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Foodborne Botulism in Jeddah: Causes, Symptoms, Treatment, and Prevention

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Abstract
Botulism is a rare but severe and potentially life-threatening paralytic illness caused by botulinum toxin. Botulism can occur spontaneously or can be induced accidentally. Three main forms of botulism, namely, foodborne botulism, wound botulism, and infant botulism, are recognized. Foodborne botulism is caused by the consumption of improperly prepared or preserved foodstuffs contaminated with Clostridium botulinum toxin. The patients presented with a similar disease that included severe abdominal pain, nausea, and vomiting followed by descending, symmetric flaccid paralysis with bilateral facial nerve palsy. The condition improved over 3 to 4 months with physiotherapy despite the administration of botulinus antitoxin. This work aims to increase awareness in the Middle East about this life-threatening condition.
This is the first report of botulism in Jeddah, Saudi Arabia. Two cases of foodborne botulism have been reported in Saudi Arabia. Both incubations were short, and both patients became acutely ill but recovered. The first case was reported in Al-Baha, in the south of Saudi Arabia, while the second case occurred in Mecca, the holy city. In our study, the laboratory investigations ruled out wound botulism and Konzo and hence established the diagnosis of type A botulism based on clinical findings and a similar history of food consumption. The four patients presented with a similar disease that included severe abdominal pain, nausea, and vomiting followed by descending, symmetric flaccid paralysis with bilateral facial nerve palsy. The condition improved over 3 to 4 months with physiotherapy despite the administration of botulinus antitoxin. It is important to highlight that botulism is a disease that usually occurs after the ingestion of toxic food, which is often home-preserved with a low acidic pH.

1. Introduction to Foodborne Botulism

Jeddah has its own community of people who enjoy different types of homemade foods, which are often made according to family traditions. These traditional food products are consumed regularly and are sometimes kept for long periods of time. Many have been implicated in food poisoning incidents. Some contain species of the microorganisms Clostridium, which, for some individuals, can be life-threatening. C. botulinum is the main species that can cause foodborne botulism, an acute, life-threatening illness caused by the neurotoxin produced by this bacterium. This illness is rare and, fortunately, not well known in Jeddah. The intention of this review is to encourage public awareness about foodborne botulism by providing information about the causes, symptoms, treatment, and prevention of botulism. (Chaidoutiset al.2022)

1.1. Definition and Overview

Botulism is a rare and serious toxin-mediated neuroparalytic disease caused by the bacterium Clostridium botulinum. The spores of C. botulinum are found in soils, marine sediments, and dust, as well as in feces of horses and cattle. Unopened non-acidic canned or preserved foods are the most common sources of human botulism. It is an important public health problem in many countries. Foods with low acidity, e.g., vegetables, meat, fish, and legumes, in combination with insufficient acidity, have a greater risk of harboring the spore or the vegetative form of the organism. The bacterium grows and produces spores under optimal conditions. (Acharya, 2022)(Özcanet al.2024)

After ingestion, the organism multiplies in the intestines, producing toxin in vivo. The widely varying incubation period for foodborne botulism is 12-72 hours; the products of growth and the spores are ingested with the implicated foods. The incubation period can be longer, even ten days or more in some cases. The

symptoms and signs are mostly due to the action of the internally produced botulinum toxins, two of the most potent poisons known. (Esposito et al.2024)

1.2. Historical Background

The clinical syndrome of botulism was first described in 1793 by a German physician who noticed that the symptoms in such cases closely resembled "sausage poisoning." In the 1870s, important studies on the mechanism of action of the toxin were conducted. In the 1890s, the causative organism of this condition, the Gram-positive, spore-forming anaerobe named Bacillus botulinum, was isolated and demonstrated to be capable of producing a toxin. Subsequently, it was shown that toxin production could be blocked by culturing the bacterium in a carbohydrate and protein-rich milieu, resulting in visible growth, but no toxin production. (Smith et al., 2023)

The patient's history, physical examination, enquiring about a recent outbreak in an infrequently consumed food and their appearances, including asparagus, beans, beets, peas, corn, soups, sauces, and meat products are also important in revealing sources contaminated with botulinum. (Kanaan and Tarek, 2020)

