

Preventing Maternal Death

Maternal Fetal Medicine
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Deaths per 100,000 live births

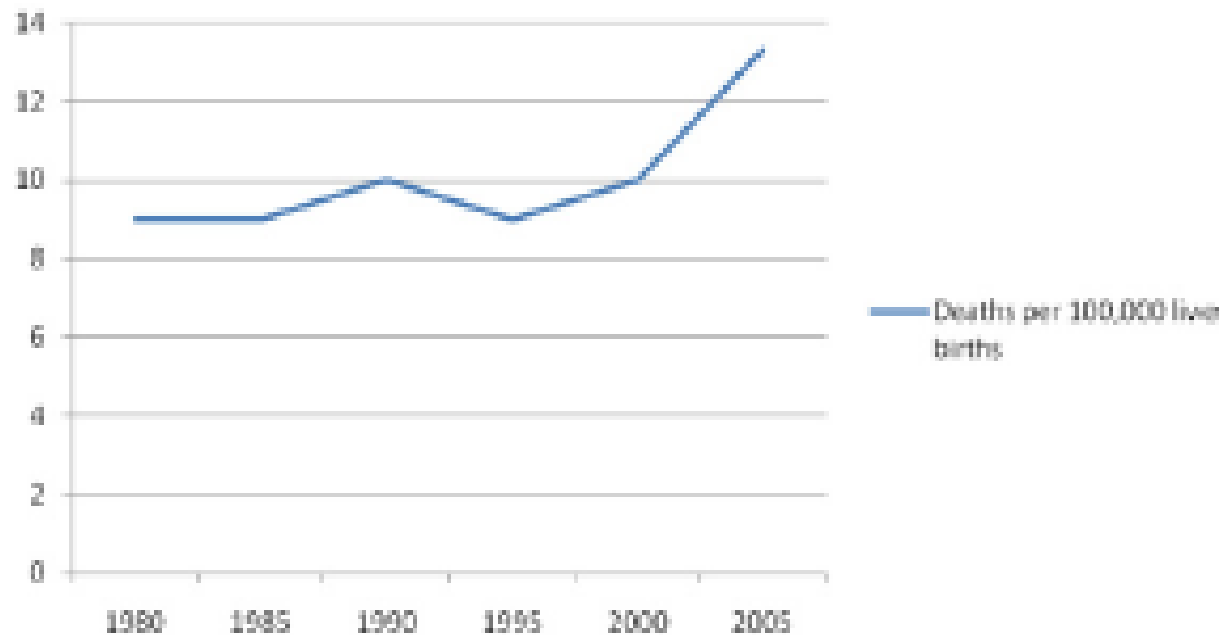


Figure 1 Maternal mortality in the United States.

Definitions

Maternal deaths include those occurring during pregnancy or in the first 42 days post partum. These conditions have traditionally been classified as follows^{1,8}:

Direct Maternal Deaths

Deaths attributable to complications of pregnancy itself. Examples include deaths due to preeclampsia or postpartum hemorrhage.

Indirect Maternal Deaths

Deaths attributable to the confounding effects of pregnancy on preexisting maternal medical conditions. Examples include decompensation due to preexisting cardiac disease or intracranial aneurysm.

Nonmaternal Deaths

Deaths occurring during pregnancy or the puerperium but unrelated in any way to pregnancy. Examples include motor vehicle accidents or homicide.

Table 1 Causes of Maternal Mortality in the United States (2000-2006)*

Cause of Death	%
Complications of preeclampsia	15
Amniotic fluid embolism	14
Obstetric hemorrhage	11
Pulmonary thromboembolism	11
Cardiac disease	11
Nonobstetric infection	7
Accident/suicide	7
Obstetric infection	7
Medication error or reaction	5
Ectopic pregnancy	1
Other	11
Total	100

*Based on 1.5 million pregnancies.¹

TABLE 2. Race-specific pregnancy-related mortality ratios*, by trimester of prenatal care initiation and live-birth order — United States, 1991–1999

Category	Pregnancy-Related mortality ratio		
	White	Black	All deaths
Prenatal care initiation (trimester)			
First	3.6	13.1	5.0
Second	4.4	12.7	6.5
Third	3.7	10.9	5.8
No care	14.9	29.1	19.8
Unknown	55.2	111.0	69.5
Live-birth order			
First	3.1	10.7	4.2
Second	3.3	14.1	5.0
Third	4.8	14.2	6.5
Fourth	6.3	15.7	8.7
Fifth or more	7.6	22.2	11.6

*Pregnancy-related deaths among women who delivered a live-born infant per 100,000 live births.

Table 2. ICU Admitting Diagnoses of All 233 Obstetric Patients, by Type of Admission (Antepartum, Postpartum) and Indication Type (Medical, Obstetric)

Indication type	Antepartum (n • 65)		Postpartum (n • 168)	
	Diagnosis	n	Diagnosis	n
Medical diagnosis (n • 92)	Pneumonia	9	Pneumonia	6
	Drug overdose	6	Acute abdomen	6
	Arrhythmia	6	Arrhythmia	5
	CHF	5	Valvular heart disease	3
	Asthma	5	Seizure	3
	Syncope	3	Other*	15
	GI bleed	3		
	Other†	17		
Obstetric diagnosis (n • 141)	NCPE‡	3	Postpartum hemorrhage	56
	OB infection	2	Preeclampsia	24
	Preeclampsia	2	Eclampsia	14
	Hyperemesis	2	HELLP	8
	PPCM	1	OB infection	8
	Arrhythmia	1	NCPE‡	7
			PPCM	5
			Other§	8

ICU • intensive care unit; CHF • congestive heart failure; GI • gastrointestinal; NCPE • noncardiogenic pulmonary edema; OB • obstetric; HELLP • hemolytic anemia, elevated liver enzymes, low platelets; PPCM • postpartum cardiomyopathy.

