Original Article

Distribution of descending necrotizing mediastinitis and efficacy of distribution-specific drainage

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Background: Descending necrotizing mediastinitis (DNM) resulting from oropharyngeal and cervical abscess is a life-threatening condition. This study attempted to improve our recognition of the extension and distribution of the abscess for ideal thoracic drainage.

Methods: We performed a retrospective clinical analysis of seven patients who underwent thoracic drainage for DNM with available clinical data. For mapping and classification of the distribution of the abscess, computed tomography and intraoperative findings were utilized.

Results: To cure patients, cervical drainage and thoracic drainage were performed 14 and 11 times, respectively. The operation time for thoracic drainage and intraoperative blood loss were 141±77 min and 103±103 g, respectively. The mean hospital stay was 66±41 days. All patients are alive without recurrence. We divided the abscess distribution into nine categories including the anterior thoracic wall, according to the computed tomography and intraoperative findings. The rate of abscess descended gradually toward the lower mediastinum. Abscesses were not necessarily continuous, and skipped lesions were occasionally noted.

Conclusions: We were able to cure all seven patients with DNM. It might be helpful to recognize the exact distribution of the abscess and distribution-specific drainage using a new map and classification of thoracic abscess.

Keywords: Descending necrotizing mediastinitis (DNM); mediastinum; drainage

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Introduction

Descending necrotizing mediastinitis (DNM) resulting from oropharyngeal and cervical abscess is a life-threatening condition. The historical mortality rate of DNM has been reported to range from 23–51% (1-4). As surgical management without delay has been understood well as a key to cure the patients, the mortality rate has been decreased (11–17.5%) (5-7). However, because of the low incidence of DNM, details concerning the extension and distribution of the abscess to the mediastinum and appropriate drainage sites remain unclear.

Video-assisted thoracoscopic drainage has been recently applied for DNM, and its efficacy has been reported (8-11). Understanding the extension and distribution of thoracic abscesses may make distribution-specific thoracoscopic drainage possible.

We herein report our retrospective analysis of patients who underwent video-assisted thoracoscopic drainage for DNM. The purpose of this study was to evaluate the efficacy of distribution-specific thoracoscopic drainage. In addition, we suggest a new concept of mapping and

Table 1 The clinical data of 7 patients

Characteristics	Values
Patients	7
Age (mean ± SD)	62±16 years (40–91 years)
Gender: male/female	5/2
Underlying disease: –/+	1/6
Diabetes mellitus	2
Hypertension	2
Alcoholic liver dysfunction	1
Hemodialysis for renal failure	1
Hyperlipemia	1
Atrial fibrillation and brain infarction	1
Traumatic brain contusion and higher-order dysfunction	1
Cardiac infarction (with overlapping)	1
WBC max (mean ± SD)	13,200±1,500/μL
CRP max (mean ± SD)	25.7±13.1 mg/dL
DNM classification	
Type I	2
Type IIA	1
Type IIB	2
Unclassified type	2
Tracheostomy	7
Cervical drainage	7
1 time	1
2 times	5
3 times	1
Thoracic drainage	7
1 time	4
2 times	2
3 times	1
VATS	
Thoracotomy	2
Incisional drainage	1
Duration of thoracic surgical operation (mean ± SD)	141±77 min (42–222 min)
Intraoperative blood loss of thoracic drainage (mean ± SD)	103±103 g (1–304 g) (including pleural effusion)
ICU stay (mean ± SD)	15.8±7.3 days (8–25 days)
Duration of mechanical respiratory assistance (mean ± SD)	12.5±7.9 days (4–24 days)
Hospital stay (mean ± SD)	66±41 days (32–147 days)
Recurrence following discharge: +/–	0/7
Prognosis: dead/alive	0/7
Observation period (mean ± SD)	747±866 days (69–2,267 days)

Table 1 (*continued*)

VATS, video-assisted thoracic surgery; SD, standard deviation; ICU, intensive care unit.

classification of the thoracic abscess distribution of DNM and distribution-specific thoracoscopic drainage.

