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Fetal and placental anatomy visualized with cinematic rendering from volumetric CT data

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ABSTRACT

Avoiding unnecessary radiation exposure in children, including fetuses or embryos, is of paramount importance. However, emergent clinical situations will arise that necessitate the use of ionizing radiation-based modalities, such as computed tomography (CT), in this patient population. In such circumstances, the use of advanced visualization methods may provide optimum diagnostic utility. We present the case of a pregnant patient with Loeys-Dietz syndrome who was evaluated with CT angiography to rule out an acute aortic syndrome. The CT data from the fetus and placenta were reconstructed using the new cinematic rendering technique that allows for photorealistic display. The potential advantages of cinematic rendering relative to traditional volume rendering are discussed.

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Introduction

According to the principles of Image Gently [1] and As Low As Reasonably Achievable (ALARA), every effort should be made to reduce or avoid ionizing radiation dose in children, including unborn children. However, in certain clinical scenarios, exposure of pregnant women and their embryos or fetuses to ionizing radiation-based imaging studies such as computed tomography (CT) may still be necessary. Examples would include severe trauma where the rapid detection of injuries that could threaten the life of the mother or conceptus is of paramount importance [2], the evaluation of fetal skeletal dysplasias in which the improved ability of CT to delineate bony structures relative to ultrasound and magnetic resonance often outweighs the risk from radiation exposure [3], and suspected acute vascular emergencies in pregnant women with underlying vascular syndromes [4].

Once the decision has been made to pursue the use of CT in a pregnant woman that will include the embryo or fetus in the field-of-view, it is important to derive all possible diagnostic yields out of the acquired images. Given the complexity of placental and fetal anatomy, visualizing any acquired CT dataset in 3D may provide valuable insight [5]. In this report, we describe our first experience with fetal and placental imaging with CT utilizing a new 3D cinematic rendering (CR)

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technique that has recently been U.S. Food and Drug Administration approved and that allows for evaluation of anatomic detail at a photorealistic level [6–8].

Case report

A 27-year-old pregnant woman with a history of Loeys-Dietz syndrome, a rare connective tissue disease in which patients often manifest vascular complications [9], presented at 36 weeks and 6 days of gestation for a scheduled Cesarean delivery. Pregnant patients with Loeys-Dietz syndrome are considered very-high-risk, and clinical services that care for these patients must be cognizant of the potentially catastrophic aortic emergencies that can occur [10]. The patient began suffering from shortness of breath and headache with labile blood pressures, and given her known underlying connective tissue disease, it was decided to proceed with contrast-enhanced CT angiogram of the chest, abdomen, and pelvis to assess for emergent vascular conditions such as an aortic dissection.

The caliber of the aorta was normal throughout its course, and there was no evidence of aortic dissection. Indeed, no acute process was appreciable on the CT angiogram. However, this relatively uncommon occurrence of a pregnant woman being imaged with CT angiography that included the fetus in the field of view provided the opportunity to reconstruct the acquired CT data with a novel method known as CR. As with traditional volume rendering (VR), CR involves taking thin slice, isotropic voxel reconstructions from spiral multidetector CT, stacking those slices to create a volume, assigning a color and transparency to each voxel in the volume based on its composition, and then projecting light through the volume to produce the 3D image. Where CR differs from VR is that the lighting model for CR is dramatically more complex and can take into account effects on rays of light such as scatter [7]. The net result of this more complex lighting schema is that the details of the 3D image are enhanced and shadowing effects are very realistic. CR can also be applied to magnetic resonance images, although we will not further discuss that in the context of this case.

In this case, the CR visualizations provided striking anatomic detail of both the fetal skeleton as well as the enhanced vasculature within the placenta. Figure 1 includes a series of VR and CR images that contrast the differences between these two visualization techniques. Although traditional VR images offer a wealth of information and provide adequate visualization of the major fetal skeletal structures, the ability to appreciate complex anatomic relationships is enhanced with the photorealistic images provided by CR. Note, for example, the shadow projected onto the top of the calvarium (red arrowheads) by the adjacent superior pubic rami—this definitively establishes the in-space relationship of these objects in a single image in a way that traditional VR cannot. The relative positions of the fetus and the numerous vessels coursing through the placenta are also well shown with CR, which suggests that this methodology may allow for accurate assessment of placental vascular pathologies such as abruptions. Further, with