* Pulmonary embolism, malignant hypertension, pulmonary hypertension, splenic vein thrombosis, stroke, acute renal failure, airway obstruction, toxic shock syndrome.

† Urinary tract infection, pyelonephritis, diabetic ketoacidosis, hemoptysis, pulmonary embolism, thyrotoxicosis, sepsis, small bowel obstruction.

‡ NCPE due to pregnancy (tocolytics, fluid overloaded state, magnesium sulfate).

§ Acute fatty liver of pregnancy, intraabdominal pregnancy, cardiovascular collapse.

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Table 3. Summary of Deceased Obstetric Patients Admitted to the ICU, 1991-1998

Year	Type	Diagnosis	SAPS II score	% risk hospital death	Delivery outcome	HOS LOS (d)	ICU LOS (d)
1991	PM	Airway obstruction	74	88.03	C	8	4
1991	POH	PPH (abruption)	64	75.32	C	1	1
1992	PM	Respiratory failure	48	41.46	C	10	5
1994	POH	PPH (uterine rupture)	63	73.63	C	3	2
1997	AM	Varicella pneumonia	31	11.68	C	23	23
1997	PO	Cardiac arrest	74	88.03	C	7	7
1998	AM	Eisenmenger's syndrome	11	1.13	C	87	87
1998	PM	Pneumocystis pneumonia	53	53.01	C	28	25

ICU • intensive care unit; SAPS II • Simplified Acute Physiologic Score; HOS LOS • hospital length of stay; ICU LOS • ICU length of stay; P • postpartum; M • medical; C • cesarean delivery; O • obstetric; H • hemorrhage; PPH • postpartum hemorrhage; A • antepartum.

Preventing Maternal Death

10 Clinical Diamonds

Steven L. Clark, MD, and Gary D. V. Hankins, MD

The death of a mother during or after childbirth is one of the most tragic events in medicine. We have identified 10 specific recurrent errors that account for a disproportionate share of maternal deaths, primarily related to pulmonary embolism, severe preeclampsia, cardiac disease, and postpartum hemorrhage. Attention to these principles and the development and adoption of local or regional clinical protocols that address these issues will help reduce the likelihood and effect of error and of maternal mortality.

(Obstet Gynecol 2012;119:360–4)

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As reported by the Centers for Disease Control and Prevention,¹ approximately 50% of maternal deaths were deemed to be *preventable*. This was further characterized by Clark et al,² who reviewed deaths over 7 years in the Hospital Corporation of America system and identified approximately 95 maternal deaths occurring in almost 1.5 million births. His top 5 diagnoses mirrored those usually associated with maternal death:

- Pregnancy-induced hypertension
- Pulmonary emboli
- Amniotic fluid embolus
- Hemorrhage
- Cardiac disease

His analysis of these deaths provided the conclusion that approximately 27% were deemed to be preventable.

Several studies have suggested that from 28% to 50% of all maternal deaths in the United States are preventable.⁶⁻⁸ In 2008, Hospital Corporation of America (HCA) examined individual causes of maternal death among 1.5 million births in 124 hospitals over 6 years.⁷ While most maternal deaths are not preventable, the study concluded that the most common preventable errors were as follows:

- Failure to adequately control blood pressure in the hypertensive woman.

- Failure to adequately diagnose and treat pulmonary edema in the woman with preeclampsia.

- Failure to pay attention to vital signs following cesarean delivery

- Hemorrhage following cesarean delivery.

A Pregnant Patient Reporting Acute Chest Pain Always Should Undergo an Immediate Computed Tomography Angiogram

- SOB, CP, tachycardia, tachypnea, fever, anxiety
- Low oxygen saturation not a common presenting sign (unless saddle embolus)
- ABG, CBC, CXR
- Spiral CT less fetal exposure VQ
- Spiral CT high sensitivity and specificity
- Cost effective

Any Patient With Identified Structural or Functional Cardiac Disease Gets a Maternal-Fetal Medicine Consultation

