Review Article

Descending necrotizing mediastinitis: 5 years of published data in Japan

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Descending necrotizing mediastinitis implies infection originating from the neck, most commonly an oropharyngeal or odontogenic focus, that spreads in the cervical fascial spaces and descends into the mediastinum. Early diagnosis is essential because descending necrotizing mediastinitis can rapidly progress to septic shock and organ failure. A comprehensive review of the current data of descending necrotizing mediastinitis in Japan was carried out using PubMed and ICHUSHI from the last 5 years. The symptoms, origins, comorbid conditions, treatment modalities, complications, and survival rates were analyzed. Tonsillar and pharyngeal origin was more identified compared to odontogenic origin. More than one-third of patients were diabetic and 28% of them were not identified as having any comorbidity. Streptococcus sp. and anaerobes were most isolated, reflecting the microflora of the oral cavity. Of the broad antibiotics, carbapenem was the most used as treatment, and clindamycin was the most co-given. Mediastinal drainage approach varied widely and the optimal approach is controversial. Twenty-one patients were treated with video-assisted thoracic surgical drainage and 15 cases by percutaneous catheter drainage, whereas transcervical approach was applied in 25 patients and thoracotomy was carried out in 21 patients. The overall mortality was 5.6%. Many authors advocated that the most effective management tool is a high degree of clinical suspicion followed by prompt and adequate drainage with intensive care including hemodynamic and nutritional support and repeat computer tomographic monitoring.

Key words: Airway emergency, cervical necrotizing fasciitis, descending necrotizing mediastinitis, percutaneous catheter drainage, video-assisted thoracoscopic drainage

INTRODUCTION

CERVICAL NECROTIZING FASCIITIS (CNF) can spread from oropharyngeal or odontogenic origin to the deep fascial planes of the neck. This polymicrobial infection is uncommon but rapidly progressive, destructive, and often fatal. Prompt diagnosis and treatment including secure airway, antibiotics, drainage, and intensive sepsis care contribute to improved survival. Nevertheless, the progression to mediastinum (descending necrotizing fasciitis, DNM) leads to a poor prognosis. Cervical necrotizing fasciitis with DNM was first described in 1938 by Pearse,[1] who reported a 49% of mortality. The spread of the infection from the neck is attributed to negative intrathoracic pressure. Diagnostic criteria for DNM were proposed by Estrera *et al.*:[2] (i) clinical evidence of severe oropharyngeal infection; (ii) characteristic radiographic features of mediastinitis; (iii) documentation of necrotizing mediastinal infection during operation or autopsy; and (iv) establishment of the relationship between DNM and the oropharyngeal process. Despite the technologic advances in diagnosis and treatment, DNM with sepsis has been reported to have high mortality.[3] Recently, less invasive drainage methods for DNM, that is, video-assisted thoracic surgical drainage (VATS),[4] mediastinoscopy,[5] and percutaneous catheter drainage,[6,7] have been reported. Although it is certain that early infection source control and drainage is crucial for DNM treatment, there are no guidelines in regard to drainage methods. In this review, the clinical features and treatment of DNM in Japan were overviewed.

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REVIEW OF PUBLISHED DATA

A COMPREHENSIVE REVIEW of the current data regarding DNM in Japan was carried out using PubMed (www.ncbi.nlm.nih.gov/pubmed) and ICHUSHI (Japan Medical Abstracts Society; http://search.jamas.or.jp/) over 5 years (2008–2013). The search terms were "descending necrotizing mediastinitis" and "cervical necrotizing

fasciitis" with Japanese patients' reports. "Deep neck infection" or "neck abscess" were carefully evaluated and the DNM cases were identified and tabulated, as these terms have been broaden the inclusion criteria. Most cases consisted of a single case report, as the condition is not common. The symptom, origin, comorbid conditions, treatment modalities, complications, and survival rates were analyzed.

Eighty-nine DNM cases (age, 63 ± 14 years) comprising 60 men and 29 women were identified in published reports. The data in Table 1 include days to admission and intervention from the first symptom, morbidity, and source of infection. In Table 2, bacteria, antibiotics, and drainage methods are clarified. Some case series did not provide sufficient information to separate individual cases; however, the intent was to investigate the clinical features and current treatment of DNM in Japan. The data or information of each case that was not provided in the published work was expressed as "*NC*, not clarified" in the tables.

INCIDENCE

NECROTIZING FASCIITIS IS most common in extremities, perineum, and trunk. Less than 5% of cases involve the cervicofacial region.[45,46] Mediastinal extension (DNM) was reported to occur in 40–45% of CNF patients.[3] Many investigators blame the rarity of the condition for its late recognition and less aggressive initial treatment.

ORIGIN

ODONTOGENIC SOURCES, TONSILLAR and pharyngeal abscesses, sialadenitis, injury by a foreign body, or catheterization are common origins of DNM. The primary origin of DNM is unknown in some cases. In our review cases, tonsillar and pharyngeal origin ($n = 55$) was identified more often than odontogenic origin ($n = 18$) (Table 1).