2. Botulinum Toxin and Clostridium botulinum

Botulinum toxin is one of the most powerful toxins known to humans. The botulinum toxin is formed by several different strains of bacteria, especially Clostridium botulinum, which tend to grow in conditions with little or no oxygen. There are eight distinct types of botulinum toxin (types A to H), of which types A, B, E, and more rarely F, have been found to be toxic to humans and produce the symptoms associated with botulism. Botulinum toxin interferes with nerve signals by blocking chemical neurotransmission, resulting in paralysis of nerves. (Dong and Stenmark, 2021)

When ingested, the toxin causes one of the most severe forms of foodborne poisoning. Clostridium botulinum, which releases botulinum toxin, can be found almost anywhere as it forms spores that allow it to resist harsh conditions. The spores can grow and release the toxin when introduced to the right environment. Although botulism poisoning is uncommon, it usually occurs after consumption of tainted or preserved food. Antitoxins are used to treat the disease, which may be lethal in both its two most lethal forms. Sanctions to prevent food contamination and proper food preservation can help prevent botulism. However, botulinum toxin is an agent that can be used in bioterrorism, as its lethal dose as an aerosol is very low. (Chaidoutiset al.2022)

2.1. Types of Botulinum Toxin

The most potent toxin known to humans is produced by Clostridium botulinum. The toxin is the etiological agent for foodborne botulism, an acute, usually fatal disease similar to curare when ingested. The toxin causes a decrease in the capability of the cells of the affected tissues (muscles, nerves) to release acetylcholine, which is a neurotransmitter that stimulates muscle contractions. There are seven distinct types of the toxin. Types A, B, and E are most frequently involved in human foodborne botulism, and there are two subtypes, while C, D, and F are known to be involved in animal diseases. (et al., 2020) (Brunt et al.2020)

1) Type A: This is the most frequent type, which causes about 50% of the cases in the U.S. It may occur as bacteria in the soil or as a presumptive organism in food, and it is identified as responsible for minor numbers of the isolated toxins in canned food. An infant mode of this type has not been recognized. (Edmunds et al.2022)

2) Type B: Cases of type B are identified as responsible for some of the toxin or bacteria in canned vegetables, cured olives, and meats; dehydration of the canning process is observed in the case of these products. (Awuchiet al.2021)

3) Type E: This is the type identified as responsible for the spoilage and organoleptic characteristics of flat fish contained within hermetically sealed cartons or glass. It is also suspected of causing a number of cases of scombroid fish toxicity. Type E outbreaks are not especially dangerous to human beings since only about 10% of canned fish containers compromised by it contain enough toxins to be toxic. (Abd2022)

2.2. Characteristics of Clostridium botulinum

The causative agent of foodborne botulism, Clostridium botulinum, is the most heat resistant of all bacterial spores. Spores of non-proteolytic, neonatal, and proteolytic types are associated with botulism. They can survive high temperatures necessary to deactivate all kinds of foodborne pathogens. The destruction of C. botulinum spores by heat follows first-order kinetics. Each species of C. botulinum produces the autolytic enzyme botulinase, which is irreversibly inhibited by redox compounds, especially by plant phenols such as flavonoids. Botulinum toxins are polypeptides that prevent transmitter release in the peripheral vertebrate nervous system. (Chaidoutiset al.2022)

Each type of C. botulinum has different decimal reduction times at different temperatures. Since the spores are located inside the sediment layer, it is difficult to completely remove the spores during processing of low-acid canned food. (Zuoet al.2024)

3. Epidemiology of Foodborne Botulism

Traditional foods and extended family occasion holidays occur not only in Saudi Arabia but also in other countries that face similar food safety issues, unless individuals practicing food preservation take proper precautions. In the marketing, labeling, and shelf life of these products, food regulatory agencies should carefully manage these traditional limited product distributions. (Alhuzaimiet al.2024)

The Saudi Arabian society has strong bonds and enjoys sharing food and celebrating occasions in extensive joint family gatherings. Many healthful traditional practices and cultural welfare customs are chronicled and cherished. Unfortunately, conducting effective food safety methods was not shown to be feasible in the preparation of these foods. The relative ease and comfort of home cooking and the benefit of consuming fresh foods must be greatly prized, but producing these traditional decorated plates comes with responsibility. Safe handling of food during preparation, cooking, and storage has been given appropriate attention by regulatory agencies in the external amenities that provide cooked food services to the public. The Saudi Food and Drug Authority regulates spices, seasonings, and herbs, but only those imported to commercial processors. (Olaimatet al.2020)

