0.014)	2.25-fold	0.03
Atony + previous CS	0 (0)	0 (0)	0	-
Abnormal placentation + primary CS	1 (0.003)	5 (0.011)	3.8-fold	<0.001
Abnormal placentation + previous CS	2 (0.006)	15 (0.034)	5.7-fold	<0.001

Abbreviations: OR = odds ratio; CI = confidence interval; CS = Caesarean section; PH = peripartum hysterectomy
* 2005-2010

arterial embolisation when the PPH was due to abnormal placentation (Table 6).

In our institution, the total number of mothers undergoing delivery has been increasing over the past 14 years (Table 7). This was complimented by a significant adjusted increase in the number of Caesarean sections (1.2-fold, p<0.001) as well as PHs being performed during

the same period. PH rates increased 3-fold from 0.028% between years 1998-2004 to 0.086% during the period of 2005-2012 ($p<0.001$).

When the latter time periods were analysed further with respect to patients undergoing PH, there were increases in the number of Caesarean sections (4.3-fold, $p<0.001$), previous Caesarean sections (6.4-fold, $p<0.001$), and patients with abnormal placentation (6-fold, $p<0.001$), even after adjusting for the increase in total number of deliveries. Those with combined abnormal placentation and previous Caesarean section increased 5.7-fold ($p<0.001$) after adjustment.

Discussion

During the study period, the frequency of interventional management including PH to manage PPH was 0.099%, or PH alone the figure was 0.062% (0.62 per 1000 deliveries) These rates were consistent with those cited in other studies[3-8]. That abnormal placentation including placenta praevia and morbidly adherent placenta were leading causes of PH was consistent with other studies[10,12-16]. Undergoing a Caesarean section was the most prevalent mode of delivery among those undergoing PH (Table 2).

Our study also looked at patients having PH and NH as two groups. Having a repeat Caesarean section and in particular a classical Caesarean section was significantly more likely in the PH group than in successfully managed NH patients. This was also the case for patients with a morbidly adherent placenta but not for other causes.

Classical Caesarean sections per se were associated with both previous Caesarean sections and abnormal placentation (placenta praevia, morbidly adherent placenta or both). Of the 11 patients having classical Caesarean sections, 10 were performed after a previous Caesarean section and all 11 of them underwent the procedure for abnormal placentation. This suggests that Caesarean section was more likely to be the underlying cause rather than being merely a risk factor for PH.

Regarding current births by Caesarean section, those having repeat sections were also more likely to belong to PH group. These findings were as expected as elective Caesarean sections are generally carried out for the major problems (e.g. abnormal placentation) and abnormal placentation is more likely after previous Caesarean sections.

Uterine atony remains an important reason for performing a PH, it was also more likely in the NH group, indicating that such hysterectomies can be prevented by a variety of methods so long as uterine atony is the underlying pathology.

PH is reported to be associated with increased maternal mortality and morbidity compared with those not requiring such a procedure[1,17]. This study reinforced recognition of additional problems associated with PH, namely: significantly increased blood loss, as well as the use of packed cells and fresh frozen plasma. The heavy bleeding that leads to a hysterectomy being performed also gives rise to DIC, and in turn this leads to a higher chance of surgical re-exploration and its complications. Notably, 17.0% of these patients endured some sort of cardiovascular injury, 8.5% had a cardiac arrest, and 4.3% died. Contrary to other studies[18], newborn Apgar scores at 1 and 5 minutes were not significantly lower in the PH group. This was likely due to the babies being delivered before haemorrhaging began.

Many reports have demonstrated the use of various surgical interventions to treat PPH whilst also avoiding PH. Prophylactic use of balloon tamponade[19] and uterine compression sutures have both been demonstrated to yield success, whilst some have suggested using a combination of these methods[20]. Success rates with uterine compression sutures can be as high as 75 to 82%[21,22], regardless of the cause (uterine atony, placenta praevia, and morbidly adherent placenta).