CLINICAL PRESENTATION

INITIAL SIGNS AND symptoms are universally mild and non-specific. The clinical signs related to cervical localization are pain, dysphagia, anorexia, dyspnea, tachypnea, fever, odynophagia, hoarseness, erythema, anterior neck edema, and crepitus. The diagnosis of DNM can be difficult, owing to the vagueness of the symptoms.[47] Symptoms of mediastinal infection include chest discomfort, respiratory insufficiency, and any septic signs.[48]

MICROBIOLOGY

THE MICROBIOLOGIC FINDINGS are complex and polymicrobial with aerobes and anaerobes, reflecting the microflora of the oral cavity. The most common aerobic bacteria are Streptococcus spp. (*S. constellatus*, *S. intermedius*, *S. agalactiae*, *S. mitis*). The common anaerobic bacteria include Peptostreptococcus, *Bacteroides fragilis*, Prevotella, and Fusobacterium.[49] In our review, Streptococcus spp. were most often isolated (Table 2). There were no bacteria detected in 11 patients, probably because antibiotics were prescribed before their admission.

RISK FACTORS

MANY DNM PATIENTS are immunocompromised, with comorbidities such as diabetes mellitus, malnutrition, advanced age, renal failure, liver cirrhosis, and underlying malignancy. However, there are a certain number of DNM patients without any identified comorbidities. In our review, 30 patients (33.7%) were diabetic and 25 patients (28.1%) without any comorbidities identified. Descending necrotizing fasciitis predominantly affects males.[50] In our study, 67% of DNM patients were male.

The factors associated with mediastinal progression (DNM) in CNF patients have been studied. Age, comorbidity (diabetes), pharyngeal origin, oral intake of glucocorticoids before hospital admission, production of gas by infecting organism, and the number of spaces involved, especially the retropharyngeal space, are predicting factors for mediastinal spreading.[7,51,52]

PATHWAYS OF SPREAD OF INFECTIONS FROM NECK TO MEDIASTINUM

WITH THE ABSENCE of barriers in the fascial planes, the mediastinal expansion may be due to mechanical or chemical properties or both of the gas produced by the bacteria, or may directly indicate virulence of the causative bacteria.[51] Understanding of the pathway begins from the knowledge of the anatomy of fascial planes and cervical spaces (Fig. 1). There are three potential pathways to the mediastinum:[54] (i) the pretracheal route to the anterior mediastinum; (ii) the lateral pharyngeal route to the middle mediastinum; and (iii) the retropharyngeal route to the posterior mediastinum.

Submandibular space

This space extends from the floor of the mouth to fascial attachments at the hyoid bone. The infection in this space is

Table 1. Published cases of descending necrotizing mediastinitis in Japan 2008–2013: patients' characteristics

