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ORIGINAL ARTICLE

Deep neck infections in children

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Abstract *Background/Purpose:* Deep neck infections (DNIs) often have a rapid onset and can progress to life-threatening complications. There are only a few reports on pediatric DNIs' clinical manifestations, diagnostic clues, and etiology in Taiwan.
Methods: A retrospective chart review of patients (aged $\leq$ 18 years) diagnosed with DNI from January 2005 to December 2014 was performed. DNIs were classified into retropharyngeal, parapharyngeal, peritonsillar, submandibular, and multispace abscesses.
Results: A total of 52 patients with DNI were identified. The most common site of DNI was the parapharyngeal space ($n = 22$, 42.3%). The most commonly associated antecedent illness was preceding upper respiratory tract infection (30.8%). The most common clinical presentation was neck mass or swelling (82.7%) and fever (75%). Pus drainage or needle aspiration was performed to obtain pus samples from the infection site for pus culture ($n = 31$). The most commonly isolated pathogen was *Staphylococcus aureus* ($n = 7$). Amoxicillin—clavulanic acid (56.6%) was the most commonly used antibiotics, followed by penicillin (15.1%). There was no long-term morbidity or mortality.
Conclusion: When a patient (regardless of age) presents with neck mass or swelling, the DNI should always be included in the differential diagnosis. The low culture rate in Taiwan and previous partial treatment of infections may have affected identification of pathogens in cultures. Performing Gram staining and acid-fast staining of pus, instead of culture alone, as early as possible before initiating the initial antimicrobial therapy are thus crucial. The recurrence of DNI should alert the physician to the possibility of an underlying bronchogenic cyst. Excision surgery is required to cure recurrent infections.

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Introduction

Deep neck infections (DNIs) often have a rapid onset and can progress to life-threatening complications, such as airway obstruction, jugular vein thrombosis, mediastinal involvement, pericarditis, pneumonia, and arterial erosion. Thus, timely diagnosis of DNI is important to improve patient survival.[1,2] Based on the anatomic sites of infection pathogenesis, the disease can be categorized as retropharyngeal, parapharyngeal, and peritonsillar abscess.[3] However, accurate diagnosis of DNI remains a challenge to pediatricians owing to its insidious clinical symptoms and signs.[4] There are only a few reports on pediatric DNIs' clinical manifestations, diagnostic clues, and etiology in Taiwan.[5–7] The aim of this study was to present our experience of the clinical course and bacteriological data of DNI encountered in our department in the past 10 years and compare it with those reported in the available literature.

Methods

Study patients

A retrospective chart review of patients, aged younger than 18 years, diagnosed with DNI (retropharyngeal, parapharyngeal, peritonsillar, or submandibular abscess) in Taichung Veterans General Hospital, Taichung, Taiwan, from January 2005 to December 2014, was performed. The diagnosis of DNI was based on clinical characteristics, imaging studies [contrast-enhanced computed tomography (CT), X-ray, and neck sonography], and surgical finding. Based on site of infection, DNI was classified into retropharyngeal, parapharyngeal, peritonsillar, and submandibular abscesses for analysis. The abscess formation around the tonsils is defined as a peritonsillar abscess, and is usually unilateral. Parapharyngeal abscess is anatomically located around the pharynx, the carotid sheath posteriorly, and the styloid process laterally. Retropharyngeal abscess is located just behind the pharynx, and may extend downward to the mediastinum.[8] The submandibular abscess, located in the submandibular space, is bounded by a superficial layer of deep cervical fascia inferiorly and by lingual mucosa superiorly.[5] If two or more spaces were concurrently involved in a significant way, they were classified as "multispace abscess."

Patients' characteristics

Demographic data, including age, sex, underlying medical condition, clinical manifestations, antecedent illness, laboratory data (white cell count, platelet, and C-reactive protein), radiology study findings, and length of hospital stay, were collected. The bacteriology results, management, complications, and outcome were also collected for analysis. Complications of DNI identified in these patients included prevertebral abscess, purulent thyroiditis, parotid gland abscess, airway compromise, jugular vein thrombosis, mediastinal involvement, pericarditis, pneumonia, arterial erosion, and bacteremia.[1,2] The clinical characteristics and laboratory data were compared among patients with retropharyngeal, parapharyngeal, peritonsillar, submandibular, and multispace abscess.

