GENERAL THORACIC SURGERY

DESCENDING NECROTIZING MEDIASTITIS: AN ANALYSIS OF THE EFFECTS OF SERIAL SURGICAL DEBRIDEMENT ON PATIENT MORTALITY

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Objectives: Descending necrotizing mediastinitis is a polymicrobial infection originating in the oropharynx with previously reported mortality rates of 25% to 40%. This investigation reviews the effects of serial surgical drainage and debridement on the survival of patients with descending necrotizing mediastinitis. **Methods:** A retrospective review of patients from 1980 through 1998 with a diagnosis of descending necrotizing mediastinitis was performed. Their records were abstracted for personal demographics, hospital course, morbidity, and mortality. Also abstracted were all reports of patients with descending necrotizing mediastinitis published in English between 1970 and 1999. **Results:** We treated 10 patients in whom descending necrotizing mediastinitis was identified. The mean age of the patients was 38 years. They underwent a mean of 6 ± 4 computed tomographic imaging studies, 4 ± 1 transcervical drainage procedures, and 2 ± 1 transthoracic drainage procedures. Three patients required abdominal exploration and 4 underwent tracheostomy. No deaths occurred. In contrast, 96 patients with descending necrotizing mediastinitis were identified from the literature with a mean age of 38 years. They underwent a mean of 2 ± 1 computed tomographic imaging studies, 2 ± 1 transcervical drainage procedures, and 0.7 ± 0.3 transthoracic drainage procedures. Sixteen (17%) patients required abdominal exploration and 34 (35%) underwent tracheostomy. Twenty-eight (29%) patients from the literature cohort died during their treatment. **Conclusion:** Descending necrotizing mediastinitis remains a life-threatening infection. On the basis of experience accrued in treating these patients, an algorithm incorporating computed tomographic imaging for diagnosis and surveillance and serial transcervical and transthoracic operative drainage is outlined in the hope of reducing the excessive mortality of descending necrotizing mediastinitis. (J Thorac Cardiovasc Surg 2000;119:260-7)

Descending necrotizing mediastinitis (DNM) is an acute, polymicrobial infection of the mediastinum. Originating as an oropharyngeal or cervical infection,

this necrotizing process descends into the mediastinum, pleural spaces, pericardium, and abdomen using the contiguous deep spaces of the neck as portals of entry (Fig 1). In the chest, DNM produces abscesses and empyemas, pleural and pericardial effusions, intrathoracic hemorrhage, and cardiac tamponade and frequently results in the death of the patient.

Despite the introduction of modern antimicrobial therapy and computed tomographic (CT) imaging, this form of mediastinitis has continued to produce mortality rates reported between 25% and 40% in the literature (Table I). This poor prognosis could be due in part to the difficulty in establishing and maintaining adequate surgical drainage as DNM spreads among the fascial compartments of the neck and chest.¹⁻³ However, serial

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Table I. Cumulative mortality of DNM in the literature

	No. of reports	No. of patients	Survivors	Mortality (%)
Pearse (1938)	1	37	18	49
1970-79	8	13	9	31
1980-89	11	26	16	38
1990-98	27	57	43	25

DNM, Descending necrotizing mediastinitis.

operative drainage and debridement, the mainstay of therapy in other necrotizing infections, has rarely been used in patients with DNM.^{4,5} The purpose of this investigation was to assess whether such repeated surgical drainage, directed by frequent cervicothoracic computed tomographic (CT) imaging, was capable of improving the survival of a series of patients with DNM.

Patients and methods

A retrospective review was performed of patients with DNM whom we treated from 1980 through 1998. Inclusion criteria for the study population were those previously defined by Estrera and associates⁶: (1) clinical manifestations of a severe infection, (2) establishment of a relationship between an oropharyngeal or cervical infection and subsequent mediastinitis, (3) demonstration of radiographic features characteristic of DNM, and (4) documentation of a necrotizing mediastinal infection at the time of operative debridement or necropsy. Specifically excluded from this review were patients with mediastinitis resulting from an esophageal perforation, because diagnosis, treatment, and outcomes in this subset of patients are fundamentally different and well studied.

A historical cohort of patients with DNM was also assembled from reports in the literature. We identified these patients by performing a MEDLINE and manual *Cumulated Index Medicus* search of English language journals between 1970 and 1999. The previously described inclusion and exclusion criteria were also applied to these patients.