Methods

A retrospective review was conducted for seven patients who underwent thoracic drainage by thoracotomy or video-assisted thoracic surgery (VATS) for DNM at Aichi Medical University Hospital between November 2011 and March 2019. Clinical data were analyzed in the present study. The DNM diagnosis was made on the basis of criteria defined by Estrera *et al.* (12) in 1983. The detailed extension and distribution of the thoracic abscess was evaluated by computed tomography (CT), and DNM was classified according to Endo's criteria as either type I (focal) mediastinitis (infection located in the superior mediastinal space, above tracheal bifurcation) or type II (diffuse) mediastinitis; type II mediastinitis was in turn subdivided into two subtypes of IIA (infection still located in the anterior inferior mediastinal space) and IIB (infection has reached the posterior inferior mediastinum) (13).

This study was approved by the Institutional Review Board of Aichi Medical University Hospital. The analyzed values are presented as the mean ± standard deviation.

Results

The clinical data of all seven patients are listed in *Table 1*.

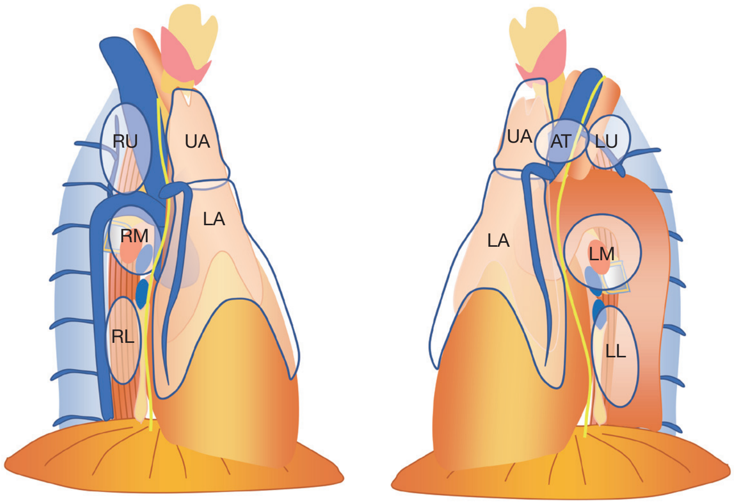

Figure 1 Proposed map of the thoracic abscess distribution. The upper portion of the anterior compartment (UA), lower portion of the anterior compartment (LA): right upper portion of the middle compartment (RU), left upper portion of the middle compartment (LU), right middle portion of the middle compartment (RM), right lower portion of the middle compartment (RL), left upper portion of the middle compartment (LM), right lower portion of the middle compartment (LL) and anterior thoracic wall (AT).

There were 5 men and 2 women with a median age of 61 years old (range, 40 to 91 years old). In 6 patients, underlying diseases that might influence the onset of DNM were present: diabetes mellitus (n=2), hypertension (n=2), alcoholic liver dysfunction (n=1), hemodialysis for renal failure (n=1), hyperlipemia (n=1), atrial fibrillation and brain infarction (n=1), traumatic brain contusion and higher-order dysfunction, (n=1), cardiac infarction (n=1) (with overlapping). The mean white blood cell (WBC) counts and C-reactive protein (CRP) immediately before drainage were 13,200±1,500/μL and 25.7±13.1 mg/dL, respectively. The DNM classification according to Endo's criteria was type I (n=2), type IIA (n=1), type IIB (n=2) and unclassified type (n=2).

Cervical and thoracic drainage and tracheostomy were performed in all seven patients. Cervical drainage was performed 14 times for cervical abscesses, and thoracic drainage was performed 11 times for thoracic abscesses. Regarding thoracic drainage, thoracoscopic drainage was performed eight times, and thoracotomy was performed twice. Repeated drainages in three patients were performed because mediastinal abscess still existed after the previous operation or appeared newly in the different portions. In addition, incisional thoracic drainage for anterior thoracic abscesses was performed in one patient. Both cervical and thoracic drainage were needed a maximum of three times in one case. The operation time for thoracic drainage and intraoperative blood loss were 141±77 min (42–222 min) and 103±103 g (1–304 g), respectively.