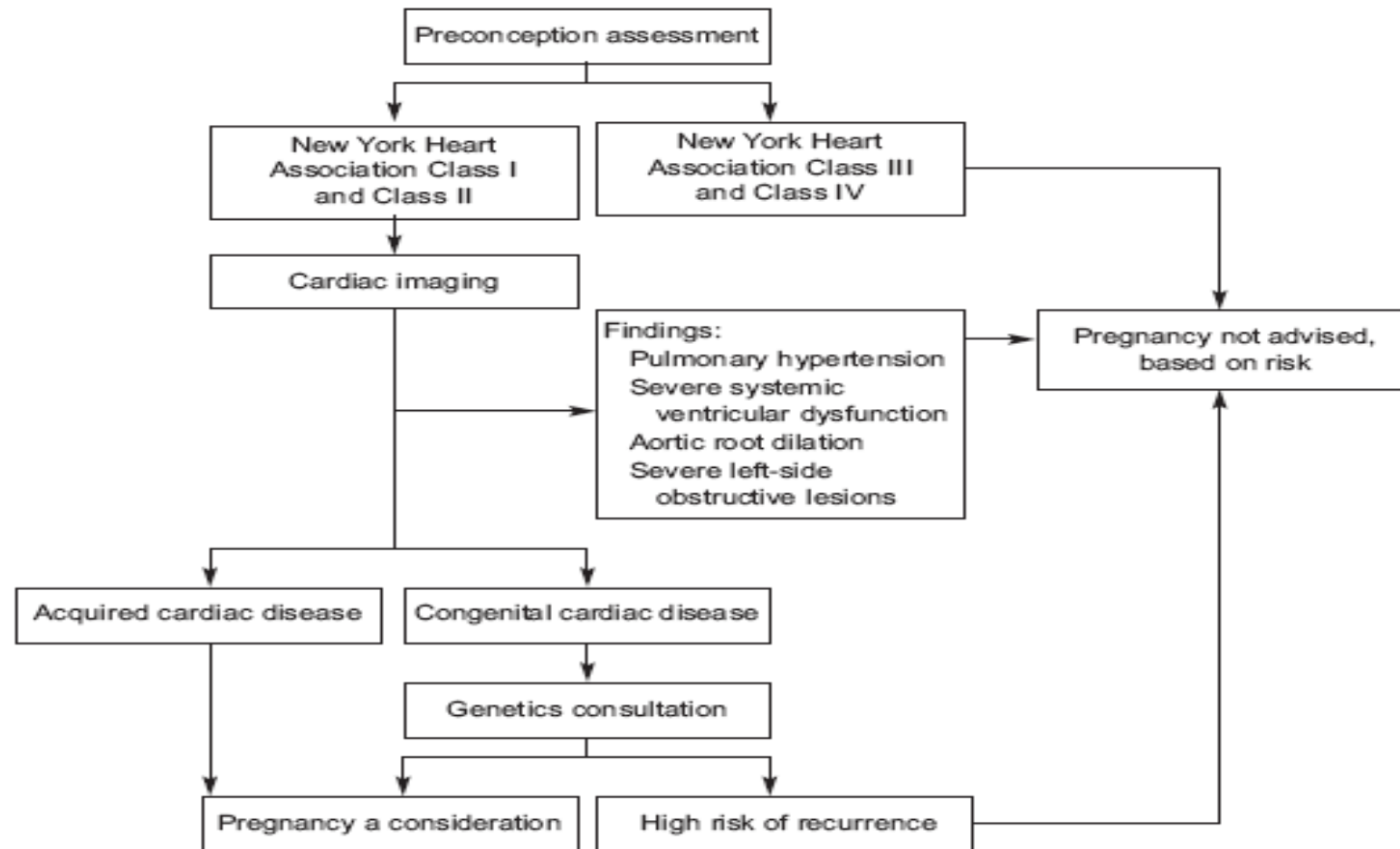


Fig. 1. Preconception assessment.

Simpson. Maternal Cardiac Disease Update. Obstet Gynecol 2012.

The New York Heart Association classification system remains the standard tool to describe a patient's functional status⁷:

- New York Heart Association class I: asymptomatic
- New York Heart Association class II: symptoms with greater than normal activity
- New York Heart Association class III: symptoms with normal activity
- New York Heart Association class IV: symptoms at bed rest.

Most women with functional class I or II tolerate pregnancy well and can expect a favorable outcome. In contrast, pregnancy is not advised for New York Heart Association class III or IV because everyday symptoms before pregnancy predict a poor prognosis.^{8,9} Pregnancy is also contraindicated in women with certain cardiac conditions regardless of functional class because the maternal risk of death is so high (25–50%)⁵:

- pulmonary hypertension
- severe systemic ventricular dysfunction
- aortic root dilation (more than 4 cm)
- severe left-sided obstructive lesions

Table 1. Predictors of Major Cardiac Event in Pregnant Patients With Heart Disease*

Predictor	Odds Ratio (95% Confidence Interval)	<i>P</i>
Prior cardiac event or arrhythmia	6 (3–14)	<.001
Heart failure		
Transient ischemic attack		
Stroke before pregnancy		
New York Heart Association class greater than II or cyanosis	6 (2–22)	.009
Left heart obstruction	6 (3–14)	<.001
Mitral valve area less than 2 cm ²		
Aortic valve area less than 1.5 cm ²		
Peak left ventricular outflow tract gradient greater than 30 mm Hg by echocardiography		
Systemic ventricular dysfunction	11 (4–34)	<.001
Ejection fraction less than 40%		

* Major cardiac event=pulmonary edema, arrhythmia requiring treatment, stroke, cardiac arrest, cardiac death; 0 predictor=5% risk; one predictor=27% risk; two or more predictors=75% risk.

Data from Siu SC, Sermer M, Colman JM, Alvarez AN, Mercier LA, Morton BC, et al. Prospective multicenter study of pregnancy outcomes in women with heart disease. *Circulation* 2001;104:515–21.

Cesarean section is indicated if:

- dilated aortic root (more than 4 cm) or aortic aneurysm
- acute severe congestive heart failure
- a history of recent myocardial infarction
- severe symptomatic aortic stenosis
- warfarin administration within 2 weeks of delivery
- need for emergency valve replacement immediately after delivery

Table 4. Comparison of Maternal Mortality in Pulmonary Hypertension Between 1978–1996 and 1997–2007 ($P=.047$)

Cases of Pulmonary Hypertension	n	Maternal Mortality 1978–1996 (%)	n	Maternal Mortality 1997–2007 (%)
Primary	27	30	29	17
Secondary	25	56	15	33
Associated with congenital heart disease*	73	36	29	28

* Includes cases with Eisenmenger syndrome.

Data from Bédard E, Dimopoulos K, Gatzoulis MA. Has there been any progress made on pregnancy outcomes among women with pulmonary arterial hypertension? *Eur Heart J* 2009;30:256–5; and Weiss BM, Zemp L, Seifert B, Hess OM. Outcome of pulmonary vascular disease in pregnancy: a systemic overview from 1978 through 1996. *J Am Coll Cardiol* 1998;31:1650–7.

Table 5. Risk of Dissection or Rupture Based on Aortic Root Size

Aortic Root Diameter (cm)	Risk of Dissection or Rupture
Less than 4	1% during pregnancy
4 or more	10% during pregnancy
4.0–4.9	2% yearly rate
5.0–5.9	3% yearly rate
6 or more	7% yearly rate

Data from Elefteriades JA. Indications for aortic replacement. J Thorac Cardiovasc Surg 2010;140(suppl):S5–9; discussion S45–51.

