The Use of 3D-CT Angiography to Measure the Normal Angle Formed by the Aorta and the SMA: The Value and Application of 3D-CT Angiography in SMA Syndrome

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Objectives. Superior mesenteric artery (SMA) syndrome is a rare clinical disease. Diagnosis is often inconclusive as findings by endoscopic and roentgenographic methods are often normal. Hypotonic duodenography combined with simultaneous SMA arteriography has been suggested as the most efficient radiologic technique, although the angiographic procedure is invasive. The purpose of this study was to describe a non-invasive procedure that consists of CT angiography with 3D reconstruction to measure the angle between the aorta and the SMA in a normal group of patients.

Methods. From July 1999 to June 2000, 2 patients with symptoms of SMA syndrome and 94 patients with other disorders were studied. We measured the aortomesenteric angle by CT angiography and three-dimensional computed tomographic (3D-CT) reconstruction.

Results. 3D-CTA reliably displayed the angle between the aorta and the SMA. The mean measured aorta-SMA angle was 45° (range, 23° to 85°) in the normal group, and 15° (range, 14° to 16°) in the patient group, respectively.

Conclusions. Helical CT angiography combined with 3D reconstruction plays a diagnostic role similar to that of conventional angiography in patients with a classic clinical presentation suggestive of superior mesenteric artery syndrome. 3D-CT angiography is a safe, rapid, and relatively noninvasive technique. **(Mid Taiwan J Med 2003;8:73-7)**

Key words

angiography, computed tomography, superior mesenteric artery, three dimension

INTRODUCTION

Superior mesenteric artery (SMA) syndrome is a rare condition in which the third portion of the duodenum is intermittently compressed between the aorta and the SMA. Characteristic clinical symptoms include postprandial epigastric pain, nausea, fullness, early satiety, weight loss, and vomiting, which may be bilious [1-3]. The symptoms are clinically relieved with postural changes. The radiologic findings include dilatation of the first and second portion of the duodenum, abrupt vertical or oblique compression of the third portion of the duodenum, and antiperistaltic flow in the proximal duodenum [4]. The basic diagnostic technique is a conventional barium study of the

Received : July 5, 2002. Revised : October 17, 2002.
Accepted : January 17, 2003.
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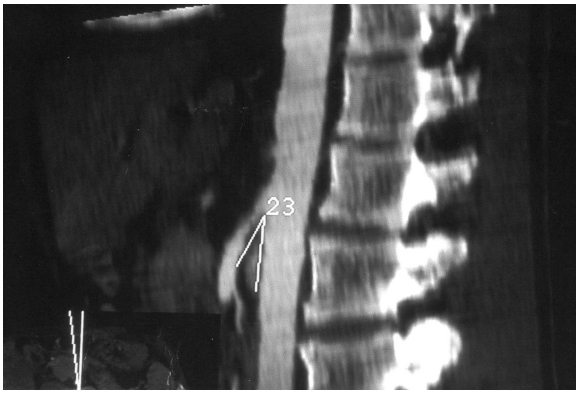

Fig. 1. A 40-year-old man from the control group. Multiplanar reformation reveals a normal aorta-SMA angle of 23 degrees.

Fig. 2. A 23-year-old woman with superior mesenteric artery syndrome. Maximum intensity projection shows a sharp aorta-SMA angle of 14 degrees.

upper gastrointestinal tract, but findings are not specific and often are non-diagnostic [5,6]. Hypotonic duodenography combined with simultaneous SMA arteriography has been suggested as the most efficient radiologic technique [7,8], but it is invasive, and some patients are unable to tolerate the angiographic procedure. However, CT angiography is a useful noninvasive diagnostic procedure which all patients are able to undergo.

Konen et al first described the use of 3D-CTA in the evaluation of SMA syndrome in 1998 [9]. In their series, three types of reformatted images were used: shade-surface displays, maximum intensity projections, and multiplanar reformations. The mean measured aortomesenteric angle was 9° in the patient group and 44.4° in the control group. The mean measured aortomesenteric angle was 45° in the normal group in our study. The result is compatible with that of a previous study [9].

In this study, we analyzed the use of CT angiography with two types of reformatted images (maximum intensity projections and multiplanar reformations) to measure the angle between the aorta and the SMA in the normal group, and evaluated the value and applications of 3D-CTA for diagnosing SMA syndrome.

MATERIALS AND METHODS

From July 1999 to June 2000, 96 patients referred to our CT center because of hepatic mass or other abdominal symptoms were prospectively studied. None of the patients had previously undergone abdominal surgical procedures. There were 57 males and 39 females (age range, 20 to 68 years; mean, 51 years) who underwent CT angiography.

Helical CT angiography was performed on a CT scanner (Elscint, CT Twin, Israel) with the following parameters: maximum scan time, 32.1 sec; dual pitch, 1; table speed, 5 mm/sec; and effective slice thickness, 6.5 mm. Through a large-bore peripheral intravenous line, 90 mL of contrast medium (Omnipaque, Nycomed, Oslo, Norway) was administered rapidly by power injector at 3.2 mL/sec. Scanning delay time was 27 sec after initiation of the bolus.

The 3D reconstructions were performed on an independent workstation (Elscint, Omnipro2). We used two types of reformatted images: maximum intensity projections, and multiplanar reformations. The tangent of the aorta-SMA angle was measured on the basis of the maximum intensity projections and multiplanar reformations.

We studied two patients with radiologic signs of relative obstruction at the level of the third portion of the duodenum with a similar protocol.

