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Three-dimensional computerized tomographic angiography for diagnosis and management of intractable postpartum hemorrhage

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ABSTRACT

Objective: To report our experience on the value of dynamic three-dimensional computerized tomographic (CT) angiography for immediate diagnosis and management of intractable postpartum hemorrhage (PPH).

Study design: Retrospective study of all cases of PPH examined by three-dimensional CT angiography between January 2007 and August 2013 in a single center. In each case, emergency dynamic CT was taken at the early arterial, late arterial and venous phases to identify the extravasated contrast agent that represents active hemorrhage. Images for three-dimensional CT angiography were reconstituted from multiplanar CT images. Based on these findings, management procedures were individually determined and those outcomes were compared with angiographic, surgical and clinical findings.

Results: Twenty-nine cases with primary PPH and 19 cases with secondary PPH were examined. In primary PPH, extravasation in the early arterial phase was noted in 12 cases. Those included vulvovaginal hematoma ($n = 4$), invasive placenta ($n = 2$), retained placenta ($n = 2$), uterine atony ($n = 1$), retroperitoneal hematoma ($n = 1$), retrovesical hematoma ($n = 1$) and rectus sheath hematoma after cesarean section ($n = 1$). Of these, ten cases were treated by transcatheter arterial embolization (TAE) of the offending vessels with or without additional therapies. In secondary PPH, extravasation was identified in 14 cases. Those included invasive placenta ($n = 8$), uterine artery pseudoaneurysm ($n = 3$), uterine arteriovenous fistula ($n = 2$), and subinvolution of placenta bed ($n = 1$), which were treated by TAE of the offending vessels with or without additional therapies. Successful hemostasis with fertility preservation was achieved in all cases. Complications were not identified except for a case of placenta increta that developed secondary amenorrhea after TAE of both uterine arteries. In subsequent gestation after TAE of both uterine arteries, normal vaginal delivery ($n = 4$), uncomplicated cesarean delivery ($n = 3$), cesarean delivery followed by recurrent arteriovenous fistula ($n = 1$) and spontaneous miscarriage followed by recurrent invasive placenta ($n = 1$) were identified.

Conclusions: This case series emphasizes that three-dimensional CT angiography has significant diagnostic value when the appropriate procedure for management of PPH was immediately determined to avoid potential maternal morbidity and mortality.

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Introduction

Despite advances in diagnostic and therapeutic modalities, postpartum hemorrhage (PPH) remains a significant cause of maternal morbidity and mortality worldwide [1,2]. If excessive blood loss is ongoing, concurrent evaluation and management of the underlying cause of PPH should be initiated. In most cases of PPH, obstetrical examination combined with ultrasonographic imaging can identify the cause, such as uterine atony, uterine inversion and retained products of conception [1]. However, when obstetricians encounter cases presenting intractable PPH with seemingly unknown cause, which resist conventional obstetrical management, immediate identification of the cause and localization of bleeding could be a crucial step to choose the most effective hemostatic procedures with a multidisciplinary approach to avoid potential maternal morbidity and mortality [1–6].

In the last decade, computerized tomography (CT), especially imaged with a multi-detector row CT (MDCT) scanner, has

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emerged as a less invasive, less time-consuming and more sensitive diagnostic modality than conventional angiography to detect active hemorrhage [5–7]. Moreover, recently evolving three-dimensional CT angiography reconstituted from multiplanar CT images provides intuitive understanding of the accurate localization and injured structure of a bleeding vessel from any direction of view required [8,9]. Reports on this imaging modality are still limited, however, in terms of the diagnosis of obstetric hemorrhages [10,11]. We present a single-center experience to assess the role of dynamic three-dimensional CT angiography in the immediate determination of appropriate management procedures for PPH.

Materials and methods

Study population

Consecutive women who received three-dimensional CT angiography along with other appropriate diagnostic imaging modalities including ultrasonography to identify the cause of PPH and individually determine the management procedures between January 2007 and August 2013 were included in this retrospective study. Medical records were obtained from the electronic chart system of the hospital and reviewed for data points including clinical status, obstetrical problems, amount of estimated blood loss [4] and blood transfusion if any, details on the subsequent management procedures and post-interventional outcomes. Estimated blood loss of >500 mL after vaginal delivery or blood loss of >1000 mL after cesarean delivery was used as inclusion criteria of primary PPH [1], while, in secondary PPH, cases with estimated blood loss of >500 mL were retrieved [12]. Serum β-hCG (value of non-pregnant woman: 0–6 mIU/mL) was measured if retained placental tissue was assumed to be the cause of secondary PPH.