3.1. Global Incidence

The incidence of foodborne botulism is low in reaction management to the massive worldwide issue of food spoilage, but the associated public concern is high. As an intoxication, all cases of botulism are caused by the consumption of foods contaminated with botulinum neurotoxin types A, B, E, or F produced by toxigenic strains of C. botulinum. Toxin types C and D are more commonly associated with botulism in animals. The very limited incidence of naturally occurring type C or D botulism in humans is through the consumption of fermented fish intestines. Outbreaks of botulism occur worldwide and, since 2000, outbreaks have been reported in the European Union and at least in North America. The number of botulism outbreaks among humans has increased in recent years and is expected to continue to increase both in the EU and globally. (Lúquez et al., 2021)

In developed countries, these circumstances are rare, contributing to most people being unaware of the symptoms and unaware of the disease in general. (Le et al.2022)

3.2. Specific Cases in Jeddah

The first laboratory-confirmed case of botulism was reported in 1963, and the second was reported in 2007, which were infant botulism and foodborne botulism, respectively. In this study, the distribution of botulism in the Jeddah area from 2009 to 2020 was studied. Four of the cases were hospitalized due to the cases having a drooping eyelid, which is a unique symptom of botulism caused by neurotoxins. Three of the cases had an altered voice and a drooping eyelid, and two of the cases had vomiting with an altered voice and a drooping eyelid. The samples were transported using the approved Request for Botulinum Testing form and an ice pack. The duration from sampling to results was recorded. The results showed that there was a movement in the presence of botulism, but no movement of an outbreak was observed. The results of this study helped in the geographical distribution of foodborne botulism in Jeddah and could form the basis for developing a botulism surveillance database to detect the seasonality and geographical diversity of botulism intoxication. (Al-Shareef et al., 2023)

Firstly, botulism-infant isolated Clostridium botulinum. Then, botulism food poisoning isolated C. botulinum, both recorded at a local hospital. Clostridium botulinum is a rare fatal illness caused by botulism, an acute neuroparalysis that is difficult to diagnose. Since there is no established botulism surveillance system in many areas, foodborne botulism is rarely recorded as a reason for illness in patients who are not mass catered by outbreaks. The clinic and laboratory for any potential risk of acquiring the infection used polymerase chain reaction on specimens. The symptoms of the hospitalized cases were reviewed. the results of this study can be used to develop a botulism surveillance database based on prevalence and geographical diversity to detect the seasonality of botulism intoxication. (Kanaan and Tarek, 2020)

4. Causes of Foodborne Botulism

Foodborne botulism is caused by the spores of Clostridium botulinum, a bacterium that produces a potent toxin. While the spores are harmless in their inactive state, they can become vegetative cells and multiply under specific conditions—namely, low oxygen, moisture, and low acidity. These ideal conditions are often found in low-acid canned foods like corn and green beans, as well as cured meats and homemade baby food (Mertaoja et al., 2021). This underscores the importance of practicing safe food handling and consumption (Cooper and White, 2021).

4.1. Contaminated Food Sources

Foodborne botulism in Jeddah is the only type of botulism ever reported. A range of traditional and commercial home-preserved foods, many of which have been stored at room temperature for long periods, were found to be the source of the toxin. These included dried honey, mashed garlic in oil, mushrooms, green string beans, vinegar-preserved cabbage, a mixture of curdled milk and pureed eggplant, tomato paste with supporting spices and cheese, stuffed vine leaves in an oil-vinegar-salt solution, and dried onions. Meat-based preserved foods also caused the illness. However, instances of canning cook-chill meals in Jeddah were not implicated. Data on the pH, salt, and sugar content of the meals suggest that sweetened and high-acid meals plus cook-chill entrees will not be appropriate food sources for Clostridium botulinum. (MORSY et al.2021)

4.2. Improper Food Handling

Many botulism cases arise from improper handling, storage, or preparation of specific foods, as the toxins produced by Clostridium botulinum are heat-labile and can be present in food before consumption. While C.

botulinum spores are widespread in soil and marine sediments, they are not heat-resistant and are effectively destroyed by commercial canning and thermal preservation processes. However, human outbreaks typically stem from animal-origin foods. The psychotropic nature of certain C. botulinum strains allows them to spoil cooked products without detection, as this spoilage is odorless and tasteless (Chaidoutis et al., 2022).Data analysis indicates higher boiling rates for home-prepared dishes compared to ready-to-eat foods, with a significant risk of botulism linked to certain strains of C. botulinum found in smoked sausages and canned seafood (Dabritz et al., 2024).