This study showed that uterine compression sutures were more likely to be in NH than PH group patients, re-enhancing the effectiveness of this technique. Balloon tamponade has only recently been utilised in our institution, and hence our experience is too limited to adequately comment on its effectiveness. Uterine or internal iliac artery embolisation as a treatment option also showed similar significant benefits, and was also more likely to have been used in NH patients.

Detailed analysis of both uterine compression sutures and arterial ligation showed that these procedures were particular effective in patients with atony. There was a 60% overall success rate, and a 64.3% success rate when compression sutures were used to control bleeding caused by uterine atony. There was 50% success rate if the cause was abnormal placentation. Results also suggested B-lynch sutures were more effective than Hayman's technique, regardless of cause. Our success rate using Hayman's technique was much lower than that suggested

by another study[23], which may be because less than 10% of their patients had placenta praevia whilst approximately 40% of ours had this condition. Overall, these findings indicate B-lynch suturing should be the first-line uterine compression technique, especially in patients with uterine atony.

On the other hand, there were diverse uses of the arterial embolisation technique. Though the effectiveness of arterial embolisation has already been demonstrated as a means of preventing PH, the chance of success was considerably greater in patients with uterine atony (73%) rather than abnormal placentation (14%). In general, despite its usefulness, its success rate was inferior to that documented in other studies, possibly because radiologists were not always be immediately available, particularly at night.

For those who underwent uterine artery or internal iliac artery ligation, there was a significantly higher chance of having a PH. This was unexpected, as it was reported that these procedures could arrest 62% of such haemorrhages and avoid PH[24]. In the latter study however[24], all arterial ligations were attempted immediately after failure of medical uterotonics. Another reason might be that internal iliac artery ligation is generally more difficult and an experienced gynaecologist may not always be immediately available. In recent years moreover, less technically difficult procedures with similar success rates have been introduced, and would be attempted in the first instance. By the time arterial ligation can be achieved, bleeding could be so profuse that minimal results can be achieved. Regarding our data, 11 uterine/internal iliac artery ligations were performed; eight were pre-2006 and only three were later. This was despite an increasing number of patients warranting such additional interventions, and indicates that alternative techniques had become more popular.

As our study evaluated the past 14 years of data retrospectively, an increasing trend in the numbers of mothers being delivered was evident. Even after adjusting for this increase, there was an increase in the popularity of Caesarean sections (1.2-fold) and an adjusted decrease in vaginal deliveries (0.9-fold).

PH was also shown to be more frequently resorted to over these years, there being an adjusted 3.0-fold increase compared to the general overall increase in mothers being delivered. This was contrary to the static trend noted in the Hong Kong territory-wide PH audit covering the 10-year period from 1994 to 2004[25], and the Annual Obstetrics report on all hospitals under the Hospital Authority of Hong Kong between 1998 and 2009[26]. The latter report described a similar adjusted 1.2-fold increase in Caesarean section rate and a similar adjusted decline in vaginal delivery rates. However, when all figures were categorised into PH and NH groups as in our study, the overall adjusted increase in PH rate was only 1.1-fold, in contrast to the 3.0-fold increase in our study (Table 7). One reason for this difference was that in 1998-2004 the PH rate was much lower in our hospital (0.028%) compared to the 0.056% territory-wide rate, which may have been due to the under-reporting or under-documentation in the newly implemented computer system. However, our figure of 0.086% between 2005 and 2012 were also higher than the stated territory-wide rate (0.063%), which was likely due to our hospital being a major referral centre for high-risk obstetrics. Moreover, our hospital was a multicultural area with numerous unbooked patients, often with an unknown past medical and obstetric history. Under-reporting in other hospitals was another possibility.