Principal investigator	Year	Cases, *n*	Time to admission, days	Time to intervention, days	Symptom	Morbidity	Source of infection
Kageyama M[8]	2013	1	3	11	ST, Dph	Others	PT
Takeno S[9]	2012	1	3	3	F, TP	None	OD
		1	10	10	NS	DM	OD
Kajiura K[10]	2012	1	5	5	F, NP	Others	PT
Takamune Y[11]	2012	1	4	9	NS, TS, Dph	DM	OD
Okamoto T[12]	2012	1	8	8	ST, Dph	Others	PT
Ishinaga H[13]	2012	9	*NC*	5.0	*NC*	DM 3 Others 3	PT 8 Fistula 1
Uemura T[14]	2011	1	7	7	F, ST	DM	PT
		1	*NC*	*NC*	*NC*	None	*NC*
		1	*NC*	*NC*	*NC*	RD	*NC*
		1	*NC*	*NC*	*NC*	DM	*NC*
Matsuhashi N[15]	2011	1	*NC*	*NC*	ST, TS	None	OD
Ueda D[16]	2011	1	4	10	ST, abdominal pain	None	OD
Oshima M[17]	2011	1	5	7	NS, tachycardia	Others	OD
Nakata Y[18]	2011	6	5.5 ± 4.3	9.0 ± 4.5	*NC*	None 5 Others 1	PT 5 Unknown 1
Nakamura K[19]	2011	1	7	7	Dpn, back pain	None	PT
Nakanishi T[20]	2011	1	4	4	Chest pain	Others	OD
Kodama M[21]	2011	1	5	5	ST	None	PT
Kawakami M[22]	2010	1	*NC*	9	*NC*	DM	*NC*
		1		8		Others	
		1		3		DM	
		1		3		DM	
		1		1		DM	
Oka S[23]	2010	1	2	*NC*	*NC*	None	PT
		1	2	2		None	PT
		1	8	8		None	PT
		1	14	14		Others	PT
		1	1	1		None	PT
Fujiwara T[24]	2010	1	7	8	Dsp, NS	DM	PT
Yamamoto M[25]	2010	1	8	8	F, NP, TS	Others	OD
Fujimaki M[26]	2010	1	3	3	F, ST, NS	None	Unknown
		1	3	4	ST, NS, Dpn	None	PT
Yamaguchi Y[27]	2010	1	2	6	F, NP, NS	Others	PT
Uno K[28]	2010	1	2	7	F, ST, NP	None	PT
Sakagami T[29]	2010	1	4	4	ST, Dpn	None	PT
Yamada K[30]	2010	1	*NC*	5	F	St, Others	Unknown
Momota K[31]	2009	1	5	6	NP, TS, Dph	DM,RD	OD
Sato K[32]	2009	1	3	5	NP, NS, Dph	DM	Unknown
		1	5	12	TP, NS	Others	OD
		1	4	7	TP, NS	None	OD
		1	1	8	F, NS	DM	PT
		1	5	8	TP, NS	None	OD
Nario K[33]	2009	1	1	6	F, ST, NS	RD	PT
		1	4	8	F, Dph	None	Unknown
		1	4	4	F, NS	Others	PT
Tanaka M[34]	2009	1	4	6	F, Dph, Dpn	None	PT
		1	3	6	ST, Dph	Others	PT
		1	2	2	ST, Dph, Dpn	None	PT
Kawai Y[35]	2009	1	4	8	NS, Dph, Dpn	Others	OD
Araki W[36]	2009	1	1	7	F, NP	DM	PT
Hatano A[37]	2009	1	5	10	ST, NP, NS	DM	PT
Murakami I[38]	2009	1	3	7	ST, Dph, Dpn	DM	PT
Hagino H[39]	2009	1	4	9	TP, TS, Dpn, NS	St	OD
Kodama Y[40]	2008	1	7	16	NP, NS	Others	OD
Yoshifuku K[41]	2008	1	4	4	ST, NP, NS, Dph	DM	PT
Ito S[42]	2008	1	3	3	F, NS, Dpn	DM	PT
		1	5	5	F, NS	Others	PT
		1	5	5	F, NS	DM, Others	PT
		1	7	7	ST, NS, Dph	DM	PT
		1	6	6	F, ST, Dph	None	PT
Usubuchi H[43]	2008	1	7	7	NS, Dpn, Dph	DM	PT
Suzuki A[44]	2008	1	2	8	ST, Dph	Others	PT
Sumi Y[7]	2008	14	5.2 ± 2.5	5.2 ± 2.5	*NC*	DM 7 St 1	PT 10 OD 2 Salivary 2
Sum/mean ± SD		89	4.5 ± 2.5	6.5 ± 2.9		DM 30	PT55 OD18

DM, diabetes mellitus; Dph, dysphagia; Dpn, dyspnea; F, fever; NP, neck pain; NS, neck swelling; *NC*, not clarified; OD, odontogenic infection; PT, pharynx and tonsil; RD, renal dysfunction; St, steroids; ST, sore throat; TP, tooth pain; TS, trismus.

Table 2. Published cases of descending necrotizing fasciitis in Japan, 2008–2013: microbiology, treatment, outcome

