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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Safer video-assisted thoracoscopic thymectomy after location of thymic veins with multidetector computed tomography

H. Shiono,[1] A. Inoue,[2] N. Tomiyama,[2] N. Shigemura,[1] K. Ideguchi,[1] M. Inoue,[1] M. Minami,[1] M. Okumura[1]

[1] Division of General Thoracic Surgery, Department of Surgery, Osaka University Graduate School of Medicine, E1, 2-2 Yamadaoka Suita, Osaka 565-0871, Japan
[2] Department of Radiology, Osaka University Graduate School of Medicine, E1, 2-2 Yamadaoka, Suita, Osaka 565-0871, Japan

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Abstract
Background: Video-assisted thoracoscopic (VATS) thymectomy has been applied as a surgical option for autoimmune myasthenia gravis. Prior identification and fine division of the thymic veins are critical to the prevention of unexpected severe bleeding that may require conversion to open surgery. Until recently, such bleeding could be avoided only by meticulous dissection of thymic fat tissue away from the left brachiocephalic vein (LBV). With recent advances in computed tomography (CT), multidetector-row computed tomography (MDCT) can readily be obtained and provides three-dimensional (3D) images. This study explored its value for preoperative identification of the thymic veins draining into the LBV, and thus for prevention of injury to these veins during endoscopic thymectomy.
Methods: Five patients with myasthenia gravis, thymoma, or both underwent enhanced MDCT preoperatively. The thymic veins draining into the LBV were visualized using both horizontal and sagittal/coronal CT images. Then 3D images were reconstructed to enable operators to simulate endoscopic views. During each VATS extended thymectomy, the numbers and branching patterns of the thymic veins were compared with the preoperative MDCT images.
Results: The thymic veins draining into the LBV were clearly identified with MDCT in all five patients examined. Reconstructed 3D images clearly located their courses in the thymic/fat tissue and their entry routes into the LBV, thus simulating the actual intraoperative endoscopic views. All tributaries divided during surgery were identified preoperatively with MDCT.
Conclusions: Location of thymic veins with MDCT can provide precise preoperative information about thymic venous anatomy. This easy and less invasive examination has the potential to make VATS thymectomy easier and safer.

Key words: Multidetector-row CT — Myasthenia gravis — Thymic vein — Video-assisted thoracoscopic thymectomy

Thymectomy is proposed as an important therapeutic option for patients with autoimmune myasthenia gravis [1, 2, 6]. The trend toward less invasive surgery has recently prompted the application of endoscopic procedures also for thymectomy [5, 7].

Appropriate handling of thymic veins is a key to successful thymectomy. However, anatomic variations can cause difficulties, particularly when the thymus is embedded in copious adipose tissue. The left brachiocephalic vein (LBV), into which the thymic veins drain, has massive blood flow and is very fragile. Therefore, injury to these vessels is one of the main causes of conversion from endoscopic to open thymectomy [4, 9]. Obviously, this vitiates the goals of video-assisted thoracoscopic surgery (VATS), as we initially found in one myasthenic woman with bleeding at the confluence of a thymic vein with the LBV. Blood loss reached 1,000 ml, and we had to make both median and trocar incisions to prevent collapse. We therefore investigated the potential of multidetector-row computed tomography (MDCT) scanning to help locate the thymic veins and their LBV entry points preoperatively and thus prevent injury to them. We now report our initial results.

Patients and methods

In our hospital, all myasthenia gravis patients selected for therapeutic thymectomy routinely undergo preoperative enhanced CT scanning to

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Correspondence to: H. Shiono

Table 1. The patients who underwent multidetector-row computed tomography (MDCT) preoperatively[a]

					No. of thymic veins	
Patient no.	Age/Sex	Disease	Operation time (min)	Blood loss (g)	Preoperative MDCT	Operative findings[b]
1	26/M	MG	255	80	3	3
2	68/F	MG	172	80	2	2
3	40/F	MG	225	50	3	3
4	51/F	MG with thymoma	215	40	3	3
5	60/F	Thymoma	190	60	2	2

