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Hemostasis for Massive Hemorrhage during Cesarean Section

Jun Takeda, Shintaro Makino and Satoru Takeda

Abstract

Arterial ligation for massive hemorrhage during cesarean section may often fail to achieve hemostasis because of abundant collateral circulation. In recent years, various methods of hemostasis have been used, of which the most common are compression sutures, uterine balloon tamponade. In cases of massive hemorrhage, patients must be kept in good systemic condition, and local hemostasis must be achieved while paying attention to the possible occurrence of coagulopathy under monitoring of fibrinogen levels. When concomitant coagulopathy is present, local hemostasis is difficult to achieve because of hemorrhagic tendency. In such a case, obstetrical damage control procedures should be performed. First, the hemorrhagic area should be compressed with a towel or balloon, and at the same time, the artery should be blocked or compressed to reduce the blood flow into the uterus. The following resuscitation must also be implemented for warming intervention; blood transfusion to maintain the circulating blood volume; and the treatment of coagulopathy by “triple C supplement,” such as combined administration of fresh-frozen plasma and concentrated coagulation factors promptly to obtain a blood fibrinogen level of at least 150–200 mg/dL. If coagulopathy is eliminated, the conventional hemostatic procedures become effective. Hysterectomy is the last measure for hemostasis.

Keywords: cesarean section, compression suture, interventional radiology, massive hemorrhage, obstetrical damage control, uterine balloon tamponade

1. Introduction

The maternal mortality rate in Japan had been decreasing steadily until 2007 (3.1 per 100,000 total births), but thereafter, it showed a fluctuating pattern. The rate was 2.7 per 100,000 total births in 2014 but increased to 3.4 per 100,000 total births in 2016. The major causes of maternal deaths include, in descending order of frequency, critical obstetrical hemorrhage, intracranial hemorrhage, amniotic fluid embolism, aortic vessel disease, respiratory disease, and infectious diseases [1]. Japan has approximately 1 million deliveries per year. A survey conducted by a study group of the Ministry of Health, Labour and Welfare estimated that 4000–5000 cases of pregnancy-related critical illness, if not death, occur every year [2]. Among these cases of critical illness, massive hemorrhage is the most frequent cause and is treated by various hemostatic procedures, hysterectomy, or transcatheter arterial embolization (TAE). An analysis of the patients who survived showed that massive hemorrhage during cesarean section accounted for approximately 70% of all cases [2]. Most cases had placenta previa accreta, bleeding from the surface of the

placental separation, or concomitant coagulopathy with hemorrhagic tendency [2, 3]. Therefore, the technique of controlling hemorrhage during cesarean section must be mastered. On the other hand, the widespread use of TAE has made it possible to save the patient's life in most cases of massive hemorrhage after vaginal delivery, unless uterine rupture or some other serious conditions occur [3, 4].

Obstetrical hemorrhage occurs abruptly and in a large quantity. If the amount of bleeding exceeds 2000 ml, disseminated intravascular coagulation (DIC) is likely to occur concomitantly. When coagulopathy is present, adequate uterine contraction may not occur, resulting in atonic hemorrhage, which causes further hemorrhage that leads to a vicious circle of adverse events. In view of this particularity of obstetrical hemorrhage, the Japanese Clinical Practice Guide for Critical Obstetrical Hemorrhage was developed in 2010. The current revised edition of this guideline [5] recommends a new concept of obstetrical transfusion therapy, treatment of coagulopathy, and hemostatic techniques such as compression sutures, intrauterine balloon tamponade, administration of uterotonics and tranexamic acid [3, 5–9]. If coagulopathy is present, the fibrinogen level becomes extremely low, and reversal of hemorrhagic tendency can be achieved only by administration of cryoprecipitate or fibrinogen concentrate or transfusion of fresh-frozen plasma (FFP) [3, 5, 10]. In addition, simulation training for obstetrical emergency care has been conducted widely to promote good team medical care in emergency settings [1].

This chapter provides an outline of hemostatic procedures that should be performed for massive hemorrhage during cesarean section, without hastily adopting hysterectomy. In addition, the methods of transfusion to achieve early hemostasis in order to meet the pathological condition of coagulopathy with hemorrhagic tendency and the procedures for obstetrical damage control in cases with DIC will also be described.

