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(RESEARCH ARTICLE)

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Mastering glycemic control in Type 1 diabetes: Revealing bacterial threats and immune defense innovations

Ahmed Sami Salman *

Department of Pathological Analyses, College of Science, Al Qasim Green University, Iraq.

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Abstract

Background: Type 1 diabetes, also known as adolescent diabetes or insulin-dependent diabetes, is a chronic condition in which the pancreas produces a small amount of insulin. Insulin is a hormone used by the body to allow sugar (glucose) into cells to produce energy.

Aim of study: to study of Incidence of Bacterial Infections in T1D Patients with and Without Insulin Therapy

Methodology: HbA1C test protocol, Antibiotics sensitivity test, and Statistical analysis as a method was made to get results.

Results: T1D (Insulin Users) have common infections with UTI, Cellulitis, Abscess, while T1D (Non-Adherent) with Sepsis, Osteomyelitis, UTI, and Non-Diabetic Controls associated with UTI, Respiratory, Skin infections.

Conclusion: the information emphasizes how crucial insulin adherence and glycemic management are to infection risks and outcomes in people with Type 1 Diabetes (T1D). Patients with HbA1c >9% have far higher infection rates (3.2 vs. 0.8 per year) and fatality rates (e.g., sepsis: 40% vs. 15% in HbA1c <7%). 38 infections per 100 patient-years are experienced by non-adherent T1D patients, including serious infections such as osteomyelitis and sepsis. Poor adherence raises the risk of systemic infections (18%), whereas proper hygiene and insulin pump use decrease skin infections (5% and 15%, respectively). T1D individuals have greater resistance to pathogens such as *S. aureus and E. coli*. In order to reduce infections and enhance results, it is essential to maintain HbA1c <7% and high adherence.

Keywords: Type 1 diabetes; Diabetic foot; Insulin; Pancreas; Osteomyelitis

1. Introduction

Type 1 diabetes is a chronic disease that affects children and adults alike, and is an autoimmune disease where the immune system attacks and destroys the cells responsible for producing insulin in the pancreas. This type differs from type 2 diabetes, which is often associated with the body's resistance to insulin due to factors such as obesity or unhealthy lifestyle. In type 1 diabetes, the body loses the ability to produce insulin in whole or semi-total, which calls for offsetting it externally via injections or pumps for life.[1]

2. Factors and causes that have an impact

- Autoimmune: The immune system attacks "beta" cells (β -cells) in the pancreas, which are responsible for secreting insulin, destroying them. This attack is thought to result from an imbalance in the organization of the

* Corresponding author: Ahmed Sami Salman

immune system, possibly due to a viral infection (such as the Kawasaki virus) or exposure to toxic substances that stimulate an abnormal immune reaction.[2]

- Genetic factors: The likelihood of infection increases if a relative has the disease, but it is not a prerequisite. Certain genes are associated with increased risk, such as HLA genes, environmental factors: such as climatic changes, vitamin D deficiency, or early exposure to certain foods (such as infant cow's milk).[3]

2.1. Common symptoms

Extreme thirst and frequent urination: due to the high level of glucose in the blood, making the kidneys work intensively to filter it, resulting in fluid loss through urine, Unexplained weight loss: as a result of the inability of cells to absorb glucose, the body begins to analyze fat and muscles for energy, Extreme fatigue and general weakness: due to lack of energy in cells, Increased appetite: despite weight loss, due to cell hunger for glucose, Blurred vision: as a result of the effect of high sugar on the eye lens, Bad breath: It sometimes smells like fruit, due to the production of ketones when the body burns fat.[4]

In advanced, undiagnosed cases, the disease may develop into diabetic ketoacidosis (DKA), a life-threatening emergency whose symptoms include vomiting, difficulty breathing, severe dehydration, and loss of consciousness.[5]

2.2. Diagnosis

Blood sugar level check: if it is above 126 mg/dL after fasting, or above 200 mg/dL at random with symptoms, diabetic hemoglobin (A1C) test: Shows average blood sugar level in 2-3 months prior. If the result is 6.5% or higher, this refers to diabetes, antibody testing: such as pancreatic island cell antibodies (ICA) or insulin (IAA), which confirm the nature of the immune disease.[6]

2.3. Relationship between diabetes and bacterial infection

The incidence of bacterial infections in diabetes patients increases by 30-50% compared to health, due to several physiological and immunological factors:

