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Systematic Review of Conservative Management of Postpartum Hemorrhage: What to Do When Medical Treatment Fails

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We performed a systematic review to identify all studies evaluating the success rates of treatment of major postpartum hemorrhage by uterine balloon tamponade, uterine compression sutures, pelvic devascularization, and arterial embolization. We included studies reporting on at least 5 cases. All searches were performed independently by 2 researchers and updated in June 2006. Failure of management was defined as the need to proceed to subsequent or repeat surgical or radiological therapy or hysterectomy, or death. As the search identified no randomized controlled trials, we proceeded to search for observational studies. This identified 396 publications, and after exclusions, 46 studies were included in the systematic review. The cumulative outcomes showed success rates of 90.7% (95% confidence interval [CI], 85.7%–94.0%) for arterial embolization, 84.0% (95% CI, 77.5%–88.8%) for balloon tamponade, 91.7% (95% CI, 84.9%–95.5%) for uterine compression sutures, and 84.6% (81.2%–87.5%) for iliac artery ligation or uterine devascularization ($P = 0.06$). At present there is no evidence to suggest that any one method is better for the management of severe postpartum hemorrhage. Randomized controlled trials of the various treatment options may be difficult to perform in practice. As balloon tamponade is the least invasive and most rapid approach, it would be logical to use this as the first step in the management.

Target Audience: Obstetricians & Gynecologists, Family Physicians

Learning Objectives: After completion of this article, the reader should be able to recall that there are no randomized controlled studies on various methods of treating postpartum hemorrhage (PPH), state that the success rate for one method is no better than another method in the management of severe PPH, and explain that after medical management fails the next logical approach is the use of the balloon tamponade.

A recent article (1) demonstrated that the role of hemorrhage is prominent in maternal mortality, especially in developing countries where it accounts for over one-third of all maternal deaths. Fourteen million cases of postpartum hemorrhage (PPH) occur each year with a case-fatality rate of 1% (2). Severe obstetric morbidity may be a more sensitive measure of pregnancy outcome than mortality alone, and in a study by Waterstone et al (3) it was shown that, of obstetric complications, the disease-specific morbidity per 1000 deliveries was highest for hemorrhage. This study called for the development and evaluation of ways of reducing the risk of severe hemorrhage. Apart from the considerable suffering for women and their families, PPH also creates major demands on health systems (2).

The cause of PPH is commonly due to abnormalities of 1 or a combination of 4 basic processes: uterine

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The authors have disclosed that the Sengstaken–Blakemore esophageal catheter, Foley catheter and condom have not been approved by the U.S. Food and Drug Administration for use in the treatment of postpartum hemorrhage. Please consult product labeling for the approved usage of these devices.

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atony; retained placenta, membranes, or blood clots; genital tract trauma; or coagulation abnormalities. Prevention of PPH rests on "active management" of the third stage by administration of prophylactic uterotonic agents (most commonly syntometrine [ergometrine and oxytocin] or oxytocin alone), early cord clamping, and controlled cord traction of the umbilical cord. This approach has been shown to reduce the risks of PPH and severe PPH; postpartum anemia and blood transfusion requirements; and prolonged third stage of labor and use of therapeutic drugs for PPH (4). It is now recommended that active management should be routine for women in maternity hospitals. Furthermore, there is no evidence to suggest that this recommendation should not include births at home or at birth centers (4).

Despite the reduction of PPH using active management, about 1%–5% of births are complicated by severe PPH of greater than 1000 mL (5). Treatment is dependent on the cause; as uterine atony is the most common cause, medical management usually consists of oxytocin 10 units by slow IV injection, ergometrine 0.5 mg by slow IV injection, methergine 0.2 mg intramuscularly, dilute oxytocin infusion, 15-methyl $PGF_{2\alpha}$ (Carboprost® or Hemabate®) intramuscularly or intramyometrially, 20 mg dinoprostone vaginally or rectally, or misoprostol 1000 μg rectally (6,7). However, there is no good evidence on what to do when such medical treatment fails.

