

Multidetector computed tomography to predict heavy bleeding and need for angiographic embolization in patients with postpartum hemorrhage

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Summary

Purpose: This retrospective study was designed to evaluate the usefulness of multidetector computed tomography (MDCT) in the identification of heavy bleeding, as a determinant of angiographic embolization (AE) in patients with postpartum hemorrhage (PPH). **Materials and Methods:** Fifty-seven consecutively registered patients with PPH underwent contrast-enhanced MDCT at Kyungpook National University Hospital between January 2009 and December 2012. The characteristics of the 33 patients who showed extravasation (EV) of contrast material in MDCT (EV group) were compared with those of the 24 patients who had no EV (noEV group). AE was performed in 23 out of 57 cases, based on the decision of the treating clinician. Direct localization of the bleeding site was compared with the results of MDCT. **Results:** A greater proportion of the EV group required AE compared with the noEV group (64% vs. 8%). The EV group showed a greater estimated blood loss (EBL) (2,100 mL vs. 1,170 mL, $p < 0.001$) and was associated with the need for massive blood transfusion (6 pints vs. 3 pints, $p < 0.001$). Disseminated intravascular coagulation was observed more frequently in the EV group (36% vs. 8%, $p = 0.027$). Of the 33 patients who were managed conservatively without AE, EBL after MDCT was greater in the EV group than the noEV group (410 mL vs. 45 mL, $p < 0.001$). The comparison of computed tomographic and angiographic findings indicated a discordant result in only 1 case. **Conclusions:** Contrast-enhanced MDCT is helpful to determine which patients are candidates for AE and to reduce unnecessary angiographic intervention.

Key words: Angiographic embolization; Estimated blood loss; Extravasation; Multidetector computed tomography; Postpartum hemorrhage.

Introduction

Postpartum hemorrhage (PPH) remains the leading cause of maternal mortality and morbidity, despite medical developments [1, 2]. In the case of severe PPH, timely diagnosis and management are essential for a positive outcome. However, hasty decision-making regarding invasive management for patients is not always necessary and may be harmful for certain patients. Estimation of the severity of PPH (estimated blood loss [EBL]) is important in terms of deciding how to manage PPH.

In contemporary practice, transcatheter selective angiographic embolization (AE) of the uterine artery, rather than peripartum hysterectomy, has become the preferred treatment option for severe PPH [3]. Recently, Cho *et al.* reported that the use of AE has increased significantly as a treatment for intractable bleeding, whereas the number of peripartum hysterectomies performed in Korea declined slightly between 2005 and 2008 [4]. Peripartum hysterectomy was performed at a rate of 1.57 cases per 1,000 deliveries in 2005, compared with 1.33 per 1,000 in 2008.

In contrast, AE was performed at a rate of 0.38 cases per 1,000 deliveries in 2005 and increased to 0.98 per 1,000 deliveries in 2008. AE plays a key role in the treatment of se-

vere PPH because of its high success rate, low complication rate, less invasive nature, and low failure rate [5]. However, the performance of AE is dependent upon the availability of allied facilities, faculties, and time for preparation. Moreover, in spite of the lower complication rate compared with hysterectomy, AE also often has serious complications, such as uterine necrosis, endometritis, and uterine synechiae. Rare complications may also include buttock necrosis, thrombosis of limb vessels, and bowel necrosis [2, 6-8]. Therefore, careful judgment on the part of the physician is required when choosing to perform an invasive intervention. Care should be taken to avoid overtreatment and unnecessary intervention. In the present study, the authors retrospectively investigated the role of multidetector computed tomography (MDCT) in the evaluation of patients with PPH, to determine suitability for AE.

Materials and Methods

At our institution, the first step for managing PPH is medical treatment [9]. Fluid resuscitation, volume expansion, vigorous uterine massage, and administration of uterotonics are among the first-line treatments. Concurrently, inspection to detect the presence of a birth canal laceration

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Figure 1. — (a) Contrast-enhanced computed tomographic image obtained during the portal phase demonstrating contrast extravasation in the uterine cavity (arrow). (b) There is no evidence of contrast material extravasation in the uterine cavity.

and an ultrasonographic examination to assess for retained placenta are performed. Subsequently, patients are assessed for leakage from vessels using MDCT, which helps to predict heavy bleeding and to determine the necessity for surgical or angiographic intervention.