Statistical analysis

Data are presented as mean $\pm$ standard deviation and median. Hypothesis testing using Chi-square test was performed to assess differences between patients of the five groups (i.e., retropharyngeal, parapharyngeal, peritonsillar, submandibular, and multispace abscesses). Continuous variables were compared using Mann–Whitney U test. A p value < 0.05 was considered statistically significant.

Results

During the 10-year study period, a total of 52 patients with DNI were identified, including 29 boys (55.8%) and 23 girls (44.2%). The mean age of these patients was 8.81 $\pm$ 6.29 years. A summary of their clinical features are presented in Table 1. The most common site of DNI was the parapharyngeal space ($n = 22$, 42.3%), followed by the submandibular space ($n = 12$, 23.1%), the retropharyngeal space ($n = 7$, 13.5%), and the peritonsillar space ($n = 6$, 11.5%). Multispace abscess occurred in five cases (9.6%). The most common known antecedent illness was upper respiratory tract infection (30.8%), followed by dental infection (15.4%) and congenital anomalies, such as congenital cysts (15.4%). Neck mass or swelling (82.7%) and fever (75%) were the most common symptoms. CT scans with contrast enhancement was performed in 44 patients (84.6%). The mean length of hospital stay was 7.50 days (7.50 $\pm$ 4.12 days). Thirty-four (66.7%) patients received surgical management, including incision and drainage, excision, and resection. Pus drainage or needle aspiration was performed to obtain pus samples from infected sites for culture. One patient was admitted to the pediatric intensive care unit due to airway compression, and one patient received emergent surgery due to airway obstruction. Six (11.6%) patients developed complications, including mediastinal abscess, prevertebral abscess, acute purulent thyroiditis, bacteremia, and a fistula into the external ear canal. There was no mortality.

The sites of DNI were found to be different among different age groups (Figure 1). All the patients with peritonsillar abscess and most patients with parapharyngeal abscess were aged between 7 years and 18 years (school-going children). The length of hospital stay and laboratory data were not different between the age groups.

The clinical characteristics and management of different infected sites are presented in Table 2. Among the five groups, there was no significant difference in age distribution and hospital stay. All patients with submandibular abscess had neck mass or swelling. This symptom was also frequently found in patients with parapharyngeal abscess (90.9%, $p = 0.024$). All patients afflicted with peritonsillar abscess and multispace abscess had fever. Fever was also common in patients with retropharyngeal abscess (85.7%). Sore throat or dysphagia ($n = 11$, 21.2%) occurred occasionally, but these conditions were not observed in patients with submandibular abscess ($p = 0.026$). Symptoms such as

Table 1 Characteristics of pediatric patients with deep neck infection.

Characteristics	
Sex	
Female	23 (44.2)
Male	29 (55.8)
Age (median; y)	8.81 ± 6.29
Length of hospital stay (d)	7.50 ± 4.12
Clinical presentation	
Fever	39 (75.0)
Neck mass or swelling	43 (82.7)
Sore throat/dysphagia	11 (21.2)
Dyspnea	2 (3.8)
Limited neck motion	2 (3.8)
Antecedent illness	
Recent URI	16 (30.8)
Dental infection	8 (15.4)
Congenital cyst	8 (15.4)
Other[a]	5 (9.6)
WBC at presentation (/mm^3)	14400.4 ± 6071.2
Platelet at presentation (10^3/mm^3)	324.00 ± 168.8
CRP at presentation (mg/dL)	7.8 ± 6.5
CT performed	44 (84.6)
Culture rate	31 (59.6)
Culture-positive rate	61.3
Surgery	34 (66.7)
Complication	6 (11.6)
Mortality	0 (0)
Diagnosis	
Retropharyngeal abscess	7 (13.5)
Parapharyngeal abscess	22 (42.3)
Peritonsillar abscess	6 (11.5)
Submandibular abscess	12 (23.1)
Multispace abscess	5 (9.6)

[a] BROVIAC catheter related (n = 2), atopic dermatitis associated, pulmonary TB, sister had pulmonary TB (n = 1 each). Data are presented as %, n (%), or mean ± standard deviation. CRP = C-reactive protein; CT = computed tomography; URI = upper respiratory tract infection; WBC = white blood cell.

dyspnea (n = 2, 3.8%), uvular deviation (n = 1, 1.9%), and limited neck motion (n = 2, 3.8%) were less common in our patient group, although they are typically found in most DNI patients.