Both groups of patients had their records or case histories abstracted for personal demographics; clinical course; indication, type, and frequency of imaging studies and operative procedures; length of hospital stay; morbidity; and mortality. Mortality, for the purposes of this review, was defined as a death occurring within 30 days of surgery or during the initial hospitalization. Historical cohort patients treated before the availability of CT imaging were excluded from the statistical analysis of CT imaging data. Data for both groups of patients are expressed as the mean $\pm$ the standard deviation of the mean except where otherwise indicated. Differences between categorical variables were evaluated by the Fisher exact test. Differences between continuous variables were measured by the 2-tailed Student *t* test.

Fig 1. The three deep spaces of the neck and their communication with the chest.

Results

Between 1980 and 1999, we treated 10 patients with DNM. Their mean age was 37.7 ± 29 years (range 15-62 years), with 9 patients being male (Table II). Symptoms included odynophagia ($n = 8$), pharyngitis ($n = 5$), pyrexia ($n = 4$), and shortness of breath ($n = 2$). The focus of the inciting infection was odontogenic ($n = 4$), a peritonsillar abscess ($n = 3$), or a retropharyngeal abscess ($n = 3$). Mean time from onset of symptoms until diagnosis was 2.7 ± 1.9 days (range 1-7 days). Patients in this series were all found to have polymicrobial, aerobic, and anaerobic infections by Gram stain. Empiric, broad-spectrum antibiotics were initiated as soon as the diagnosis was suspected, and the program was modified as culture and sensitivity results became available.

Contrast-enhanced CT imaging of the neck and chest was obtained on admission for all 10 patients. Cervicothoracic CT imaging was also repeated 48 to 72 hours after any operative drainage or debridement or with any deterioration of the patient's clinical condition. CT imaging of the abdomen was performed when the patient's clinical condition failed to improve or worsened in the presence of a normal cervicothoracic CT scan or if the patient had signs or symptoms consistent with an intra-abdominal infection. This resulted

Table II. Clinical characteristics of our series and the English language reports in the literature from 1970 to 1998, with a statistical comparison of interventions and outcome

	Our series	Literature cohort	P value
N	10	96	
Age (y)			
Mean	37.7	38.1	
Range	15-62	1-71	
Male (%)	90	83	
Initial site of infection (%)			
Odontogenic	40	64	
Peritonsillar abscess	30	20	
Retropharyngeal abscess	30	16	
CT imaging, mean $\pm$ SD	6 $\pm$ 4	2 $\pm$ 1	.02
Operative therapy, mean $\pm$ SD (range)			
Tracheostomy (%)	40	35	.8
Transcervical	4 $\pm$ 1 (2-5)	2 $\pm$ 1	.0001
Transthoracic	2 $\pm$ 1 (2-4)	0.7 $\pm$ 0.3	.003
Abdominal (%)	30	17	.06
Hospital stay, mean days (range)	46 $\pm$ 30 (14-113)	NA	
Mortality (%)	0	29	.05

CT, Computed tomography; SD, standard deviation.

in a mean of 6 $\pm$ 4 (range 3-15) CT imaging studies per patient. Of the 46 CT scans performed after the initial diagnosis, 24 were indicated because of clinical deterioration. The remaining 22 CT scans were performed empirically as surveillance studies, and 13 (59%) of these 22 scans identified clinically unsuspected spread of DNM, necessitating further operative therapy in 12 (92%) of the 13 cases.

All 10 patients in this series also underwent operative drainage and debridement procedures of the neck and thorax after the diagnosis of DNM. These procedures were performed by a multidisciplinary team comprising a head and neck surgeon, a thoracic surgeon, and an oral maxillofacial surgeon if odontogenic disease was encountered. The need for subsequent operative procedures was determined by cervicothoracic CT imaging as previously discussed. Specifically, the accumulation of fluid or air and the identification of an abscess in the neck, chest, or abdomen were indications for further operative drainage and debridement. The mean number of operative procedures per patient in this series was 6 $\pm$ 2 (range 4-8) and included a mean of 4 $\pm$ 1 (range 2-5) transcervical and 2 $\pm$ 1 (range 2-4) transthoracic procedures. Included in these figures were 5 patients who underwent staged, bilateral, posterolateral thoracotomies and 1 patient who required simultaneous, bilateral thoracotomies to achieve adequate drainage of their infections. Intra-abdominal infections developed as a result of DNM in 3 patients in this series, and they all underwent abdominal exploration. Tracheostomy was indicated in 4 patients.