A recent ACOG practice bulletin suggests that tamponade of the uterus can be effective in decreasing hemorrhage secondary to uterine atony, and that procedures such as uterine artery ligation or B-Lynch suture may be used to obviate the need for hysterectomy. In patients with stable vital signs and persistent bleeding, arterial embolization may be suitable, especially if the rate of loss is not excessive. Furthermore, it is suggested that if hysterectomy is performed for uterine atony, there should be documentation of other therapy attempts (7).

In the United Kingdom recent reports recommended that obstetricians must consider all available interventions to stop hemorrhage, including B-Lynch suture, embolization of uterine arteries, or radical surgery (8). In addition recommendations have been made that all hospitals with delivery units should aim to provide an emergency interventional radiology service as these have the potential to save lives of patients with catastrophic PPH (9).

Such national recommendations prompted us to perform a systematic review of the current literature on the conservative surgical and radiological management of major PPH—namely arterial embolization, balloon tamponade, compression sutures, and pelvic devascularization—to evaluate the success rates of these different fertility-preserving and morbidity-reducing treatment modalities.

METHODS

We used published guidelines for the systematic review of observational studies (the MOOSE guidelines) (10).

Identification of Studies

An electronic search strategy was developed for medical literature databases [The Cochrane Library 2006:2, PubMed (1966–2006), Medline (1966–2006), Embase (1980–2006), and the National Research Register], and all searches were updated in June 2006. Searches were performed independently by 2 of the researchers (S.D., A.P.) to identify all studies evaluating the success rates of treatment of PPH by uterine balloon tamponade, uterine compression sutures, pelvic devascularization, and arterial embolization. Database search terms used were the keywords "postpartum" or "post partum" or "obstetric" and "haemorrhage/hemorrhage" and "balloon," "tamponade," "artery embolization/embolisation," "compression suture," "B-Lynch," "artery ligation," or "devascularization/devascularisation." In addition, references of articles identified were checked for eligibility. We restricted the search to human subjects, but no other filters were applied.

The original intention was to perform a review of randomized controlled trials; however, as no such studies were identified (see Results) the research focus shifted to a systematic review of observational studies. No language restriction was applied in the search for randomized trials. However, due to the large volume of single case reports in other languages, we restricted the search to English-language articles in the search for observational studies. A reference database (EndNote 9.0, Thomson) was used to incorporate all references, and duplicate hits from the searches were excluded.

Study Selection and Definitions

Studies were selected in 3 stages. First, the abstracts of all articles in the database were examined independently by the 2 researchers. We subsequently examined the full text of each article, and for inclusion in the review, used an arbitrary cutoff of articles with at least 5 cases reported.

The third step was careful scrutiny of full-text articles where inclusion criteria were met. Cases were excluded if measures were taken prophylactically, where the intervention was used after previous surgical or radiological measures including hysterectomy, and if the gestational age at delivery was less than 20 weeks. A large number of studies reported not only on PPH, but also on women who had hemorrhage due to other causes, including first trimester miscarriage or termination of pregnancy, ectopic pregnancy, gestational trophoblastic disease, gynecological malignancies, or after hysterectomy. We extracted data to include only those cases where the treatment was for PPH, after 20 weeks of gestational age. Studies were excluded where it was not possible to distinguish those women who had treatment for PPH from those who received it for other causes. In addition, a number of studies reported on prophylactic alongside therapeutic procedures for PPH. Wherever possible we excluded prophylactic cases and included therapeutic cases only; where it was not possible to separate prophylactic and treatment procedures, studies were excluded. Seventeen studies were excluded at this stage (references available upon request).

Failure of management was defined as the need to proceed to subsequent or repeat surgical or radiological therapy or hysterectomy, or death. Not all the studies reported the same definition; for example, in some studies successful management consisted of temporary arrest of PPH, or even arrest of hemorrhage after using a second method. Our aim was to eliminate positive outcome bias, and a uniform definition of success and failure, applicable to all studies, was decided on.

Both authors assessed studies for inclusion and any discrepancies were resolved by discussion or referral to a third author (S.A.).