MG, myasthenia gravis
[a] All patients underwent extended thymectomy by bilateral video-assisted thoracoscopic surgery (VATS)
[b] The number of thymic veins clipped and divided during thymectomy

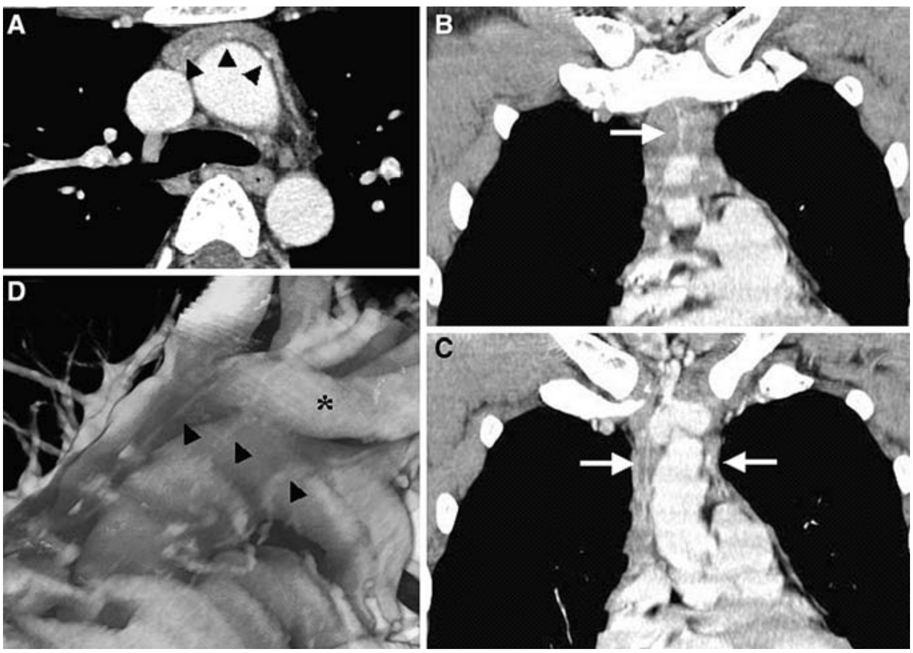

Fig. 1. Eight-channel multidetector-row computed tomography (MDCT) images obtained from patient 1 (Table 1). **A** Horizontal two-dimensional image showing three thymic veins in the thymus grand (black arrowheads). **B, C** These veins also are identified in coronal images (white arrows): C is dorsal to B. **D** Reconstructed three-dimensional image clearly demonstrating how thymic veins (black arrowheads) are draining into the left brachiocephalic vein (*).

exclude a tumor. We studied five consecutive patients with myasthenia gravis between May 2003 and February 2004 with their written informed consent (Table 1).

We obtained 8-channel MDCT images from these patients. The MDCT was performed on a scanner (GE Light Speed Ultra; GE Yokogawa Medical Systems, Tokyo, Japan) using a slice thickness of 1.25 mm reconstructed at 0.63-mm intervals with contrast material injection by a mechanical injector at a rate of 2 ml/s, for a total dose of 90 ml. Thymic veins draining into the LBV were visualized using both horizontal and sagittal/coronal CT images. Then three-dimensional (3D) images were reconstructed and meticulously rotated on the display so that operators could simulate operative views.

We performed VATS extended thymectomy for myasthenia gravis patients using our recently developed anterior chest wall–lifting method [8] with the cervical incision (T-2b in the Myasthenia Gravis Foundation of America (MGFA) thymectomy classification) [3]. The thymic/fat tissue was dissected with an ultrasonically activated device by bilateral VATS. While exposing LBV, with MDCT images in mind, we carefully located and divided any thymic veins with endoscopic clips and scissors. Their actual numbers and branching patterns were compared with the preoperative MDCT images in each case.