One hundred two patients with DNM were also identified from 49 reports published in the English literature between 1970 and 1999. Ninety-six of these patients met the criteria for inclusion in this review (see appendix). Their mean age was 38.1 $\pm$ 29 years (range 11 months–71 years) and included 80 (83%) male patients. All but 4 (4%) of these patients had mixed aerobic and anaerobic infections; in the 4 exceptions the sole pathogen was β -hemolytic *Streptococcus*. The origin of the infectious process producing DNM in this population was predominantly odontogenic (Table II). All of these patients were also treated with intravenous antibiotics.

CT imaging of the neck and chest and operative drainage and debridement were used significantly less frequently in the literature cohort of patients than in our series (Table II). Specifically, patients underwent a mean of 2 $\pm$ 1 (range 1-4) CT imaging studies, 2 $\pm$ 1 (range 1-3) transcervical operations, and 0.7 $\pm$ 0.3 (range 0-2) transthoracic operations (Table II). Sixteen (17%) of these patients required exploration of the abdomen because of DNM and 34 (35%) patients underwent tracheostomy.

Mean hospital length of stay for patients in our series was 46 $\pm$ 30 days (range 14-113 days). All of these patients had at least one episode of significant morbidity in the postoperative period. These problems included adult respiratory distress syndrome (n = 4), cardiac tamponade (n = 3), acute renal failure necessitating dialysis (n = 2), stroke (n = 2), pneumonia (n = 2), and chylothorax (n = 1). Similar information regarding morbidity and length of hospital stay was not consis-

tently available for patients in the literature cohort. No operative mortality occurred in our series of patients, whereas 28 (29%) patients in the literature cohort died during the course of treatment.

Discussion

Efforts to reduce the mortality associated with DNM have been only moderately successful over the past half century. In the first modern series of patients with DNM published in 1938, Pearse⁷ reported that 49% of patients died during their treatment. However, despite the subsequent introduction of intravenous antibiotics, vast improvements in anesthesia and critical care, and the development of CT imaging, our review found that the frequency of death for patients with DNM reported in the literature over the past 3 decades has remained high (Table I).

The rarity of DNM has likely been one factor in its continued lethality. As in other uncommon disorders, prospective investigation of these patients is extremely difficult, if not impossible. Reports of large series of patients with DNM are also unusual, as evidenced by the fact that this is only the second series of 10 patients with DNM reported since 1960. Combine this lack of published information with the reality that a thoracic surgeon may see only one or two patients with DNM during his or her career, and it is understandable that the care of these patients remains challenging.

Much of the current treatment of patients with DNM has been derived from a review of 10 patients with DNM reported in 1983 by Estrera and associates.⁶ In addition to emphasizing the need for empiric antibiotic therapy in these patients, they were the first to appreciate the value of CT imaging in establishing the diagnosis of DNM in patients who often have a nonspecific constellation of symptoms and a paucity of physical findings. Their enthusiasm for CT imaging in these patients was also confirmed by other investigators.⁸⁻¹⁰ Brunelli and colleagues¹¹ found cervicothoracic CT imaging to be immediately diagnostic in all patients in whom it was used. Yang and Soimakallio,¹² in a subsequent review of imaging techniques used in the diagnosis of patients with DNM, found that contrast-enhanced cervicothoracic CT imaging delivered the most timely and accurate information available. CT was preferable to soft tissue radiography, indium white blood cell scanning, echocardiography, and magnetic resonance imaging.

The results of our review also support the use of contrast-enhanced cervicothoracic CT imaging as the diagnostic study of choice for patients in whom DNM is suspected. However, we also found that CT imaging was equally valuable in identifying the unsuspected

progression of DNM into previously unaffected areas of the neck and chest. When CT imaging is used frequently for surveillance, it allows prompt, directed operative drainage, often before clinical signs of deterioration would have prompted reinvestigation.

As in other types of necrotizing infections, operative drainage and debridement are essential in the treatment of patients with DNM. Cervical exploration and drainage, including definitive treatment of the inciting oropharyngeal or cervical infection, is considered compulsory therapy.¹³⁻¹⁵ However, because of the anatomic relationships of the cervicothoracic region, the progressive nature of DNM, and the variety of incisions available, controversy exists as to whether transthoracic drainage and debridement of the mediastinum and chest is universally required and what the optimal surgical approach should be.

