Evaluation of the Risk of Intercostal Artery Laceration During Thoracentesis in Elderly Patients by Using 3D-CT Angiography

Hiroshi Yoneyama, Masahisa Arahata, Rie Temaru, Shinji Ishizaka and Shinji Minami

Abstract

Objective  Our study was undertaken to determine the location of the tortuous intercostal artery in elderly patients by using 3D-CT angiography in order to prevent laceration during thoracentesis.

Methods  We evaluated the data of 3D-CT angiography of the intercostal artery in consecutive patients who had undergone contrast chest CT scan in our hospital from December 2007 to April 2008. We considered the “percent safe space” (the shortest lower rib-to-intercostal artery distance/the upper rib-to-lower rib distance) to be an index of safety that can be used to prevent laceration of the intercostal artery during thoracentesis. We measured this index at 3 points: the total site (5-10 cm lateral to the spine), the lateral site (9-10 cm lateral to the spine), and the medial site (5-6 cm lateral to the spine).

Results  We evaluated 33 cases (25 males and 8 females; mean age, 74.2 years). The mean percent safe space at the total site was 58.6%. The percent safe space at the total site tended to decrease with advancing age, but the correlation was low (p=0.0378, r=-0.3631). The percent safe space at the lateral site (mean, 79.8%) was significantly higher than that at the medial site (mean, 79.8%) was significantly higher than that at the medial site (61.2%, p<0.0001).

Conclusion  We showed that the intercostal artery is tortuous and does not always lie along the inferior edge of the rib and that the percent safe space at the lateral site is significantly higher than that at the medial site in elderly patients.

Key words: intercostal artery, elderly, thoracentesis, hemothorax, 3D-CT angiography

Introduction

Thoracentesis is a well-established diagnostic procedure for patients with pleural effusion. Major complications of thoracentesis include pneumothorax, hemothorax, intra-abdominal organ injury, and post-expansion pulmonary edema (1, 2). Of these complications, hemothorax is a rare but serious complication, which is thought to be due to intercostal artery laceration during the insertion of the needle. Intercostal vessels and nerves are thought to lie at the inferior edge of the rib; thus, the needle must advance along the superior surface of the rib.

Using aortography, Carney and Ravin observed that the intercostal artery becomes increasingly tortuous with age, and the amount of space available for safe insertion of the needle during thoracentesis decreases (3). However, the study population was between the ages of 10 and 70 years, and the number of patients over the age of 70 was very small.

The development of multi-detector row computed tomography (MDCT) and the workstation enables the use of high-resolution three-dimensional (3D) computed tomography (CT) angiography. Our hospital is located in Nanto City, which is in the western region of Toyama Prefecture in Japan; the proportion of aged people in this city is high. We started performing 64-row CT scan in our hospital in March 2007.

Thus, we studied the amount of space available for the safe insertion of the thoracentesis needle using 3D-CT angiography.
ography in elderly patients who underwent contrast chest CT scan in our hospital.

**Methods**

**Patients and 3D-CT data**

We reviewed the cases of consecutive patients who had undergone contrast chest CT scan in our hospital from December 2007 to April 2008. We used a 64-row CT scanner (Aquilion 64; Toshiba, Tokyo, Japan). All CT scans were performed using our standard protocol. Contrast material containing 450 mg/kg of iodine was administered intravenously either via drip infusion (approximately 10 minutes) or as a bolus injection (30 s).

From the scan data, we obtained intercostal artery images in the coronal view by using the workstation system (ZIOSTATION System 610; AMIN, Tokyo, Japan). The 3D-CT angiography data were included in our study if they demonstrated the intercostal arteries related to the eighth or ninth rib within the area 5 to 10 cm lateral to the spine. We primarily selected intercostal artery images involving the right ninth rib; if this criterion was not fulfilled, we selected images involving the right eighth, left ninth, or left eighth rib, in that order of priority.

**Measurement methods**

We measured the indexes by using the method described by Carney and Ravin (3), described below (Fig. 1). The rib-to-intercostal artery distance was measured from the superior surface of the lower rib to the inferior border of the intercostal artery at the point where this distance was shortest. This represents the safe space into which the needle may be inserted during thoracentesis without a risk of intercostal artery laceration. The rib-to-rib distance was measured from the superior border of the lower rib to the inferior border of the upper rib. The percent safe space was defined using the rib-to-rib distance as the denominator and the rib-to-intercostal artery distance as the numerator.

These indexes were measured at 3 points: at a point lying between 5 and 10 cm from the spine (total site), at a point lying between 5 and 6 cm from the spine (medial site), and at a point lying between 9 and 10 cm from the spine (lateral site).

**Patient data**

We obtained the patient data (age, sex, purpose of CT scan, and history of medication) from the hospital records.

**Data analyses**

We performed statistical analysis using the Prism software program version 5.0 (GraphPad, San Diego, CA, USA). The correlation between the age and the percent safe space at the total site was analyzed by using Pearson’s correlation coefficient. The percent safe space at the medial site and that at the lateral site were compared by using a paired t test. A p value of <0.05 was considered significant.

**Results**

A total of 72 contrast chest CT scans were performed in our hospital from December 2007 to April 2008. Of these 72 cases, 40 cases fulfilled our criteria, and 7 patients underwent contrast CT scan twice during this period. Thus, we evaluated 33 cases in all.

