J. Bio-Sci. 31(1): 39-49, 2023 **ISSN 1023-8654**
http://www.banglajol.info/index.php/JBS/index
DOI: https://doi.org/10.3329/jbs.v31i1.69533

COMPARATIVE EFFICACY OF INSULIN, BIGUANIDES AND SULFONYLUREAS IN THE GLYCEMIC CONTROL OF NEWLY DIAGNOSED DIABETES MELLITUS PATIENTS IN RAJSHAHI, BANGLADESH

Md. Saif Zaman[1*], Parvez Hassan[1*], S. M. Shahinul Islam[1], Md. Anayet Ullah[2] and Md. Golam Rabbani[2]

[1]Institute of Biological Sciences, University of Rajshahi, Rajshahi-6205, Bangladesh
[2]Barind Medical College, Rajshahi-6207, Bangladesh

Abstract

The goal of the present study was to examine how well three distinct kinds of anti-diabetic drugs- insulin, biguanides and sulfonylureas performed in Bangladeshi patients who had recently been diagnosed with diabetes mellitus. This was an observational study and carried out on 102 patients admitted in different hospitals in Rajshahi, Bangladesh during the study period. Majority (32.02%) respondents belonged to 51-60 years age group, followed by 41-50 years and the least >60 years age group viz. 7.19%. Female preponderance was noticed in the study population where 59.80% were females; whereas 40.20% males. Results of distribution of respondents based on residence and class of anti-diabetic medication use showed in insulin receiving group 66.67% were urban people and 33.33% were rural resident; biguanides receiving groups 64.71% were urban resident and 35.29% were rural resident; sulfonylureas receiving groups 58.82% were urban resident and 41.18% were rural residents. Data on participant's lifestyle and smoking habit showed lifestyle of 65.70% patients were sedentary and 34.30% were active and according to smoking habit of the patients 14% were smokers while 86% were non-smokers. Family history of DM among the patients showed 17% had familial history and 83% did not have. Data showed that the patients taken insulin, biguanides and sulfonylurea as with BMI were mostly in 18.50 - 24.99 with p-value 0.621. Although no statistically significant difference was noticed among the groups regarding treatment response of three drugs (p = 0.252, 0.284, 0.675 for HbA1c, FBS and PPBS respectively) after 3 months follow-up of medication use and (p = 0.284, 0.323, 0.817 for HbA1c, FBS and PPBS respectively) after 6 months follow-up. However, p-value was not significant but insulin receiving patients had relatively better treatment response than biguanide receiving group than sulfonylurea receiving group at 3rd and 6th month. In insulin receiving group 90.19 % had desired glycemic control. In biguanide receiving group 76.47 % had desired glycemic control. In sulfonylurea receiving group 84.31 % had desired glycemic control. So it appears that insulin provides the best glycemic control followed by sulfonylurea and the biguanides are relativity less potent in glycemic control of newly diagnosed patients in our study area. In this study, the sample size was quite small, which may not represent the whole population and the research used purposeful sampling, which may have skewed the results.

Key words: Biguanide, diabetes mellitus, HbA1c, insulin, sulfonylurea.

Introduction

Diabetes mellitus (DM) is a syndrome characterized by a persistently elevated blood glucose level that can be brought on by insulin resistance, insulin insufficiency, or both (Hossain et al. 2022). Additionally, it could occur as a result of improper protein, lipid, and carbohydrate metabolism (Zimmet et al. 2014, Hossain et al.

*Author for correspondence: saifzamananando@gmail.com / hassanparvez@ru.ac.bd

2021a&b). Glycated hemoglobin (HbA1c) levels a good predictor of glycemic management were measured in order to evaluate the effectiveness of medications. With the ultimate goal of improving patient care and outcomes in Bangladesh, the study aimed to provide insightful data to the continuing discussion regarding the best ways to manage newly diagnosed patients with diabetes mellitus. Three different types of DM are fundamental: while type 1 diabetes develops in children when there is an insulin insufficiency, type 2 diabetes is more common in adults and is often brought on by relative insulin deficiency. Gestational diabetes develops during pregnancy as a result of an imbalance of placental hormones (Akbar et al. 2011).