Table 6. Outcome of Subsequent Pregnancies After Peripartum Cardiomyopathy

History of Peripartum Cardiomyopathy	n	Congestive Heart Failure (%)	Maternal Mortality (%)	Preterm Delivery (%)
Normalization of left ventricle function	28	21	0	11
Nonnormalization of left ventricle function	16	44	19	37

Data from Elkayam U, Tummala PP, Rao K, Akhter MW, Karaalp IS, Wani OR, et al. Maternal and fetal outcomes of subsequent pregnancies in women with peripartum cardiomyopathy. *N Engl J Med* 2001;344:1567-71.

Table 7. Congenital Heart Disease: Estimated Risk of Cardiac Complications in Pregnancy

High Risk of Complications or Death	Moderate Risk of Complications (5–15%)	Low Risk of Complications (Less Than 1%)
Left-to-right shunt with pulmonary hypertension	Mild-to-moderate aortic stenosis	Isolated atrial septal defect, repaired or unrepaired
Reversal of shunt with Eisenmenger's syndrome	Marfan syndrome with normal aorta	Isolated ventricular septal defect, repaired or unrepaired
Marfan syndrome with aortic root dilation	Unrepaired cyanotic defects such as tetralogy of Fallot	Pulmonic or tricuspid valve disease
Coarctation of aorta, uncorrected with proximal aortic dilation	Systemic right ventricle such as complete and congenitally corrected transposition of great arteries	Coarctation, repaired with normal proximal aortic size
Severe symptomatic left-sided obstructive lesions such as aortic stenosis, hypertrophic cardiomyopathy	Well-functioning Fontan palliation for hypoplastic ventricles, complex defects	Repaired tetralogy of Fallot with normal right ventricular function and competent pulmonic valve
	Palliated tetralogy of Fallot with severe pulmonic regurgitation and right ventricular dysfunction	

Modified with permission from Elsevier from Harris IS. Management of pregnancy in patients with congenital heart disease. *Prog Cardiovasc Dis* 2011;53:305–11; and Hung L, Rahimtoola SH. Prosthetic heart valves and pregnancy. *Circulation* 2003;107:1240–6.

SUMMARY

The complexity of cardiac disease observed in pregnant women is changing:

- Cardiac disease is now the leading cause of indirect maternal mortality.
- Congenital heart disease comprises more than 50% of cardiac disease seen in pregnancy.
- Ischemic heart disease is on the rise as a result of delayed childbearing, obesity, hypertension, and diabetes.
- Pregnancy is contraindicated in women with pulmonary hypertension of any etiology, severe systemic ventricular dysfunction, dilated aortopathy, and severe left-sided obstructive lesions.

A Patient With Preeclampsia Reporting Shortness of Breath Should Undergo a Chest X-ray Immediately

- Chest X-ray
- Pulse oxymeter
- Furosemide
- Magnesium level
- All pre eclamptic strict IOs

Any Hospitalized Patient With Preeclampsia Experiencing Either a Systolic Blood Pressure of 160 or a Diastolic Pressure of 110 Should Receive an Intravenous Antihypertensive Agent Within 15 Minutes

Box 1. Order Set for Severe Intrapartum or Postpartum Hypertension Initial First-Line Management With Labetalol*

1. Notify physician if systolic BP measurement is greater than or equal to 160 mm Hg or if diastolic BP measurement is greater than or equal to 110 mm Hg.
2. Institute fetal surveillance if undelivered and fetus is viable.
3. Administer labetalol (20 mg IV over 2 minutes).
4. Repeat BP measurement in 10 minutes and record results.
5. If either BP threshold is still exceeded, administer labetalol (40 mg IV over 2 minutes). If BP is below threshold, continue to monitor BP closely.
6. Repeat BP measurement in 10 minutes and record results.
7. If either BP threshold is still exceeded, administer labetalol (80 mg IV over 2 minutes). If BP is below threshold, continue to monitor BP closely.
8. Repeat BP measurement in 10 minutes and record results.
9. If either BP threshold is still exceeded, administer hydralazine (10 mg IV over 2 minutes). If BP is below threshold, continue to monitor BP closely.
10. Repeat BP measurement in 20 minutes and record results.
11. If either BP threshold is still exceeded, obtain emergency consultation from maternal–fetal medicine, internal medicine, anesthesia, or critical care specialists.
12. Give additional antihypertensive medication per specific order.
13. Once the aforementioned BP thresholds are achieved, repeat BP measurement every 10 minutes for 1 hour, then every 15 minutes for 1 hour, then every 30 minutes for 1 hour, and then every hour for 4 hours.
14. Institute additional BP timing per specific order.

Abbreviations: BP, blood pressure; IV, intravenously.

*See text for important adverse effects and contraindications.

Data from Report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Pregnancy. *Am J Obstet Gynecol* 2000;183:S1–S22.

**Box 2. Order Set for Severe Intrapartum
or Postpartum Hypertension Initial
First-Line Management With Hydralazine***

1. Notify physician if systolic BP is greater than or equal to 160 mm Hg or if diastolic BP is greater than or equal to 110 mm Hg.
2. Institute fetal surveillance if undelivered and fetus is viable.
3. Administer hydralazine (5 mg or 10 mg IV over 2 minutes).
4. Repeat BP measurement in 20 minutes and record results.
5. If either BP threshold is still exceeded, administer hydralazine (10 mg IV over 2 minutes). If BP is below threshold, continue to monitor BP closely.
6. Repeat BP measurement in 20 minutes and record results.
7. If either BP threshold is still exceeded, administer labetalol (20 mg IV over 2 minutes). If BP is below threshold, continue to monitor BP closely.
8. Repeat BP measurement in 10 minutes and record results.
9. If either BP threshold is still exceeded, administer labetalol (40 mg IV over 2 minutes) and obtain emergency consultation from maternal–fetal medicine, internal medicine, anesthesia, or critical care specialists.
10. Give additional antihypertensive medication per specific order.
11. Once the aforementioned BP thresholds are achieved, repeat BP measurement every 10 minutes for 1 hour, then every 15 minutes for 1 hour, then every 30 minutes for 1 hour, and then every hour for 4 hours.
12. Institute additional BP timing per specific order.

