# Variation of Hepatic Artery by 3-D Reconstruction MDCT Scan of Liver in Siriraj Hospital

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***Objective:*** *To evaluate the prevalence of hepatic arterial variant in Siriraj Hospital.*
***Material and Method:*** *A retrospective study that was approved by ethic committee of Siriraj Hospital. Between August and October 2006, 200 studies of abdominal MDCT were randomly sampled and multi-planar reformatted by using program* Vitrea 2. *Both axial, two- and three-dimensional images were evaluated for possible variants of hepatic vasculature. The results were classified by Michel classification and analyzed in percentage. Moreover, a small group (23 studie s) that had digital subtraction angiography (DSA) was compared to know accuracy and Interco relation between the two reviewers (Kappa value).*
***Results:*** *Of 200 studies, 83.5% had type I,1% type II, 6% type III, 0.5% type IV, 3.5% type V, 1% type VI, 0.5% type VIII, 1% type IX, 0.5% Type X, and 2.5% others type. Accuracy of MDCT for detection hepatic artery variation as compared with DSA was 78.3%.*
***Conclusion:*** *All variation is about 16%. Type III is most common variation of patients in Siriraj Hospital.*

***Keywords:*** *Hepatic artery, 3D reconstruction MDCT scan of liver*

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The rapid evolution and increasing complexity of liver-directed therapies have forced the medical community to further advance its understanding of hepatic arterial anatomy. The anatomy of the mesenteric system, and particularly the hepatic arterial bed, has been demonstrated to have a high degree of variation. This is important when considering pre-surgical planning, catheterization, and transarterial chemoembolization (TACE)[1].

Recent articles suggest excellent correlation between findings at helical CT angiography and those at catheter angiography[2]. CT angiography is more convenient for the patient, without the morbidity and mortality associated with catheter angiography[3]. In addition to obviating analgesia and periprocedural nursing care, use of CT angiography results in substantial reductions in cost and radiation burden. Some institutions use routine CT angiogram in all liver donors to evaluate liver volume and vascular anatomy[4,5].

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Michel classification (Table 1) was first established in 1966 by Michel. This study was a classified variation of hepatic artery after cadaveric dissection of 200 cadavers. They found that the normal type of hepatic artery is about 55%. In Thailand, there was a study[6] in 120 cadavers (1986) by another classification. The normal type was 74.16%.

The main purpose of the present study was to evaluate and describe the prevalence of hepatic arterial variant. To the authors' knowledge, no previous study use the same protocol as this study. Accuracy of abdominal MDCT when using DSA as the gold standard was also done.

## Material and Method

Two hundred studies of abdominal CT scans were performed by multi-detector abdominal CT (MDCT) in Siriraj Hospital between August and October 2006. They were randomly sampled by date of study.

Imaging was performed with a 16-slice multidetector CT scanner (Light speed plus; General Electric Medical System, Milwaukee, Wis., USA). Contrast

material was injected by injector through an 18-20-gauge intravenous cannula at a rate of 4 mL/sec. Post contrast scan was performed in different protocol. All were used this following parameter 120 Kvp 300 mA and 1.25 mm reconstruction thickness. In a small group (23 studies) that had digital subtraction angiography, the hepatic angiograms were performed with Allura integris (Philips Medical Systems, Eindhoven, The Netherlands). 35-50 mL contrast agent was injected at 6-12 mL/sec with pressure 300 psi.

The only exclusion criteria is the patient who had undergone hepatic resection.

The data was reviewed by one interventional radiologist (25-years experience) and one second-year diagnostic radiology resident after2-D multiplanar reformatting and 3-D volume rendering by program Vitrea2 (Vital Images, Plymouth, Minn USA). Hepatic artery variation was classified by using Michel classification (Table 1). In 23 studies that had DSA in PACS system, DSA were reviewed and compared with CT scan classification for accuracy. Results of two reviewers were also compared for agreement between the two reviewers.

***Statistical analysis***

Percentage of each variation, classified using Michel classification, was given. Compared accuracy in detection of hepatic artery variation between MDCT and DSA (gold standard) was provided.

Kappa value for study agreement between two reviewers) using program Stat-exact 6 was given.