Data Extraction and Statistical Analysis

Tables were created for each study representing the total number of cases and those that were treated successfully. The success rates using each treatment method were calculated, and comparison made using a χ^2 test. Two-tailed P tests are reported.

Quality Assessment

Articles meeting the selection criteria were assessed for methodological quality of factors likely to influence results. Items assessed were prospective design, consecutive recruitment, adequate description of cases included and procedures undertaken, and complete reporting of outcomes and complications.

RESULTS

The search identified no randomized controlled trials. The database searches identified 393 studies that met the initial inclusion criteria. In addition, 2 studies were identified from scrutiny of references (11,12), and we also included a study from our center that has been submitted for publication, giving a total number of 396 articles (Fig. 1). Of these, 333 studies were excluded after abstract and manuscript scrutiny (available on request). In addition, 17 studies were

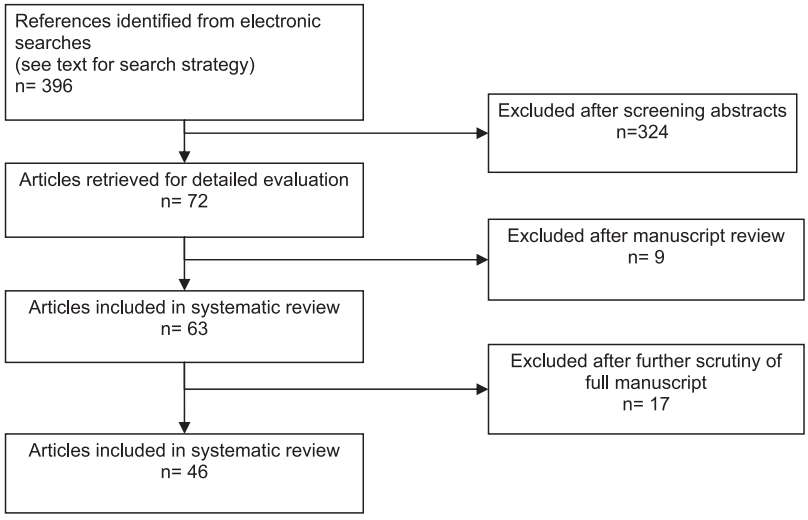

Fig. 1. Study selection.

excluded at the third step of review (references available upon request). All studies identified were either case reports or case series ranging from 5 to 265 cases. The methodological quality of the included studies was generally poor. Most of the papers included small numbers of subjects and did not report characteristics of patients.

The cumulative outcomes showed success rates of 90.7% for arterial embolization, 84% for uterine balloon tamponade, 91.7% for uterine compression sutures, and 84.6% for internal iliac artery ligation or pelvic devascularization (Tables 1–6), and there was no significant difference in success rates between the 4 procedures ($\chi^2 = 7.31$, $P = 0.06$).

DISCUSSION

In this review we evaluated the different methods of conservative surgical and radiological management of PPH. To achieve this we performed an extensive and comprehensive literature search. No randomized controlled trials regarding the effectiveness of the interventions under investigation were identified. However, a large number of case series were identified, and we used strict predefined inclusion and exclusion criteria to assess their validity to keep potential bias to a minimum. Due to the large number of case reports in the literature, we used a cutoff of at least 5 reported cases in an attempt to

TABLE 1
Studies reporting on the use of arterial embolization as a single measure for the management of major PPH