2. Hemostatic strategy for massive hemorrhage during cesarean section

2.1 Systemic management and treatment of hypofibrinogenemia

Once hemorrhage has occurred, it is important not only to determine red blood cell (RBC) count, hemoglobin level, hematocrit value, and biochemical parameters but also to measure plasma fibrinogen levels over time by using a simple rapid fibrinogen measuring instrument as point-of-care testing in order to perform early diagnosis and treatment of coagulopathy [5, 10]. In cases of massive hemorrhage, it may be difficult to assess the accurate amount of bleeding. In many cases, the amount of bleeding is underestimated, and the timing of transfusion may be delayed. Therefore, maintaining the blood pressure such as infusion of large volumes of artificial colloid solution and albumin solution, and quick implementation of temporizing hemostatic procedures such as packing, manual uterine compression, and aortic compression, are important until the access to blood transfusion [3].

If circulatory failure persists despite these procedures or if coagulopathy occurs, transfusion of RBC concentrate alone cannot maintain the sufficient circulation blood volume, on the contrary, it may lead to dilution coagulopathy. Administration of FFP is necessary for achieving the elevation and maintenance of blood pressure and colloid osmotic pressure. It should be noted that if the patient experiences shock, RBC transfusion alone cannot increase blood pressure; FFP and RBC should be administered at a ratio of 1:1 in the same manner as in cases of trauma [3, 5, 10]. In cases of consumption coagulopathy, such as in placenta abruption or amniotic fluid embolism, and coagulopathy following massive hemorrhage, the blood fibrinogen level is often <100 mg/dL. Therefore, elimination of the hemorrhagic tendency requires

transfusion of 10–15 units of FFP; usually 15 units of FFP are necessary to increase the blood fibrinogen level by 100 mg/dL. To eliminate the hemorrhagic tendency, rapid transfusion of at least 10 units of FFP, rather than RBC, must be performed. Without this treatment, hemorrhage may persist, and the hemorrhagic tendency may continue for days [11]. The mainstay coagulopathy management is elimination of coagulopathy within 6 h. For this purpose, rapid transfusion of FFP should be performed to obtain a blood fibrinogen level of ≥ 150 –200 mg/dL, and a prothrombin time of $\geq 70\%$ should be targeted [3, 5, 10, 11]. After these treatments, the FFP/RBC ratio of the total transfusion volume may exceed 2.0 in some cases. If blood of the same type is lacking or there is no time for cross-matching in cases of life-threatening critical hemorrhage, not crossmatched compatible RBC such as type O RBC and type AB FFP should be used without hesitation [5]. Rapid transfusion of FFP may cause asymptomatic (saturation of percutaneous oxygen [SpO_2] of $\leq 95\%$) or symptomatic pulmonary edema [5]. Therefore, early treatment with a diuretic, carperitide, or a β -agonist should be provided while monitoring the central venous pressure or SpO_2 , or more concentrated blood product, such as fibrinogen concentrate and cryoprecipitate, should be given.

In patients with hypofibrinogenemia, the blood fibrinogen level could be more promptly, more efficiently elevated by administration of 3 g of fibrinogen concentrates (3 g of fibrinogen concentrate is almost equivalent to fibrinogen in 12 units of FFP) or three bags of cryoprecipitate (one bag of cryoprecipitate is derived from approximately 480 ml of FFP) [10–13]. If the patient develops coagulopathy, any other coagulation factors than fibrinogen will also decrease. Therefore, FFP and cryoprecipitate are necessary to maintain the sufficient circulation blood volume and supplement other coagulation factors. As the supplies of fibrinogen concentrate and cryoprecipitate have limitations according to the country and region, “Combined administration of FFP and concentrated coagulation factors (triple C) supplement” has been recommended for treating coagulopathy through efficient administration of these three agents to supplement sufficient coagulation factors, especially fibrinogen, to replace blood volume and to maintain blood pressure and colloid osmotic pressure. Management of massive hemorrhage with a focus on “triple C supplement” never caused hemostatic failure that required hysterectomy in >300 patients with cesarean section in whom placenta abruption was accompanied by coagulopathy.