Investigator	Bacteria			Antibiotics	Drainage time	Mediastinal drainage methods	Outcome
	Streptococcus spp.	Anaerobe	Others/ND				
Kageyama M[8]			ND	PM	1	VATS	Survived
Takeno S[9]		1		PM, CLDM, LZD	2	VATS	Survived
	1			PM, CLDM, LZD	2	VATS	Survived
Kajiura K[10]	1			CP	3	THC	Survived
Takamune Y[11]	1			PM, CLDM	3	VATS	Survived
Okamoto T[12]			ND	PM	1	THC, VATS	Survived
Ishinaga H[13]	2	1	Coryne 1, Others 3	CP, CLDM	2.0 ± 0.7	THC 6 MS 2 TC 1	Survived
Uemura T[14]			Kleb, Enterococcus	PM	2	VATS	Survived
	1			*NC*	*NC*	*NC*	Survived
	1	1		*NC*	*NC*	VATS	Survived
		1		*NC*	*NC*	VATS	Survived
Matsuhashi N[15]			Coryne	PM, CLDM	3	TC	Survived
Ueda D[16]	1	1		CP, CLDM	2	THC	Survived
Oshima M[17]	1			*NC*	2	TC, THC	Survived
Nakata Y[18]	*NC*			*NC*	*NC*	*NC*	Survived
Nakamura K[19]	1			PM, CLDM, FLCZ	2	None	**Dead**
Nakanishi T[20]	1	2		PM, PC	*NC*	CD	**Dead**
Kodama M[21]			ND	*NC*	2	VATS	Survived
Kawakami M[22]	1			*NC*	*NC*	TC	Survived
	1	2	MRSA			TC	Survived
	1	1				TC	Survived
	1		Kleb			TC	Survived
	1	2				TC	Survived
Oka S[23]			MSSA	*NC*	3	VATS	Survived
	1		MSSA		2	VATS	Survived
	1				2	VATS	Survived
			ND		1	TC	Survived
		1			1	TC	Survived
Fujiwara T[24]	1			CP, CLDM	2	VATS	Survived
Yamamoto M[25]	1	2		CP, CLDM	2	TC	Survived
Fujimaki M[26]			ND	PM, CLDM	2	THC	Survived
	1			PM, CLDM	*NC*	TC	**Dead**
Yamaguchi Y[27]	1			PM, CLDM	3	TC, VATS	Survived
Uno K[28]			ND	PC, CLDM	2	TC, VATS	Survived
Sakagami T[29]	1	1		PM, CLDM, FLCZ	3	TC, VATS	Survived
Yamada K[30]		1	Kleb	PM	2	TC	Survived
Momota K[31]	1	1		CP, CLDM	2	TC, THC	**Dead**
Sato K[32]	1			PM, CLDM	1	THC	Survived
	1	1		PM	2	TC	Survived
	1	1		PM	2	THC	Survived
	1			PM, CLDM	1	SB, THC	Survived
	1	1		PM, CLDM	2	TC, SB	Survived
Nario K[33]			ND	PM, CLDM	1	VATS	Survived
			ND	PM	1	THC	Survived
	1	2		PM	2	TC, MS	Survived
Tanaka M[34]	*NC*			*NC*	3	THC	Survived
					2	VATS	Survived
					3	VATS	Survived
Kawai Y[35]	1	2		PC, CLDM	2	TC	Survived
Araki W[36]	1			PM, CLDM	2	*NC*	Survived
Hatano A[37]			MSSA	CP, CLDM	2	TC, SB	Survived
Murakami I[38]	1			PM, CLDM	3	TC, VATS	Survived
Hagino H[39]			ND	PM, CLDM	5	TC, SB	Survived
Kodama Y[40]		1		CP	3	TC	Survived
Yoshifuku K[41]	1			PM, CLDM	3	THC	Survived
Ito S[42]	1			PC, CLDM, FLCZ	3	THC	Survived
			MSSA, Enterococcus	PC, CP, CLDM	2	THC	Survived
	1	1		PM	1	*NC*	Survived
			Kleb	PC, ISP	1	*NC*	Survived
			ND	PM, CLDM	*NC*	*NC*	Survived
Usubuchi H[43]	1			PM, CLDM	3	THC	Survived
Suzuki A[44]			ND	CP, CLDM	2	THC, MS	Survived
Sumi Y[7]	10	8	Kleb, MRSA	PM, PC	*NC*	CD 14	**1 Dead**,14 Survived
Summary	51	33	ND 11	PM 30, CLDM 29 CP 9, PC 7	2.12 ± 0.8	TC25, THC21, VATS21, CD15	**5 Dead**, 84 Survived

Streptococcus spp.: *S. constellatus*, *S. intermedius*, *S. agalactiae*, *S. mitis*, the other Streptococcus sp. Anaerobic bacteria: Peptostreptococcus sp, Prevottela sp, Fusobacterium sp, Bacteroides sp. CD, catheter drainage; CLDM, clindamycin; Coryne, Corynebacterium; CP, cephem; FLCZ, fluconazole; ISP, isepamicin; Kleb, Klebsiella sp.; LZD, linezolid; MRSA, methicillin-resistant *Staphylococcus aureus*; MS, mediastinoscopic drainage; MSSA, methicillin-sensitive *Staphylococcus aureus*; *NC*, not clarified; ND, not detected; PC, penicillin; PM, carbapenem; SB, subxiphoidal drainage; TC, transcervical approach; THC, thoracotomy; VATS, video-assisted thoracic surgical drainage.