Central to these issues is a knowledge of the cervicothoracic anatomy. Comprehensive reviews of the cervicomediastinal fascial planes and spaces exist but are beyond the scope of this discussion.^{1,3} In brief, the deep cervical fascia of the neck is composed of a superficial, a visceral, and a prevertebral layer, which create a pretracheal, retrovisceral, and prevertebral space, respectively, in the neck (Fig 1). Each of these potential spaces contains loose areolar tissue and, by virtue of their continuity with the pericardium, parietal pleura, and mediastinum, readily serves as a portal of entry for an oropharyngeal or cervical infection into the chest.

Some authors have recommended a selective approach to surgical drainage of the chest in patients with DNM. Howell,¹⁶ Estrera,⁶ and others have reported that mediastinal drainage is best accomplished through a transthoracic approach when the necrotizing process extends below the level of the fourth thoracic vertebra posteriorly or the tracheal bifurcation anteriorly.¹³ In the absence of these findings, they advocate transcervical drainage of the mediastinum.

However, in light of the rapid spread of this type of infection facilitated by the previously discussed regional anatomy, it is not surprising that other investigators have advocated mandatory transthoracic mediastinal exploration regardless of the level of involvement. Marty-Ane,¹⁴ Wheatley,¹³ Brunelli,¹⁷ and their associates suggest that such compulsory transthoracic mediastinal drainage may confer a survival advantage to patients with DNM. Corsten and colleagues,¹⁵ in a subsequent meta-analysis, were able to identify a statistically significant difference in survival between patients undergoing transcervical mediastinal drainage (53%) versus those receiving transthoracic mediastinal drainage (81%) ($P < .05$).

Fig 2. Treatment algorithm for patients with descending necrotizing mediastinitis (DNM). CT, Computed tomography.

Although individual practitioner bias and clinical circumstances will ultimately determine whether a transcervical or transthoracic approach for mediastinal drainage will be used in any individual patient, several results from this review are pertinent to such a decision. All 10 patients in this series underwent at least one transthoracic mediastinal drainage and debridement procedure. In each instance, cervicothoracic CT imaging had identified a mediastinal or other intrathoracic focus of infection that was not believed to be amenable to transcervical drainage by the multidisciplinary team of physicians involved. Furthermore, despite what was considered adequate drainage at the initial operation, the patients in this series required an average of one more transthoracic and three more transcervical debridement procedures during their care. Hence physicians should anticipate that repetitive transcervical and transthoracic operative procedures will be required in patients with DNM if adequate drainage is to be achieved.

The literature describes several approaches for optimal transthoracic drainage and debridement in patients with DNM. Reports recommending the use of a subxiphoid approach, clamshell incision, median sternotomy, or a thorascopic approach can all be

found.^{13,18-20} Although each of these techniques offers potential advantages and disadvantages, the posterolateral thoracotomy incision remains the standard by which other transthoracic approaches should be measured. In this series, it allowed comprehensive access to a hemithorax including the ipsilateral mediastinum and pericardium. A posterolateral thoracotomy provides the broadest exposure of the prevertebral and paraesophageal planes without the risk of sternal osteomyelitis encountered with a sternotomy or clamshell incision. Furthermore, posterolateral thoracotomy is generally tolerated even by acutely ill patients.¹¹

The absence of operative mortality in this series is encouraging. This is due, at least in part, to the treatment algorithm developed from the experience accrued while caring for the patients in this series (Fig 2). Besides the prompt initiation of broad-spectrum intravenous antibiotics, this algorithm includes the use of contrast-enhanced cervicothoracic CT imaging in all patients with deep space infections of the neck in an attempt to recognize DNM early in its course. CT imaging of the neck and chest are subsequently performed with any clinical deterioration of the patient or empirically 48 to 72 hours after operative drainage pro-

cedures to identify any progression of the infection. Surveillance is continued until no evidence of progressive infection is found on CT imaging and the patient displays no clinical signs of infection. The strategy of empiric surveillance CT scanning is supported by the fact that 59% of these scans in our series identified unanticipated progression of the necrotizing infection necessitating further surgical therapy.

