DIAGNOSTIC APPROACHES AND MANAGEMENT OF DEEP NECK SPACE INFECTIONS

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DIAGNOSTIC APPROACHES AND MANAGEMENT OF DEEP NECK SPACE INFECTIONS (Abstract): Deep neck infections (DNI) represent critical medical conditions involving the deep cervical spaces and demand urgent and precise diagnostic measures to prevent severe complications such as airway obstruction, mediastinitis, and sepsis. Accurate and early diagnosis is paramount for effective management and improved patient outcomes. The study has in mind an analysis that provides a component for the efficiency of the medical act and resources, in order to optimize diagnostic strategies and to prevent the occurrence of sepsis. **Materials and methods**: An observational analytical retrospective study was conducted on a group of 110 patients selected from January 1, 2016 to December 31, 2022. **Results**: The most frequent clinical presentation was the infection of the lateral cervical space, the frequency of cases being 61 (55.45%), followed by the parapharyngeal and prevertebral locations 24 (21.82%). Considering the laboratory investigations, the white blood cell count was above the normal value with a mean of 15410.1 (SD: 5455). Positive culture was obtained from 61 patients (55.45%). Isolated aerobic bacteria were isolated in 29 (48.3%), gram positive aerobic bacteria were identified in 38 (34.55%), and Gram-negative aerobic bacteria in 8 (7.27%). Nonbacterial culture was observed in 47 patients (42.73%). All 110 patients received intravenous broad-spectrum antibiotics, which were subsequently upgraded based on culture and sensitivity report. Complications were encountered in 46 patients (41.82%). Airway Obstruction was presented by 24 patients (21.82%), and Mediastinitis was found in 31 patients (28.18%) (tab. III). The average number of days of hospitalization in the hospital was 17.3 days (SD: 10.49), and it varied between 2 days and 51 days. **Conclusions**: Success in the therapy of deep neck infections lies in early and accurate diagnosis, appropriate use of antibiotics, timely surgical intervention when necessary and a multidisciplinary approach to care. This ensures effective infection control and minimizes the risk of complications, ultimately improving patient outcomes. **Keywords**: DEEP NECK SPACE INFECTIONS.

INTRODUCTION

Deep neck infections (DNI) are infections in the potential spaces and fascial planes of the neck with abscess formation or cellulites (1). These involve the deep spaces of the neck and are bacterial infections originating in the upper aero digestive tract. DNI represents pathology with multiple implications, being a major surgical emergency with rapid evolution towards complications that, if not treated timely, can lead to death (2).

The incidence of this disease was relatively high before the advent of antibiotics, requiring prompt recognition and early interventions (3). Odontogenic infection is one of the most common causes, especially in developing countries (4). Clinical manifestations of DNI depend on the spaces involved and include pain, fever, malaise, fatigue, swelling, odynophagia, dysphagia, trismus, dysphonia, otalgia, and dyspnea (5, 6).

Descending necrotizing mediastinitis is the most feared complication and results from retropharyngeal extension of infection into the posterior mediastinum. Septic shock is associated with a mortality rate of 40-50% (7, 8). In addition, suppurative thrombophlebitis of the internal jugular vein associated with pulmonary septic embolism, cavernous sinus thrombosis, and carotid artery erosion have been reported (9).

Management of deep cervical infections includes prompt diagnosis, antibiotic therapy, airway management, and surgery. The therapeutic approach is traditionally based on prompt surgical drainage of the abscess followed by antibiotics or non-surgical treatment using appropriate antibiotics in the case of cellulites (10). Proper diagnosis and prompt management can effectively overcome the disease and provide a cure without complications. However, for this to be possible, otolaryngologists must have a good insight into the presentation, etiology, investigations, and access to appropriate medical and surgical interventions (11, 12).

The aggressiveness of this pathology with a mortality of 20-25%, which can reach 40% of cases through mediastinal extension, requires multidisciplinary, Otolaryngology, oral and maxillofacial treatment, thoracic surgery, anesthesia and intensive therapy (13, 14). These infections are frequently polymicrobial, with a symbiotic relationship between aerobic and anaerobic bacteria (15). Streptococci, *Peptostreptococcus species*, *Staphylococcus aureus* and anaerobes are the most commonly cultured organisms in DNI (16). Many authors recommend urgent drainage, as the infection from cervical abscesses can easily spread and have life-threatening complications such as acute obstruction of the upper respiratory tract, mediastinitis, sepsis, even death (16, 17).