Pus cultures were available only for 31 patients, and 61.3% (19/31) had an identifiable organism (Table 3). The most commonly isolated pathogen was *Staphylococcus aureus* [including 6 (19.4%) methicillin-sensitive *S. aureus* (MSSA) and 1 methicillin-resistant *S. aureus* (MRSA)]. Others pathogens isolated included coagulase-negative *Staphylococcus* (n = 3, 9.7%), mixed flora (n = 3, 9.7%) *Mycobacterium tuberculosis* (n = 2, 6.5%), anaerobic bacteria (n = 2, 6.5%), *Klebsiella pneumoniae* (n = 1, 3.2%), and viridans streptococci (n = 1, 3.2%). Further analysis of pathogens isolated from different locations is presented in Table 3. Retropharyngeal abscess tends to have predominance of Gram-negative intestinal bacteria. Other space infections tend to be polymicrobial.

All patients received empirical antimicrobial therapy to treat infections caused by oral flora, *S. aureus*, and enteric Gram-negative pathogens. Amoxicillin—clavulanic acid (56.6%) was most commonly used, followed by penicillin (15.1%). The antimicrobial agents and their doses were adjusted according to bacterial culture and clinical response.

Discussion

Adult patients with DNI often present with obvious clinical signs and symptoms; however, children with DNI tend to have a subtle presentation.[9] A comprehensive history taking and physical examinations are very crucial to diagnose this infection in children. In our study, neck mass or swelling (82.7%) was the most common symptom, regardless of the DNI location. When a patient (regardless of age) presents with neck mass or swelling, the DNI should always be included in the differential diagnosis.[10] Although DNI is a febrile disease, only 75% of patients had fever in this study. *M. tuberculosis* and anaerobic pathogens tend to cause afebrile infection. Other common symptoms, such as poor appetite, sore throat, and irritability were unspecific. Only two patients developed dyspnea. In addition, uvular deviation, unsymmetrical tonsils size, and limited neck motion may be other clues besides fever to diagnose DNI in children.

There are a few clinical characteristics that can serve as a guide to identify DNI. In our DNI series, all submandibular patients had neck mass or swelling, and all patients afflicted with peritonsillar abscess and multispace abscess had fever. The most common site of infection was the

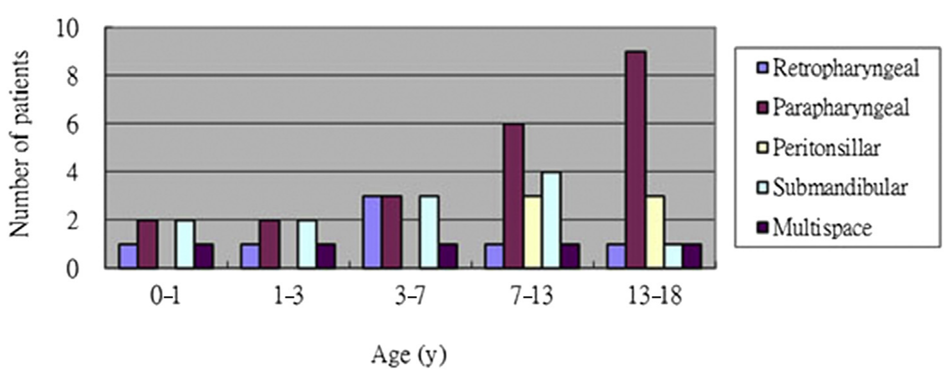

Figure 1. Age distribution of deep neck infections.

Table 2 Clinical characteristics, laboratory data, and management of patients with different sites of deep neck infections.