This algorithm also emphasizes the importance of surgical drainage and debridement. Because initial operative drainage is often inadequate in patients with DNM, clinicians should expect that serial transcervical and transthoracic procedures will be needed. These drainage procedures are best performed by a multidisciplinary team of physicians guided by CT imaging. A transthoracic approach, especially in the form of unilateral or bilateral posterolateral thoracotomies, should be used without hesitation when it appears they would provide superior exposure and drainage. Exploration, debridement, and drainage of the retroperitoneum and peritoneal cavity may also be required. The need for tracheostomy should be assessed on an individual basis for patients with DNM.

In summary, DNM remains a life-threatening infection. An improved understanding of the natural history of this infectious process and the relevant anatomy continue to promote improvements in therapy for affected patients. Specifically, the results of this review support the use of a treatment algorithm that emphasizes early diagnosis and surveillance with CT imaging, serial transcervical and transthoracic operative drainage and debridement, and the involvement of a multidisciplinary team of surgeons. Incorporating these measures into the patients' treatment should reduce the excessive mortality associated with DNM.

REFERENCES

- Moncada R, Warpeha R, Pickleman J, Spak M, Cardoso M, Berkow A, et al. Mediastinitis from odontogenic and deep cervical infection. *Chest* 1978;73:497-500.
- Wills PI, Vernon RP Jr. Complications of space infections of the head and neck. *Laryngoscope* 1981;91:1129-36.
- Furstenberg AC, Yglesias L. Mediastinitis: a clinical study with practical anatomic considerations of the neck and mediastinum. *Arch Otolaryngol* 1937;25:539-54.
- Greinwald JH, Wilson JF, Haggerty PG. Peritonsillar abscess: an unlikely cause of necrotizing fasciitis. *Ann Otol Rhinol Laryngol* 1995;104:133-7.
- Baumgartner FJ, Omari BO, Klein SR. Appropriate exposure and drainage for descending necrotizing mediastinitis. *Ann Thorac Surg* 1997;64:883-92.
- Estrera AS, Landay MJ, Grisham JM, Sinn DP, Platt MR. Descending necrotizing mediastinitis. *Surg Gynecol Obstet* 1983;157:545-52.
- Pearse HE. Mediastinitis following cervical suppuration. *Ann Surg* 1938;108:588-611.
- van der Bempt X, Derue G, Severin F, Colin I, Gilbeau J-P, Heller F. Ludwig's angina and mediastinitis due to *Streptococcus milleri*: usefulness of computed tomography. *Eur Respir J* 1990;3:728-31.
- Becker M, Zbaren P, Hermans R, Becker CD, Marchal F, Kurt AM, et al. Necrotizing fasciitis of the head and neck: role of CT in diagnosis and management. *Radiology* 1997;202:471-6.
- Izumoto H, Komoda K, Okada O. Successful utilization of the median sternotomy approach in the management of descending necrotizing mediastinitis: report of a case. *Surg Today* 1996;26:286-8.
- Brunelli A, Sabbatini A, Catalini G, Fianchini A. Descending necrotizing mediastinitis: Cervicotomy or thoracotomy? *J Thorac Cardiovasc Surg* 1996;111:485-6.
- Yang X, Soimakallio S. The role of different imaging procedures on early diagnosis and management of descending necrotizing mediastinitis. *Eur Arch Otorhinolaryngol* 1996;253:316-7.
- Wheatley MJ, Stirling MC, Kirsh MM, Gago O, Orringer MB. Descending necrotizing mediastinitis: Transcervical drainage is not enough. *Ann Thorac Surg* 1990;49:780-4.
- Marty-Ane CH, Alauzen M, Alric P, Serres-Cousine O, Mary H. Descending necrotizing mediastinitis: advantage of mediastinal drainage with thoracotomy. *J Thorac Cardiovasc Surg* 1994;107:55-61.
- Corsten MJ, Shamji FM, Odell PF, Frederico JA, Laframboise GG, Reid KR, et al. Optimal treatment of descending necrotizing mediastinitis. *Thorax* 1997;52:702-8.
- Howell HS, Prinz RA, Pickleman JR. Anaerobic mediastinitis. *Surg Gynecol Obstet* 1976;143:353-9.
- Brunelli A, Sabbatini A, Catalini G, Fianchini A. Descending necrotizing mediastinitis. *Arch Otolaryngol Head Neck Surg* 1996;122:1326-9.
- Ris HB, Banic A, Furrer M, Caversaccio M, Cerny A, Zbaren P. Descending necrotizing mediastinitis: surgical treatment via clamshell approach. *Ann Thorac Surg* 1996;62:1650-4.
- Roberts JR, Smythe WR, Weber RW, Lanutti M, Rosengard BR, Kaiser LR. Thoracoscopic management of descending necrotizing mediastinitis. *Chest* 1997;112:850-4.
- Takanami I, Naruke M, Kodaira S. The surgical approach for descending necrotizing mediastinitis: a report of two cases. *Surg Today* 1998;28:1200-2.