The aim of our study was to present the experience of the Otolaryngology and Oromaxillofacial Departments of the "Sf. Spiridon" County Clinical Emergency Hospital in Iasi, Romania regarding clinical aspects, involved locations, bacteriology, management and complications in deep neck infections. The study focuses on an analysis that provides a component for the efficiency of the medical act and resources, in order to optimize diagnostic strategies and to prevent the occurrence of sepsis.

MATERIALS AND METHODS

An observational analytical retrospective study was conducted on a group of 110 patients selected from January 1st, 2016 to December 31st, 2022. Patients included in

the study were hospitalized for deep throat infection, surgical and medical treatment. The medical data recorded in the patients' electronic records were processed, alongside appropriate imaging (computed tomography and intraoperative photo images). The study was approved by the Clinical Research Ethics Committee at the "Sf. Spiridon" County Clinical Emergency Hospital in Iasi, Romania 15/03/2021.

Inclusion criteria comprised of hospitalized patients who were diagnosed with deep throat infection; with bacteriological examination performed; CT examination and who required surgery.

Exclusion criteria included patients with fistulized or incised peritonsillar phlegmon without affecting the deep cervical spaces, patients with infections in the cervical region that did not require surgical interventions, as well as patients with fistulized intra-oral abscesses.

The identification and documentation of the cases considered the existing changes at the cervico-facial level, the associated lesions and associated pathology, etiology, imaging investigations, treatment method, time elapsed from the diagnosis to the surgical intervention, follow-up in the dynamics of postoperative healing, the complications, surgical reinterventions to avoid the extension of the infection to mediastinum.

The following parameters were analyzed: patient age, sex, antibiotic therapy before admission, imaging and radiological investigations, symptoms, comorbidities, location of infections, treatment, intraoperative findings, bacteriological culture results, complications, length of hospitalization. Abscess locations were divided into 6 regions: submandibular and retrostylian, parapharyngeal and prevertebral. lateral cervical, anterior cervical, retropharyngeal and cervical mediastinitis. All patients were operated under general anesthesia. All 101 patients received IV antibiotic therapy. The choice of antibiotic drugs was decided according to the patient's age, comorbidities and whether he had previously received antibiotic treatment. Antibiotic treatment was reviewed based on culture results and patient response. The selected antibiotics were: cefort and gentamicin or with amoxicillin and clavulanic acid; amoxicillin and clavulanic acid with clindamycin; meropenem, clindamycin and vancomycin +/- colistin; ceffort and clindamycin; cefort and metronidazole.

Microbiology cultures were obtained for all 110 patients for both aerobic and anaerobic agents. The identification of pathogens in the first 24-48 hours was carried out by bacteriological examination of secretions from the abscess, taken by puncture or from the surgical wound. To identify the germs, the MALDITOF device was used, the antibiograms were performed on cards on Team Freedom Evo. Results were checked after the institution of the treatment according to the antibiogram to see if negative.

Statistical Analysis. The statistical analysis of data was performed using a *SPSS version 29* statistical package program. Descriptive statistics of the analyzed variables were performed. Continuous variable was reported as mean values and standard deviation (SD) or median with 25^{th}–75^{th} percentiles (range), depending on the normality and homogeneity of the data series. The Kolmogorov–Smirnov test was applied to verify the normal distribution of the variables. The qualitative variables were presented as absolute (n) and relative (%) frequencies, and the comparison among the groups was based on the results of the

Pearson chi-square test. The significance level calculated in utilized tests (p-value) was considered for the values of $p < 0.05$.

RESULTS

In the "Sf. Spiridon" County Clinical Emergency Hospital in Iași, Romania between January 1st, 2016 and December 31st, 2022, 1,921 patients were treated in the departments of Otolaryngology and Oro-maxillo-facial. According to the inclusion and exclusion criteria mentioned in the material and method section, 110 patients with deep neck infections (DNI) were included in the study. The analysis of patient characteristics indicated a large predominance of male patients (74.55%). Their average age in the analyzed group was 53.77 (standard deviation: 15.3).

Considering the laboratory investigations, the white blood cell count was above the normal value with a mean of 15410.1 (SD: 5455). The mean values and standard deviations of the results of laboratory investigations are presented in table I. The mean C reactive protein (CRP) level was 25.58 mg/L, and the mean blood sugar level was 125.8 mg/dL. There were 34 patients with diabetes (30.91%) (tab. I).