Abbreviations: BP, blood pressure; IV, intravenously.

*See text for important adverse effects and contraindications.

Data from Report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Pregnancy. *Am J Obstet Gynecol* 2000;183:S1–S22.

Any Woman With Placental Previa and One or More Cesarean Deliveries Should Be Evaluated and Delivered in a Tertiary Care Medical Center

- Planned delivery with multidisciplinary team
- Decreased maternal mortality
- Decreased maternal morbidity
- Accreta/ Increta can be diagnosed suspected on US

**Never Treat “Postpartum Hemorrhage”
Without Simultaneously Pursuing an Actual
Clinical Diagnosis**

**If More Than A Single Dose of Medication Is
Necessary to Treat Uterine Atony, Go to the
Patient’s Bedside Until the Atony Has
Resolved**

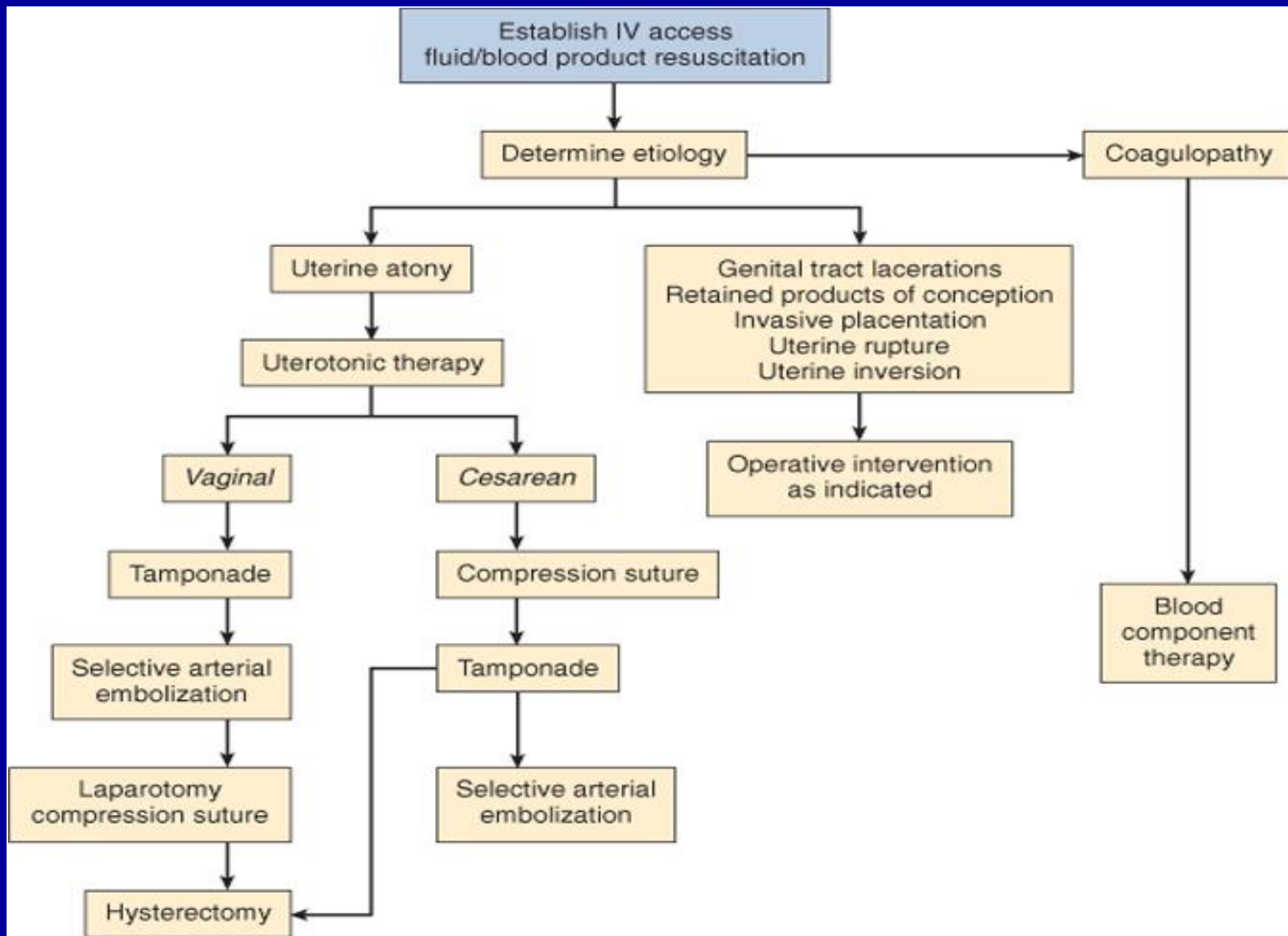
**Angiographic Embolization Is Not Meant to Be
Used for Acute, Massive Postpartum
Hemorrhage**

**In the Postpartum Patient Who Is Bleeding or
Who Recently Has Stopped Bleeding and Is
Oliguric, Furosamide Is Not the Answer**