Results

In all five patients examined, the thymic veins draining into LBV were clearly identified with MDCT. For example, we preoperatively located three thymic veins in patient 1 (Fig. 1). Although his thymus was embedded in much fat tissue, all three branches were easily found and divided safely with the help of reconstructed 3D CT images (Fig. 1D). Also in patient 2, 3D CT images from preoperative MDCT were able to simulate operative views through the endoscope (Fig. 2). In this patient, we preoperatively identified two thymic veins, which were appropriately divided with right-sided VATS. In patient 4, preoperative examination had shown veins that unusually drained upward from the cranial pole of the thymus into the superior aspect of the LBV (Fig. 3A and B). Although a 4-cm thymoma obstructed endoscopic visualization, three thymic veins were safely divided (Fig. 3C).

Five VATS extended thymectomies were completed without substantial bleeding. The numbers of thymic veins identified preoperatively with MDCT were identical to those found at surgery (Table 1).

Discussion

Recently, VATS has been successfully applied for thymectomy, with the major advantages of better

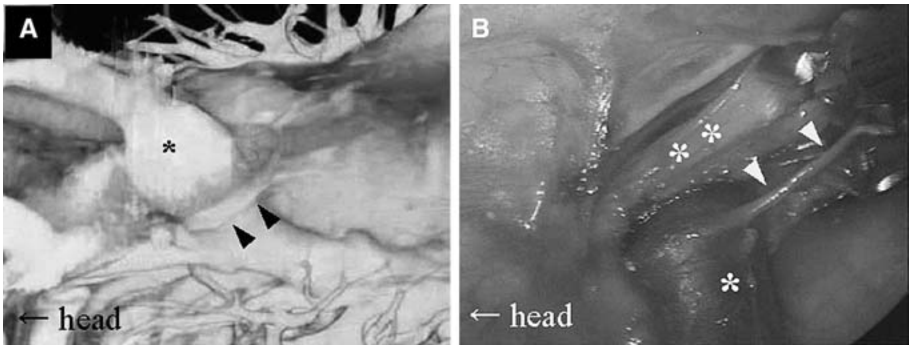

Fig. 2. The multidetector-row computed tomography (MDCT) image and the intraoperative view obtained from patient 2 (Table). **A** Three-dimensional images were rotated to simulate the view from the right pleural cavity and show the right lateral vein (*black arrowheads*) in a position identical to that found during video-assisted thoracoscopic surgery (VATS) (**B**), enabling us to divide it safely from the right pleural cavity (*yellow arrowheads*). *Left brachiocephalic vein. **The thymus.