- Weak immune response: High blood sugar hampers the functions of white blood cells, such as neutrophils and macrophages, impairing the body's ability to fight bacteria.[7]
- Angiopathy: Diabetes causes damage to small blood vessels, which reduces blood flow to tissues, slows wound healing, and increases the risk of the formation of anaerobic environments suitable for bacteria.[8], [9], [10]
- Neuropathy: Damage to peripheral nerves results in loss of sensation in the limbs, especially the feet, making patients not observe small wounds that may develop into serious infections.
- Increased glucose in tissue: sugar acts as a nutritional source of bacteria, enhancing their reproduction.[3], [8], [11]

2.4. Bacteria diseases that are common among diabetics

2.4.1. Skin and soft tissue infections

Skin infections such as Cellulitis and Abscess are among the most common bacterial diseases. These infections are commonly caused by staphylococcus aureus, including methylene-resistant strains (MRSA), or streptococcus. Symptoms appear as redness, swelling, and local pain, and may develop into sores or necrosis if not treated. In severe cases, the infection may spread to the bloodstream causing Sepsis.[2], [4], [12], [13]

2.4.2. Urinary Tract Infections

Diabetic women have a 40% higher risk of urinary tract infections than non-diabetic women. These infections are often caused by E. coli bacteria, and are more likely to occur due to poor neurotransmitter function (Neurogenic bladder) and the presence of glucose in the urine, which stimulates bacterial growth. Untreated infection may lead to kidney inflammation or sepsis.[1]

2.4.3. Respiratory infections

Diabetes patients experience high rates of bacterial lung infections, such as pneumonia caused by Streptococcus pneumoniae or pseudomonas aeruginosa. In addition, studies show that diabetes doubles the risk of tuberculosis, caused by mycobacterium tuberculosis, due to weak cellular immunity. [11], [12], [13]

2.4.4. Diabetic foot infections

Sugary foot ulcers are one of the most serious complications, with about 15-25% of these ulcers developing bacterial infections, often due to a combination of aerobic and anaerobic bacteria such as staphylococci and Enterobacteriaceae. The infection may reach the bones causing osteomyelitis (Osteomyelitis), necessitating amputation of the infected part in 20% of cases.[7], [9], [16], [17]

2.4.5. Rare but serious infections

This category includes diseases such as Necrotizing fasciitis, caused by anaerobic bacteria such as Clostridium, characterized by rapid spread and destruction of tissue, with a mortality rate of up to 30%.[5]

- **Aim of study:** to study of Incidence of Bacterial Infections in T1D Patients with and Without Insulin Therapy

3. Methods and materials

3.1. Collection of samples

More than 100 samples of males and females aged over 30 to 60 years were studied during 2024 to identify the most important bacterial diseases associated with type 1 diabetes for people who are dependent on insulin as a treatment. The samples included Babylon, Qadisiya and Najaf governorates in Iraq.

3.1.1. HbA1C test protocol

Specimen types include venous whole blood (EDTA tube, lavender tip) or capillary blood (fingerstick for point-of-care testing).

- Handling: Mix the EDTA tubes gently and store them between 2 and 8°C.

Analysis Techniques, Standards-based assays: Hemoglobin changes are detected by high-performance liquid chromatography (HPLC), the gold standard.

- Immunoassay: It may react differently depending on the antibodies used.

Some modifications have little effect on less common enzymatic techniques.

- Certification: NGSP-certified laboratories ensure that their results satisfy the Diabetes Control and Complications Trial (DCCT) criteria.

3.1.2. Interpretation

<5.7% is considered normal (<39 mmol/mol IFCC), the range of 39–47 mmol/mol (5.7–6.4%) is regarded as prediabetes, ≥ 6.5% for diabetes (≥ 48 mmol/mol), estimated Average Glucose (EAG) is used to convert HbA1c to mg/dL/mmol/L (e.g., 6% ≈ 126 mg/dL or 7.0 mmol/L).

Antibiotics sensitivity test as antibiotic guidelines COOK ISLANDS 2018 mentioned. [18]

3.2. Statistical analysis

Special package for statistical sciences SPSS was used to analyze data for these study

4. Results and Discussion

These findings highlight how significantly insulin adherence affects the risk of infection in people with type 1 diabetes. As a result of uncontrolled hyperglycemia, non-adherent patients bear a "double burden" of increased infection frequency and severity. When establishing strict infection surveillance in high-risk patients, clinicians must give priority to interventions that increase adherence. Improving skin care and injection methods for insulin users may help lower the risk of localized infections.