Appendix: Literature cohort references

- Albertsen J, Thomsen EM. Nonclostridial deep gas-producing infection in the neck. *Arch Otolaryngol* 1970;92:383-5.
- Janecka IP, Rankow RM. Fatal mediastinitis following retropharyngeal abscess. *Arch Otolaryngol* 1971;93:630-3.
- Cogan MIC. Necrotizing mediastinitis secondary to descending cervical cellulitis. *Oral Surg* 1973;36:307-20.
- Enquist RW, Blank RR, Butler RH. Nontraumatic mediastinitis. *JAMA* 1976;236:1048-9.
- Scully RE, Galdabini JJ, McNelly BU. Case 15-1978. Case records of the Massachusetts General Hospital. *N Engl J Med* 1978;298:894-902.
- Howell HS, Prinz RA, Pickleman JR. Anaerobic mediastinitis. *Surg Gynecol Obstet* 1976;143:353-9.
- Hendler BH, Quinn PD. Fatal mediastinitis secondary to odontogenic infection. *J Oral Surg* 1978;36:308-10.

8. Moncada R, Warpeha R, Pickleman J, Spak M, Cardoso M, Berkow A, et al. Mediastinitis from odontogenic and deep cervical infection. *Chest* 1978;73:497-500.
9. Strauss HR, Tilghman DM, Hankins J. Ludwig angina, empyema, pulmonary infiltration, and pericarditis secondary to extraction of a tooth. *J Oral Surg* 1980;38:223-9.
10. Young JN, Samson PC. Extraleural empyema thoracis as a direct extension of Ludwig's angina. *J Thorac Cardiovasc Surg* 1980;80:25-7.
11. Wills PI, Vernon RP Jr. Complications of space infections of the head and neck. *Laryngoscope* 1981;91:1129-36.
12. Economopoulos GC, Scherzer HH, Gryboski WA. Successful management of mediastinitis, pleural empyema, and aortopulmonary fistula from odontogenic infection. *Ann Thorac Surg* 1983;35:184-7.
13. Estrera AS, Landay MJ, Grisham JM, Sinn DP, Platt MR. Descending necrotizing mediastinitis. *Surg Gynecol Obstet* 1983;157:545-52.
14. Snow N, Lucas AE, Grau M, Steiner M. Purulent mediastinal abscess secondary to Ludwig's angina. *Arch Otolaryngol* 1983;109:53-5.
15. Bounds GA. Subphrenic and mediastinal abscess formation: a complication of Ludwig's angina. *Br J Oral Maxillofac Surg* 1985;23:313-21.
16. Levine TM, Wurster CF, Krespi YP. Mediastinitis occurring as a complication of odontogenic infections. *Laryngoscope* 1986;96:747-50.
17. Rubin MM, Cozzi GM. Fatal necrotizing mediastinitis as a complication of an odontogenic infection. *J Oral Maxillofac Surg* 1987;45:529-33.
18. Zachariades N, Mezitis M, Stavrinidis P, Konsolaka-Agouridaki E. Mediastinitis, thoracic empyema, and pericarditis as complications of a dental abscess: report of a case. *J Oral Maxillofac Surg* 1988;46:493-5.
19. Musgrove BT, Malden NJ. Mediastinitis and pericarditis caused by dental infection. *Br J Oral Maxillofac Surg* 1989;27:423-8.
20. Wheatley MJ, Stirling MC, Kirsh MM, Gago O, Orringer MB. Descending necrotizing mediastinitis: Transcervical drainage is not enough. *Ann Thorac Surg* 1990;49:780-4.
21. Guardia SN, Cameron R, Phillips A. Fatal necrotizing mediastinitis secondary to acute suppurative parotitis. *J Otolaryngol* 1991;20:54-6.
22. Caratea-Crelgo J, Gay-Escoda C. Mediastinitis from odontogenic infection. *Int J Oral Maxillofac Surg* 1991;20:65-8.
23. Chong WH, Woodhead MA, Millard FJC. Mediastinitis and bilateral thoracic empyema complicating adult epiglottitis. *Thorax* 1990;45:491-2.
24. Baker AR, Moir AA, Donnelly PK. Life-threatening peripharyngeal sepsis with mediastinitis. *Br J Clin Pract* 1990;44:640-1.
25. van der Bempt X, Derue G, Severin F, Colin I, Gilbeau J-P, Heller F. Ludwig's angina and mediastinitis due to *Streptococcus milleri*: usefulness of computed tomography. *Eur Respir J* 1990;3:728-31.