2.2 Local hemostasis

2.2.1 Hemostasis for the surface of the placental separation

For severe hemorrhage from the surface of the placental separation in cases of placenta previa or placenta accreta, pressure hemostasis with gauze and suture hemostasis have been performed commonly, but these procedures are often unsuccessful in the presence of bleeding from a large area. Although separation of the bladder may be necessary on the anterior wall, the use of a simple suture or Z-suture, piercing the whole myometrium at several sites [3]; a large U-shaped suture; an interrupted circular suture consisting of repeated simple sutures in the entire circumference of the anterior and posterior walls [14]; and a suture of the muscular layer to block blood flow in four directions has been reported [3, 14, 15]. On the other hand, Bakri [16] reported that uterine balloon tamponade was effective for controlling hemorrhage from the surface of separation of the placenta previa. This method is also effective for hemostasis during cesarean section (**Figure 1**) [6].

On the other hand, the success rate of internal iliac artery ligation and uterine artery ligation for uterine bleeding is limited and unsatisfactory, because of marked blood inflows via abundant anastomosis of the peripheral uterine artery from the

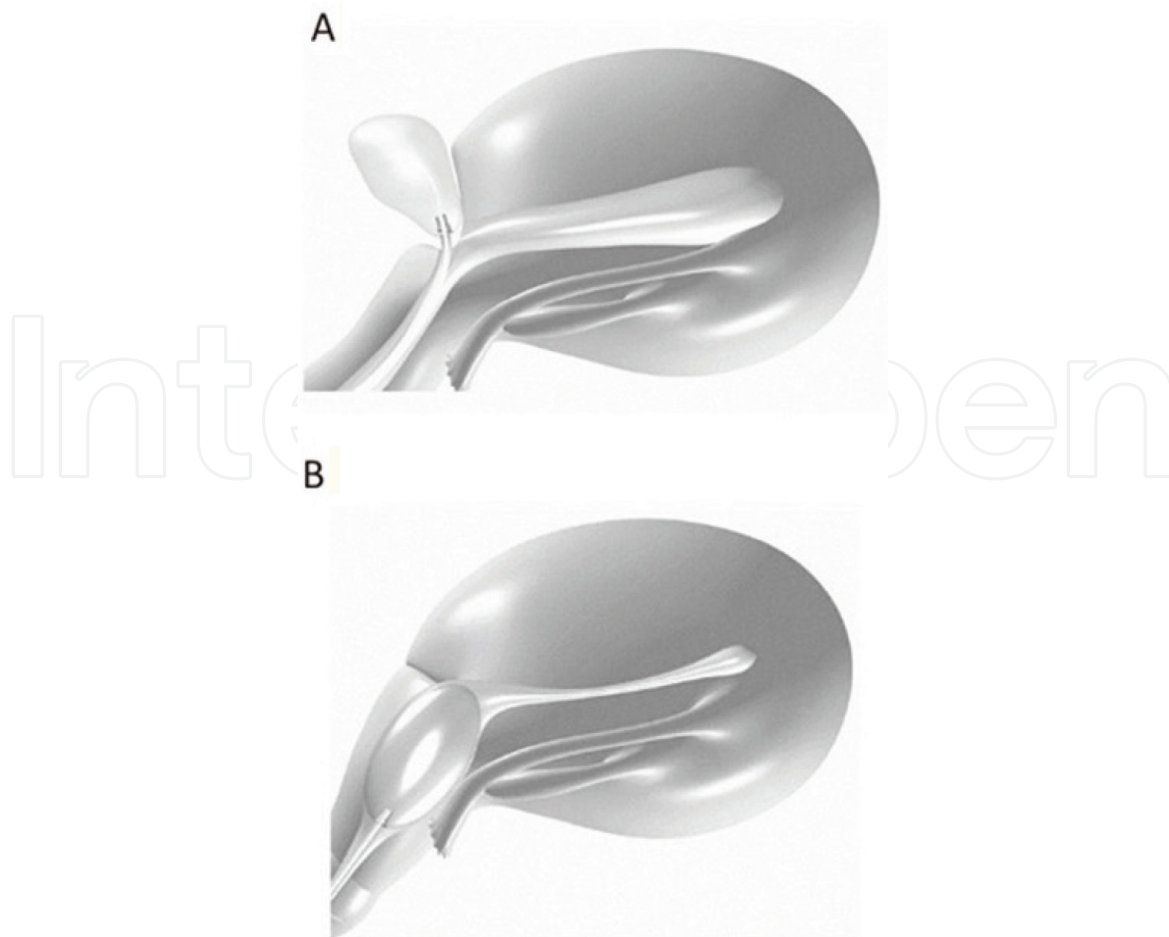


Figure 1. Balloon insertion during cesarean section. (Produced with permission from Makino et al. [6].) (A) Balloon was inserted through the uterine wound. (B) Eighty to two hundred milliliter of saline is sufficient to achieve hemostasis.