The most frequent clinical presentation was the infection of the lateral cervical space, the frequency of cases being 61 (55.45%), followed by the parapharyngeal and prevertebral locations 24 (21.82%) (tab. I). The most common etiology in our study proved to be the pharyngo-tonsillar localization of the infection, constituting 52.7% of cases. Sore throat 81 (73.64%) and dysphagia were the most common symptoms 84 (76.36) (tab. I).

Comorbidities were found in 52.73% of patients (58 cases). Very frequently they were associated, 82.3% of patients presented two or more associated comorbidities (tab. I). Diabetes mellitus was found in 30.91% of cases (34 patients), and cardiovascular diseases were reported in 35.45% of cases (39 patients). Cardiovascular disease included coronary heart disease or other prior myocardial disease, congestive heart failure, prior stroke, or transient ischemic attack. Immunocompromised status was also found in 20.19% of cases (23 patients) and malignant tumors in 3.64% of cases (4 patients). In the group of immunocompromised patients, we included patients receiving drugs for autoimmune diseases or other known immunodeficiencies. Alcohol excess was mentioned in the patient's history in 5.45% of cases (6 patients) (tab. I).

Positive cultures were obtained from 61 patients (55.45%). Isolated aerobic bacteria were isolated in 29 (48.3%), gram positive aerobic bacteria were identified in 38 (34.55%), and Gram-negative aerobic bacteria in 8 (7.27%). Nonbacterial culture was observed in 47 patients (42.73%) (tab. II).

All 110 patients received intravenous broad-spectrum antibiotics, which were subsequently upgraded based on culture and sensitivity report. Complications were encountered in 46 patients (41.82%). Airway obstruction was presented by 24 patients (21.82%), and Mediastinitis was found in 31 patients (28.18%) (tab. III). The average number of days of hospitalization in the hospital was 17.3 days (SD: 10.49), and it varied between 2 days and 51 days (fig.1).

There was no significant relationship between length of hospitalization and patients' comorbidities ($p = 0.0874$). Also, the statistical analysis did not reveal a statistically significant relationship between the hospitalization time and the location of deep neck infections. ($p = 0.0791$).

TABLE I.

Baseline characteristics of the patients with deep neck infections

Characteristics	Group study,n=110 cases
Gender, male / female, n (%)	82 / 28 (74.55 / 25.45)
Age, years, mean (SD)	53.77 (15.13)
Blood test	
Leukocytes, mm^3, mean (SD)	15410.1 (5455)
C-reactive protein, mg/L, mean(SD)	25.28 (9.04)
ESR (erythrocyte sedimentation rate), mean (SD)	49.2 (16.75)
Fibrinogen, mg/dL, mean (SD)	595.6 (98.8)
Presepsin, pg/m, mean (SD)	527.2 (114.4)
Blood sugar, mg/dL, mean (SD)	125.8 (57.7)
Neutrophil ratio (%)	81.2 (13.5)
Creatinine (µmol/L)	76.9 (11.6)
Location	
submandibular and retrostylian	15 (13.64)
parapharyngeal and prevertebral	24 (21.82)
lateral cervical	61 (55.45)
anterior cervical	17 (15.45)
retropharyngeal	14 (12.73)
cervical mediastinitis	21 (19.09)
Etiology factors	
odontogenic infections	9 (8.18)
pharyngo-tonsillar infections	58 (52.73)
epiglottis	16 (14.55)
foreign body	3 (2.73)
congenital cyst or trauma	14 (12.73)
laryngo-tracheal infections	12 (10.91)
lymphadenopathy	15 (13.64)
Symptoms	
pain	39 (35.45)
sore throat	81 (73.64)
dysphagia	84 (76.36)
dyspnea	19 (17.27)
dysphonia	7 (6.36)
otalgia	6 (5.45)
chest pain	9 (8.18)
fever	57 (51.82)
Comorbidities	58 (52.73)
Diabetes mellitus	34 (30.91)
Cardiovascular diseases	39 (35.45)
Alcohol abuse	6 (5.45)
Immunocompromised status	23 (20.91)
Malignant tumors	4 (3.64)

Continuous variables were expressed as mean (standard deviation),
the variables did have a normal distribution. Categorical variables: number (%).

TABLE II.