Authors	Year	Country	Method	Total (n)	Successful Treatment (n)	Success Rates (%)	95% CI (%)
Gilbert et al (21)	1992	USA	IIAE	7	7/7	100	63.0–99.9
Mitty et al (22)*	1993	USA	Internal pudendal and UAE	7	6/7	85.7	47.3–96.8
Yamashita et al (23)	1994	Japan	AE	15	13/15	86.7	61.7–96.0
Merland et al (24)	1996	France	UAE	16	15/16	93.8	71.3–98.5
Pelage et al (25)	1999	France	UAE	14	14/14	100	78.5–100
Ledee et al (26)	2001	France	AE	7	5/7	71.4	35.9–91.8
Deux et al (27)	2001	France	AE	25	24/25	96	80.5–99.3
Cheng et al (13)	2003	Taiwan	AE	13	12/13	92.3	66.7–98.6
Ornan et al (28)	2003	USA	AE	21	19/21	90.5	71.1–97.4
Tourne et al (29)	2003	France	UAE	12	11/12	91.7	64.6–98.5
Tsang et al (30)	2004	Hong Kong	AE	8	8/8	100	67.6–100
Hong et al (31)	2004	Taiwan	IIAE	5	5/5	100	56.6–100
Boulleret et al (32)	2004	France	AE	35	30/35	85.7	70.6–93.7
Ojala et al (33)	2005	Finland	AE	8	6/8	75	40.1–92.9
Total				**193**	**175/193**	**90.7**	**85.7–94.0**

*One case excluded (abdominal pregnancy).

IIAE indicates internal iliac artery embolization; UAE, uterine artery embolization; AE, arterial embolization (artery not specified or various arteries embolized).

TABLE 2
Studies reporting on the use of uterine balloon tamponade as a single measure for the management of major PPH

Authors	Year	Country	Method	Total (n)	Successful Treatment (n)	Success Rate (%)	95% CI (%)
Goldrath (34)	1983	USA	Foley catheter	20	19/20	95.0	76.4–99.1
Condous et al (35)	2003	England	SBEC	16	14/16	87.5	64.0–96.5
Akhter et al (36)	2003	Bangladesh	Condom	23	23/23	100	85.7–100
Penney and Brace (11)	2003	Scotland	Balloon (various)	6	5/6	83.3	43.7–97.0
Penney et al (12)	2004	Scotland	Balloon (various)	21	15/21	71.4	50.1–86.2
Seror et al (37)	2005	France	SBEC	17	12/17	70.6	46.9–86.7
Keriakos and Mukhopadhyay (38)	2006	England	Rusch balloon	8	7/8	87.5	52.9–97.8
Dabelea et al (39)	2006	USA	Not reported	24	19/24	79.2	59.5–90.8
Doumouchtsis et al	Submitted for publication	England	SBEC	27	22/27	81.5	63.3–91.8
Total				**162**	**136/162**	**84.0**	**77.5–88.8**

SBEC indicates Sengstaken–Blakemore esophageal catheter.

TABLE 3
Studies reporting on the use of B-Lynch or other uterine compression sutures as a single surgical measure for the management of major PPH

Authors	Year	Country	Method	Total (n)	Successful Treatment (n)	Success Rates (%)	95% CI (%)
B-Lynch et al (16)	1997	England	B-L	5	5/5	100	56.6–100
Cho et al (17)	2000	Korea	CS	23	23/23	100	85.7–100
Pal et al (40)	2003	India	B-L	6	6/6	100	61.0–100
Smith and Baskett (41)	2003	Canada	B-L	7	6/7	85.7	48.7–97.4
Penney and Brace (11)	2003	Scotland	B-L	10	9/10	90	59.9–98.2
Penney et al (12)	2004	Scotland	B-L	19	13/19	68.4	46.0–84.6
Wohlmuth et al (42)	2005	USA	B-L	12	11/12	91.7	64.6–98.5
Pereira et al (19)	2005	Portugal	CS	7	7/7	100	64.6–100
Hwu et al (43)	2005	Taiwan	CS	14	14/14	100	78.5–100
Nelson and Birch (18)	2006	Canada	B-L (modified)	5	5/5	100	56.6–100
Total				**108**	**99/108**	**91.7**	**84.9–95.5**

B-L indicates B-Lynch sutures; CS, compression sutures.