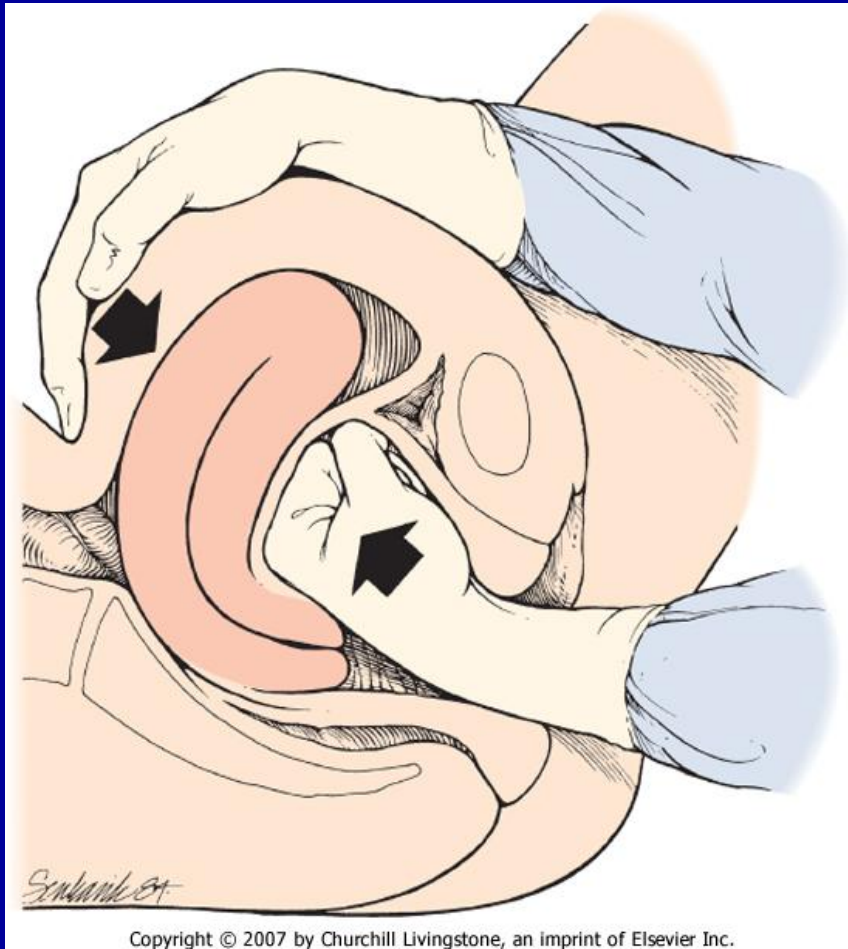
**If Your Labor and Delivery Unit Does Not
Have a Recently Updated Massive Transfusion
Protocol Based on Established Trauma
Protocols, Get One Today**

Post Partum Hemorrhage (Early vs. Late)

- **Lower genital tract lacerations (perineal, vaginal, cervical, periclitoral, labial, periurethral, rectum)**
- **Upper genital tract lacerations (broad ligament)**
- **Lower urinary tract lacerations (bladder, urethra)**
- **Retained products of conception (placenta, membranes)**
- **Infection**
- **Retained products of conception**
- **Placental site sub involution**
- **Coagulopathy**