RESULTS

No difficulties were encountered in most of our patients when ventilation was suspended for

32 seconds. Although a few of the patients were not able to hold their breath for 32 seconds, it did not affect the measurement of the aortomesenteric angle. No definite extravasation of contrast medium was noted during injection. Timing of the contrast bolus was also controlled to achieve maximal vascular opacification. With this technique, the angle between the aorta and the SMA was displayed reliably with 3D-CTA. Parasagittal reformations and maximum intensity projections were found to be useful for measuring the aorta-SMA angle at the level of the duodenum. The mean measured normal aorta-SMA angle was 45° (range, 23° to 85°) (Fig. 1). In the two patients with related obstruction at the level of the third portion of the duodenum, the mean measured aorta-SMA angle was 15° (range, 14° to 16°) (Fig. 2).

DISCUSSION

SMA syndrome is a rare disease. There are multiple predisposing factors, including a) congenital anomalies such as high insertion or hypertrophy of the Treitz ligament [10], b) marked weight loss due to severe wasting diseases such as cancer and burns [11], c) the application of a body cast to treat scoliosis or vertebral fracture [12], and d) idiopathy due to emaciation, and loss of mesenteric fat [4,13]. There are a number of therapeutic approaches to superior mesenteric artery syndrome. For example, nonoperative treatment should be attempted first [14,15]. Simple gravitational maneuvers, such as placing the patient into the prone knee-chest or left lateral decubitus position after eating, may relieve the problem. For patients in whom conservative methods fail, operative relief of superior mesenteric artery syndrome has been described. Three operations have been found to be useful: gastrojejunostomy, duodenojejunostomy, and Strong's operation [15].

Obstruction of the duodenum in SMA syndrome is caused by narrowing of the angle between the aorta and the SMA [1,3]. Conventional barium meal and hypotonic duodenography have been recommended as screening methods. Positive findings include dilatation of the first, second, and third portion of the duodenum, an abrupt vertical filling defect at the level of the SMA, retention of barium within the duodenum, and frequent relief of obstruction in the left lateral decubitus or prone positions [4,16,17]. Unfortunately, these radiologic appearances are non-specific for SMA syndrome and have been reported in various conditions such as slceroderma, diabetes, pancreatitis, peptic ulcer, lupus erythematosis and idiopathic intestinal pseudoobstruction [4-6,18].

In the past, angiographic measurement of the aortomesenteric angle was noted as being a more accurate investigation than a routine barium meal examination [7,8]. However, the procedure is invasive, and some patients are unable to tolerate it. More recently, the development of spiral CT has made CT angiography a well-recognized and reliable technique which obtains excellent anatomic detail of the aorta and its branches [19].

The main advantage of spiral CT angiography is its ability to construct high-quality 3D renderings of the abdominal vasculature without the need for invasive angiography. Measurements of the aortomesenteric angle obtained in our series, based on CT angiography 3D reformations, were similar to those of previous angiographically based reports [2,7,8].

Although conventional angiography probably will remain the diagnostic gold standard, spiral CT angiography is less invasive, less expensive, easier to perform, and quicker than conventional angiography. The reconstructed images provide excellent anatomic detail that easily enables accurate diagnosis and preoperative planning. Spiral CT angiography reduces the risk of invasive diagnosis and is not dependent on the catheterization skills of the operator.

In conclusion, our initial experience has shown that spiral CT angiography with 3D reconstruction is a safe, reliable, and useful noninvasive diagnostic technique. With the rapid explosion of clinical testing and refinement in techniques, spiral CT angiography with 3D reconstruction undoubtedly will become a routine diagnostic tool in the feature.

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以三度空間之電腦斷層血管攝影測量腹主動脈與上腸繫膜動脈之間的正常角度：三度空間之電腦斷層血管攝影對於上腸繫膜動脈症候群之價值

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背景 上腸繫膜動脈症候群是一少見的疾病，此症候群在內視鏡及傳統的放射線學檢查結果通常是正常的。過去，放射線學上對於上腸繫膜動脈症候群的診斷主要是依據上腸胃道攝影及傳統的侵入性血管攝影檢查。但是血管攝影是一具有侵入性的檢查。此研究的目的是要描述以非侵入性的檢查，也就是利用電腦斷層血管攝影及三度空間電腦斷層血管攝影重組的技術來測量腹主動脈與上腸繫膜動脈之間的正常角度，藉此提供一項診斷上腸繫膜動脈症候群之依據 。

方法 從1999年七月至2000年六月之間，共有96位病患前來接受此檢查。其中有二位病人是因有上腸繫膜動脈症候群的症狀，其餘的94位病患則因其它的原因。我們利用電腦斷層血管攝影及三度空間電腦斷層血管攝影重組的技術來測量腹主動脈與上腸繫膜動脈之間的角度。

結果 利用此技術，可以可靠地以三度空間電腦斷層血管攝影重組的技術來顯示出主動脈與上腸繫膜動脈之間的角度。測得的主動脈與上腸繫膜動脈之間的平均正常角度爲45°(範圍，23°至85°)。在上腸繫膜動脈症候群的病患中爲15°(範圍，14°至16°)。

結論 對於高度懷疑爲上腸繫膜動脈症候群的病患，螺旋電腦斷層血管攝影及三度空間電腦斷層血管攝影重組的技術是一可靠的診斷工具。它具有安全，快速，且不具侵入性的好處。（中台灣醫誌 **2003;8:73-7**）

關鍵詞

血管攝影，電腦斷層，上腸繫膜動脈，三度空間

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收文日期：2002年7月5日 修改日期：2002年10月17日

接受日期：2003年1月17日