Sulfonylureas, biguanides, and insulin are a few of the medications used to treat diabetes mellitus (Zaman et al. 2022). Their usage is complicated by a number of side effects, including hypoglycemia and weight gain from sulfonylureas and hypoglycemia and weight gain from sulfonylureas. Cost and the route of administration are additional crucial aspects to take into account when prescribing medication (Chang and Chuang 2010). This reason drives the continual search for newer, safer, and more challenging-to-administer medications. Metabolic condition type 2 diabetes mellitus (T2DM), which worsens over time, is becoming recognized as a potential global epidemic reported by Reasner and Defronzo (2001). Type 2 diabetes mellitus has increased sharply over the past 20 years and has continued to emerge as an uncontrollable type of disease in Bangladesh (Feinglos and Bethel 1998). There are numerous anti-diabetic medications currently available to treat type 2 diabetes mellitus, including sulfonylureas, glinides, thiazolidinediones, biguanides, and glucosidase inhibitors (Luna et al. 1999).

Insulin is an essential hormone and it helps body turn food into energy and controls blood sugar levels. It is the leading cause of death, disability, and economic loss, and, thus, it is identified as a major threat to global development. Insulin is often the preferred initial injectable therapy, when oral medications and lifestyle measures are no longer effective. Biguanides are used as monotherapy, or in combination with sulfonylureas, other anti-diabetic medications, or with insulin. Sulfonylureas function by promoting the release of insulin from pancreatic beta cells, and they may merely slightly worsen insulin resistance in peripheral target tissues (muscle, fat cells) was reported by Opara et al. (1999). On the contrary, biguanides act by reducing the amount of glucose produced by the liver and, to a lesser extent, by improving the sensitivity of peripheral and liver tissues to insulin. The most common adverse effect of biguanides is gastrointestinal distress, including diarrhea, cramps, nausea, vomiting, and increased flatulence. Long-term use of biguanides has been associated with decreased absorption of vitamin B12. Sulfonylureas continue to be the most well-known medication for treating type 2 diabetes, despite the multitude of anti-diabetic medications available on the market (De Fronzo and Goodman 1995). Sulfonylureas can cause adverse reactions such as gastrointestinal upset and weight gain. However, hypoglycemia is the most common serious side effect and it is potentially fatal. Insulin had relatively better but not statistically significant better efficacy over biguanides and sulfonylurea and biguanides had relatively worse efficacy over insulin but relatively better efficacy over sulfonylurea.

The objective of the present study was to compare the effectiveness of three different classes of anti-diabetic medications - insulin, biguanides (specifically metformin) and sulfonylureas in achieving glycemic control among newly diagnosed diabetes mellitus patients in Bangladesh assessed by using the measurement of glycated hemoglobin (HbA1c) levels. HbA1c reflects the average blood glucose concentration over the past two to three months, and thus is a reliable indicator of glycemic control. The study also aimed to contribute valuable data to the ongoing conversation about the most effective methods of managing diabetes mellitus in newly diagnosed patients, with the ultimate goal of enhancing patient care and outcomes in Bangladesh.

Methodology

This is an observational study and carried out in the admitted patient's Department of Medicine, Rajshahi Medical College Hospital, Barind Medical College Hospital, Diabetic Association Hospital in Rajshahi, and Chapainawabganj Hospital, Bangladesh. The duration of the research was 3 years (August 2019 to July 2022). This study was carried out on 102 admitted patients to find out the diabetic population including male and female. All the patients with diabetes (HbA_1C>7.0%) attending the mentioned areas during the study period was considered as inclusion criteria. Patients who were not interested to participate using intra uterine device (IUD) and sub-dermal contraceptive implants were excluded from this study. Data were collected by the researchers from the diabetes patients. Statistical evaluation of the data was done via the use of a window-based computer software program devised with Statistical Packages for Social Sciences (SPSS-24).