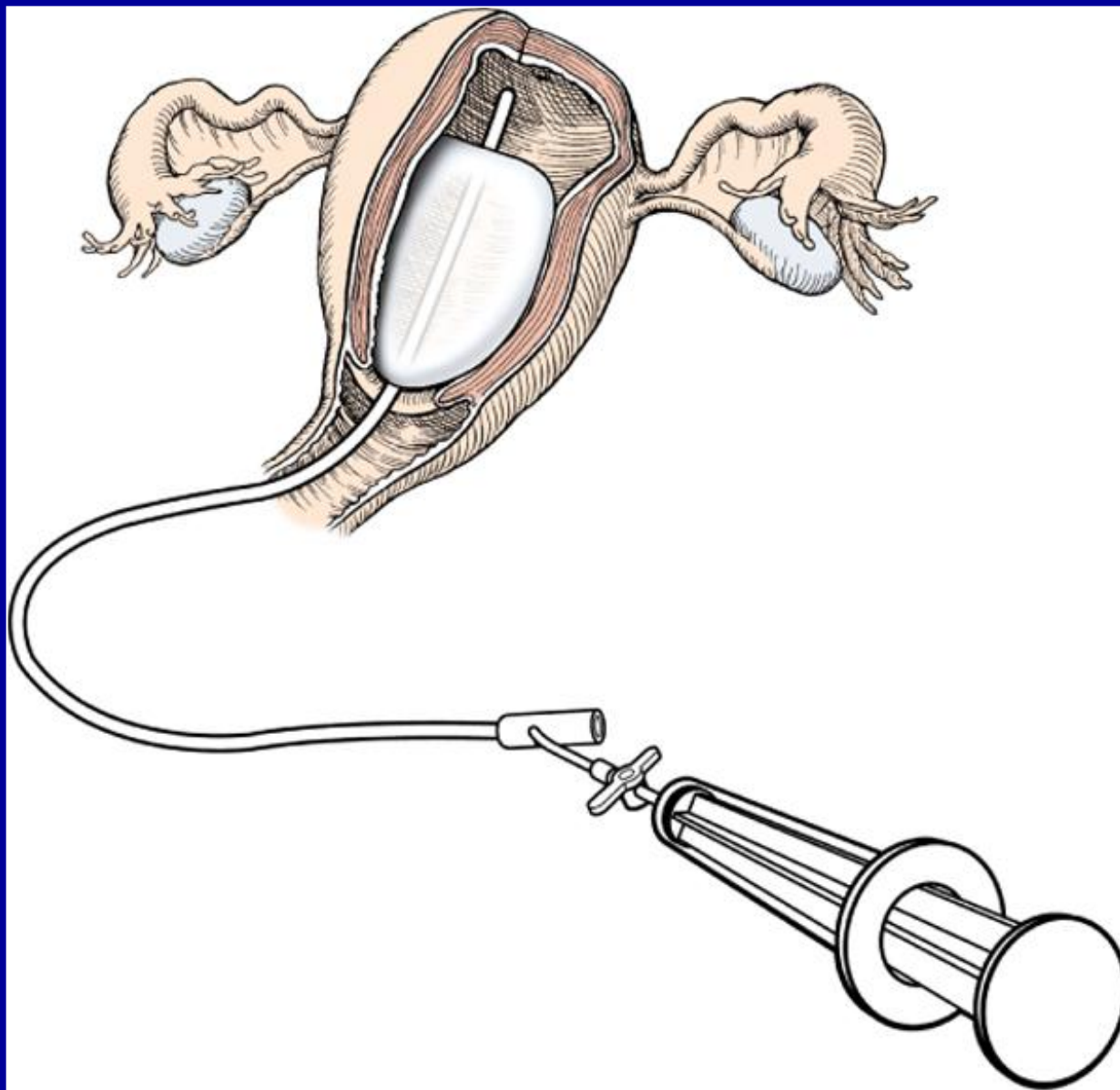


AGENT	DOSE	ROUTE	DOSING FREQUENCY	SIDE EFFECTS	CONTRAINDICATIONS
<u>Oxytocin</u> ^{Rx} (Pitocin)	10-80 units in 1,000 ml of crystalloid solution	First line: IV Second line: IM or IU	Continuous	Nausea, emesis, water intoxication	None
Methylergonovine (Methergine)	0.2 mg	First line: IM Second line: IU or PO	Every 2-4 h	Hypertension, hypotension, nausea, emesis	Hypertension, preeclampsia
15-Methyl Prostaglandin F_{2α} (Hemabate)	0.25 mg	First line: IM Second line: IU	Every 15-90 min (8-dose maximum)	Nausea, emesis, diarrhea, flushing, chills	Active cardiac, pulmonary, renal or hepatic disease
Prostaglandin E₂ (<u>Dinoprostone</u> ^{Rx})	20 mg	PR	Every 2 h	Nausea, emesis, diarrhea, fever, chills, headache	Hypotension
<u>Misoprostol</u> ^{Rx} (Cytotec)	600-1000 mcg	First line: PR Second line: PO	Single dose	Tachycardia, fever	None



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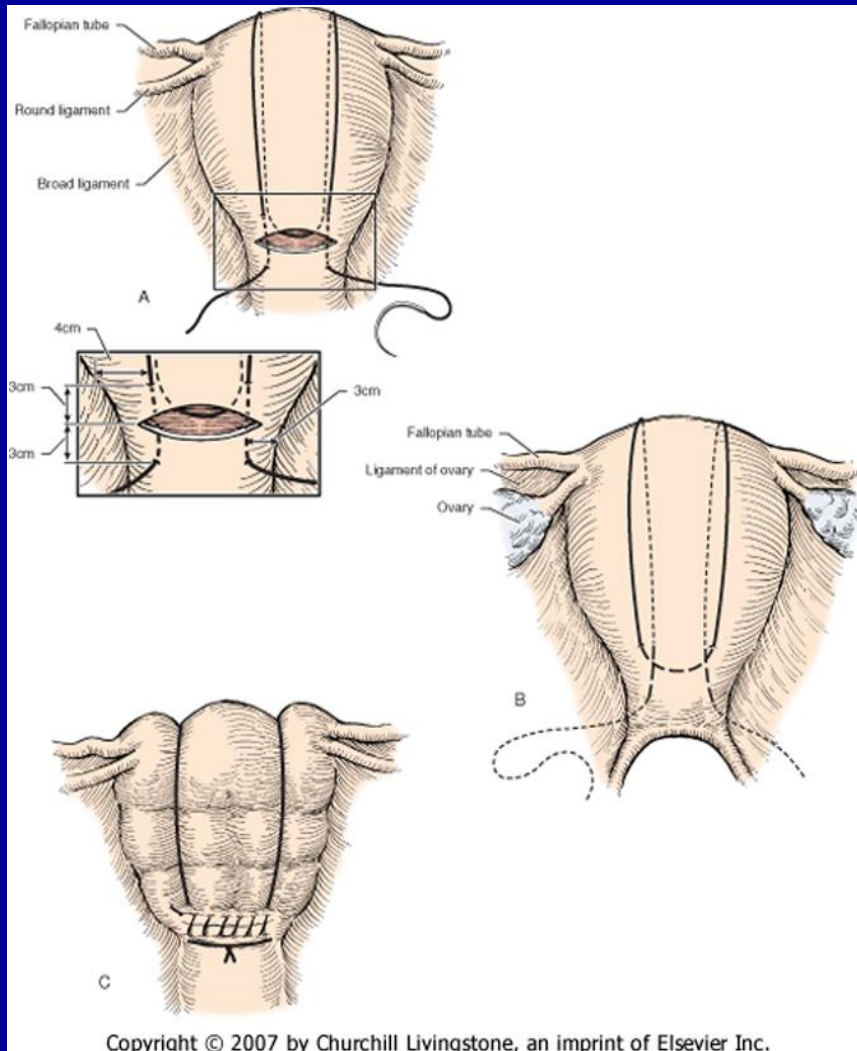
- Call for help
- Empty bladder
- Bimanual massage
- IV access