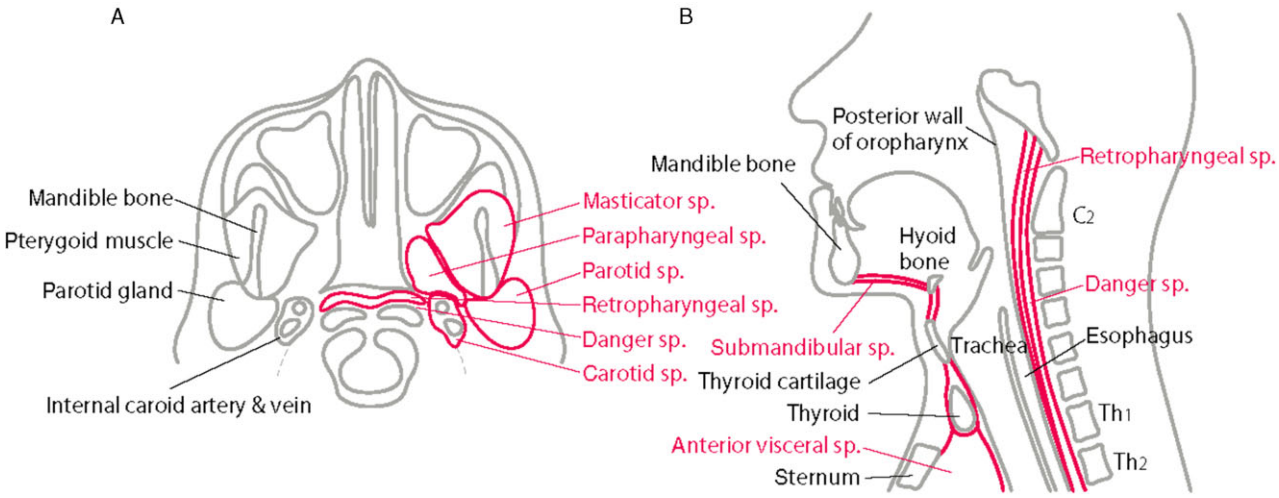

Fig. 1. Cervical spaces important for mediastinal progression (reproduced from Sumi (2013),[53] "Current treatment for burn injury"). A, Axial schematic view: parapharyngeal space (sp.) is the hub for deep space infections, which communicates with the major spaces: submandibular space, retropharyngeal space, and carotid space. B, Sagittal schematic view: submandibular space to anterior mediastinum (anterior visceral space), retropharyngeal space to the posterior mediastinum via danger space.

typically odontogenic and called Ludwig's angina, which refers to its historically lethal nature.[55]

Anterior visceral space

This space contains the thyroid, trachea, and esophagus extending from thyroid cartilage into superior mediastinum. Infection down to this route can lead to pericarditis and empynema.

Parapharyngeal space

This space serves as an anatomic hub for deep space infections, which communicates with spaces that are important route to mediastinum: submandibular space, retropharyngeal space, carotid space.[52]

Carotid space

The carotid space is located in the posterior of the parapharyngeal space and includes the internal carotid artery, jugular vein, and cranial nerves, extending from the skull base to the aortic arch. The route to the anterior and middle mediastinum through this space is called Lincoln's pathway.[56]

Retropharyngeal space

This space extends from the skull base to the level of the Th2 vertebral body. Posterior to this space is the danger space, which goes to the level of the diaphragm, providing a pathway into the posterior mediastinum. Abscesses in the retropharyngeal space often rupture in the danger space and result in posterior mediastinitis.

DIAGNOSIS

DIAGNOSIS OF DNM requires a high index of suspicion, which can be very difficult clinically. Studies have shown that only 15–34% of patients with CNF/DNM have an accurate diagnosis on admission.[57] In our review cases, the time until admission from first symptoms was 4.5 ± 2.5 days and the time until intervention was 6.5 ± 2.9 days. This discrepancy is due to a lack of recognition of DNM on admission and/or progression to DNM from CNF without adequate treatment. Careful examination, as below, and a high level of suspicion for DNM are key components to a prompt diagnosis.

Laboratory data

Not only data to indicate inflammatory response (white blood cell counts, C-reactive protein, procalcitonin), but to assess the general condition, including renal and respiratory function, unknown risk factors (HbA1c), complicated disseminated intravascular coagulation, and nutrition status, must be delivered. It is crucial to diagnose sepsis and organ failure and recommended to evaluate the lactate level and oxygenation by arterial blood gas analysis.[58]

Imaging

Imaging is an essential tool to diagnose the location and extent of infection and to define the management for CNF and DNM.

1. Chest X-ray:
   Chest X-ray can indicate not only airway malposition, that is, tracheal shift due to cervical edema, but widened mediastinum, and pleural effusion. It may be useful in the demonstration of s.c. emphysema and gas extending from cervical spaces to mediastinum.
2. Contrast-enhanced multidetector row computed tomography:

Contrast-enhanced computed tomography (CT) of the neck and chest is a golden standard to evaluate the spread of infection. The features of CNF/DNM include diffuse thickening of the cutis and subcutis, reticular enhancement of the s.c. fat, thickening and enhancement of cervical fasciae, platysma, muscles, and mediastinal fat, s.c. gas, fluid collections, pericardial effusion, and pleural effusion (Figs 2 and 3). Identification of continuity of an infectious process from the neck into the thorax establishes the diagnosis of DNM. Understanding the pathway of mediastinal extension is pivotal to establish the effective drainage. Multiplanar reconstruction imaging with multidetector CT is useful.[54,59] Endo *et al.* proposed a