26. Horowitz MD, Sosa JL, Lickstein DA. Descending necrotizing mediastinitis. *Ann Thorac Surg* 1990;50:859-60.
27. Seaman M, Ballinger P, Sturgill TD, Maertins M. Mediastinitis following nasal intubation in the emergency department. *Am J Emerg Med* 1991;9:37-9.
28. Lalwani AK, Caplan MJ. Mediastinal and thoracic complications of necrotizing fasciitis of the head and neck. *Head Neck* 1991;113:531-9.
29. Ogiiso A, Tamura M, Minemura T, Kurashina K, Kotani A. Mediastinitis caused by odontogenic infection associated with adult respiratory distress syndrome. *Oral Surg* 1992;74:15-8.
30. Civen R, Vaisanen M-L, Finegold SM. Peritonsillar abscess, retropharyngeal abscess, mediastinitis, and nonclostridial anaerobic myonecrosis: a case report. *Clin Infect Dis* 1993;16:299-303.
31. Watanabe M, Ohshika Y, Aoki T, Takagi K, Tanaka S, Ogata T. Empyema and mediastinitis complicating retropharyngeal abscess. *Thorax* 1994;49:1179-80.
32. Marty-Ane CH, Alauzen M, Alric P, Serres-Cousine O, Mary H. Descending necrotizing mediastinitis: advantage of mediastinal drainage with thoracotomy. *J Thorac Cardiovasc Surg* 1994;107:55-61.
33. Greinwald JH, Wilson JF, Haggerty PG. Peritonsillar abscess: an unlikely cause of necrotizing fasciitis. *Ann Otol Rhinol Laryngol* 1995;104:133-37.
34. Zeitoun IM, Dhanarajani PJ. Cervical cellulitis and mediastinitis caused by odontogenic infections: report of two cases and review of literature. *J Oral Maxillofac Surg* 1995;53:203-8.
35. Jackson BS, Sproat JE. Necrotizing fasciitis of the head and neck with intrathoracic extension. *J Otolaryngol* 1995;24:60-3.
36. Li KK, Varvares MA, Meara JG. Descending necrotizing mediastinitis: a complication of dental implant surgery. *Head Neck* 1996;18:192-6.
37. Brunelli A, Sabbatini A, Catalini G, Fianchini A. Descending necrotizing mediastinitis: Cervicotomy or thoracotomy? *J Thorac Cardiovasc Surg* 1996;111:485-6.
38. Ris HB, Banic A, Furrer M, Caversaccio M, Cerny A, Zbaren P. Descending necrotizing mediastinitis: surgical treatment via clamshell approach. *Ann Thorac Surg* 1996;62:1650-4.
39. Brunelli A, Sabbatini A, Catalini G, Fianchini A. Descending necrotizing mediastinitis. *Arch Otolaryngol Head Neck Surg* 1996;122:1326-9.
40. Kruyt PM, Boonstra A, Fockens P, Reeders J, VanLanschoot JJB. Descending necrotizing mediastinitis causing pleuroesophageal fistula. *Chest* 1996;109:1404-7.
41. Cardero L, Torre W, Freire D. Descending necrotizing mediastinitis syndrome treated by aggressive surgical treatment. *J Cardiovasc Surg* 1996;37:87-8.
42. Baumgartner FJ, Omari BO, Klein SR. Appropriate exposure and drainage for descending necrotizing mediastinitis. *Ann Thorac Surg* 1997;64:883-92.
43. Corsten MJ, Shamji FM, Odell PF, Frederico JA, Laframboise GG, Reid KR, et al. Optimal treatment of descending necrotizing mediastinitis. *Thorax* 1997;52:702-8.
44. Nomori H, Horio H, Kobayashi R. Descending necrotizing mediastinitis secondary to pharyngitis. *Scand Cardiovasc J* 1997;31:233-5.
45. Roberts JR, Smythe WR, Weber RW, Lanutti M, Rosengard BR, Kaiser LR. Thoracoscopic management of descending necrotizing mediastinitis. *Chest* 1997;112:850-4.
46. Haraden BM, Zwemer FL. Descending necrotizing mediastinitis: complication of a simple dental infection. *Ann Emerg Med* 1997;29:683-6.
47. Temes RT, Crowell RE, Mapel DW, Ketai L, Pett SB, Wernley JA. Mediastinitis without antecedent surgery. *Thorac Cardiovasc Surg* 1998;46:86-8.