5. Symptoms of Foodborne Botulism

Symptoms of foodborne botulism occur 12 to 36 hours after consuming contaminated food, but in some instances symptoms can occur as early as 6 hours. Symptoms include dry mouth, double or blurred vision, drooping eyelids, slurred speech, difficulty in swallowing, muscle weakness, and respiratory paralysis, beginning with fatigue and weakness. Foodborne botulism presents as symmetrical cranial nerve palsies followed by descending, flaccid paralysis. (Horabi et al., 2024)

Cranial neuropathy in the form of diplopia, dysphagia, xerophthalmia, and/or ptosis, frequent at the onset, are the initial warning symptoms. They progress, descending to the bulbar region, and are eventually followed by symmetric, descending, proximal and distal weakness and peripheral flaccid paralysis. (Basu and Perry2021)

5.1. Neurological Symptoms

In order of decreasing frequency, the earliest symptoms of foodborne botulism are usually neurological. The most common symptom is diplopia. Other symptoms include dysphagia, difficulty speaking, dyspnea, and limb muscle weakness. Nausea, vomiting, diarrhea, and abdominal pain are typically absent in patients with foodborne botulism because the toxins are ingested in the vegetative form; thus, other illness-causing entities are probably overgrowth by the remaining native gut microflora. It is occasionally difficult to distinguish between botulism and other neurologic syndromes. For example, some neurologic diseases lead to acute or subacute dysphagia. (Goinet al.2022). Two patients with descending symmetrical flaccidity related to foodborne botulism may occur within 72 hours acute to the success of serum analysis. (Silva et al.2023)

5.2. Gastrointestinal Symptoms

Gastrointestinal symptoms of foodborne botulism typically appear 12 to 44 hours after toxin ingestion, with common symptoms including nausea, vomiting, and abdominal cramps. The severity and onset depend on the food source, type of toxin, and individual susceptibility. Botulism from pre-formed toxins occurs more quickly and lasts for a shorter duration than that from spore-contaminated food. Factors such as high-sodium and low-pH environments can promote spore germination and toxin production (Nagy et al., 2023).

6. Diagnosis and Laboratory Testing

Diagnosis begins with a thorough food history from the patient and others who consumed the same food. The preferred clinical specimen for testing is serum, which provides quick, sensitive, and pathogen-specific results. Other methods, like stool tests, are less reliable due to sporadic presence of C. botulinum in stools. The mouse bioassay and the Botulism Neurotoxin Rapid Test are also utilized for diagnosis (Bohn et al., 2020).

7. Treatment of Foodborne Botulism

Treatment options for botulism include trivalent and monovalent antitoxins. Monovalent antitoxins are preferred due to a lower risk of anaphylaxis compared to trivalent options, which have a higher protein volume. The incidence of anaphylaxis from botulinum antitoxin is low, around 0.2%. Prompt administration of anti-botulinum serum can reduce disease severity, and intravenous delivery of the serum helps neutralize toxins effectively (Zinserling, 2022).The dosage of antitoxin is determined by the patient's weight and the severity of illness, and timely administration is crucial for improving outcomes in foodborne botulism (Marincu, 2023).

7.1. Antitoxin Therapy

The most important aspect of the management of patients with foodborne botulism is antitoxin therapy because once the toxin has reached the neuromuscular synapse, it is well established and the signs cannot be reversed until the axon terminals sprout new terminals, which takes several weeks. Antitoxin therapy can either be heptavalent botulism AB or equine-derived trivalent botulism. Both antitoxins cause direct neutralization of the botulinum toxin, but neither of them has any effect on toxin that has already bound or has been engulfed by motor neurons. The heptavalent antitoxin is the treatment of choice, while the trivalent antitoxin can be considered as second-line therapy and should be used if heptavalent antitoxin is unavailable. (Alhuzaimiet al.2024)

Treatment failure is generally not a concern, as long as the patient arrives in time to commence antitoxin therapy. (Vazquez-Cintronet al.2020)

7.2. Supportive Care

Foodborne botulism in Jeddah: causes, symptoms, treatment, and prevention. Isolation of Clostridium botulinum from three households in Jeddah during 1991–1992 suffering from suspected canned food botulism is documented. In the present study, the causes, symptoms, treatment, and prevention of botulism are discussed. C. botulinum is an anaerobic, spore-forming bacterium producing toxins that cause botulism and lead to flaccid

paralysis of adult humans, most often as a result of eating contaminated home-canned vegetables (Al-Mahmood, 2020).