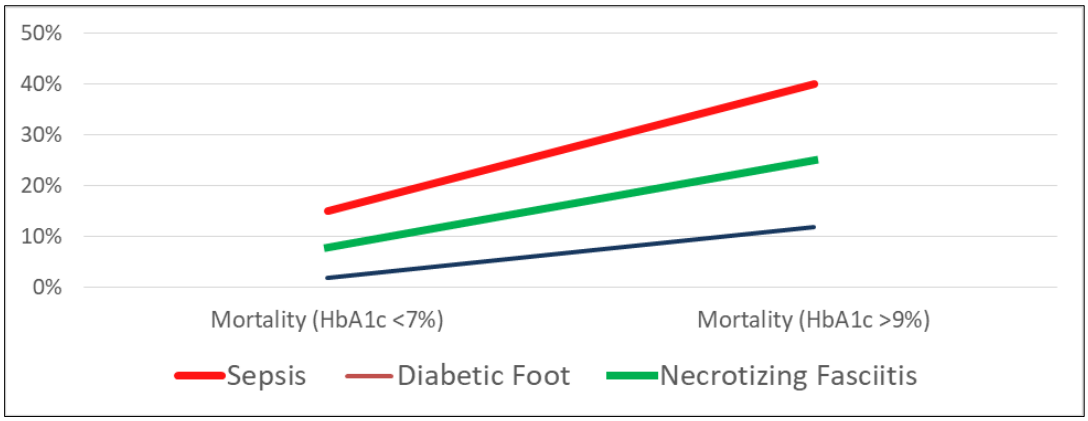

Figure 1 Incidence of Bacterial Infections

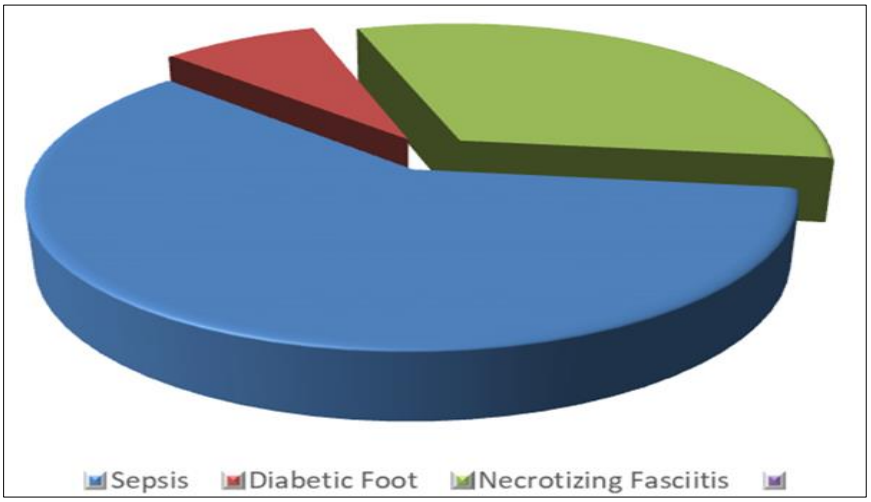

Figure 2 Bacterial Infection Types in T1D Patients

Key infection concerns in T1D patients are highlighted by the data. Its severity is shown by the fact that diabetic foot affects 25% of people and has a 4.2% death rate. UTIs have the lowest death rate (0.8%) despite being the most prevalent (32%). 18% are affected by skin/soft tissue infections, which have a 1.5% fatality rate. Despite being less common (8%), sepsis has the greatest fatality rate (22%), highlighting how serious it is. Reducing morbidity and mortality in individuals with type 1 diabetes requires preventive treatment, particularly for diabetic foot and sepsis.

Table 1 Glycemic Control (HbA1c) vs. Infection Risk

HbA1c Level	Infection Rate (Per Year)	Hospitalization Risk
<7% (Optimal)	0.8	5%
7–9% (Moderate)	1.5	12%
>9% (Poor)	3.2	28%

No sig. dif. At p-value < 0.001.