**Results**

Two hundred images were used in the present study, 100 from male patients. The accuracy was 82.6%, the sensitivity was 61.5%, and the specificity was 100% as calculated from Table 1.

Five images were false negative. All were classified as conventional anatomy on MDCT, three were type V, one was type IX, and one was other types on DSA.

**Table 1.** Detection of variation MDCT compared with DSA as gold standard

| | DSA (gold standard) conventional anatomy | Variation |
|---|---|---|
| MDCT conventional anatomy | 10 | 5 |
| Variation | 0 | 8 |

The result of the variation is described in Table 2. Five patients had other types that were not classified by Michel classification such as accessory right hepatic artery from hepatic artery proper (3 patients), common trunk of superior mesenteric artery and celiac artery (1 patient), and accessory right hepatic artery from left gastric artery (1 patient), as shown in Fig. 2.

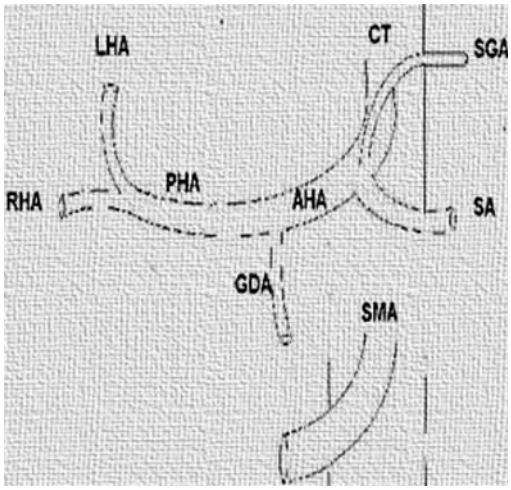


**Fig. 1A** Type I (conventional anatomy). The main hepatic artery (AHA) originating from celiac truncus (CT) gives off the gastroduodenal artery (GDA) and the proper hepatic artery (PHA), and the proper hepatic artery splits into the left (LHA) and the right (RHA) hepatic arteries (SGA: left gastric artery, SA: splenic artery, SMA: superior mesenteric artery

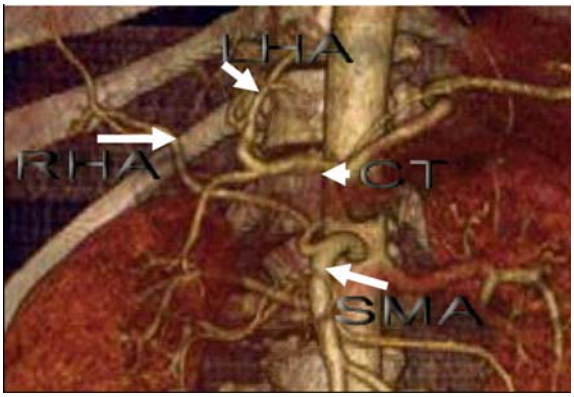


**Fig. 1B** Example picture of 3-D reconstruction Type III (replaced right hepatic artery). The right hepatic artery (RHA) originates from the superior mesenteric artery (SMA**)**

**Table 2.** Michel classification of hepatic artery variation and percentage of each variation in this study

| Type | Description | F | M | Total |
|---|---|---|---|---|
| I | Conventional type: main hepatic artery originating from celiac truncus gives off the gastroduodenal artery and the proper hepatic artery and the proper hepatic artery splits into the left and the right hepatic arteries | 87 | 81 | 168 (84%) |
| II | Replaced left hepatic artery: :Left hepatic artery originates from left gastric artery | 0 | 2 | 2 (1%) |
| III | Replaced right hepatic artery:Right hepatic artery originates from superior mesenteric artery | 6 | 6 | 12 (6%) |
| IV | Combination of replaced right and replaced left hepatic artery | 0 | 1 | 1 (0.5%) |
| V | Accessory left hepatic artery:Left hepatic artery originates from hepatic artery properAccessory left hepatic artery originates from left gastric artery | 5 | 2 | 7 (3.5%) |
| VI | Accessory right hepatic artery:Right hepatic artery originates from hepatic artery properAccessory right hepatic artery originates from superior mesenteric artery | 0 | 2 | 2 (1%) |
| VII | Accessory left and right hepatic artery | 0 | 0 | 0 |
| VIII | Replaced right hepatic artery originates from superior mesenteric artery Accessory left hepatic artery originates from left gastric artery or replaced left hepatic artery with accessory right hepatic artery | 0 | 1 | 1 (0.5%) |
| IX | Main hepatic artery originates from superior mesenteric artery | 1 | 1 | 2 (1%) |
| X | Main hepatic artery originates from left gastric artery | 0 | 0 | 0 |
| | Other types | 1 | 4 | 5 (2.5%) |