external iliac artery and the aorta [3]. Uterine devascularization, by which the distal portion of uterine artery and the ovarian artery are ligated on the uterine side, has a strong hemostatic effect [17]. However, functional disorders of the uterus and ovaries were reported, such as ovarian dysfunction, oligomenorrhea, endometrial hypoplasia, infertility, uterine cavity adhesions and uterine necrosis [3, 18].

2.2.2 Compression sutures

In cases of atonic hemorrhage, the technique of compression sutures (B-Lynch technique), which was first reported by B-Lynch et al. [19], is used when bimanual compression and administration of uterotonics fail to control bleeding. This technique uses compression of the bleeding surface by joining the anterior and posterior walls of the uterus together. The B-Lynch technique is effective for both hemorrhage from the surface of separation of the placenta previa and atonic hemorrhage and is used for controlling hemorrhage in the lower segment (isthmus) and body of the uterus. As the B-Lynch technique consists of complicated procedures, various modifications have been devised and reported [3, 20]. Various hemostatic techniques include those involving the uterine body or the lower uterine segment (isthmus) alone, or both parts of the uterus for atonic hemorrhage [21, 22].

In our technique of uterine isthmus vertical compression sutures, we used two vertical sutures to achieve pressure hemostasis by sewing the anterior and posterior walls at the uterine isthmus together vertically. This technique is effective for controlling not only hemorrhage in the placenta previa but also atonic hemorrhage