Characteristics	Retropharyngeal	Parapharyngeal	Peritonsillar	Submandibular	Multi-space [a]	p
Case No.	7	22	6	12	5	
Age (median, y)	5.50	9.17	12.75	4.59	4.50	0.172
Length of hospital stay (mean, d)	10.00	7.00	5.00	6.00	10.00	0.193
Clinical presentation						
Fever	6 (85.7)	15 (65.2)	6 (100)	7 (58.3)	5 (100)	0.17
Neck mass or swelling	4 (57.1)	20 (90.9)	3 (50)	12 (100)	4 (80)	0.024
Sore throat/dysphagia	2 (28.6)	4 (18.2)	4 (66.7)	0 (0)	1 (20)	0.026
Dyspnea	0 (0)	0 (0)	0 (0)	1 (8.3)	1 (20)	0.233
Limited neck motion	0 (0)	0 (0)	1 (16.7)	0 (0)	1 (20)	0.098
Computed tomography scan	7 (100)	17 (77.3)	6 (100)	9 (75)	5 (100)	0.284
Culture rate	1 (14.3)	16 (72.7)	2 (33.3)	8 (66.7)	4 (80)	0.035
Surgical intervention	2 (28.6)	16 (72.7)	3 (60)	8 (66.7)	5 (100)	0.11
Complication	1 (14.3)	3 (13.6)	0 (0)	1 (8.3)	1 (20)	
Mortality	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	

[a] Two or more spaces were involved.
Data are presented as *n* (%).

parapharyngeal space ($n = 22$, 42.3%) in our review. This is because the peritonsillar, submandibular, and parotid spaces communicate with the parapharyngeal space, and infection in these spaces can spread to the parapharyngeal space.[11] Previous studies reported a different result concerning the distribution of DNI (Table 4). In a study on DNI in central Taiwan by Yen et al[6], the retropharyngeal space was reported as the most common site for DNI. However, in a study on DNI in north Taiwan,[7] the peritonsillar space was reported as the most common site for DNI in adolescents, which was similar to the results observed in our school-age group. Children in the school-age group are more prone to peritonsillar abscess because they are often candidates for *Streptococcus pyogenes* throat infections that may lead to peritonsillar abscesses.[12] However, no *S. pyogenes* was identified in peritonsillar abscess in our study. Empirical

Table 3 Pus culture of patients with deep neck infections.

Microorganisms	No. of cases
No growth	12
Methicillin-sensitive *Staphylococcus aureus*	6
Coagulase-negative *Staphylococcus* (includes *Staphylococcus epidermidis*)	3
Mixed flora [a]	3
Mycobacterium tuberculosis	2
Anaerobic bacteria [b]	2
Klebsiella pneumoniae	1
Viridans streptococci	1
Methicillin-resistant *S. aureus*	1
Pathogens isolated from different site of deep neck infections	
Retropharyngeal	*Escherichia coli* (n = 1), *Klebsiella pneumoniae* (n = 1), *Veillonella* (n = 1)
Parapharyngeal	Methicillin-sensitive *S. aureus* (n = 3), methicillin-resistant *S. aureus* (n = 1), *M. tuberculosis* (n = 2), *Propionibacterium acnes* (n = 1), viridans streptococci (n = 1), *Neisseria* spp. (n = 1), beta-lactamase (−) (n = 1), *Eikenella corrodens* (n = 1), *Tissierella praeacuta* (n = 1), *Prevotella* sp. (n = 1), *S. epidermidis* (n = 1), Group F *Streptococcus* (n = 1), *Anaerococcus (Peptostreptococcus) prevotii* (n = 1), *Fusobacterium nucleatum* (n = 1)
Peritonsillar	None
Submandibular	Methicillin-sensitive *S. aureus* (*n* = 3), *K. pneumoniae* (*n* = 1), Coagulase-negative *Staphylococcus* (*n* = 1), Group F *Streptococcus* (*n* = 1)
Multispace	Methicillin-sensitive *S. aureus* (n = 1), Coagulase-negative *Staphylococcus* (n = 1)

[a] Mixed flora included the following: (1) viridans streptococci, *Neisseria* spp., beta-lactamase (−), *E. corrodens*; (2) *E. coli*, *K. pneumoniae*, *Veillonella* spp. (3) Group F *Streptococcus*, *A. (P.) prevotii*, *F. nucleatum*
[b] Anaerobic bacteria: *P. acnes*, *T. praeacuta*, and *Prevotella* sp.

Table 4 Comparison of recent studies about deep neck infection in children.