Although there were no mortal cases or severe complications following drainage, surgical hemostasis was performed for postoperative bleeding in one patient. The mean hospital stay was 66±41 days. Laboratory data on inflammation parameters were almost normal by discharge (WBCs: 4,600±1,680/μL, CRP: 0.46±0.38 mg/dL). The mean observation period was 747±866 days. All patients are alive without recurrence.

Proposal of classification and map of thoracic abscess distribution

Thoracic abscesses of DNM are typically classified according to Endo's criteria (13). However, in the present study, two patients had an unclassified type. Therefore, we propose a new classification and mapping system for thoracic abscess distribution referred to the International Thymic Malignancy Interest Group (ITMIG) mediastinal compartment (14). We have outlined nine categories of distribution based on the differences in incision sites for drainage, including the anterior thoracic wall, as shown in *Figures 1,2*, based on the CT and intraoperative findings:

(I) Upper portion of the anterior compartment (UA): the cervical abscess extends to the anterior mediastinum along the sternum. Abscesses of the

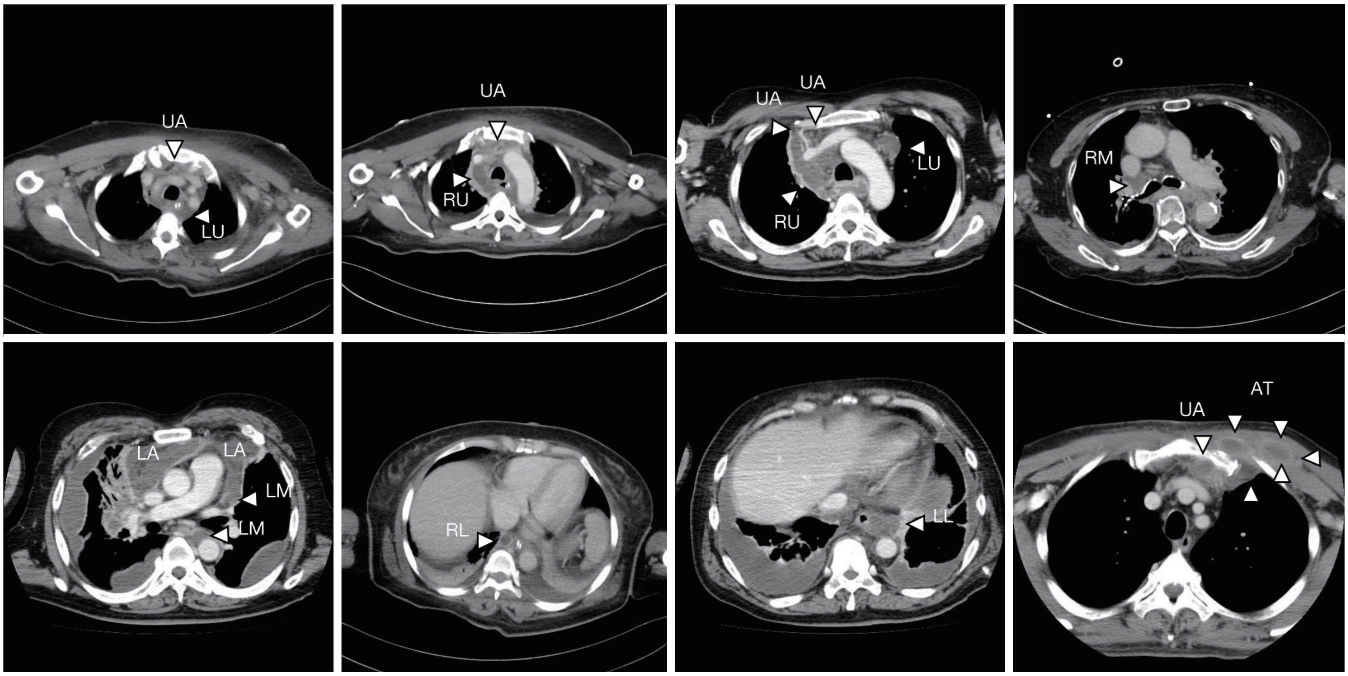

Figure 2 Chest CT findings for each category of thoracic abscess distribution. Upper portion of the anterior compartment (UA), lower portion of the anterior compartment (LA): right upper portion of the middle compartment (RU), left upper portion of the middle compartment (LU), right middle portion of the middle compartment (RM), right lower portion of the middle compartment (RL), left upper portion of the middle compartment (LM), right lower portion of the middle compartment (LL) and anterior thoracic wall (AT).

UA are usually drained via the cervical approach. However, residual abscesses can be drained by VATS. The internal thoracic vein is a milestone for UA abscesses, and the proximal pleura of the internal thoracic vein should be opened for drainage;