Results

Distribution of study subjects and medication intake of three different classes of anti-diabetic medications - insulin, biguanide and sulfonylureas as per age groups of the present study has been shown in Fig.1. The age of the study population ranged from 18 to >60 years and the majority (32.02%) of the respondents were in the 51-60 years age group, followed by 41-50 years age group (26.14%), 31-40 years age group (22.22%), 18-30 years age group (12.41%) and >60 years age group (7.19%). Regarding type of anti-diabetic medications usage among different age groups in case of 18-30 year groups Insulin, biguanide and sulfonylureas treatment patient number were 04 (11.76%), 05 (14.71%) and 04 (11.76%), respectively. For 31-40 years age group it was 06 patients (17.65%), 07 patients (20.59%) and 09 patients (26.47%); Among 41-50 years age group was 09 (26.47%)**,** 08 (23.53%) and 09 (26.47%) at; 12 (35.29%), 12 (35.29%) and 09 (26.47%) when age 51-60 and 03 (08.82), 02 (5.88), 03 (8.82) when age was >60 respectively. Chi-squared test (χ^2) was performed to compare between three groups and the calculated p-value was 0.985 (Fig. 1).

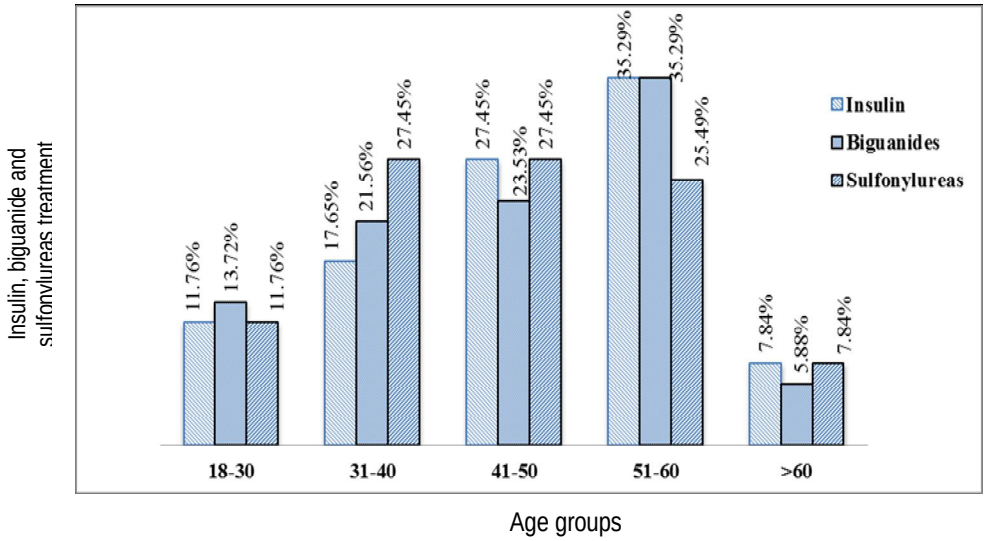

Fig. 1. Distribution of the patients and medication intake of insulin, biguanide and sulfonylureas according to age of 102 (p-value = 0.985).

Fig. 2 shows the distribution of the study population according to sex. Clearly female preponderance was noticed among the total study population of 102. About 14 (41.18%), 15 (44.12%), 12 (35.29%) of the insulin, biguanides and sulfonylureas receiving respondents were males and 20 (58.82%), 19 (55.88%), 22 (64.71%) of the insulin, biguanides and sulfonylureas receiving respondents were females, respectively. and the calculated p-value was 0.752.

Fig. 2: Distribution of the study population according to sex.

The distribution of the study population (Total 102) of present study was categorized according to the Body Mass Index (BMI) classifications set by the World Health Organization (WHO). According to WHO, a BMI less than 18.5 is considered underweight, 18.5-24.9 is normal, 25-29.9 is overweight as shown in Table 1.

Table 1. Distribution of the study population according to BMI classifications and medication type.