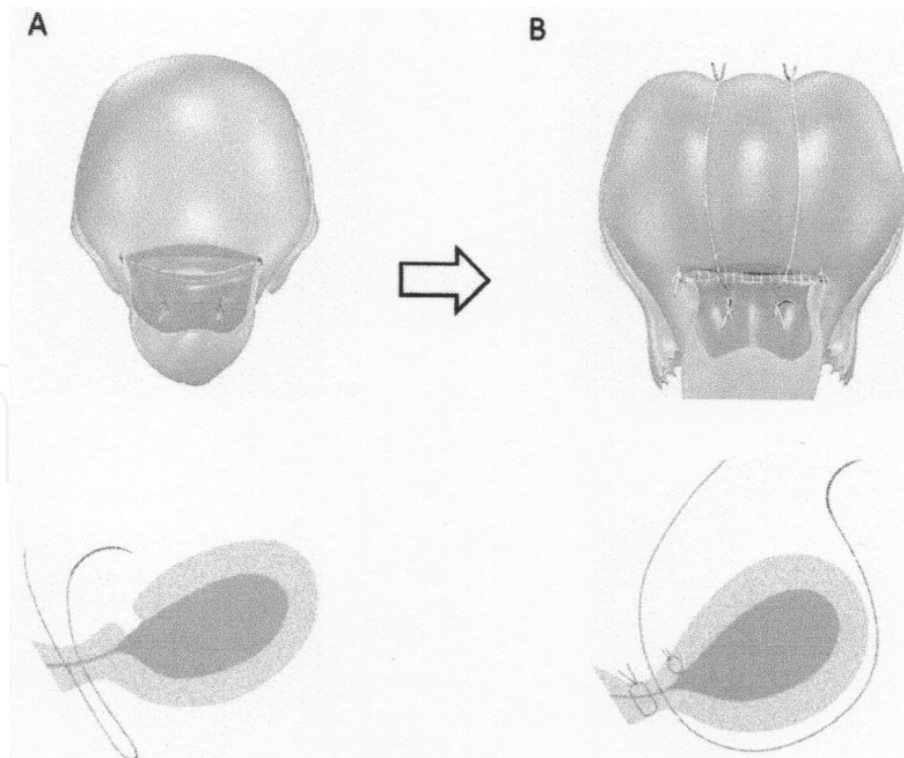


Figure 2.
 Double vertical compression sutures. (Produced with permission from Makino et al. [6].) Compression sutures at the uterine isthmus are placed to achieve hemostasis for the atonic bleeding or hemorrhage from a placenta previa. Additional sutures could be placed, as with the modified B-Lynch suture technique, if (A) is not effective.

(**Figure 2**) [3, 6, 21–23]. After exposing the muscular layer in the lower uterus, two stitches piercing the anterior and posterior walls, one each on the right and left sides, were made to place ligation sutures vertically. When the initial vertical compression sutures fail to achieve hemostasis or when there is concomitant coagulopathy, the technique of double vertical compression sutures, a combination of compression sutures and a modified B-Lynch technique, should be used (**Figure 2**) [6, 21]. Synthetic absorbable threads such as Vicryl Rapide® are used. Only two stitches of vertical sutures can also cause pain because of uterine ischemia in some patients, and laparoscopic removal of the thread is required occasionally [24]. This suggests that the procedure of vertical compression sutures not only causes hemostasis by pressing the bleeding surface but also blocks the blood flow entering the uterus from the right and left sides through thread suturing the uterus vertically [22, 25–27]. Therefore, further investigation is necessary as to whether thread removal should be performed even when a quickly absorbable thread is used.

2.2.3 Interventional radiology

Techniques of interventional radiology (IVR) for massive hemorrhage during cesarean section include the arterial balloon occlusion technique by which an arterial balloon catheter is inserted preoperatively to prevent massive hemorrhage and the TAE technique, which is performed intraoperatively in the hybrid operating room [3, 28–30]. The former technique is used in cases of placenta previa accreta and in myomectomy after fetal delivery in cases of pregnancy with a giant myoma. When massive hemorrhage is predicted preoperatively or when hysterectomy is to be performed for placenta accreta, an arterial balloon is placed in the aorta, common iliac artery, and so on. In cases where a procedure that may induce hemorrhage is used or where hemorrhage occurs, the balloon will be inflated to block the arterial