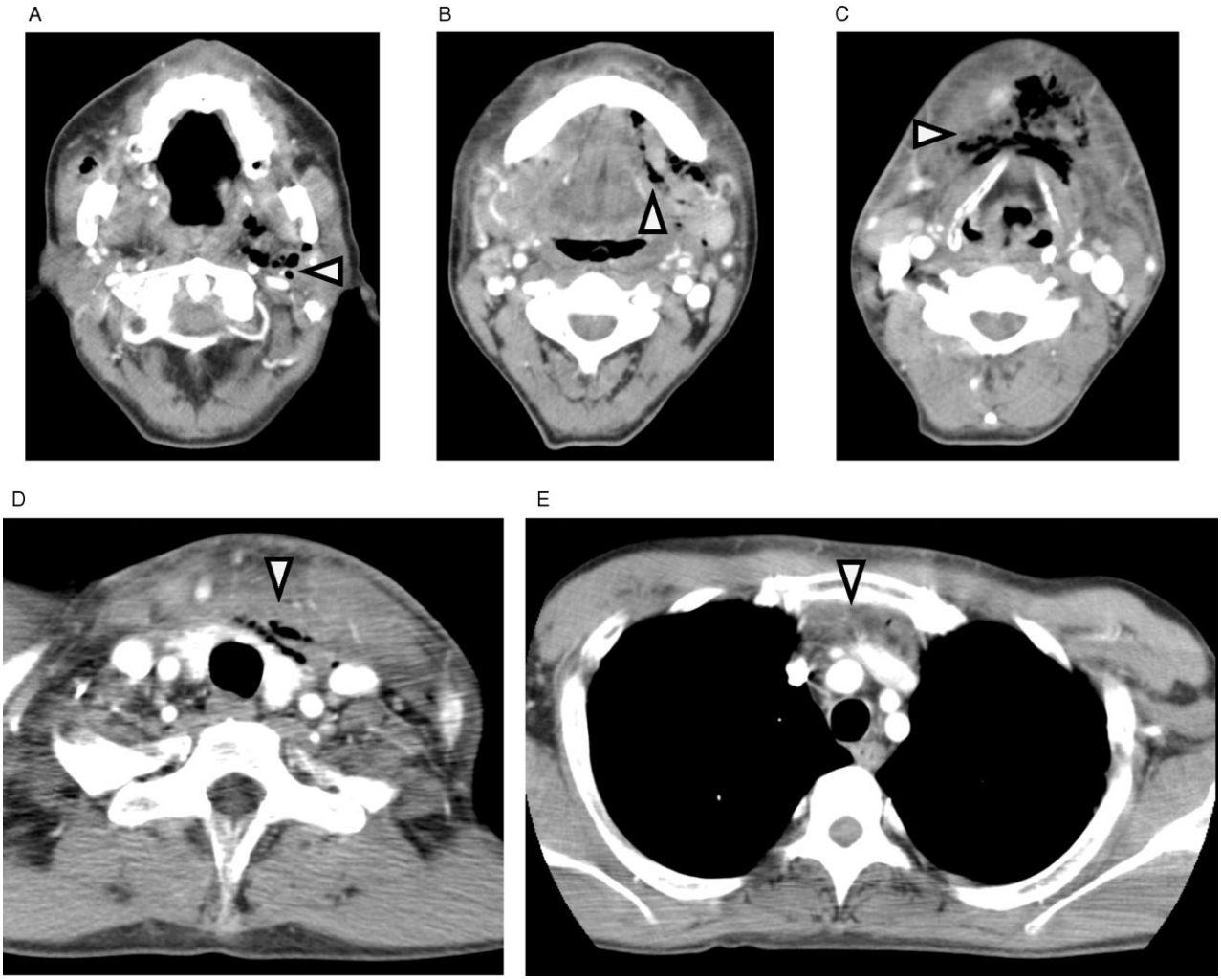

Fig. 2. Contrasted computed tomography of neck and chest: anterior mediastinitis due to odontogenic source (reproduced from Sumi (2013),[53] "Current treatment for burn injury"). A, Gas collections in left masticator, parapharyngeal, and carotid spaces. B, C, Diffuse thickening of the subcutis, reticular enhancement of s.c. fat, and gas collections in submandibular space. D, Reticular enhancement of s.c. fat, and gas collections in pretracheal and anterior visceral space. E, Thickening and enhancement of anterior mediastinal fat and fluid collections.

classification of the extent of DNM based on CT findings and facilitate management.[60] Type 1 is a localized infection above the carina, can be managed with transcervical drainage, Type 2A is characterized by diffuse anterior mediastinal involvement, requires transcervicotomy and subxiphoid approach and Type 2B involves both the anterior and posterior mediastinum, requires thoracotomy. Repeat CT allows for visualization of the extent of the infection and identification of new or untreated space involvement.

Gram stain and culture

It is essential to identify the bacteria that causes CNF and DNM. As soon as possible, Gram stain of infectious area and blood should be carried out. Cultures for aerobes and anaerobes are required. Without open wounds, aspiration or debridement of infectious areas is needed to obtain a specimen.

Histology

The histological findings are confirmatory. It shows superficial fascial necrosis and dense infiltration of neutrophils in deeper parts of s.c. tissue and fascia. Subcutaneous fat edema and necrotic vasculitis may be present.

PROGNOSIS

THE MORTALITY RATES are exceedingly high in the case of CNF with DNM and septic shock. Sarna *et al.*[3] reported that, in 100 cases of CNF, the mortality rate for CNF with DNM was 41% compared with 20% for CNF alone. Descending necrotizing mediastinitis approximately triples the risk of developing septic shock (23% versus 7%). Delay in diagnosis increases mortality,[61] and those who survive need more extensive surgery and reconstruction. With early diagnosis, outcome is much improved and significant long-term disability is reduced or prevented.[62] In our review series, the mortality rate (5.6%) was much lower than in previous reports, perhaps because most of the cases were single case reports. Four patients died from multiple organ failure and one died from cervical hemorrhage (Table 2).

TREATMENT

ONCE DNM IS diagnosed, the patient should be admitted to the intensive care unit for frequent monitoring and sepsis management, or referred to the right facilities capable of critical care.