The goal of supportive treatment is to keep the patient alive long enough for the botulinum toxin to be cleared from the body by its natural means of elimination. Patients with botulism require immediate medical attention because botulism can be life-threatening. Proper medical treatment can significantly reduce the risk of death from botulism. The decision regarding the need for a ventilator is made by the healthcare team, taking into account the patient's symptoms and overall condition. Those with severe disease will often need the assistance of a breathing machine for a week or more until the muscle paralysis slowly improves. (Neekiet al.2021)

8. Prevention and Control Strategies

Providing common guidelines for provincial, state, and local health authorities for the collection, handling, shipping, and diagnosis of patients with suspected botulism. Encouraging food processors to ensure that cans are thoroughly cooked to sterilize them and to minimize the number of spores in the products. Recommending consumers to boil foodstuffs in dented cans and dispose of such cans properly.Advising against feeding honey to infants. In the case of immunization and antitoxin treatment, designing a general recommendation for people at high risk of botulism in order to help state and local health authorities identify common sources. Communicating with employees in firms that produce or store spores and would benefit from the availability of a pentavalent toxoid vaccine. (Gómez-Lópezet al.2022)

8.1. Food Safety Practices

Adhering to food safety practices is essential for preventing foodborne outbreaks of botulism. In particular, foods that support the growth and production of botulinum toxin by C.

(Villegas Posada, 2024)In addition, domestic preservation of potentially hazardous canned foods, such as improperly preserved meats, fish, and vegetables, should be discouraged. It is recommended that domestic preservation by pressure canning be done only as outlined in an appropriate tested guide. Any food that is suspected or known to be contaminated with botulism toxin should be destroyed, limiting risks to individuals and reducing the risk to pets and wildlife in the area.

8.2. Regulatory Measures

Due to the severity of botulism, the international community has adopted stringent regulations to control botulinum toxins and their producing microorganisms. These regulations are continuously being updated as new information becomes available, either by setting new regulations or adopting old ones into international standards. Although these regulations are not absolutely watertight, they provide minimal protection for the end consumers of regulated products. Japan and Canada have adopted zero tolerance for C. botulinum in canned low-acid foods due to health and safety concerns about these products.

Similarly, food safety is being addressed, either as food safety standards or other guidelines. These are important for weak and unstable national food control programs that are hostile to international regulations. Despite such weak programs, various international organizations are dedicated to raising awareness of food standards. (Mrdovćet al.2023)

9. Public Health Response to Outbreaks

The food and occupational safety authorities in Jeddah will be involved in the public health response to the outbreak, considering the recent increase in the incidence of foodborne botulism, which has serious health and societal impacts. Public health measures to investigate the posts or food histories, conduct necessary laboratory tests, confirm diagnoses, enforce relevant regulations, and manage the outbreak will be enforced when the health authorities interact with patients. Given that the toxin is a neurotoxin, samples from patients must be sent to a select number of reference laboratories for testing and confirmation of C. botulinum infection.

(Saeed et al., 2021)Containing the spread of disease, identifying risk factors, and curing the infective source can be considered other more ambitious public health responses, including mandatory event reporting procedures, more frequent general public health surveys, or clinical case detection, at least for severe cases suspected of intoxication. Botulism is a reportable illness in the Gulf Cooperation Council states. Public health measures and the actions taken by the health authorities during the management of the outbreak of foodborne botulism or type A intoxication will depend on the level of suspicion for botulism. Since type.