(II) Lower portion of the anterior compartment (LA): abscesses of the UA often extend to the lower portion of the anterior mediastinum. The distal pleura of the internal thoracic vein along the sternum and/or the phrenic nerve should be opened for drainage (*Figure 3A,B*);

(III) Right upper portion of the middle compartment (RU): when cervical abscesses extend to the mediastinum, they do not always pass in front of the thymus. When they extend behind or on the lateral sides of the thymus, the abscesses appear in the right upper portion of the middle mediastinum. For thoracic drainage of RU abscesses, the azygos vein is a milestone, and the proximal pleura of the azygos vein along the right vagus nerve and/or the right brachiocephalic vein should be opened for drainage (*Figure 3C,D*);

(IV) Right middle portion of the middle compartment (RM): RU abscesses sometimes extend to more distal areas around the right hilum. For drainage of RM abscess, the pleura around the right hilum should be opened;

(V) Right lower portion of the middle compartment (RL): RM abscesses sometimes extend to more distal areas beyond the right hilum along the esophagus. The pleura around the inferior pulmonary vein or pulmonary ligament along the esophagus should be opened for drainage;

(VI) Left upper portion of the middle compartment (LU): for drainage of LU abscesses, the aortic arch and the subclavian artery are milestones, and the distal pleura of the aortic arch along the subclavian artery should be opened for drainage;

(VII) Left middle portion of the middle compartment (LM): LU abscesses may extend to the more distal mediastinum around the left hilum. They may extend from LA abscesses. For drainage of LM abscesses, the pleura around the left hilum should