The inter-observer agreement is good. Kappa value is 0.7364 (95% confident interval is 0.5029, 0.9699)
When compared between two reviewers. Four images had different classification, two had type V, one had type IX and the last one had an other type

## Discussion

Variations were found in 16% of the patients. This is lower in Thailand than in Western countries, and is the same as the Sreesai study[6].

Twelve images were type III, which are the most common of the variation of hepatic artery (Fig. 1B). The second most common is type V.

The results, based on Michel classification, were the same as Sreesai' study[6]. However, they were different from the Covey study of 700 patients. The Covey study showed that type V was the most common. Type VII and type X were identified. This difference could be from too small a sample size. Males had type II and VII variation more than females. On the other hand, females had type V more than male. A future study would be interesting.

Type V was the most common missed variation (false negative) in the present study because peripheral branch is not always well opacified in CT reconstruction. Therefore, time and rate of contrast injection must be accurate. The protocol used in the present study was the same as in the one of 2001[8] that used 20-25 sec for scanning arterial phase. Masato Tanikake[2] study in 2003 found that an injection rate of 5 mL/sec was superior to the rate of 4 mL/sec at both visual evaluation and quantitative evaluation of hepatic artery. In the present study, the authors used the injection rate of 4 ml/sec. However, the sub segmental branch cannot be visualized. New protocol is suggested because TACE and surgery need sub segmental detail of hepatic artery.

As suggested in a previous study[9], when looking for collateral circulation in the patient who does not have complete lipiodol staining after TACE, the

**Table 3.** Comparison with previous study

| Type | This study | Covey[7] | Sreesai[6] |
|---|---|---|---|
| I | 84% | 61% | 74.16% |
| II | 1% | 4% | 5% |
| III | 6% | 9% | 5% |
| IV | 0.5% | 1% | - |
| V | 3.5% | 11% | 3.33% |
| VI | 1% | 2% | 3.33% |
| VII | - | 1% | - |
| VIII | 0.5% | 3% | - |
| IX | 1% | 2% | 3.33% |
| X | - | - | - |
| Others | 2.5% | 6.6% | 3.35% |

lesion that is close to the ventral surface may be supplied by the internal mammary artery. From the present study, variation could also have caused incomplete lipiodol staining. Moreover, it is suggested that MPR be performed before TACE in patients with hepatocellular carcinoma. One case in the present study had a history of incomplete lipiodol staining after the fifth TACE. After the MPR dual phase, CT of liver revealed accessory right hepatic artery from superior mesenteric artery. The authors performed SMA angiogram (Fig. 3).

Low sensitivity in the present study is demonstrated, and could be due to the low quality control of MDCT and too small a sample size. Many protocol of abdominal CT was used, causing varied quality of images. However, Kappa value in the present was good. This could be from the advantage of CT that can give multiplanar reconstruction and Michel classification, which is easy to recognize.

There were three man limitations of the present study. First, it was a retrospective study. Then, only a small group of samples (23 studies) had DSA in PACS. This was too small sample data to calculate the accuracy for MDCT when using DSA as the gold standard, thus the second reason. The last reason is that the multi-planar reformation in the present study


A B

**Fig. 2** Example of hepatic artery variation (A) type VIII (replaced right hepatic artery originates from superior mesenteric artery, accessory left hepatic artery originates from left gastric artery) and (b) type IX (main hepatic artery (AHA) originates from superior mesenteric artery)