BMI categories	No. of participants (%)			Total (%)	p-value
	Insulin	Biguanides	Sulfonylureas		
Underweight (<18.5)	1 (0.98)	0	0	1 (0.98)	-
Normal (18.5-24.99)	17 (16.67)	17 (16.67)	20 (19.60)	54 (52.94)	0.621
Overweight (25-29.9)	16 (15.68)	17 (16.67)	14 (13.73)	47 (46.08)	-

Number of patients in each BMI category who were prescribed each of the three types of medication insulin, biguanides, and sulfonylureas. It provided a clear snapshot of the medication preference across different BMI categories in the study population. When, BMI were <18.5 the insulin, biguanides and sulfonylureas users were 1 (0.98%), 0 (0.0), 0 (0.0); when BMI category 18.50-24.99 the insulin, biguanides and sulfonylureas users were 17 (16.67%), 17 (16.67%), 20 (19.60%); and when BMI was >25, the insulin, biguanides and

sulfonylureas users were 16 (15.68%), 17 (16.67%), 14 (13.73%) and 47 (46.08%), respectively. The calculated p-value was found to be 0.621 which is statistically insignificant (Table 1).

Table 2 shows the population distribution based on the patients' glycemic control after three months of diabetic medicine intake. When, variable was HbA1c and insulin was <7.0, biguanides and sulfonylureas were 28 (82.35%) and 24 (70.59%). Biguanides and sulfonylureas were 06 (17.65%) and 10 (29.41%) when insulin was ≥7 and p-value was 0.252. Once, the variable was FBS and insulin was <7.2, biguanides and sulfonylureas were 30 (88.24%) and 26 (76.47%). Biguanides and sulfonylureas were 04 (11.76%) and 08 (23.53%) when insulin was ≥ 7.2 and calculated p-value was 0.284. When, the variable was PPBS and insulin was <10, biguanides and sulfonylureas were 28 (82.35%) and 25 (73.53%); Biguanides and sulfonylureas were 06 (17.65%) and 09 (26.47%) when insulin was ≥10 and calculated p-value was 0.675.

Table 2. Demonstration and distribution of the study according to glycemic control of the patients at 3rd month follow up (n = 102).

Variables	Insulin (%)	Biguanides (%)	Sulfonylureas (%)	p-value
HbA1c	<7.0	28 (82.35)	24 (70.59)	0.252
	≥7.0	06 (17.65)	10 (29.41)	
FBS	< 7.2	30 (88.24)	24 (76.47)	0.284
	≥ 7.2	04 (11.76)	08 (23.53)	
PPBS	<10	28 (82.35)	25 (73.53)	0.675
	≥ 10	06 (17.65)	09 (26.47)	

Table 3 demonstrated the distribution of the study population according to glycemic control of the patients at the 6th months of the study period. When, variable was HbA_1C and insulin (%) was <7.0, biguanides (%) and sulfonylureas (%) were 30 (88.24%) and 26 (76.47%). Biguanides (%) and sulfonylureas (%) were 04 (11.76%) and 08 (23.53%) when insulin (%) was ≥7.0 where p-value was 0.284. Once, variable was FBS and insulin (%) was <7.2, biguanides (%) and sulfonylureas (%) were 31 (91.18%) and 27 (79.41%). Biguanides (%) and sulfonylureas (%) were 03 (8.82) and 07 (20.59) when insulin (%) was ≥7.2. P-value was 0.323. When, variable was PPBS and insulin (%) was <10.0, biguanides (%) and sulfonylureas (%) were 29 (85.29) and 27 (79.41) and p-value was 0.817.

Table 3. Distribution of the study population according to glycemic control of the patients at 6th month (n = 102).

Variables		Insulin (%)	Biguanides (%)	Sulfonylureas (%)	p-value
HbA1c	<7.0	30 (88.24)	26 (76.47)		0.284
	≥7.0	04 (11.76)	23.53		
FBS	<7.2	31 (91.18)	79.41		0.323
	≥7.2	8.82	20.59		
PPBS	<10.0	85.29	79.41		0.817

Fig. 3 demonstrated that the distribution of the respondents by residence. In insulin receiving group 67.60% were urban residents and 32.40% were rural. In biguanide receiving group 64.70% was urban and 35.30% were rural residents and among sulfonylurea receiving group 58.80% were urban and 41.20% were rural residents.