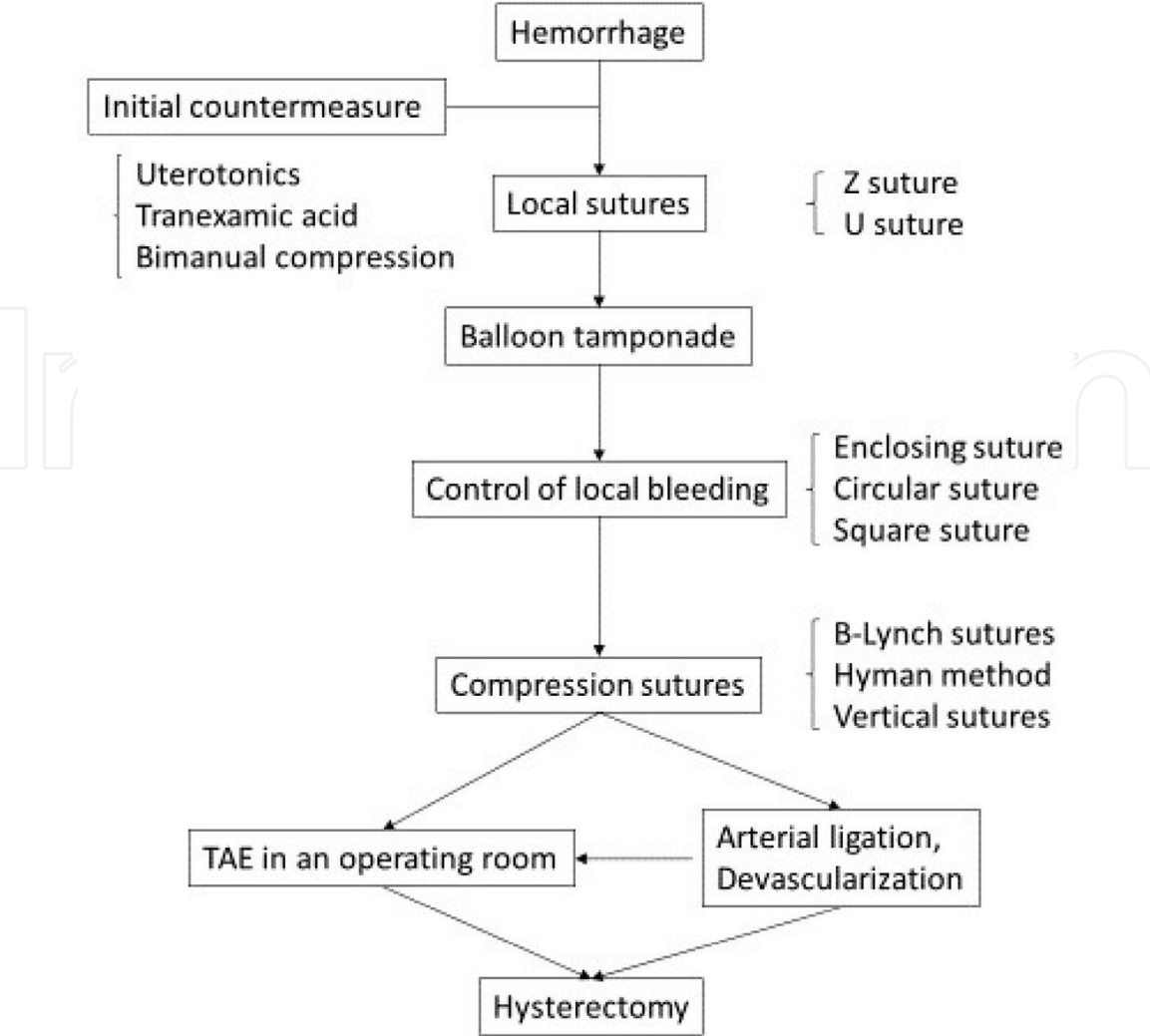


Figure 3. Hemostatic strategy during cesarean section. (Produced with permission from Takeda et al. [3].) Balloon tamponade or several sutures have priority over TAE or arterial ligation. TAE: transcatheter arterial embolization.

blood flow temporarily to reduce hemorrhage (**Figure 3**) [29–32]. The TAE technique is used for embolization of the bleeding artery in patients operated on in a hybrid operating room equipped with the fluoroscopic apparatus or in surgical patients who are temporarily transferred to a room where a fluoroscopic apparatus is available. This technique is considered useful for patients in whom various local hemostatic procedures have failed to control hemorrhage [28, 29]. However, the association of TAE with prolonged uterine ischemia has become apparent, even when an absorbable embolus such as Spongel® is used [33, 34]. The following complications of TAE have been reported: Asherman syndrome; infertility; ovarian dysfunction (increase in follicle-stimulating hormone levels); endometrial hypoplasia; menstruation disorders (e.g., amenorrhea, menstrual irregularity, oligomenorrhea, and hypomenorrhea); and pregnancy wastage, puerperal massive hemorrhage, placenta accreta, placenta previa, and uterine rupture in subsequent pregnancies [3, 4, 28, 29, 33, 34]. Therefore, TAE and hysterectomy should be recognized as a last measure to be used only when the aforementioned techniques have failed to achieve hemostasis (**Figure 2**) [3].