Pathogen spectrum in deep neck infections

Pathogens	Group study, n=110 cases
Species	
Monomicrobial	46 (41.82)
Gram-positive aerobe	38 (34.55)
Gram-negative aerobe	8 (7.27)
Polymicrobial	15 (13.64)
2 pathogens	11 (10)
3 pathogens	4 (3.64)
Gram-positive aerobes	
Streptococcus viridans	7 (6.36)
Staphylococcus aureus	14 (12.73)
Group C Streptococci	5 (4.55)
Streptococcus B hemolyticus	4 (3.64)
Streptococcus constellatus	12 (10.91)
Streptococcus anginosus	3 (2.73)
Pseudomonas aeruginosa	8 (7.27)
Klebsiella pneumoniae	7 (6.36)
Other gram-positive cocci	4 (3.64)
Enterococcus species	2 (1.82)
Peptostreptococcus	2 (1.82)
Gram-negative aerobes	
Escherichia coli	4 (3.64)
Haemophilus influenzae	2 (1.82)
Acinetobacter	5 (4.55)
Enterobacter cloacae	3 (2.73)
Fusobacterium species	1 (0.91)

Categorical variables: number (%).

TABLE III.

Morbidity and mortality of patients with deep neck infections

	Group study, n=110 cases
Complications	46 (41.82)
Without complications	64 (58.18)
Airway Obstruction	24 (21.82)
Mediastinitis	31 (28.18)
Pneumonia	9 (8.18)
Necrotizing fasciitis	5 (4.55)
Spontaneous fistulization	15 (13.64)
Internal Jugular Vein Thrombosis	3 (2.73)
Renal insufficiency	15 (13.64
Mortality	10 (9.09)
Number of days of hospitalization, mean (SD)	17.3 (10.49)

Categorical variables: number (%).

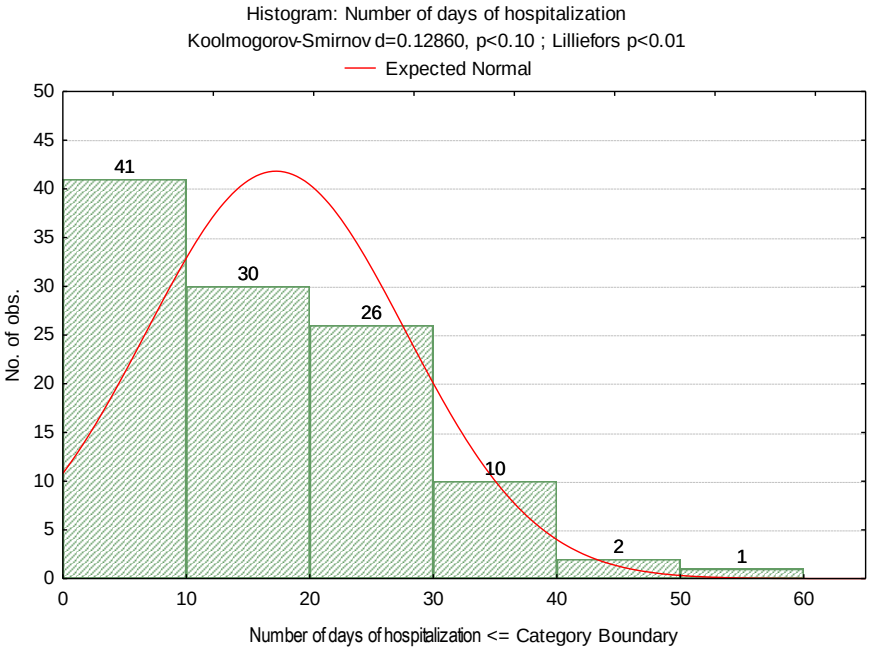

Fig. 1. Histogram of the hospitalization length (days)

DISCUSSION

Recent studies indicate that the incidence of DNI has not significantly declined despite advances in antibiotic therapy, likely due to increased rates of antibiotic resistance and the prevalence of comorbid conditions such as diabetes mellitus and immunosuppression (18). Common pathogens include *Streptococcus species*, *Staphylococcus aureus*, MRSA, and anaerobic bacteria. The rise in odontogenic infections as a primary source of DNI has also been noted, suggesting the need for improved dental care and early intervention for dental abscesses (19).