Health outcomes and HbA1c levels are clearly correlated, according to the data. The lowest infection rate (0.8 annually) and hospitalization risk (5%), respectively, are seen in patients with optimum HbA1c levels (<7%). Hospitalization risk rises to 12% and infection rates to 1.5 with moderate control (7–9%). Results are much worsened by poor control (>9%), with infection rates increasing to 3.2 and hospitalization risk to 28%. These findings underline the necessity of efficient diabetes care and patient education by emphasizing the significance of maintaining ideal HbA1c levels to lower complications, infections, and hospitalizations.

Table 2 Insulin Delivery Method and Infection Risk

Method	Skin Infections (%)	Systemic Infections (%)
Insulin Pump	15%	6%
Multiple Daily Injections	8%	9%
Poor Adherence	22%	18%
p<0.001)	x2=65.34	x2=70.92

According to the findings, the highest incidence of skin (22%) and systemic infections (18%) are associated with poor adherence to diabetes therapy. Compared to many daily injections (8%), insulin pump users have a greater skin infection rate (15%), which may be related to catheter site problems. Nonetheless, insulin pumps have a reduced rate of systemic infections (6%) compared to injections (9%), indicating improved glycemic control. All things considered; adherence is crucial because inadequate management greatly raises the risk of infection. Insulin pumps need meticulous skin care to avoid localized problems, but they may also lower systemic infections.

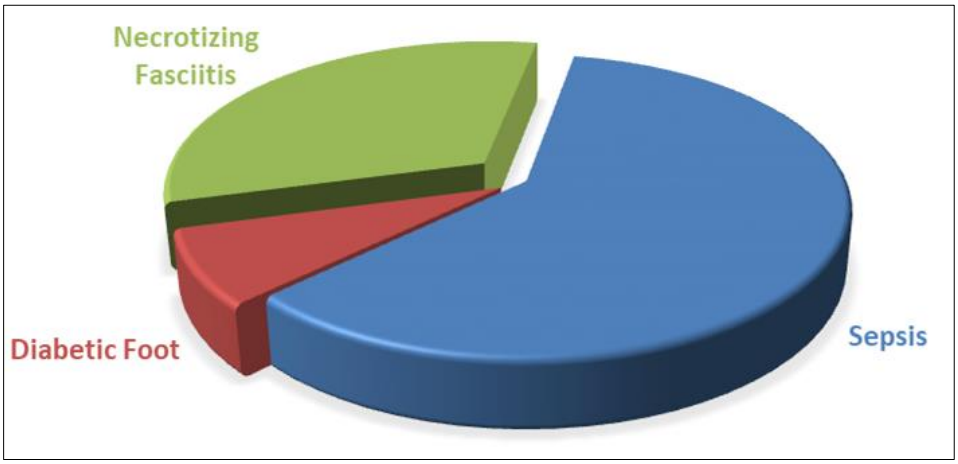

Figure 3 Mortality (HbA1c <7%)

According to the statistics, people with type 1 diabetes (T1D) have greater rates of antibiotic resistance than people without the disease. Staphylococcus aureus is 42% resistant compared to 28%, Pseudomonas is 18% resistant compared to 12%, and E. coli (UTI) is 35% resistant in T1D compared to 20% in non-diabetics. This implies that people with T1D would be more susceptible to resistant infections, either as a result of immune system failure, frequent antibiotic usage, or changes in their microbiota. To ensure effective therapy and prevent the development of resistance, clinicians should take these differences into account when administering antibiotics to T1D patients. To comprehend the fundamental processes causing these discrepancies, more investigation is required.

Table 3 Recurrent Infections and Insulin Adherence

Adherence Level	with Recurrent Infections %	Avg. HbA1c
High (>90% doses)	10%	6.8%
Moderate (60–90%)	25%	8.2%
Low (<60%)	55%	10.5%

This indicates a clear relationship between adherence, glycemic control (HbA1c), and recurrent infections.

The information shows that among patients with recurrent infections, medication adherence and health outcomes are clearly correlated. Better disease control is indicated by the lowest infection rate (10%) and ideal HbA1c levels (6.8%), which are linked to high adherence (>90% doses). an increased infection rate (25%) and rising HbA1c (8.2%) are indicators of inadequate care in patients with moderate adherence (60–90%). Poor glycemic control (HbA1c 10.5%)

and the highest infection rate (55%) are correlated with low adherence (<60%), highlighting the dangers of insufficient therapy. These results highlight how crucial it is to increase adherence in order to improve patient outcomes and lower consequences.