Considering the 3.0-fold increase in PH rate, the non-significant rise in the rate of uterine atony suggests that other factors may be responsible. Caesarean sections, previous caesarean sections, and abnormal placentation (morbidly adherent placenta and/or placenta praevia) appear to be the major contributors. As for causes/risks of PH, there was an adjusted 4.3-fold increase in Caesarean section rate ($p<0.001$), a 6.4-fold increase in persons who had had a prior Caesarean section ($p<0.001$), and a 6.0-fold increase in abnormal placentation ($p<0.001$). These findings were similar to those described in a recent study from the United States[10].

Earlier, all these factors were described as leading causes/factors giving rise to PH, but they are all actually interlinked. Caesarean section is generally associated with repeat Caesarean sections, as well as placenta praevia (particularly anterior placenta praevia)[27,28] and morbidly adherent placenta[29], just as they also increase the risk of PH individually. A combination of these factors no doubt further increases PH rates. This was evident when PHs due to abnormal placentation increased 6.0-fold, while there was a 5.7-fold increase in the presence of abnormal placentation coupled with a prior Caesarean section. Overall, repeat Caesarean sections lead to future risk factors which continue the increasing trend in PH, if rates and numbers of the Caesarean sections also continue to increase.

Limitations

This was an overview of experience in our hospital

data over the past 14 years. Data obtained during the earlier years (when the CMS record system was first introduced) may have been inaccurate. In the future, therefore, every aspect of this study should be carried out separately, particularly the analysis of different management options for PPH and the subsequent prevention of Caesarean hysterectomy. Ideally, these analyses should all be performed prospectively.

Conclusions

This paper reinforces the need for obstetricians to be made aware of the serious consequences of maternal morbidity and mortality associated with increasing PH rates. Much of this increase appeared due to the two leading causative factors, namely: abnormal placentation and Caesarean section. As most of these causes are known factors associated with a Caesarean section, these data provide further impetus to control the rapidly increasing Caesarean section rate including those resulting only from patient requests. In addition, when interventional management for PPH is inevitable, methods such as uterine compression sutures and arterial embolisation should be considered at an early stage, with a view to preventing PH, especially if due to uterine atony.

Declaration

No conflicts of interest were declared by the authors.