TABLE 4
Studies reporting on the use of arterial ligation or pelvic devascularization as a single surgical measure for the management of major PPH

Authors	Year	Country	Method	Total (n)	Successful Treatment (n)	Success Rates (%)	95% CI (%)
O'Leary and O'Leary (44)	1966	USA	UAL	10	8/10	80.0	49.0–94.3
Evans and McShane (45)	1985	USA	IIAL	14	6/14	42.9	21.4–67.4
Clark et al (46)	1985	USA	IIAL	19	8/19	42.1	23.2–63.7
Fahmy (47)	1987	Kuwait	UAL	25	20/25	80.0	61.0–91.1
Fernandez et al (48)	1988	France	IIAL	8	8/8	100	67.6–100
Thavarasah et al (49)	1989	Malaysia	IIAL and ovarian artery ligation	14	9/14	64.3	38.8–83.7
Chattopadhyay et al (50)	1990	Saudi Arabia	IIAL	29	19/29	65.5	47.4–80.1
Likeman (51)	1992	Australia	IIAL	9	9/9	100	70.1–100
Allahbadia (52)	1993	India	IIAL	17	13/17	76.5	52.7–90.4
AbdRabbo (20)	1994	Egypt	Stepwise uterine devascularization	103	103/103	100	96.4–100
O'Leary (53)*	1995	USA	UAL	141	138/141	97.8	93.9–99.3
Das and Biswas (54)	1998	India	IIAL	11	10/11	90.9	62.3–98.4
Ledee et al (26)	2001	France	IIAL	48	43/48	89.6	77.8–95.5
Hebisch and Huch (55)	2002	Switzerland	Transvaginal UAL	13	12/13	92.3	66.7–98.6
Penney et al (12)	2004	Scotland	UAL	5	2/5	40	11–8–76.9
Verspyck et al (56)	2005	France	Pelvic devascularization	7	5/7	71.4	35.9–91.8
Papp et al (57)	2005	Hungary	IIAL	28	11/28	39.3	23.6–57.6
Total				**501**	**424/501**	**84.6**	**81.2–87.5**

*In the study by O'Leary (53) cases before 1973 were excluded, as these are reported in O'Leary and O'Leary (44,58).
IIAL indicates internal iliac artery ligation; UAL, uterine artery ligation.

minimize reporting and positive-outcome bias. On the basis of the best available data, we calculated the success rates of the various management options for the treatment of PPH after failure of medical therapy. We have shown that the success rates for arresting PPH are 84.0% for balloon tamponade, 90.7% for arterial embolization, 91.7% for compression sutures, and 84.6% for pelvic devascularization (including uterine or internal iliac artery ligation). There is no statistically significant difference in success rates between these procedures.

Arterial embolization under fluoroscopic guidance requires expertise in interventional radiology. In this review, the success rate was 91%. Although the procedure has the potential of preservation of fertility, the need for specialized equipment combined with the urgency of ongoing PPH means that the procedure is limited to centers with a high degree of expertise. The use of prophylactic embolization may have a role in conjunction with a planned caesarean section for placenta accreta or increta (13).

TABLE 5
Complications of surgical and radiological management of PPH

Arterial embolization
Buttock ischemia small bowel necrosis (59)
Transient foot ischemia (60)
Transient buttock numbness, numbness in buttock, urinary frequency, small bowel infarct, incontinence (28)
Numbness of the right leg (30)
Thrombosis of left popliteal artery, vaginal necrosis, and paresthesia of the right leg (33)
Uterus and bladder necrosis after uterine artery embolization for postpartum hemorrhage (61)
Uterine necrosis and sepsis after vascular embolization and surgical ligation (62)
Uterine necrosis after arterial embolization for postpartum hemorrhage (63)
Fetal growth restriction in the next pregnancy after uterine artery embolization for postpartum hemorrhage (64)
Puncture-site false aneurysm; regressive lower-limb paresthesia; femoral vein thrombosis; puncture-site hematomas (32)
B-Lynch—compression sutures
Pyometria after hemostatic square suture technique (65)
Erosion of a B-Lynch suture through the uterine wall (66)
Partial ischemic necrosis of the uterus after a uterine brace compression suture (67)
Uterine cavity synechiae after hemostatic square suturing technique (68)
Uterine necrosis (69)
Pelvic devascularization—arterial ligation
Postischemic lower motor neuron damage; obstruction of right common iliac artery (requiring treatment by bypass graft) (45)
Acute intestinal occlusion (48)
Wound dehiscence, transient claudication pain over left buttock (52)
Broad ligament hematomas (53)
Peripheral nerve ischemia (70)