Computed tomography (CT) with contrast remains the gold standard for diagnosing DNI, offering detailed information on the extent of the infection and the presence of abscesses. Magnetic resonance imaging (MRI) has shown promise in specific scenarios, such as when evaluating potential complications like vascular involvement or when CT results are inconclusive (20). Ultrasound has gained traction for initial evaluations and guiding needle aspirations, particularly in pediatric populations (21).

Empirical broad-spectrum antibiotic therapy remains a cornerstone in managing DNI, with regimens typically including coverage for both aerobic and anaerobic bacteria. Studies highlight the increasing importance of tailoring antibiotic therapy based on culture results to combat antibiotic resistance effectively (22).

There is ongoing debate regarding the necessity of surgical intervention in all cases of DNI. Recent data suggests that in selected cases, particularly with smaller abscesses (<3 cm), conservative management with antibiotics alone may be sufficient (23). However, surgical drainage

remains essential for larger abscesses and when there is imminent risk of airway compromise or progression to mediastinitis. Minimally invasive procedures, such as CT-guided needle aspiration and endoscopic drainage, have been increasingly utilized and show promise in reducing the morbidity associated with traditional open surgical procedures. These techniques are particularly useful for patients with significant comorbidities who may not tolerate more invasive surgery (24).

Recent literature highlights the high risk of complications associated with DNI, including airway obstruction, mediastinitis, and septic shock (25). Early intervention remains critical in preventing these severe outcomes. The role of corticosteroids in reducing inflammation and preventing airway compromise is being explored, with some studies indicating potential benefits in selected patients (26).

Management of DNI in pediatric populations requires special consideration due to anatomical and immunological differences compared to adults. Studies emphasize the importance of conservative approaches and the judicious use of imaging and surgical interventions to minimize long-term sequelae in children (27).

Deep neck infections are serious and potentially life-threatening conditions that require prompt diagnosis and effective management. They involve the potential spread of infection in the deep spaces of the neck, which can lead to severe complications such as airway obstruction, sepsis, and mediastinitis (28).

Identifying the profile of the patient with deep throat infection allows doctors to provide appropriate and timely treatment to manage the infection. Prompt airway protection for patients with deep neck infections and mediastinitis is extremely important. Upper airway obstruction and subsequent respiratory failure require emergency tracheostomy. Effective management of the deep neck infections requires a multidisciplinary approach involving otolaryngologists, infectious disease specialists, radiologists, and critical care teams to address both the infection and its potential complications (29).

Deep neck infections occur in the potential spaces and fascial planes of the neck. The management of such infections typically involves the use of diagnostic imaging, such as CT scans or MRI, to accurately locate and determine the extent of the infection. Treatment generally includes a multidisciplinary approach engaging various specialists like otolaryngologists, infectious disease experts, head and neck surgeons, radiologists, microbiologists, and intensive care specialists (30).

The primary aims of treatment are to control the infection and prevent complications. This often involves surgical intervention to drain any abscesses and debride necrotic tissue. Antibiotic therapy is essential and typically broad-spectrum to cover a variety of bacteria until specific pathogens can be identified. In advanced cases, reconstructive surgery or tissue grafts may be necessary to repair or replace tissues damaged by the infection (31). Continuous research and advancements in head and neck reconstructive techniques are crucial for improving long-term outcomes and restoring both function and appearance for patients following a deep neck infection (32).

In order to reduce the duration and costs of hospitalization, we propose dynamic evaluation of bacteriological examinations, of local evolution through serial computer

tomography examinations, as well as establishing the moment of surgical intervention (tracking the number of days that elapse from hospitalization to the surgical procedure (33). Information regarding the sequencing in the dynamics of biological and imaging parameters will contribute to the safety of the therapeutic act. The retrospective, but especially prospective, follow-up study will bring information on bacteriological variability, which will contribute to preventive therapeutic strategies (targeted antibiotic therapy) for severe complications (IJV thrombophlebitis, sepsis).

Deep abscesses of the cervical region are of major importance due to their frequency and severe complications. Similarly, with Singhal *et al*., 2022, our studies observed a higher incidence in the young male population (34).

However, Huang *et al*. and other studies also show an upward trend in the incidence of infections in elderly patients and patients with systemic diseases. In this group, defense mechanisms would be less effective, recovery rates would be slower and complications would be more frequent (35).

In the pre-antibiotic era, pharyngeal, tonsillar infections were responsible for 70% of deep throat infections (36).