Seventy-four patients were consecutively diagnosed with PPH at Kyungpook National University Hospital between January 2009 and December 2012. PPH was defined as an EBL greater than 500 cm³ after vaginal delivery or 1,000 cm³ after cesarean delivery [10]. Twenty-two patients delivered at our center, and 45 were transferred from other hospitals. Among these patients, 57 who underwent MDCT were included in this retrospective study. Seventeen patients were excluded because MDCT was not performed. In 4 cases, hysterectomy was performed immediately after arrival at the center, owing to unstable vital signs. Another 4 patients underwent a cesarean hysterectomy due to placenta accrete. Nine patients were sufficiently stable to allow management with observation. In these cases, MDCT or other surgical interventions were not required. Of the 57 eligible patients, MDCT revealed EV in 33 cases (EV group); the 24 remaining patients showed no signs of EV (noEV group).

The MDCT protocol for PPH in this institution includes a nonenhanced phase, followed by an arterial phase and a portal phase. In the nonenhanced image, intrauterine hematoma, calcification, and various materials used for hemostasis, such as gauze and uterine tamponading balloons, are hyperattenuated. This assists in differentiating these features from active bleeding. In the arterial phase, most active bleeding is depicted, and we can identify the source vessels. Portal phase images allow the identification of minute or slow bleeding, such as arterial or venous oozing [11, 12].

We used a 64-MDCT scanner with a slice thickness of 5

mm, coverage speed of 49.21 mm/s, gantry rotation time of 0.8 s, and pitch of 0.98 mm and 120 kVp. We first obtained unenhanced images from the pulmonary arteries bilaterally, to the inferior pubic ramus. Then, contrast medium (2 mL/kg) was intravenously administered at a flow rate of 2 to 2.5 mL/s. Arterial phase scanning and portal phase scanning were performed for 40 and 70 seconds after injection of the contrast medium, respectively. MDCT images were reviewed by a radiologist with a specialization in abdominopelvic imaging. Active bleeding was diagnosed in the presence of EV of contrast material, distinct from normal postpartum vessel markings, when the contrast material was detected on the arterial or portal phase MDCT images (Figure 1). In addition, in cases in which AE was performed, the locations of EV on MDCT were confirmed retrospectively, by comparison with the angiographically detected leakage sites.

The performance of angiographic intervention was determined by the physician's assessment of MDCT findings and other clinical findings indicative of massive bleeding. After a joint radiological and obstetrical decision-making process, intervention was performed by abdominal radiological intervention specialists.

The usual approach was via the right femoral artery. Aortoiliac angiography was performed initially to detect the bleeding sites and responsible vessels. After this, selective catheterization of the pelvic vessels, including the internal iliac artery, uterine artery, and in some cases, the ovarian or vaginal arteries, was performed. When identifying the leakage, transcatheteric embolization of the responsible vessels was performed with variable hemostatic materials, including gelfoam and alcohol. Coils were used in intractable cases.

Various methods were used to estimate blood loss, and the results were compared between the EV and noEV

Table 1. — Maternal and obstetrical characteristics.

	EV (n = 33)	noEV (n = 24)	p value
Age, years, median (range)	34 (19-38)	31 (22-43)	NS
Primiparity, n (%)	15 (45)	13 (54)	NS
GAD, days, median (range)	273 (180-290)	274 (225-287)	NS
Birth weight, g, median (range)	3410 (870-4120)	3150 (2420-3800)	NS
Cesarean section, n (%)	14 (42)	9 (38)	NS
Multiple pregnancy, n (%)	2 (5.8)	1 (4.1)	NS
AE, n (%)	21 (64)	2 (8)	< 0.001
Hysterectomy	1	0	NS

AE, angiographic embolization; EV, group with extravasation on multidetector computed tomography; GAD, gestational age at delivery; noEV, group with no extravasation on multidetector computed tomography; NS, no specified.