Airway management

Airway management is critical because the CNF process may produce neck edema, which may result in the difficulty of intubation. The awake intubation techniques that use direct visualization with bronchoscopy are the most prudent approach. Sometimes tracheotomy is unavoidable to secure the airway. There is a notion that the tracheotomy should be carried out very carefully to avoid extending the infection into the tracheotomy.[62] In our review cases, seven patients (7.9%) presented with airway emergency and 36 patients (40%) were treated with either urgent or planned tracheotomy (data not shown).

Antibiotics

Antibiotic therapy should be started immediately.[58] Because polymicrobial CNF/DNM is more commonly seen, antibiotics need to be broad enough to cover Gram-positive cocci,Gram-negative rods, and anaerobic bacteria. Several empirical regimens include piperacillin–tazobactam and vancomycin and clindamycin with ceftriaxone or carbapenems have been described in the published reports.[63,64] It is suggested that, in cases of DNM complicated by streptococcal toxic shock syndrome, the use of protein synthesis inhibitors such as clindamycin proves more effective than penicillin.[65] In our review, carbapenem was given most often, and clindamycin was co-given most often (Table 2). Antibiotic therapy should be tailored as cultures and sensitivities become available. The duration of i.v. antibiotic therapy would be at least 7–10 days.[65] Not only before the treatment, but during the clinical course, the culture must be taken, as there may be antibiotic-resistant bacteria growth with open wounds.

Source control

Once the origin is identified, the management of original infection needs to be done. Extracting the tooth, removal of the foreign body, and drainage of retropharyngeal abscess by intraoral incision may be considered.

Drainage and debridement

Early aggressive intervention and medical optimization can halt the progression of DNM and to septic shock, drastically improving survival. Cervical drainage in the involved area is indisputable. However, the optimal form of mediastinal drainage remains controversial. Mediastinal drainage approach varies widely, namely, thoracotomy, median stenotomy, clamshell incision, a subxiphoid approach, a transcervical approach, VATS, mediastinoscopy, and percu-