3. Obstetrical damage control

Hemostasis often cannot be achieved promptly in cases of massive hemorrhage accompanied by coagulopathy. In such cases, damage control surgery (DCS) and

resuscitation, which represent the therapeutic concept of life-saving intervention for severe trauma accompanied by massive hemorrhage, should be performed [35, 36]. In the field of emergency medical care, DCS rather than standard surgery is performed in patients having hemorrhagic shock. The primary cause of intraoperative and postoperative deaths in patients with severe trauma accompanied by massive hemorrhage is not loss of blood from the uncontrollable bleeding source but a combination of three abnormalities, namely metabolic acidosis, hypothermia, and blood clotting disorder. These abnormalities are called the lethal triad of death from trauma, resulting from collapse of physiological homeostasis [35, 36]. To treat this condition, gauze or towel packing of the abdomen or the whole pelvis should be performed to provide pressure hemostasis as a part of the DCS [37, 38]. In the meantime, the patient's vital signs and body temperature must be monitored and assessed over time. The patient should be managed to keep in appropriate body temperature. Blood transfusion should be performed to resuscitate the patient from shock and coagulopathy. If hemostasis is judged to be unachievable, the patient should be transported to a higher-level medical facility after performing temporary abdominal closure with intra-abdominal packing [3]. Charoenkwan reported the use of Barki balloon, a method similar to towel packing, to control hemorrhage from the pelvic floor after hysterectomy and from the posterior aspect of the uterus after cesarean section [39, 40].

Hemorrhage may become uncontrollable owing to coagulopathy during cesarean section for cases such as placenta abruption. In these cases, the first measure to be taken is not immediate initiation of hysterectomy. Instead, both application of pressure with a towel or a balloon, and treatment of coagulopathy, in an attempt to prevent the lethal triad of death, may allow avoidance of hysterectomy [11]. Treatment of coagulopathy is accomplished with "triple C supplement" that is a combined administration of FFP and concentrated coagulation factors, such as fibrinogen concentrate, cryoprecipitate, antithrombin, and so on. As the patient's condition may worsen during hysterectomy, pressure should be applied with gauze or a towel after removal of the uterus, and the focus should be on volume replacement, warming of the patient, and treatment of coagulopathy. When the hemorrhagic tendency is improved, drain insertion and abdominal closure are performed. Thus, implementation of resuscitation while the surgical procedure is suspended allows avoidance of unnecessary hysterectomy and hemorrhagic death [3, 11].

In any event, it is important to be familiar with the practice guidelines and emergency care measures for obstetrical critical hemorrhage and to run a simulation of the preparation and actions to be taken in emergency settings. Such simulation training should involve the whole hospital, including not only the obstetrical team consisting of medical and paramedical staff members but also the clerical personnel in charge of the arrangement of blood transfusion, human resources, transfer of patients, and so on. This study emphasizes the importance for obstetrical staff to actively participate in educational programs about maternal emergency in order to prepare for any emergency [1].

4. Conclusion

In cases of massive hemorrhage during cesarean section and in other situations, performing local hemostatic measures while keeping the patient in good systemic condition, monitoring the fibrinogen level, and paying attention to possible occurrence of coagulopathy are important. Minimally invasive hemostasis that has little influence on subsequent pregnancies and deliveries should be attempted [3]. If DIC is present, hemorrhage becomes difficult to control with the usual hemostatic

procedures; therefore, “triple C supplement,” such as combined administration of concentrated coagulation factors and FFP is necessary in parallel with hemostasis.

If massive hemorrhage occurs during surgery and coagulopathy occurs concomitantly, effective hemostasis cannot be achieved because of the hemorrhagic tendency. In this case, obstetrical damage control should be performed [3, 11]. First, pressure should be applied to the hemorrhagic area with a towel or balloon, and at the same time, arterial blockage or compression should be performed to decrease the blood flow into the uterus. Second, warming of the patient should be implemented. Third, blood transfusion should be performed to maintain the sufficient circulation blood volume. Rapid “triple C supplement” is also important to obtain a blood fibrinogen level of at least 150–200 mg/dL for the treatment of coagulopathy. If coagulopathy is eliminated, the usual balloon tamponade, compression sutures, arterial ligation, and so on become effective. Hysterectomy should be considered as a last hemostatic measure.

Conflict of interest

None.

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