References

1. Knight M, Callaghan WM, Berg C, et al. Trends in postpartum hemorrhage in high resource countries: a review and recommendations from the International Postpartum Hemorrhage Collaborative group. *BMC Pregnancy Childbirth* 2009; 9:55.
2. Rossi AC, Lee RH, Chmait RH. Emergency postpartum hysterectomy for uncontrolled postpartum bleeding: a systematic review. *Obstet Gynecol* 2010; 115:637-44.
3. Stanco LM, Shrimmer DB, Paul RH, et al. Emergency peripartum hysterectomy and associated risk factors. *Am J Obstet Gynecol* 1993; 168:879-83.
4. Forna F, Miles AM, Jamieson DJ. Emergency peripartum hysterectomy: a comparison of cesarean and postpartum hysterectomy. *Am J Obstet Gynecol* 2004; 190:1440-4.
5. Bakshi S, Meyer BA. Indications for and outcome of emergency peripartum hysterectomy. A five year review. *J Reprod Med* 2000; 45:733-7.
6. Kayabasoglu F, Guzin K, Aydogdu S, et al. Emergency peripartum hysterectomy in a tertiary Istanbul hospital. *Arch Gynecol Obstet* 2008; 278:251-6.
7. Kastner ES, Figueroa R, Garry D, et al. Emergency peripartum hysterectomy: experience at a community teaching hospital. *Obstet Gynecol* 2002; 99:971-5.
8. Zelop CM, Harlow BL, Frigoletto FD, et al. Emergency peripartum hysterectomy. *Am J Obstet Gynecol* 1993; 168:1443-8.
9. Spiliopoulos M, Kareti A, Jain N, et al. Risk of peripartum hysterectomy by mode of delivery and prior obstetric history: data from a population based study. *Arch Gynecol Obstet* 2011; 283:1261-8.
10. Bateman BT, Mhyre JM, Callaghan WM, et al. Peripartum hysterectomy in the United States: nationwide 14 year experience. *Am J Obstet Gynecol* 2012; 206:63.e1-8.
11. Doumouchtsis S, Papgeorghlou A, Arulkumaran S. Systematic review of conservative management of postpartum hemorrhage: what to do when medical treatment fails. *Obstet Gynecol Surv* 2007; 62:540-7.
12. Jou HJ, Hung HW, Ling PY, et al. Peripartum hysterectomy in Taiwan. *Int J Gynecol Obstet* 2008; 101:269-72.
13. Imudia AN, Awonuga AO, Dbouk T, et al. Incidence, trends, risk factors, indications for, and complications associated with cesarean hysterectomy: a 17 year experience from a single institution. *Arch Gynecol Obstet* 2009; 280:619-23.
14. Knight M, Kurinczuk JJ, Spark P, et al. Cesarean delivery and peripartum hysterectomy. *Obstet Gynecol* 2008; 111;97-105.
15. Yamasmit W, Chaithongwongwatthana S. Risk factors for cesarean hysterectomy in tertiary centre in Thailand: a case-control study. *J Obstet Gynaecol Res* 2009; 35:60-5.
16. Bodelan C, Bernabe-Ortiz A, Schiff MA, et al. Factors associated with peripartum hysterectomy. *Obstet Gynecol* 2009; 114:115-23.
17. Orbach A, Levy A, Wiznitzer A, et al. Peripartum cesarean hysterectomy: critical analysis of risk factors and trends over the years. *J Matern Fetal Neonatal Med* 2011; 24:480-4.
18. Awan N, Bennett MJ, Walters WA. Emergency peripartum hysterectomy: a 10-year review at the Royal Hospital for Women, Sydney. *Aust N Z J Obstet Gynaecol* 2011; 51:210-5.
19. Albayrak M, Ozdemir I, Koc O, et al. Post-partum haemorrhage from the lower uterine segment secondary to placenta praevia/accreta: successful conservative management with Foley balloon tamponade. *Aust N Z J Obstet Gynaecol* 2011; 51:377-80.
20. Diemert A, Ortmeyer G, Hollwitz B, et al. The combination of intrauterine balloon tamponade and the B-Lynch procedure for the treatment of severe postpartum hemorrhage. *Am J Obstet Gynecol* 2012; 206:65.e1-4.
21. Kayem G, Kurinczuk JJ, Alfirevic Z, et al. Uterine compression sutures for the management of severe postpartum haemorrhage. *Obstet Gynecol* 2011; 117:14-20.
22. Baskett TF. Uterine compression sutures for post partum hemorrhage: efficacy, morbidity and subsequent pregnancy. *Obstet Gynecol* 2007; 110:68-71.
23. Ghezzi F, Cromi A, Uccella S, et al. The Hayman technique: a simple method to treat postpartum haemorrhage. *BJOG* 2007; 114:362-5.
24. Joshi VM, Otiv SR, Majumder R, et al. Internal iliac artery ligation for arresting postpartum haemorrhage. *BJOG* 2007; 114:356-61.
25. Hong Kong territory wide audit on post partum haemorrhage. *Hong Kong College of Obstetricians and Gynaecologists*; 2004.
26. Annual Obstetrics report on all hospital under Hospital Authority, Hong Kong: 1998-2009. *Hong Kong: Hospital Authority*.
27. Memon S, Kumari K, Yasmin H, et al. Is it possible to reduce rates of placenta praevia? *J Pak Med Assoc* 2010; 60:566-9.
28. Zaideh SM, Abu-Heija AT, El-Jallad MF. Placenta praevia and accreta: analysis of a two-year experience. *Gynecol Obstet Invest* 1998; 46:96-8.
29. Jauniaux E, Jurkovic D. Placenta accreta: pathogenesis of a 20th century iatrogenic uterine disease. *Placenta* 2012; 33:244-51.