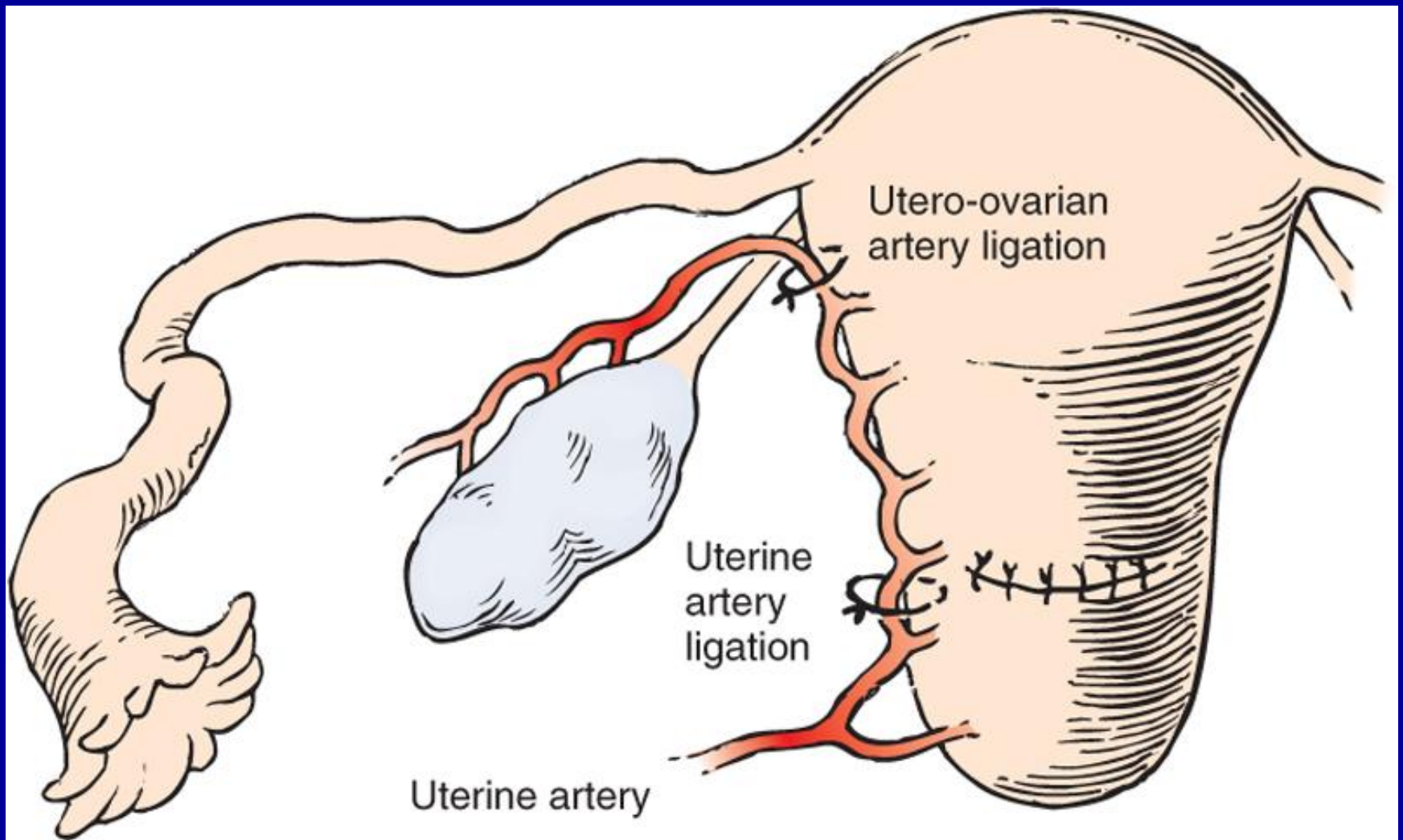
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HEMORRHAGE CLASS	ACUTE BLOOD LOSS	% LOST	PHYSIOLOGIC RESPONSE
1	900 ml	15	Asymptomatic
2	1,200-1,500 ml	20-25	Tachycardia and tachypnea
			Narrowed pulse pressure
			Orthostatic hypotension
			Delayed hypothermic refilling
3	1,800-2,100 ml	30-35	Worsening tachycardia and tachypnea
			Hypotension
			Cool extremities
4	>2,400ml	40	Shock
			Oliguria/Anuria

What to do when medical treatment fails?



- Arterial embolization 90.7%
- Balloon tamponade 84.0%
- Uterine compression sutures 91.7%
- Iliac Aa ligation uterine desvascularization 84.6%



Post Partum hysterectomy: systematic review

- 981 cases of emergency postpartum hysterectomy were retrieved.
- Maternal morbidity 549 (56.0%)
- Blood transfusion 428 (44.0%)
- Maternal mortality 26 (2.6%)
- total hysterectomies 314 of 601 [52.2%]
subtotal hysterectomies 287 of 601 [47.8%]
- additional surgery was required in 103 (10.5%)
- Women at highest risk of emergency hysterectomy: multiparous, had a cesarean delivery in either a previous or the present pregnancy or abnormal placentation.

Peripartum Hysterectomy

Table 4. Rate of Peripartum Hysterectomy by Year in the Calgary Health Region

Year	Total Deliveries (n)	Cesarean Deliveries [n (% of Total Deliveries)]	PH (n)	Rate of PH per 1,000 Deliveries	95% CI
1999	12,370	2,563 (20.7)	16	1.3	0.7–2.1
2000	12,276	2,686 (21.9)	11	0.9	0.4–1.6
2001	12,358	2,988 (24.2)	24	1.9	1.2–2.9
2002	13,021	3,292 (25.3)	7	0.5	0.2–1.1
2003	13,690	3,665 (26.8)	8	0.6	0.3–1.2
2004	13,990	3,792 (27.1)	3	0.2	0–0.6
2005	14,729	4,264 (28.9)	5	0.3	0.1–0.8
2006	15,720	4,461 (28.4)	13	0.8	0.4–1.4

PH, peripartum hysterectomy; CI, confidence interval.