Discussion

Dr John Benfield (*Los Angeles, Calif*). It has been about half a century since Alexander Fleming discovered penicillin, then thought to be a miracle drug. Since my father was a practicing physician at the time, I recall the thought in the medical community that penicillin would conquer the problem of infection. We know that hope has not come to fruition. Antibiotic therapy is indeed very important for the treatment of infection, but the basic principle remains that adequate and prompt drainage and debridement are fundamental for success.

Two facts surface as the most important ones in your manuscript. First, among 22 surveillance imaging studies done empirically without specific evidence of clinical deterioration, 13 or 59% identified unsuspected foci of infection. The patients with these findings then required further operations. Second, none of the patients from the University of Washington died, whereas 25% to 40% of similar patients reported by others died. You and your colleagues correctly attribute your success to the liberal use of cervicothoracic imaging 48 to 72 hours after each operation and to your willingness to reoperate again and again when there were either clinical or radiographic indications to do so.

This is the analog of the aggressive and anticipatory approach one must take to the treatment of clostridial infections or to the management of necrotizing pancreatitis. In my experience with the management of infections such as those and the cervicothoracic infections you have discussed, I cannot recall a single instance of regret in having decided to operate. I can recall many cases in which more prompt operation would have served the patient better. The results of your study underscore the validity of the principle that the *conservative* management of surgical infections is to operate promptly when the patient's condition is not improving. Watching and waiting under such circumstances is *radical*; the *conservative* approach is to find the infection, explore, and debride and drain.

It is interesting to view this report in the context of today's cost-containment health care environment. The current philosophy is to see whether one can get away with doing less

with the hope that this will result in lower costs. I could not help asking myself how many of the life-saving imaging studies that you did empirically would have passed the scrutiny of insurance companies and reviewers. Clearly your judgement to do the studies was correct, and it would have cost more had they not been done.

I have had occasion to successfully treat DNM resulting from perforation of a radiated esophagus with video-assisted transthoracic mediastinal drainage. Using the video-assisted approach, one can inspect and irrigate the mediastinum and precisely place chest tubes. This approach should be kept in mind, in conjunction with appropriate cervical drainage. Have you had occasion to use video-assisted surgery, Dr Freeman?

Dr Freeman. Thank you for your kind comments, Dr Benfield. Certainly we have used the thoracoscope to drain intrathoracic infections. However, in these 10 patients video-assisted techniques were not used. All 10 patients had fairly disseminated infections, and in each instance the primary surgeon thought that a posterolateral thoracotomy provided the best exposure, especially for the posterior spaces, allowing the placement of drains virtually from the cervical incisions all the way down to the diaphragm. Thus the short answer in this series is, no.

Dr Mark Reed (*Honolulu, Hawaii*). What sort of CT criteria led you to transthoracic drainage in addition to or as opposed to transcervical drainage? Is pleural effusion an adequate criterion, or is there some extent of the mediastinal phlegmon that leads you to open the chest as well?

Dr Freeman. In the 1980s some of the small series advocated transcervical drainage of the mediastinum if the infection identified on imaging studies did not descend inferior to the level of the fourth vertebra or the carina anteriorly. However, we believe that infection anywhere in the mediastinum is best drained transthoracically. All three spaces should be opened and drained widely. There were instances in this series in which a simple pleural effusion without the characteristics of an empyema was drained initially with a chest tube. Those patients had no mediastinal involvement that we could see at the time.