Study	Study period/Case No./M:F	Most clinical manifestation	Risk factors	Pathogens	Country
This study	2005–2014/52/29:23 [a]	Neck swelling, fever	Upper respiratory tract infection, odontogenic, congenital cyst	Methicillin-sensitive *Staphylococcus aureus* (mostly), Coagulase-negative *Staphylococcus*, *Mycobacterium tuberculosis*, anaerobic bacteria, Methicillin-resistant *S. aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, & mixed flora	Taiwan
Yen et al[6]	1994–2004/52/32:20 [a]	Neck swelling		Viridians streptococci (mostly), coagulase-negative *Staphylococcus*, oxacillin-resistant *S. aureus*, oxacillin-sensitive *S. aureus*, & *Eubacterium lentum*	Taiwan
Chang et al[7]	1996–2007/50/29:21 [a]	Fever, odynophagia, neck pain/mass		*Streptococcus* (mostly *Streptococcus pyogenes*), mixed flora, normal flora, anaerobic bacteria, *S. aureus*, *K. pneumoniae*, & *Bartonella henselae*	Taiwan
Raffaldi et al[27]	2006–2012/60/32:28 [a]			*Streptococcus* sp. (mostly *S. pyogenes*), *S. aureus*, *Veillonella*, *Mycobacterium scrofulaceum*, *Gemella morbillorum*, *Pseudomonas aeruginosa*, *Bacteroides uniformis*, & *Prevotella melaninogenica*	Italy
Novis et al[29]	2000–2009/ [b]				USA
Cheng & Elden [28]	2007–2012/178/116:62 [c]			Methicillin-resistant *S. aureus*, beta-hemolytic *Streptococcus* group A, methicillin-sensitive *S. aureus*, *Haemophilus influenzae*, *Streptococcus milleri*, *Enterobacter*, & *Klebsiella*	USA
Santos Gorjón et al[17]	1999–2009/48 [d] /28:20		Pharyngotonsillitis, odontogenic cyst, lesions/trauma		Spain

[a] All children aged $<$ 18 years.
[b] The incidence of retropharyngeal abscess increased significantly from 0.10 cases/10,000 in 2000 to 0.22 cases/10,000 in 2009 ($p = 0.02$). There was no significant change during this period in the incidence of combined deep neck infections (1.07–1.37 cases/10,000; $p = 0.07$), peritonsillar abscess (0.82–0.94 cases/10,000, $p = 0.12$), or parapharyngeal abscess (0.08–0.14 cases/10,000; $p = 0.13$).
[c] Number of children aged $<$12 years.
[d] Number of children aged $<$14 years.

antibiotics already initiated before obtaining culture sample might have masked the culture result. When pus drainage was available, we will remind the physician to set the Gram stain of pus instead of culture only if initial antimicrobial therapy already administrated. Because the culture results may be negative and at this time, Gram stain is helpful and necessary for pathogens identified.

Preceding upper respiratory tract infection (30.8%), dental infection (15.4%), and congenital anomalies, such as congenital cysts (15.4%), were the leading causes of DNI in our study. These findings were consistent with previous other studies.[7,13,14] This association can be explained as follows: infection of the ears, nose, or throat may spread to deep neck spaces by direct continuity or by lymphatic drainage to lymph nodes in these regions.[9] Five patients with bronchogenic cyst had recurrent disease. These congenital lesions with infection were noted more frequently in pediatric patients.[5,15] They all received excision surgery to treat recurrent infections. Jin and Zhang[16] and Santos Gorjón et al[17] reported that chocking with foreign bodies, trauma, and prior surgery were risk factors to DNI. In our study, DNI in two patients was associated with Port-A catheter-related infection. These two patients were diagnosed to have immature teratoma and Langerhans cell histiocytosis at their 7th day and 6th month, respectively. In these two patients, a small port-A catheter (BROVIAC catheter, 301 8th Street South, Kirkland, Washington 98033, USA) was inserted for chemotherapy. The BROVIAC catheter was implanted from the neck region, and pushed down through the jugular vein until it reached the superior vena cava. Catheter-related parapharyngeal abscess was noted in both patients, with the former also acquiring bacteremia. There was no case of children choking on foreign bodies. Pathogens were not identified in two fifth of patients (38.7%), with no clear trigger. It appears that our data are consistent with a previous study,[18] in which nonidentified causes of pediatric DNI varied between 35% and 40%.