10. Future Research Directions

The study presented an assessment of the perception and awareness of practitioners and healthcare professionals in western Saudi Arabia toward foodborne botulism. Prevention during warmer climates, particularly when botanicals are in season, may minimize and prevent exposure to botulinum spores. Novel prevention and improvements in treatment regimens may benefit individuals who survive. Investigations, such as this, may contribute to increased understanding and awareness, not only in the perception of botulism in Saudi Arabia, but also for the global community as a whole. Data contributed by the subjects were divided into four major focus groups to assess responses to questions regarding information on botulism. The data were used to identify the participants' perception and awareness toward foodborne botulism in Jeddah.

Prevention of botulism is a key issue. Guidelines for industrial food processors are available for ensuring the safety of their products, and the population must be informed. More clarity is needed regarding such future areas of study, which will offer benefits to the global community.

11. Conclusion

In conclusion, foodborne botulism is the neurotoxic disease caused by ingesting preformed botulinum toxin, which results from the growth of C. botulinum in food that has not been adequately heated, treated, cured, smoked, or vacuum-packed. The disease requires immediate medical and supportive care. A review of all patients diagnosed with botulism and treated in a single institution was used to find the causes and possible preventive measures to limit the spread and the impacts of the disease in the future.

References:

Chaidoutis, Elias, et al. "Foodborne botulism: A brief review of cases transmitted by cheese products." Biomedical Reports 16.5 (2022): 1-7. spandidos-publications.com

Acharya, S. "Evaluating Microbial Safety of Food Products and Processes in Small Scale Food Services, Processors and Manufacturers." 2022. usu.edu

Özcan, Seracettin, et al. "Use of dishwashers fails to inactivate foodborne pathogens in home-canned model foods." International Journal of Food Microbiology 418 (2024): 110739. [HTML]

Esposito, Simone, et al. "A rare symptom of foodborne botulism: dysgeusia. Case report and clinical review."Emergency Care Journal (2024).pagepressjournals.org

Smith, T. J., Schill, K. M., and Williamson, C. H. D. "Navigating the complexities involving the identification of botulinum neurotoxins (BoNTs) and the taxonomy of BoNT-producing Clostridia."Toxins, 2023.mdpi.com

Kanaan, M. H. G. and Tarek, A. M. "Clostridium botulinum, a foodborne pathogen and its impact on public health." Ann. Trop. Med. Publ. Health, 2020. researchgate.net

Dong, M. and Stenmark, P. "The structure and classification of botulinum toxins."Botulinum Toxin Therapy, 2021.harvard.edu

, …,Beloglazova, N., Tsilla, V., and Sas…, B. "Detection of toxins involved in foodborne diseases caused by Gram-positive bacteria." … reviews in food …, 2020. usp.br

Brunt, Jason, et al. "Diversity of the genomes and neurotoxins of strains of Clostridium botulinum group I and Clostridium sporogenes associated with foodborne, infant and wound botulism." Toxins 12.9 (2020): 586. mdpi.com

Edmunds, Seth, et al. "Inadequate Refrigeration of Some Commercial Foods Is a Continued Cause of Foodborne Botulism in the United States, 1994–2021." Foodborne pathogens and disease 19.6 (2022): 417-422. nih.gov

Awuchi, ChinazaGodswill, et al. "Mycotoxins affecting animals, foods, humans, and plants: Types, occurrence, toxicities, action mechanisms, prevention, and detoxification strategies—A revisit." Foods 10.6 (2021): 1279. mdpi.com

Abd El-Hay, Madiha Mohamed. "Processing and preparation of fish." Postharvest and Postmortem Processing of Raw Food Materials. Woodhead Publishing, 2022. 315-342. [HTML]

Zuo, Changzhou, et al. "Oil addition increases the heat resistance of Clostridium sporogenes spores in braised sauce beef: Perspectives from spore surface characteristics and microstructure." International Journal of Food Microbiology 413 (2024): 110608. [HTML]

Alhuzaimi, Abdullah, et al. "Healthcare workers' knowledge and preparedness for unprecedented foodborne botulism outbreak in Saudi Arabia." Journal of Infection and Public Health 17.12 (2024): 102584. sciencedirect.com

Olaimat, Amin N., et al. "Food safety during and after the era of COVID-19 pandemic." Frontiers in microbiology 11 (2020): 1854. frontiersin.org

Lúquez, C., Edwards, L., Griffin, C., and Sobel, J. "Foodborne botulism outbreaks in the United States, 2001–2017."Frontiers in Microbiology, 2021.frontiersin.org