Table 1 lists the patient characteristics and results. The study included 25 men and 8 women of a mean age of 74.2 years (range, 55-94 years). The purpose of performing the CT scan was mainly the evaluation of malignancy (lung cancer, lymphoma, etc.) or vascular disease (thoracic aorta aneurysm, lung infarction, etc.). In 22 cases the scans were obtained at the right ninth intercostal artery; in 6 cases, at the right eighth intercostal artery; in 4 cases, at the left eighth intercostal artery; and in 1 case, at the left eighth intercostal artery. The mean percent safe space at the total site was 58.6% (range, 37.2-86.4%). Figure 2 shows the correlation between the age and the percent safe space at the total site. The percent safe space tended to decrease with advancing age, but the correlation was low (p=0.0378, R=-0.3631).

The mean percent safe space at the lateral site was 79.8%, which was significantly higher than the mean percent safe space at the medial site (61.2%; p<0.0001; Fig. 3).

**Discussion**

Hemothorax is a rare complication of thoracentesis. However, once it occurs, it requires appropriate surgical management and drainage via a thoracostomy tube. The intercostal artery is thought to lie along the inferior edge of the rib; thus, the needle must be advanced along the superior surface
of the rib. Carney and Ravin reported that the intercostal arteries become increasingly tortuous with age, and the amount of space available for the safe insertion of the needle during thoracentesis (the percent safe space) tends to decrease with increasing age (3).

We analyzed 33 cases (mean age, 74.2 years) and found that the average percent safe space at the total site (the shortest distance between the intercostal artery and the lower rib/the upper rib-to-lower rib distance within 5 to 10 cm lateral to the spine) was 58.6% and that the intercostal arteries did not always lie along the inferior edge of the rib in elderly patients.

Coarctation of the aorta may result in highly tortuous intercostal arteries, which provide collateral blood flow that circumvents the stenotic aortic segment. In the present study, we did not observe such findings on the contrast CT scans. In our study, we found that the percent safe space tended to decrease with advancing age, but the correlation was low (R=-0.3631). The age of our study population was mainly over 60 years, while that in the study by Carney and Ravin ranged between 10 and 70 years. We speculate that the tortuosity of the intercostal arteries in elderly patients involves many factors other than age (blood pressure level, cholesterol level, presence of diabetes, etc.).

In thoracentesis, regarding the needle insertion lateral to the spine, the distance is yet unclarified, and different descriptions are given in different textbooks. In “Videos in Clinical Medicine” of (N Engl J Med), Thomsen et al recommend that the needle be inserted 5-10 cm lateral to the spine (2). Moreover, in the textbook “Atlas of Bedside Proce­dures” (2nd edition), the authors recommend that the needle be inserted at the posterior axillary line (4). In the present study, we showed that the lateral site (9-10 cm lateral to the spine), rather than the medial site (4-5 cm lateral to the spine), provided more space for safe insertion of the thoracentesis needle in elderly patients. Thus, we recommend lateral site insertion in order to prevent intercostal artery laceration in elderly patients. In practice, we frequently use superficial landmarks as reference points while performing thoracentesis, and we must consider the differences in the body size of the patients. Therefore, it is reasonable to perform thoracentesis with the patient in the seated position on the posterior axillary line, which is the most suitable lateral site.

In 1 case, we observed highly tortuous intercostal arteries throughout the medial and lateral sites (Fig. 4). Therefore, we must also keep in mind that lateral site insertion does not necessarily prevent hemothorax. Careful follow-up after thoracentesis is important; reversal agents may be considered in patients with severe coagulopathy, and platelet transfusion may be considered before thoracentesis in elderly patients with clinically significant thrombocytopenia.

In the present study, we mainly evaluated the intercostal arteries related to the ninth rib, however we typically insert the needle beyond the ninth rib during thoracentesis in order

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Table 1. Basic Characteristics and Results

<table>
<thead>
<tr>
<th></th>
<th>Total (n)</th>
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<tbody>
<tr>
<td>male (n)</td>
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<td></td>
</tr>
<tr>
<td>female (n)</td>
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<td></td>
</tr>
<tr>
<td>age (years)</td>
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<tr>
<th>Contrast methods</th>
<th>bolus injection (n)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>drip infusion</td>
<td>25</td>
<td></td>
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| Measurement site | right 9th intercostal artery (n) | 22 |
|                 | right 8th intercostal artery      | 6  |
|                 | left 9th intercostal artery       | 4  |
|                 | left 8th intercostal artery       | 1  |

| Percent safe space | total site (%) | 58.6±11.9 |
|                   | medial site (%)| 61.2±11.1 |
|                   | lateral site (%)| 79.8±10.7 |

Age and percent safe space represent as mean ± standard deviation.

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Figure 2. Figure 2 shows the correlation between the percent safe space and age. A generalized decrease in the percentage of the safe space with advancing age was observed at the total site, but the correlation was low (p=0.0378, R=-0.3631).

Figure 3. Figure 3 shows the comparison between the percent safe space at the lateral site and that at the medial site. The mean percent safe space at the lateral site was 79.8%, and it was significantly higher than that at the medial site (61.2%; p<0.0001).
to prevent intra-abdominal organ injury (3). In practice, we occasionally insert the needle below the ninth rib under echographic-guidance. In our study, the tortuosity of intercostal arteries related to the eighth rib and of those related to the ninth rib was similar; moreover, we think that the tortuosity of the intercostal arteries of the other ribs does not differ largely from that of the intercostal arteries related to the ninth rib.

In practice, we may perform thoracentesis on the patient in the supine position at the midaxillary line, the anterior axillary line, or the midclavicular line. Therefore, in order to prevent laceration, we must know the location of the intercostal arteries and internal mammary arteries at these sites. We think that this is an important topic for future study.

In conclusion, we showed that the intercostal artery is tortuous and does not always lie along the inferior edge of the rib and that the percent safe space at the lateral site is significantly higher than that at the medial site in elderly patients.

References


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