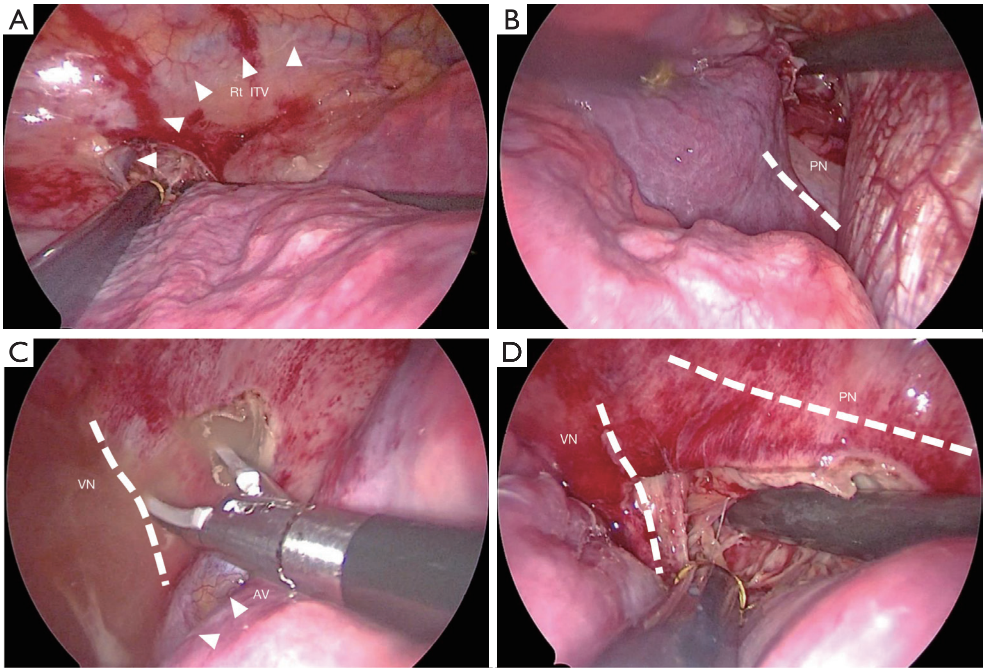

Figure 3 Intraoperative findings during mediastinal drainage and debridement. The abscess located at the lower portion of the anterior compartment (LA) was drained (A,B). The RU lesion was approached from the mediastinal pleura, which was partitioned by the right internal thoracic vein (Rt ITV) and phrenic nerve (PN). The abscess located at the right upper portion of the middle compartment (RU) was drained (C,D). The RU lesion was approached from the visceral pleura, which was partitioned by the vagus nerve (VN), azygos vein (AV) and PN.

be opened;

(VIII) Light lower portion of the middle compartment (LL): LM abscesses may extend to more distal areas beyond the left hilum. The pleura around the inferior pulmonary vein or pulmonary ligament along the esophagus should be opened for drainage;

(IX) Anterior thoracic wall (AT): we experienced extension of UA abscesses to the anterior thoracic wall. For percutaneous drainage of such abscesses, the skin should be incised just above the abscess.

The frequency of the abscess distribution for each category is shown in *Table 2*. The frequency of abscesses accompanying DNM gradually descends from the neck toward the lower mediastinum. However, abscesses are not necessarily continuous, and skipped lesions are occasionally noted.

Discussion

We investigated the patients with DNM who underwent surgical drainage for thoracic abscess and suggest a new mapping and classification system for the thoracic abscess distribution and distribution-specific drainage. As oropharyngeal and/or cervical abscess usually precedes DNM, we collaborate with head and neck surgeons. As the historical mortality rate of DNM has been high (1-4), DNM is well known to be a life-threatening condition. Prompt surgical management is understood to be the key to curing patients, and the mortality rate has been decreased with this approach (5,6,15). However, because of the low incidence of DNM, the details concerning the extension and distribution of abscesses to the mediastinum and appropriate approaches for drainage remain unclear.

Open thoracotomy and extensive mediastinal pleural incision with extensive debridement have been performed as the principal treatment and selected to achieve a cure in patients with DNM. While the efficacy has been suitably demonstrated, bilateral open thoracotomy might be more invasive for DMN patients than VATS drainage. VATS drainage has recently been applied for DNM, and its efficacy has been reported (8-11). To rescue critical patients, this minimally invasive drainage may be an ideal approach. As DNM lesions do not necessarily spread and extend

Table 2 Classification of the mediastinal portion and frequency of abscess distribution of each portion in seven patients

Portion of mediastinum and abscess distribution	Patient No.	Rate of distribution (%)
Upper portion of anterior compartment (UA)	1, 2, 3, 4, 7	5/7 (71.4)
Lower portion of anterior compartment (LA)	4, 7	2/7 (28.6)
Right upper portion of middle compartment (RU)	1, 5, 6, 7	4/7 (57.1)
Right middle portion of middle compartment (RM)	2, 5	2/7 (28.6)
Right lower portion of middle compartment (RL)	1, 7	2/7 (28.6)
Left upper portion of middle compartment (LU)	1, 5, 7	3/7 (42.9)
Left middle portion of middle compartment (LM)	5	1/7 (14.3)
Light lower portion of middle compartment (LL)	1	1/7 (14.3)
Anterior thoracic wall	3	1/7 (14.3)
DNM classification		
Type I	6, 7	2/7 (28.6)
Type IIA	4	1/7 (14.3)
Type IIB	1, 5	2/7 (28.6)
Unclassified type	2, 3	2/7 (28.6)