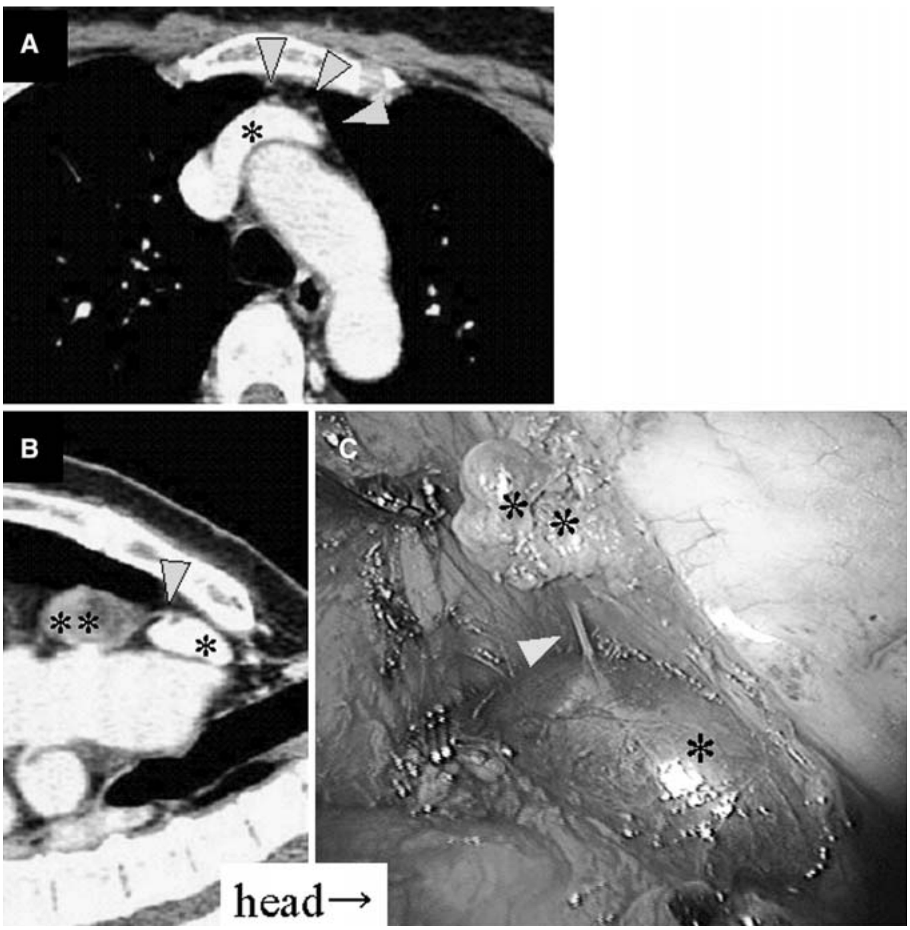

Fig. 3. Multidetector-row computed tomography (MDCT) images and the intraoperative view obtained from patient 4 (Table). **A** Horizontal image showing three thymic veins. **B** One of the tributaries unusually runs upward into the superior side of the brachiocephalic vein (*yellow arrowhead*). **C** The corresponding thymic vein was safely divided by left-sided video-assisted thoracoscopic surgery. *The left brachiocephalic vein. **The thymus.

visualization and minimal invasiveness. In this report, we show that preoperative MDCT visualization of venous anatomy is easy and not invasive, and can make VATS thymectomy safer by preventing unexpected bleeding.

The venous drainage of the thymus usually is through two or three thymic veins that run about 2 to 3 cm, usually into the LBV. However, there are anatomic variations. The right lateral thymic vein sometimes drains directly into the superior vena cava, whereas some veins may anastomose with the thyroid venous drainage [13].

Surgeons must always remember this variability during dissection. At open surgery, the thymus can readily be mobilized, and its veins divided or sutured if injured. By contrast, at endoscopic surgery, there is a higher risk of puncturing these veins in the smaller working space. This can cause severe bleeding, which may demand conversion to open sternotomy, as in one of our previous cases.

Our current results show that improved MDCT adds an enhanced safety to the established advantages of endoscopic thymectomy. Preoperative MDCT enabled us to locate all the thymic veins we needed to divide, and to define their course through the thymic/fat tissue. Particularly when the patient is obese, MDCT images make it much easier to find these veins. Moreover, the anatomic information on the cranial side of the LBV is helpful because visualization there is poor with both the VATS and infrasternal approaches. Although our series is small, and we are still trying to make the MDCT imaging even more sensitive, we have not encountered unexpected injury or massive bleeding since we started to apply this novel method of locating thymic veins during routine preoperative assessment at our institution.

Recent advances in CT technology have made MDCT easier and quicker, and reconstructed images have helped us to decide the operative approach [11] and to avoid intraoperative injury of vessels [12]. If enhanced CT scanning is already used routinely to exclude tumors, MDCT entails no additional time or cost, while considerably enhancing safety.

Current workstations are useful for assessing MDCT data not only in transverse sections, but also volumetrically. We can obtain favorable 3D images in any direction needed by the operating crews. These images can be seen any time before or even during surgery as a navigation system. Furthermore, such venous orientation techniques can be used also in robot-assisted surgery, as shown by their recent application to mediastinal lesions [10].

One further advantage of MDCT examination is that it should provide useful educational illustrations of thoracic venous anatomy for medical students. Surgical residents also could exploit this information in both conventional open operations and endoscopic surgery.

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