Dynamic three-dimensional CT angiography

With cardiopulmonary resuscitation by anesthesiologists if necessary, emergency dynamic three-dimensional CT angiography was performed with a 64-channel MDCT scanner (Aquilion 64; Toshiba Medical Systems, Tochigi, Japan) [8–10] to detect extravasation of contrast media. Scanning was performed from the infrarenal aorta to the femoral bifurcation after determining the location using a scout digital radiograph. A total of 2.0 mL/kg of body weight of an iodine contrast medium, Iohexol (Omnipaque 300 syringe; Daiichi Sankyo, Tokyo, Japan), was administered at a rate of 3.5 mL/s with a power injector (Dual Shot GX; Nemoto Kyorindo, Tokyo, Japan), which was then flushed with 35 mL of normal saline solution, also at 3.5 mL/s. The scan delay was set with an automatic triggering system (Surestart; Toshiba Medical Systems).

Continuous low-dose fluoroscopy (120 kV, 50 mA) performed at the level of the descending aorta was started 10 s after the start of contrast material injection. Attenuation of the round, 1-cm-diameter region of interest in the descending aorta was measured 3 times/second. When this value reached a preset threshold at an absolute attenuation value of 200 Hounsfield units two consecutive times, a helical CT scanner started automatically to obtain images for the identification of extravasated contrast media. Early arterial, late arterial and venous phase scanning was performed at a fixed delay of 8 s, 20 s and 90 s, respectively.

In all patients, volumetric data from the infrarenal aorta to the femoral bifurcation were acquired in the craniocaudal direction. The obtained images were transferred to a computer workstation and reconstituted using three-dimensional computer graphics software (Ziostation2; Ziosoft, Tokyo, Japan) [8]. Eighteen semitransparent volume-rendering images and 18 maximum intensity projection images from each volume were generated in frontal and oblique views at 30-degree intervals, rotating 180°. This process could usually be achieved within 15 min.

After evaluation of three-dimensional CT angiography images by diagnostic radiologists and obstetricians, management procedures were individually determined. Bleeding vessels were identified according to the pelvic vascular anatomy described [7,13]. If a potential source of hemorrhage was identified in a portion with difficult surgical access [7], emergency digital subtraction angiography (DSA) followed by transcatheter arterial embolization (TAE) [8–10] was chosen with or without subsequent surgical or medical therapies. If hemorrhage was detected in a surgically accessible portion [7], surgical management such as drainage of hematoma and suturing repair was chosen. In cases without active extravasation, conventional medical and surgical management was chosen.

Emergency digital subtraction angiography and transcatheter arterial embolization

Emergency DSA was performed using an AXIOM Artis FA angiography system (Siemens-Asahi Medical Technologies, Tokyo, Japan) as previously described [8]. A nonselective pelvic angiogram was obtained to confirm the site of apparent extravasation. Once the site of bleeding vessel was reconfirmed, the offending artery was selectively catheterized. As embolic agents, gelatin sponge particles made from gelatin sponge sheets (Spongel; Yamanouchi Pharmaceutical Co., Tokyo, Japan) and porous gelatin sponge particles (Gelpart; Astellas Pharmaceutical Co., Tokyo, Japan) were initially used as reversibly embolized materials. If insufficient embolization was noted owing to the large diameter of the injured vessels, platinum interlocking detachable coils (Boston Scientific Co., Natick, MA) and platinum Tornado microcoils (Cook Medical, Bloomington, IN) were placed to induce further thrombosis. After embolization, a complete angiogram was obtained to confirm occlusion of the bleeding artery. With completion of hemostasis with or without any further surgical or medical management needed, the patient was admitted to the intensive care unit at least overnight, and then moved to the obstetric ward after hemodynamic stability was achieved.

Clinical data analysis

All statistical analyses were performed with Microsoft Excel 2011 for Mac OS X (Redmond, WA) using the add-in software Statcel 3 (OMS Pub. Inc., Saitama, Japan). First, variables were tested for normality using the Kolmogorov–Smirnoff test. Since variables in the present study were not normally distributed, results are expressed as the median value and range (minimum–maximum).

Results

Clinical characteristics of cases with postpartum hemorrhage

Twenty-nine cases of primary PPH and 19 cases of secondary PPH examined by three-dimensional CT angiography to determine the management procedures were retrieved for analysis. Clinical characteristics of these cases are shown in Table 1. The mode of delivery was normal vaginal delivery ($n = 29$), cesarean ($n = 11$), vacuum ($n = 7$) and forceps delivery ($n = 1$). The median estimated blood loss was 2000 mL for primary PPH and 1200 mL for secondary PPH. As embolic agents, gelatin sponges were used in 19 cases, while

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