Currently, many studies show a significant decrease in incidence, with odontogenic infections being the most common cause. In our study, bacterial tonsillitis was the most common cause (31.68%), followed by odontogenic infection (23.7%), totaling 55.3% of our samples (37).

In a study by Kusumoto *et al*., the dental focus was the origin of the most frequent abscesses in 37% of patients, while pharyngeal tonsils and disorders were present in 20% of cases, not being possible to identify the source of infection in 33% of patients (38). For Sennes *et al*. odontogenic infection was the cause in 42.1% of patients, tonsillitis in 17.5%, post infections of the upper airways in 15.8% and unknown cause in 8.8% lymphadenitis (39).

Other authors have also reported a significant proportion of deep cervical space infections of unknown primary origin, reaching up to 50% of cases (40).

In 14.8% of our patients, the etiology infection could not be determined, probably because the initial infection was not promptly diagnosed, although it preceded the abscess. Thus, the average time from symptom onset to diagnosis in our study was 8 days, but it was up to 20 days and the main symptoms were fever and sore throat (41).

Knowledge of the anatomical relationships between the spaces of the neck is important for therapeutic management, because the fascia limiting these spaces represent important anatomical barriers to the spread of infection, but also serves to direct infection once its natural resistance is overcome (42).

Other indicators of health care use, such as medications used before and frequency, were not possible to obtain because most patients received treatment for their acute episodes in remote locations, either by their primary care physicians or by their local ENT specialist. However, this may probably be caused by the history of antibiotic abuse and antibiotic resistance explained by the indiscriminate use of antibiotics, especially in colds and other viral infections, which are more prevalent in children than in adults. Prior antibiotic use is correlated with greater recovery of resistant organisms and increased incidence of lactamase-producing bacteria (43).

Adults have infections of the cervical

spaces with multiple interest, this being due to the increased incidence of comorbidities in adults compared to children. Patients with comorbidities tend to have weaker defenses against infections and thus result in higher rates of severe infections that also lead to death.

The microbiology of deep cervical suppurations is characterized by being generally polymicrobial infections, including aerobic and anaerobic, gram positive in particular. Among the pathogens commonly found were: *Streptococcus viridans*, *Streptococcus milleri*, *Prevotella spp.*, *Pepto streptococcus spp.* and *Klebsiella pneumoniae*, the latter being more common in diabetic patients (26). Sennes found *Streptococcus viridans* in 41.5% of cases, *Staphylococcus aureus* in 20.7% of them and 3.8% with *Haemophilus influenzae* (44).

Many studies have shown the association of diabetes mellitus with deep suppurations (9, 11). In patients with diabetes, hyperglycemia can affect several humoral defense mechanisms of the host, such as the modification of neutrophil values, function: adhesion, chemotaxis and phagocytosis, leading to increased predisposition to infection and complications (21). Huang *et al*. found high rates of *Klebsiella pneumoniae* infection in diabetic patients (35).

The management of deep neck infections has evolved significantly over the years, due to ongoing input from by clinical studies, retrospective analyses, and expert consensus.

The literature consistently prioritizes airway management due to the potential for rapid deterioration in patients with DNI. Early recognition of airway compromise and proactive measures, such as intubation or tracheostomy, are critical to prevent life-threatening complications (17).

There is strong consensus on starting broad-spectrum antibiotics immediately upon diagnosis to cover the common pathogens (e.g., *Streptococcus*, *Staphylococcus*, and anaerobes). Empiric regimens often include combinations like ampicillin-sulbactam or clindamycin with a third-generation cephalosporin (25).

Adjusting antibiotic therapy based on culture results and sensitivity patterns is emphasized to avoid resistance and ensure efficacy. This tailored approach is supported by numerous studies highlighting improved outcomes with targeted therapy.

CONCLUSIONS

The management of DNI requires a nuanced approach that balances prompt, aggressive treatment with careful consideration of individual patient factors. Advances in diagnostic imaging and minimally invasive techniques offer new avenues for improving patient outcomes while reducing the risks associated with traditional surgical interventions. Ongoing research and clinical trials are essential to refine these approaches further and address the challenges posed by antibiotic resistance and evolving pathogen profiles. The key to successful management lies in early and accurate diagnosis, appropriate use of antibiotics, timely surgical intervention when necessary, and a multidisciplinary approach to care. This ensures effective control of the infection and minimizes the risk of complications, ultimately improving patient outcomes.

CONFLICT OF INTEREST AND FUNDING

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