throughout the mediastinum, distribution-specific drainage with VATS techniques may be useful. We were able to cure all of the patients who underwent VATS drainage in the present study. This minimally invasive drainage can be repeated if necessary. Three of the seven cases in the present study underwent repeated VATS drainage to cure their DNM completely because mediastinal abscess still existed after the previous operation or appeared newly in the different portions. While the detailed data were not shown, the operation time for drainage after the first attempt was reduced on subsequent drainage attempts. It is important to know the exact location of the abscess in order to perform appropriate drainage. We therefore suggest a new mapping and classification system for the thoracic abscess distribution using CT findings and distribution-specific drainage.

Regarding the distribution of DNM, Endo *et al.* classified DNM into types I and II (13). Type II mediastinitis was further subdivided into two subtypes (IIA and IIB). However, we experienced cases that were difficult to classify based on these conventional categories. In our experience, the distribution of the abscess was not continuous, with isolated lesions sometimes scattered about. Drainage of all lesions is necessary to achieve complete treatment. We therefore suggested a map of mediastinal abscesses of DNM that was divided into nine categories. The location of the mediastinal pleural incision or skin incision was different in none categories as stated above.

We have referred ITMIG definition of the mediastinal compartment for mapping of the distribution of the mediastinal abscess. The ITMIG classification includes three compartments, the prevascular (anterior), visceral (middle), and paravertebral (posterior) compartments. It does not adapt superior mediastinal compartment (or mediastinum). The DNM descends from oropharyngeal and cervical abscess and it can extend to any directions (15). The mediastinal incision sites for drainage varies depending on the direction of the extension even in the superior compartment. While the mediastinum is a continuum, we recognize anatomical barriers to complete the mediastinal drainage. Typical barriers include the azygos vein, internal thoracic veins and phrenic nerves. We attempt to preserve these structures whenever possible. Both the azygos vein and internal thoracic vein can be sacrificed, but the stump may be ruptured by subsequent infection. The azygos vein is the boundary landmark of RU and RM, while the internal thoracic veins are the boundary landmark of UA and LA. The phrenic nerves and bilateral brachiocephalic veins are also boundary landmarks. We did not include the "paravertebral compartment (posterior mediastinum)" in our map of thoracic abscess distribution as we have not observed any abscesses of the paravertebral compartment. The paravertebral compartment has been defined as the area of the thoracic spine and the posterior area of the descending aorta (14). It was defined as the paravertebral compartment which was bounded by 1cm posterior to the anterior margin of the thoracic vertebral body (16). We have not observed any abscesses of the paravertebral component because it seems to be difficult for the abscess to descend to the area anatomically.

While the results of this study are encouraging, any conclusions should be tempered by the major limitation of the small number of patients. However, we can propose the categorization of distribution of DNM and distribution-specific drainage. Distribution-specific drainage is possible under the detail recognition of distribution of DNM. I hope that this proposal can be accepted widely and a new study of DNM patients will be planned.

Conclusions

We were able to cure all seven cases with DNM. Successful management may depend on rapid treatment being performed in collaboration with head and neck surgeons and appropriate thoracic drainage. For appropriate thoracic drainage, recognizing the exact distribution of the thoracic abscess is necessary, and our new mapping and classification approach with nine categories of thoracic abscess distribution may be helpful. In addition, repeated drainage may be needed to achieve a complete cure of DNM.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jtd.2020.03.82). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was approved by the Institutional Review Board of Aichi Medical University Hospital (No. 2019-208).

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