From our review, the recurrence of DNI should alert the physician to the possibility of an underlying bronchogenic cyst. Prompt imaging studies are helpful to detect such congenital anomalies early and provide adequate treatment. CT scanning is the most widely used modality for diagnosing DNI because it is less expensive and readily available.[19] In our experience, 44 patients (84.6%) used CT as an initial evaluation method to identify the site of infection and location of abscess formation. We agree that CT has advantages of fast and accurate diagnosis, enabling the quick formulation of a treatment plan with safe and appropriate drainage.[20] We suggest that physicians should perform CT imaging examination on all patients exhibiting signs and symptoms of DNI for better diagnosis.

DNIs are most often polymicrobial. The pathogens commonly isolated from pus cultures are group A *Streptococcus*, oropharyngeal anaerobic bacteria, and *S. aureus*.[5,7,8,21] Other pathogens may include *Haemophilus influenzae*[22] and *Klebsiella pneumoniae* in diabetic patients.[23,24] In our study, 31 (59.6%) pus cultures were obtained, and this rate is similar to previous studies in Taiwan.[5–7] It is not common to obtain cultures because these children required sedation and even required general anesthesia for drainage of abscess. Intravenous antimicrobial therapy was the first treatment option. Surgical intervention was performed if the symptoms did not show good improvement or if the infections recurred with pus formation. Among the pus samples obtained, 12 of the 31 pus cultures were sterile. This is mostly because patients with DNI transferred to this hospital had been already received antimicrobial agents before bacterial culture. The most commonly identified pathogen was *S. aureus* (Table 3). Seven of the 31 pus cultures yielded *S. aureus*, which included six MSSA and one MRSA cultures. Our finding is different from previous reports. Bolton et al[25] and Abdel-Haq et al[26] demonstrated an increased risk of MRSA in children younger than 2 years and an association between MRSA and mediastinitis. These two studies were performed in North American regions. However, our study showed no predominance of MRSA in pediatric DNI cases, with similar results being obtained in other Asian and Taiwanese studies.[5–7,23] In the studies by Raffaldi et al,[27] Cheng and Elden,[28] and Chang et al,[7] *S. pyogenes* was the most common pathogen. However, none of the cultures yielded *S. pyogenes* in our study. This is because in the aforementioned studies, peritonsillar space was the most common site of DNI, which is prone to *S. pyogenes* infection. In our study, peritonsillar abscess occurred only in few patients, and their cultures yielded different microorganisms. Two of our patients had DNI caused by *M. tuberculosis*. These two patients initially presented with DNI. One patient was diagnosed with pulmonary tuberculosis (TB) afterward, and the other was diagnosed with only TB DNI. Between these two patients, one patients sister had pulmonary TB. Thus, we strongly recommend history taking, as it could provide clues to accurate diagnoses.

From our review, it is clear that antibiotic spectrum should cover both Gram-positive and Gram-negative, and both aerobic and anaerobic pathogens. We suggest amoxicillin—clavulanic acid alone, or third-generation cephalosporins, either alone or in combination with metronidazole, as the first-line treatment. Antibiotics were subsequently adjusted according to susceptibility test results. Twenty-one patients (40.4%) were successfully treated with antimicrobial therapy alone. In a previous study, medical therapy failure occurred in children aged $\leq$ 15 months ($p = 0.002$) and for abscesses $\geq$ 2.2 cm ($p = 0.0001$).[28] Based on our study results, surgical intervention was strongly suggested for bronchogenic cyst. However, a small sample size and absence of standardized management in each case in our study limited further analysis. Thus, a well-designed, prospective study should be considered to identify clinical characteristics that would predict successful nonoperative management.

In general, patients with DNI rarely had bacteremia. Only one (1/52) patient (female), with the former also acquiring bacteremia. She was under chemotherapy and was an immunocompromised host. All children had resolution of infection without mortality or long-term morbidity. This can attributed to the current developments in medical care and mirror a good clinical practice.

Limitations of this study include its retrospective design, small sample size due to the relatively low prevalence of this infection, and single-medical center data. Empirical antimicrobial coverage may have affected the microbiologic findings. However, the characteristics of DNI in children can still be identified from this study. Besides, we also isolated causative pathogens from cultures.

In summary, DNI in children can often be successfully managed with medical therapy and surgical intervention if they are diagnosed early. Emergent condition and complications were less common in the recent years of the post-antibiotics era. However, clinicians must be aware of such infections and should not underestimate their potential extent or severity.

Conflicts of interest

The authors declare that they have no conflict of interest.

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