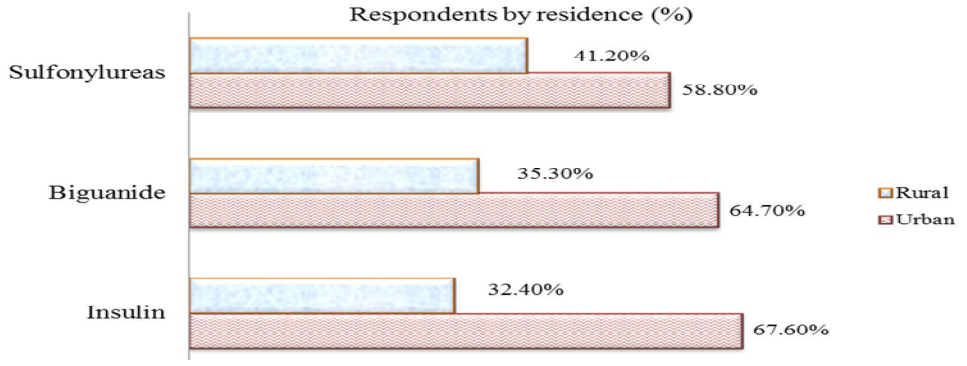

Fig. 3: Distribution of the respondents by residence/location.

Fig. 4 demonstrated that the distribution of the respondents by occupation. According to occupation of the patient's government employee, non-government employee, businessman, housewife, unemployed and others were 12.70%, 14.70%, 17.60%, 35.30%, 9.80% and 9.80%.

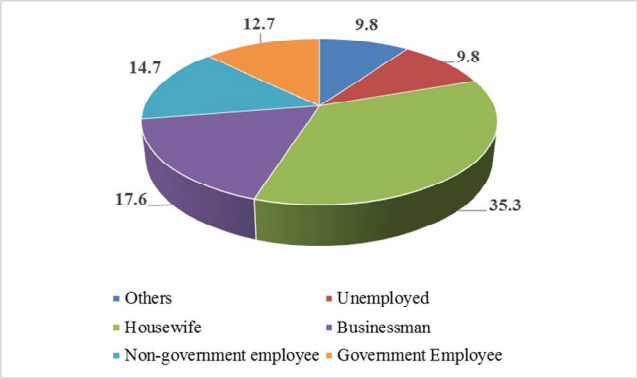

Fig. 4: Distribution of the respondents by occupation.

Fig. 5 demonstrated the distribution of the respondents by family history of DM. According to family history of DM among the patients 17% were Yes and 83% were No.

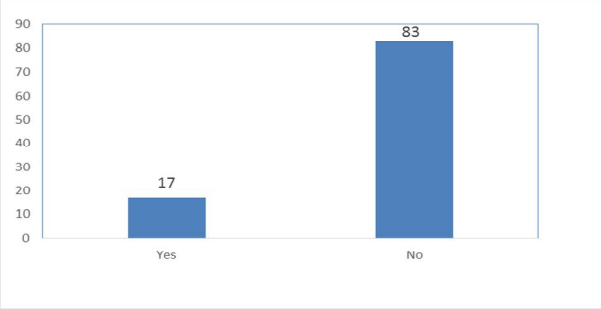

Fig. 5: Distribution of the respondents by family history of DM.

Table 4 demonstrated the distribution of the respondents by lifestyle and smoking habit. According to lifestyle of the patients 65.70% were sedentary and 34.30% were active. And according to smoking habit of the patients 14% were smoker and 86% were non-smoker.

Table 4. Distribution of the respondents by lifestyle and smoking habit.

Parameters	**N = 102**	**%**
Lifestyle of patients		
Sedentary	67	65.70
Active	35	34.30
Smoking habit of the patients		
Non-smoker	88	86
Smoker	14	14