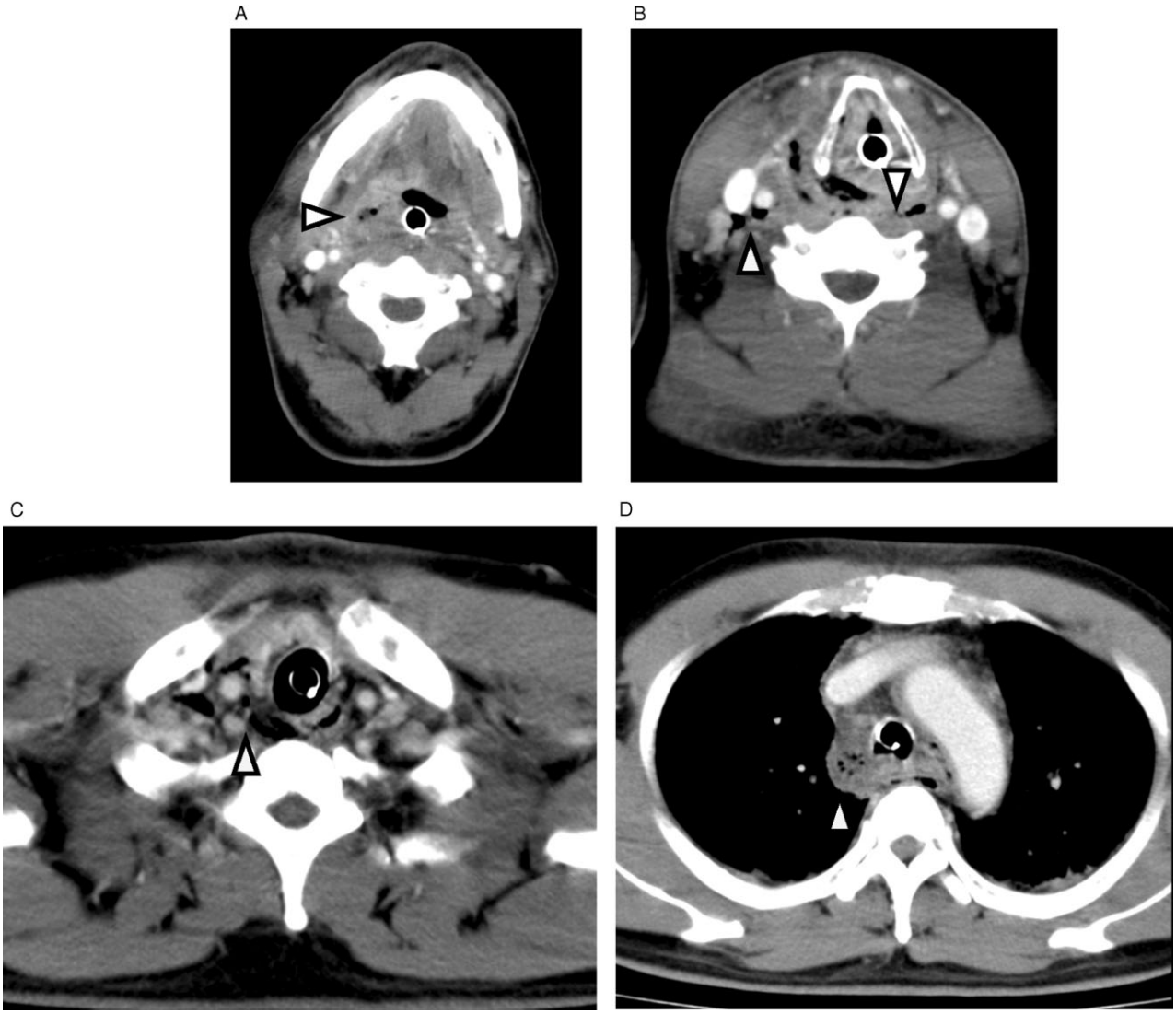

Fig. 3. Contrasted computed tomography of neck and chest showing posterior mediastinitis due to tonsillar abscess (reproduced from Sumi (2013),[53] "Current treatment for burn injury"). A, Diffuse thickening and gas collection in retropharyngeal space. B, C, Diffuse thickening and gas collection in carotid and danger space. D, Diffuse thickening of mediastinal fat and gas collection in posterior mediastinum.

taneous catheter drainage. Many authors have recommended that for advanced DNM (i.e., Endo type II),[60] the optimal treatment should include radical surgical debridement of affected tissue through an open thoracic approach.[66–70] However, these invasive methods are high-risk approaches for critically ill patients with overwhelming sepsis and may lead to unfavorable outcomes with complications.

In 2004, Isowa *et al.* first reported the successful management of DNM patients with VATS.[71] At around that time, more and more authors advocated VATS as one of the treatments for DNM and emphasized the excellent visualization of the entire thoracic cavity, the lower degree of invasiveness, and favorable outcome.[4,72,73] The VATS technique has the universal advantages of minimally invasive surgery, such as little pain, better cosmetics, and faster recovery.

Nakamori *et al.* first reported the effectiveness of percutaneous catheter drainage as a novel treatment for DNM a decade ago.[6] This technique is superior in terms of pain control, prevention of protein leakage from the wound site,

and less secondary infection by antibiotic-resistant bacteria. Although some questioned the reliability diagnosing the CNF/DNM without surgical exploration and how the necrotic tissue is debrided with this less invasive technique,[62] the mortality with their method is promising (0%) and 3.1% in our follow-up report.[7]

Although the diagnostic criteria by Estrera *et al.*[2] is widely accepted, documentation of necrotizing mediastinal infection during operation or autopsy is not always applied with less invasive drainage methods.

In this review, many cases with less invasive drainage approaches were uncovered. Twenty-one patients were treated with VATS and 15 cases by catheter drainage, the transcervical approach was taken in 25 patients, and thoracotomy was carried out in 21 patients (Table 2).

Of five non-survivors, thoracotomy was carried out in two patients, and the other two patients were treated by catheter drainage. There was no significant difference in mortality among mediastinal drainage methods. Repeat CT scanning allows us to monitor new or untreated space involvement and encourage frequent drainage. In our review, 2.12 times of drainage was required, and some cases required repeated drainage more than three times (Table 2).

Sepsis management

Aggressive hemodynamic and nutritional support and intensive care according to the surviving sepsis campaign[58] are the cornerstones for successful management of DNM.

Wound management and reconstruction

After the open debridement, meticulous daily wound care is essential. A daily regimen of wound irrigation and dressing change is recommended. Topical negative pressure therapy can reduce edema and stimulate the formation of granulation tissue. Once the infection has resolved and healthy granulation tissue is present, the wound may be closed with skin flaps or split-thickness grafts.

Hyperbaric oxygen

The use of hyperbaric oxygen (HBO) therapy has been advocated in published reports.[74,75] No patient was treated with HBO therapy in this review series, mostly because of less accessibility of HBO devices. The HBO is directly bactericidal to the anaerobic bacteria and should increase polymorphonuclear cell function. There still remains the need for a randomized controlled trial of the use of HBO to substantiate its adjunctive role in the treatment of CNF/DNM.[74,75]

COMPLICATIONS

COMPLICATIONS INCLUDE COMPROMISED airway, jugular vein thrombosis, suppurative jugular thrombophlebitis (Lemierre's syndrome),[76] carotid artery erosion and rupture, septic shock, empyema, and bronchocavitary fistula.

CONCLUSION

DESCENDING NECROTIZING FASCIITIS is a lethal condition if we do not diagnose promptly and start a multidisciplinary approach as soon as possible. Early diagnosis, drainage management, and aggressive monitoring and resuscitation in the intensive care unit as well as use of CT to guide repeated intervention are centerpieces to achieve a favorable outcome. Although the optimal approach to the mediastinum is not standardized, more recently, less invasive approaches successfully using thoracoscopic or mediastinoscopic or percutaneous catheter drainage have been reported.

CONFLICT OF INTEREST

NONE.

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