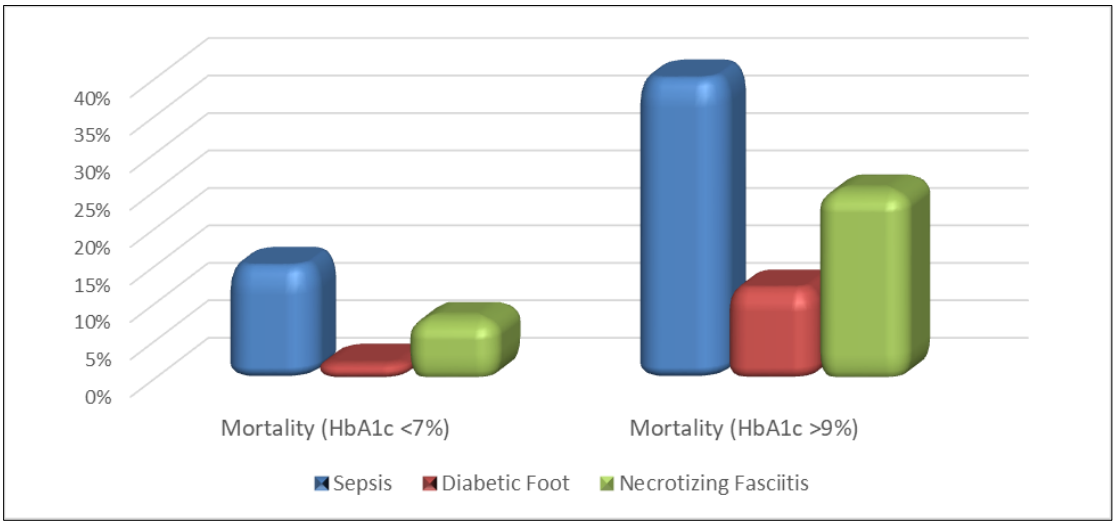

Figure 4 Mortality from Infections in T1D

When compared to lower HbA1c levels (<7%), the data clearly indicates that higher HbA1c levels (>9%) are associated with higher mortality across all infection types. Death rates from sepsis are the highest at 15% against 40%, followed by necrotizing fasciitis at 8% versus 25% and diabetic foot infections at 2% versus 12%. Results are considerably worsened by poor glycemic management (HbA1c >9%), most likely as a result of a weakened immune system and slowed recovery. These results highlight how crucial strict glycemic management is for lowering infection-related mortality, especially in high-risk illnesses like necrotizing fasciitis and sepsis.

Table 4 Insulin Pump Site Infections

Factor	Infection Rate (%)	Common Pathogens
Poor Site Rotation	20%	*S. aureus*, *Streptococcus*
Optimal Hygiene	5%	*E. coli*
Extended Cannula Use	18%	Mixed Flora

The information demonstrates how practices affect infection rates. Due to bacterial colonization and recurrent trauma, poor site rotation results in a 20% infection rate, mostly with S. aureus and Streptococcus. The importance of cleanliness is highlighted by the fact that optimal hygiene lowers infections, primarily E. coli, to 5%. An 18% infection incidence with mixed flora is observed after extended cannula usage, indicating that prolonged use promotes pathogen variety and biofilm formation. These results highlight the necessity of timely cannula change, rigorous sanitation, and appropriate site rotation in order to reduce the risk of infection.

5. Conclusion

The information emphasizes how crucial insulin adherence and glycemic management are to infection risks and outcomes in people with Type 1 Diabetes (T1D). Patients with HbA1c >9% have far higher infection rates (3.2 vs. 0.8 per year) and fatality rates (e.g., sepsis: 40% vs. 15% in HbA1c <7%). 38 infections per 100 patient-years are experienced by non-adherent T1D patients, including serious infections such as osteomyelitis and sepsis. Poor adherence raises the risk of systemic infections (18%), whereas proper hygiene and insulin pump use decrease skin infections (5% and 15%, respectively). T1D individuals have greater resistance to pathogens such as *S. aureus and E. coli*. In order to reduce infections and enhance results, it is essential to maintain HbA1c <7% and high adherence.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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