groups. These methods included the direct measurement of blood loss and parameters indicative of hypovolemia. Direct measurement of blood loss was achieved by directly weighing maternity pads (pad count). In the case of transferred patients, the patient's history was obtained from the transferring hospital. In terms of parameters indicative of hypovolemia, relevant values included blood pressure, pulse rate, volume of blood products transfused, and laboratory findings, including hemoglobin (Hb) concentration measured before (pre-computed tomography[CT]) and 1 day after (post-CT) MDCT. Laboratory findings indicative of disseminated intravascular coagulation (DIC) were compared between the 2 groups. DIC was defined as the presence of prothrombin time and activated partial thromboplastin time prolongation, a decrease in platelet count, and fibrinogen, and elevated fibrinogen degradation products or D-dimer [13].

We used Statistical Package for the Social Sciences, version 12.0 (SPSS, Inc., Chicago, IL), for statistical analysis. A nonparametric Mann-Whitney U test was performed to compare medians. The sensitivity, specificity, positive predictive value, and negative predictive value were also assessed.

Results

Maternal and obstetrical characteristics of the 2 groups, according to the presence of EV, are shown in Table 1. Age, primiparity, gestational age at delivery, and birth weight of neonates did not differ significantly between the 2 groups. Risk factors for PPH, including delivery mode and cause of PPH, were also compared. The leading cause of PPH was uterine atony (n = 34), followed by birth canal laceration, retained placenta, vulvar hematoma, placenta previa, and placenta accreta. There were 2 cases of intraperitoneal bleeding and 1 case of operation site rebleeding. There were no differences in the causes of PPH between the 2 groups. The rate of performance of AE was 64% in the EV group and 8% in the noEV group.

Table 2 compares the parameters indicative of EBL in the 2 groups. EBL was greater and the volume of blood products transfused was larger in the EV group than in the

noEV group. Although pre-CT Hb concentrations did not differ significantly between the 2 groups, post-CT Hb concentration was significantly lower in the EV group.

Sensitivity, specificity, positive predictive value, and negative predictive value for performance of the AE following MDCT were 91%, 67%, 66%, and 92%, respectively.

Among the 57 patients, hysterectomy was performed in 1 case from the EV group. Twenty-three cases were managed with AE. Of the 33 patients who were managed conservatively without AE, the EBL after MDCT was greater in the EV group than in the noEV group (410 mL [range, 50-1,070 mL] vs. 45 mL [range, 0-450 mL]; $p < 0.001$).

We classified the EV sites on MDCT into 3 groups: right, left, and bilateral. After AE, the embolization sites on angiography and the EV sites on MDCT were compared. Among the 33 cases, 16 cases had EV on the right side, 11 had EV on the left side, and 6 showed bilateral EV. A discrepancy between the 2 methods of imaging was seen in only 1 case in which MDCT showed EV on the right side, whereas the vessel involved was shown to be the left uterine artery. As the EV was near the central area of the uterine cavity, precise detection of the location was considered challenging in this case.

Discussion

Compared with angiography, MDCT offers several advantages. It is a less invasive modality for patients as an initial diagnostic tool for determining heavy bleeding and is very quick to perform [14]. MDCT also has a higher spatial and temporal resolution [15], is more sensitive for detecting active arterial bleeding [16], has a high rate of accessibility and reproducibility, and can detect extrauterine causes of bleeding [11, 15].

MDCT is usually the first choice for the diagnosis of traumatic vessel injury, postsurgical bleeding, or other complications, owing to its accessibility [17-19]. It enables visualization of the entire abdomen and provides images in various planes.

AE often requires a long time to determine the bleeding vessel using angiography, and peristalsis of vessels can sometimes make interpretation more difficult. These fac-

Table 2. — Parameters indicative of estimated blood loss.