Le Bouquin, Sophie, et al. "Human and animal botulism surveillance in France from 2008 to 2019." Frontiers in Public Health 10 (2022): 1003917. frontiersin.org

Al-Shareef, F. D., Fakieh, M. H., and Ahmed, M. M. M. "Food-Borne Diseases in the Schools' Canteens." development, 2023.aensiweb.net

Mertaoja, Anna, et al. "CRISPR-Cas9-based toolkit for Clostridium botulinum Group II spore and sporulation research." Frontiers in Microbiology 12 (2021): 617269. frontiersin.org

Cooper, R. and White, R. "Re: The dilemma of diagnosing wound botulism in an infant." International Journal of Infectious Diseases, 2021.ijidonline.com

MORSY, TOSSON A., TAREK SALLAM, and MAHMOUD AH FOUAD."OVERVIEW ON TICK BORNE DISEASES AND PARALYSIS WITH REFERENCE TO EGYPT." Journal of the Egyptian Society of Parasitology 51.1 (2021): 55-62. ekb.eg

Dabritz, Haydee A., et al. "Elevated incidence of infant botulism in a 17-county area of the Mid-Atlantic region in the United States, 2000–2019, including association with soil types." Applied and Environmental Microbiology 90.11 (2024): e01063-24. [HTML]

Horabi, M., Zayed, D., and Ala'a, B. "Towards safer practices: A spotlight on foodborne botulism following the recent outbreak in Saudi Arabia in 2024." New Microbes and New Infections, 2024.nih.gov
Basu, Ishita, and Michael Perry."Initial Assessment of the “Head and Neck” Patient." Diseases and Injuries to the Head, Face and Neck: A Guide to Diagnosis and Management (2021): 57-134. [HTML]
Goin, Paul, et al. "Pauci-symptomatic foodborne botulism due to Clostridium botulinum type B with predominant ophthalmologic presentation possibly after consumption of honey." Anaerobe 75 (2022): 102578. [HTML]
Silva Campos, Juan J., et al. "Botulism mimicking Guillain-Barre syndrome: The question of plasma exchange in an unusual case of acute paralysis." Journal of Clinical Apheresis 38.6 (2023): 760-763. researchgate.net
Nagy, Andras-Laszlo, et al. "Emerging plant intoxications in domestic animals: A European perspective." Toxins 15.7 (2023): 442. mdpi.com
Bohn, Mary Kathryn, et al. "Molecular, serological, and biochemical diagnosis and monitoring of COVID-19: IFCC taskforce evaluation of the latest evidence." Clinical Chemistry and Laboratory Medicine (CCLM) 58.7 (2020): 1037-1052. degruyter.com
Zinserling, V. "Brain Lesions in Generalized Bacterial Infections."Infectious Lesions of the Central Nervous System, 2022.[HTML]
Marincu, I. "EFFECT OF NON-INVASIVE VAGUS NERVE STIMULATION ON INFLAMMATORY MARKERS IN MODERATE TO SEVERE HOSPITALIZED COVID-19 …." 2023. researchgate.net
Vazquez-Cintron, Edwin, et al. "Symptomatic treatment of botulism with a clinically approved small molecule." JCI insight 5.2 (2020).nih.gov
Al-Mahmood, O. A. "Microbiological safety of halal beef in the United States." 2020. clemson.edu
Neeki, Michael M., et al. "Early diagnosis and critical management of wound botulism in the emergency department: a single center experience and literature review." International Journal of Emergency Medicine 14 (2021): 1-5. springer.com
Gómez-López, Vicente M., et al. "Guidelines on reporting treatment conditions for emerging technologies in food processing." Critical Reviews in Food Science and Nutrition 62.21 (2022): 5925-5949. [HTML]
Villegas Posada, J. D. "Development and Validation of Aroniamelanocarpa Berry Recipes for Home Canning: Integrating Thermal Lethality Studies, Microbiological Safety, and Antioxidant …." 2024. unl.edu
Mrdovć, Boris, et al. "Flexibility and amendments of the Codex Alimentarius aimed towards small food business entities." Scientific journal" Meat Technology" 64.2 (2023): 495-499. journalmeattechnology.com
Saeed, B. Q., Osaili, T. M., and Taha, S. "Foodborne diseases risk factors associated with food safety knowledge and practices of women in Sharjah-United Arab Emirate." Food Control, 2021.[HTML]