TABLE 6
Success rates of surgical and radiological measures in the management of PPH

Method	No. Cases	Success Rates (%)	95% CI (%)
B-Lynch/compression sutures	108	91.7	84.9–95.5
Arterial embolization	193	90.7	85.7–94.0
Arterial ligation/pelvic devascularization	501	84.6	81.2–87.5
Uterine balloon tamponade	162	84.0	77.5–88.8

There was no statistically significant difference between the 4 groups ($P = 0.06$).

The use of uterine packing in the management of PPH fell into disfavor after the 1950s, following concerns of concealing ongoing hemorrhage, development of infection, and its "nonphysiological approach" (14). More recently, Maier concluded that uterine packing is a safe, quick, and effective procedure for controlling PPH (15). Given the difficulty and potential traumatic procedure of insertion of roller gauze packs, the use of uterine balloon tamponade has been favored more recently. Successful use of a variety of balloon devices has been reported, and the Sengstaken–Blakemore esophageal catheter has been the most frequently reported device (Table 2). We have previously shown that it can be used as a "Tamponade Test." This arrests bleeding in the majority of women with severe PPH, and allows the obstetrician to identify which women will require surgical intervention. Advantages of this method include avoidance of laparotomy; easy and rapid insertion with minimal anesthesia, and that it can be performed by relatively inexperienced personnel; painless removal; and rapid identification of failed cases.

If the patient is stable and bimanual compression of the uterus successfully arrests the bleeding, then compression sutures may be of value. Various modifications have been reported to the original B-Lynch (16) suture technique (17–19). The ease of application of such sutures is a major advantage, and fertility is preserved (14). The obvious disadvantages are the need for laparotomy and usually hysterotomy (although some modified types have avoided the latter surgical step of the procedure), and reported complications (Table 5).

Pelvic devascularization also requires laparotomy, and progressive, step-wise devascularization has been described (20), whereby uterine, tubal branches of the ovarian and finally internal iliac arteries are ligated. Primary ligation of the internal iliac arteries is usually effective in arresting bleeding from all sources within the genital tract. Both devascularization and arterial ligation are technically challenging procedures carrying well-documented risks (Table 5). They can be time consuming; therefore, substantial surgical expertise and a hemodynamically stable patient are prerequisites. When arterial ligation fails, hysterectomy is usually required; this may carry a higher morbidity when compared with patients undergoing hysterectomy without previous attempted arterial ligation (14).

Our study has failed to demonstrate that any one method for the management of severe PPH is superior to any other. The feasibility of performing a randomized controlled trial to compare 2 or more of the treatment modalities may be limited by the relative rarity of the need to resort to such measures, and by the urgency of the situation. Furthermore, the different clinical scenarios in which PPH can occur could make stratification complicated (for example, PPH at the time of caesarean section may be most rapidly managed by

compression sutures, while after vaginal birth balloon tamponade may be easiest). Finally, levels of expertise using one or other method are highly dependent on the setting and the individual accoucheur, and this may lead to further practical and ethical difficulties in performing such a study. In view of this, we believe it is of the utmost importance to present case series accurately and completely. We would urge authors to restrict reports to one type condition, rather than combining PPH and hemorrhage due to other conditions; to collect data prospectively to reduce bias; to define treatment failure as the need for a repeat procedure, hysterectomy or death; and to report complications fully. Setting up international registries for the reporting of cases may also be of use, although selective reporting may be a problem.

In the meantime, and until stronger evidence becomes available, it would be logical to use the least invasive, easiest, and most rapid approach. We therefore believe that the use of balloon tamponade should be considered as the first step in the management of intractable PPH, which is not due to genital trauma or retained tissue, and which does not respond to medical treatment.

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