	EV (n = 33)	noEV (n = 24)	p value
EBL, mL, median (range)	2100 (870-6500)	1170 (700-2420)	< 0.001
Transfusion, pints, median (range)	6 (2-32)	3 (2-9)	0.001
Pre-CT Hb, g/dL, median (range)	8.9 (4.5-12.5)	9.2 (5.3-12.2)	NS
Post-CT Hb, g/dL, median (range)	8.2 (4.8-10.1)	9.0 (7.4-13.1)	0.008
Platelets, 10e3/uL, median (range)	137 (39-279)	166 (60-347)	0.024
Fibrinogen, mg/dL, median (range)	96 (14-347)	220 (25-449)	0.032
DIC, n (%)	12 (36%)	2 (8%)	0.027

DIC, disseminated intravascular coagulation; EBL, estimated blood loss; EV, group with extravasation on multidetector computed tomography; Hb, hemoglobin; noEV, group with no extravasation on multidetector computed tomography; NS, not specified.

tors could increase the risk of ischemia, and consequently increase the risk to the patient. Therefore, a more accurate and faster modality for the identification of the focus of bleeding is needed before AE can be performed.

In several studies, MDCT has been shown to have greater sensitivity than angiography. Roy-Choudhury *et al.* reported that the sensitivity for detecting leakage from an artery was greater when using MDCT than digital subtraction angiography [20].

MDCT also shows high accuracy for detecting leakage sites in patients with PPH. Lee *et al.* reported that overall location-based sensitivity, specificity, accuracy, positive predictive value, and negative predictive value for the detection of PPH with MDCT were 100%, 96%, 97%, 84%, and 100%, respectively [15]. The current study also showed a high sensitivity for detecting leakage sites through MDCT. There was only 1 case with a discrepancy between the EV sites on MDCT and AE. Recently, a small observational study was conducted regarding the utility of MDCT for decision-making for managing PPH [9]. It suggested that classification of leakage site through MDCT images made it possible to triage the patients for further management planning, such as intrauterine ballooning, angiographic intervention, surgical management or conservative treatment. This study also proposed that MDCT could help make decisions. Compared with the previous study, the authors included a larger number of patients and used statistical analysis for suggesting the usefulness of MDCT to predict the necessity of AE. In this study, blood loss of patients in the EV group was greater than for patients in the noEV group. This highlights the fact that AE is more frequently required in the EV group. The rate of AE was 64% in the EV group, but only 8% in the noEV group.

The present study shows a high sensitivity (91%) and negative predictive value (92%) for performing AE after MDCT. Notably, 92% of patients who did not have EV on MDCT were treated conservatively, without AE, and made a full recovery. This indicates that AE could be unnecessary and excessive for these patients, which is an important point considering the cost of the intervention, the efforts of the medical team, and the discomfort of the patient.

In the present institute, we assessed bleeding loss by di-

rectly weighing the patient's maternity pads every hour. When a patient's vital signs are stable, it is not easy to predict whether ongoing bleeding will cease without AE. MDCT can be helpful in this situation. The presence of EV on an MDCT scan, despite the patient being hemodynamically stable, would indicate a need for AE, because of the risk of ongoing heavy bleeding. Indeed, of the 33 patients who were managed conservatively without AE, EBL after MDCT was greater in the EV group than the noEV group. However, the absence of EV on MDCT cannot always exclude ongoing active bleeding [18]. For example, in the cases of severe uterine atony and DIC, EV would not be apparent owing to the decreased bleeding rate. If PPH continues, surgical or angiographic intervention, based on the patient's clinical status and the physician's decision, should be considered. In this study, we experienced 2 cases of AE in the noEV group. With the use of MDCT, we can also detect extrauterine causes of bleeding such as uterine rupture, direct vessel injury, rectus sheath hematomas, dehiscence of the cesarean scar, or bladder flap hematoma [11, 15]. In this study, we diagnosed 3 cases of intraperitoneal bleeding accompanied by heavy vaginal bleeding.

Conclusion

In conclusion, MDCT can provide quick and accurate information on the leakage sites in patients with PPH. Perhaps most importantly, patients who do not have EV on MDCT can be allowed to recover without unnecessary intervention in most cases.

Ethics Approval and Consent to Participate

Approval for the present study was obtained from the institutional review board of Kyungpook National University (KNUH 2020-06-018).

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Conflict of Interest

The authors declare no conflict of interest.

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