**Fig. 3A** Right hepatic angiogram showed incomplete lipiodol staining (arrow)

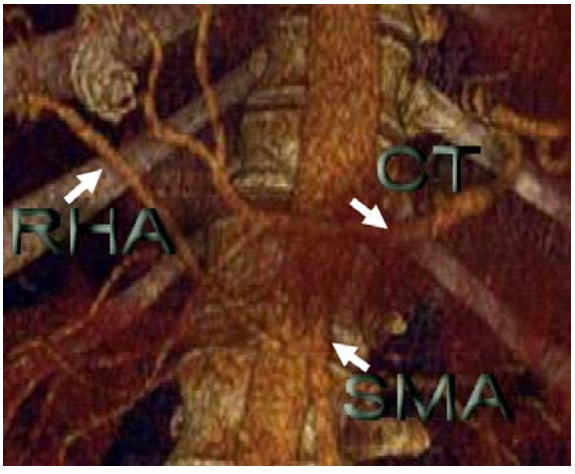


**Fig. 3B** 3-D reconstruction revealed accessory right hepatic artery from superior mesenteric artery (arrow)

was performed by using Vitrea 2 program. If the authors had used an experienced person, then accuracy would have been gained. This reason supports the disadvantages of MDCT angiography and includes the need to train technologists. It also highlight the increased time required for image processing[10].

## Conclusion

There is low prevalence (16%) of hepatic variations in Thailand compared with Western countries in the present study. The most common of variation of hepatic artery are type III (6%). The second most common is type V (3.5%).

New variation types (Siriraj types) that were found in the present study were accessory right hepatic artery from hepatic artery proper, common trunk of superior mesenteric and celiac artery, and accessory right hepatic artery from left gastric artery.

## Abbreviations

DSA = digital subtraction angiography
MDCT = multi-detector computed tomography
MPR = multi-planar reformation
PACS = picture archiving and communication systems
TACE = transarterial chemoembolization

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## *การศึกษาลักษณะทางกายวิภาคของหลอดเลือดแดงตับโดยใช้เอกซเรย์คอมพิวเตอร์ในโรงพยาบาลศิริราช*

*กฤษฎี ประภาสะวัต, ชัชชัย หอมเกตุ*

***วัตถุประสงค์**: เพื่อทราบความชุกของความผันแปรของหลอดเลือดแดงตับ ในผู้ป่วยที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์ช่องท้องในโรงพยาบาลศิริราช*

***วัสดุและวิธีการ**: การศึกษาย้อนหลังที่ผ่านการพิจารณาของคณะกรรมการจริยธรรมของโรงพยาบาลศิริราช โดยทำการสุ่มกลุ่มศึกษา 200 คน ระหว่าง เดือนสิงหาคม ถึง ตุลาคม พ.ศ. 2549 ที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์ช่องท้อง ข้อมูลภาพจะถูกสร้างเป็นภาพ 2 มิติในแนวต่าง ๆ และภาพ 3 มิติ โดยโปรแกรม Vitrea 2 แล้วนำมาจำแนกเป็นแบบต่าง ๆ ตามแบบของมิเกล ผลที่ได้จะนำมาคำนวณเป็นเปอร์เซ็นต์ นอกจากนี้มีการนำกลุ่มศึกษา 23 คน มาเปรียบเทียบกับวิธีการฉีดสีทางหลอดเลือดผ่านสายสวน เพื่อแสดงความแม่นยำเบื้องต้นและเปรียบเทียบผลการจำแนกของผู้ศึกษาทั้ง 2 คน*

***ผลการศึกษา**: การศึกษา 200 คน 83.5% แบบที่ 2 1%, แบบที่ 3 6%, แบบที่ 4 0.5%, แบบที่ 5 3.5%, แบบที่ 6 1%, แบบที่ 7 0%, แบบที่ 8 0.5%, แบบที่ 9 1%, แบบที่ 10 0.5% อื่นๆ 2.5%. ความแม่นยำของการใช้ เอกซเรย์คอมพิวเตอร์ในการศึกษาความแปรผันของหลอดเลือดแดงตับเท่ากับ 78.3%*

***สรุป**: ความแปรผันโดยรวม 16% และ แบบที่ 3 เป็นชนิดที่พบบ่อยที่สุดในโรงพยาบาลศิริราช*