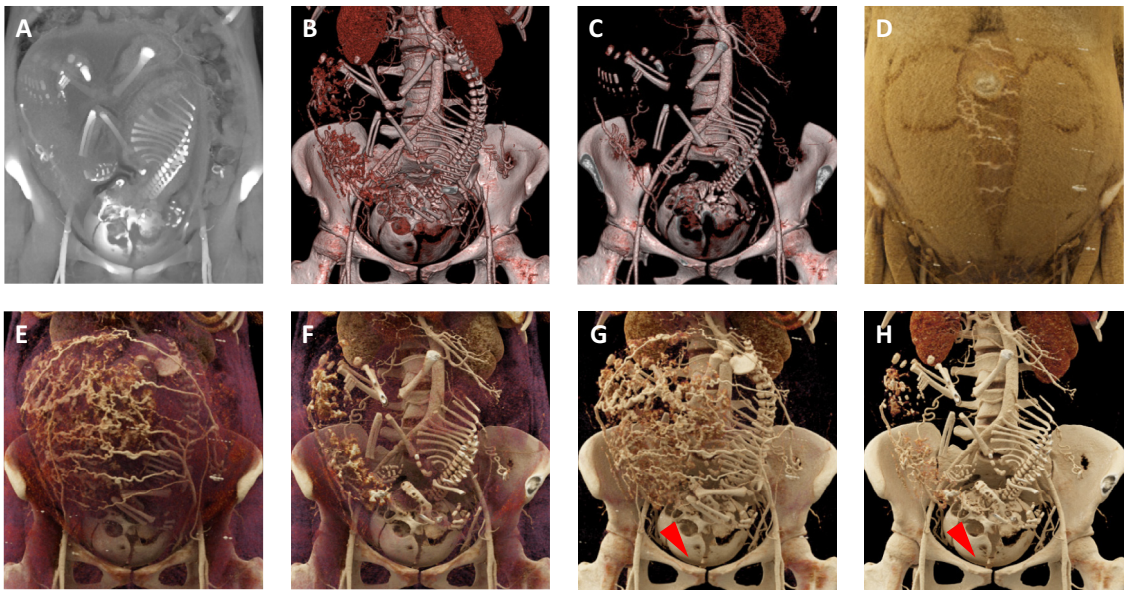

Fig. 1 – (A) through (C): VR images of the 36-week, 6-day fetus described in this case. Excellent detail of the bony structures is apparent, although the level of anatomic detail is less than in the CR images that are also presented. (D) through (H): CR visualizations of the same field of view. Note the fine soft-tissue detail that can be achieved with CR (such as the texture of the diastatic rectus abdominis musculature in (D)). By varying the window width and level, different amounts of soft tissue, vascularity, and bone can be emphasized and a complete photorealistic anatomic picture of the fetal skeletal structure and placental vascularity can be achieved. As one example of the more robust 3D effects produced by CR, note that the superior pubic rami cause a shadow over the top of the fetal calvarium (red arrowheads in (G) and (H)), an effect that is not possible with the simpler lighting model in the traditional VR images. This realistic shadowing effect more definitively establishes the relative positions of the structures. CR, cinematic rendering; VR, volume rendering.

the proper window widths and levels, CR can be utilized to show very fine detail in soft tissues, such as the texture of muscles and other organs.

Discussion

Although this pregnant patient with Loeys-Dietz syndrome did not have an acute aortic syndrome despite her medical history and symptomatology, she was nevertheless appropriately and urgently worked-up with a contrast-enhanced CT angiogram. The inclusion of the fetus in the imaged field of view provided the first opportunity to utilize CR to visualize fetal and placental anatomy.

CR is a newly available and U.S. Food and Drug Administration-approved method of 3D visualization for tomographic image data with isotropic voxels. This method has made it possible to create photorealistic images from CT data, which has not previously been possible with preexisting 3D visualization methodology. Ultimately, the clinical utility of these striking images and the real-world advantages and disadvantages relative to traditional VR remain unknown, but will begin to be addressed through appropriately designed studies as CR technology becomes more widely available and both radiologists and clinicians become more familiar with it. Potential advantages would include easier abstraction of complex anatomic data from a single CR image, improved communication with patients who may better understand these photorealistic images, and facilitation of accurate 3D printed models.

We also note that the images shown in this case report were reconstructed from a standard clinical CT acquisition with no additional radiation exposure to the pregnant patient or the fetus.

REFERENCES

[1] Image Gently. 2017. Available from: http://www.imagegently.org. [Accessed August 29, 2017].
[2] Kopelman TR, Berardoni NE, Manriquez M, Gridley D, Vail SJ, Pieri PG, et al. The ability of computed tomography to diagnose placental abruption in the trauma patient. J Trauma Acute Care Surg 2013;74:236–41.
[3] Imai R, Miyazaki O, Horiuchi T, Asano K, Nishimura G, Sago H, et al. Ultra-low-dose fetal CT with model-based iterative reconstruction: a prospective pilot study. AJR Am J Roentgenol 2017;208:1365–72.
[4] Frise CJ, Pitcher A, Mackillop L. Loeys-Dietz syndrome and pregnancy: the first ten years. Int J Cardiol 2017;226:21–5.
[5] Adler Levy Y, Yagel S, Nadjari M, Bar-ziv Y, Simanovsky N, Hiller N. Use of low dose computed tomography with 3D reconstructions for the prenatal evaluation of suspected skeletal dysplasia. Isr Med Assoc J 2017;17:42–6.
[6] Eid M, De Cecco CN, Nance JW Jr, Caruso D, Albrecht MH, Spandorfer AJ, et al. Cinematic rendering in CT: a novel, lifelike 3D visualization technique. AJR Am J Roentgenol 2017;209:370–9.
[7] Johnson PT, Schneider R, Lugo-Fagundo C, Johnson MB, Fishman EK. MDCT angiography with 3D rendering: a novel cinematic rendering algorithm for enhanced anatomic detail. AJR Am J Roentgenol 2017;209:309–12.
[8] Dappa E, Higashigaito K, Fornaro J, Leschka S, Wildermuth S, Alkadhi H. Cinematic rendering—an alternative to volume rendering for 3D computed tomography imaging. Insights Imaging 2016;7:849–56.
[9] Westerland O, Frigiola A, Robert L, Shaw A, Blakeway L, Katsanos K, et al. Vascular manifestations of syndromic aortopathies: role of current and emerging imaging techniques. Clin Radiol 2015;70:1344–54.
[10] Wanga S, Silversides C, Dore A, de Waard V, Mulder B. Pregnancy and thoracic aortic disease: managing the risks. Can J Cardiol 2016;32:78–85.