Discussion

Due to the rise of non-communicable diseases (NCDs), of which diabetes mellitus being a major component, the burden on global health is increasing (Hossain et al. 2021a&b). Additionally, oxidative stress might be crucial in the emergence and progression of DM's short- and long-term problems (Dario et al. 1996). Several methods are used to provide DM in order to get the desired glycemic level (Hossain et al. 2022). Due to the possible benefit on glycemic status, pharmacological drugs such as biguanides, sulfonylureas, thiazolidinediones, and glycosidase inhibitors are frequently utilized for the administration of DM (Baynes and Thorpe 1999, Zaman et al. 2022). In a previous study, Siddique et al. (2016) reported that the mean age of the total study population was 50±9 years. Among them, 31% were male and 69% were female. Biguanides and sulfonylureas groups were matched for age, sex and glycemic status, but not matched for body mass index (BMI) and acute glycemic status (FPG and PPG). In our study, out of 102 patients most patients of diabetes mellitus belonged to 18 - >60 years category. According to sex, male and female of insulin, biguanides and sulfonylureas were 14 (41.18%), 15 (44.12%), 12 (35.29%) and 20 (58.82%), 19 (55.88%), 22 (64.71V) respectively. Our understanding of the effectiveness of diabetic medication and its effects on human health came from this observational research. This research was done among diabetic patients who had been enrolled in many medical schools and hospitals in Rajshahi and adjoining areas Bangladesh. The distribution of cases by sex was originally equal between the categories ($p = 0.752$).

Similar to our findings, Adeniyi et al. (2016) found that the majority of contributors had been females (70.3%) and resided in rural areas (88.7%) (Adeniyi et al. 2016). Regarding BMI of the respondents, the present study found 0.98% had BMI <18.50 kg/m^2 52.94% had BMI between 18.50 - 24.99 kg/m^2 and 46.08% had BMI >25 kg/m^2. BMI repute of the patients was once matched amongst the groups ($p = 0.621$). Nearly 90% of diabetic patients develop T2DM often concerning to extra body weight in accordance to the World Health Organization (WHO 2011). Furthermore, obesity is strongly inherited (Maritim et al. 2003). At the third month, it was determined that patients on insulin had significantly better glycemic control than those taking biguanides or sulfonylurea. In this present study, according to BMI, when BMI were <18.50, 18.50 - 24.99 and >25 the insulin, biguanides and sulfonylureas were 01 (0.98), 00 (00), 0 (00); 17 (50), 17 (50%), 20 (58.82) and 16 (47.06), 17 (50%), 14 (41.76) respectfully. And according to glycemic control of the patients at 6th month. Our study shows the variables according to glycemic control of the patients at 6th month where, HbA_1C and insulin (%) was <7.0, biguanides (%) and sulfonylureas (%) were 30 (88.24) and 26 (76.47). Biguanides (%) and sulfonylureas (%) were 04 (11.76) and 08 (23.53) when insulin (%) was ≥7.0. And p-value was 0.284. The design of Hermann's learns about allowed mainly short-term evaluation of low-dose combination therapy with single-drug therapies. All topics who did no longer obtain the blood glucose target early have been given high-dose aggregate treatment (Faure et al. 1999). This may additionally have decreased evidences of variations between treatments. There are various evidences that hyperglycemia enhances oxidative stress (Abdulkadir et al. 2012). The activation of the polyol pathway is one of these autoxidation of glucose's most crucial components. Due to the fact that biguanides and sulfonylureas are both potent antihyperglycemic medications, a decreased glucose oxidation rate and the deactivation of the polyol pathway can also significantly increase the antioxidants by regulating blood sugar levels. Antioxidants

such as vitamin C, and α-lipoic acid are effective in reducing diabetic complications, indicating that it may be beneficial either by ingestion of natural antioxidants or through dietary supplementation. This fact aids our findings because the biguanides group and the sulfonylureas group were matched for persistent glycemic status (Signorini et al. 2002).

Our study shows, according to residence of the patients, insulin 67.60% was urban and 32.40% was rural. When it is biguanide 64.70% was urban and 35.30% was rural. And according to sulfonylureas 58.80% was urban and 41.20% was rural. And according to lifestyle and smoking habit of the patients 65.70% were sedentary and 34.30% were active. And 14% were smoker and 86% were non-smoker. Numerous studies have shown that hyperglycemia increases oxidative stress. The stimulation of the polyol pathway (Faure 2008) is crucial to this autoxidation of glucose (Benzie and Strain et al. 1996). Since biguanides and sulfonylureas are both potent antihyperglycemic drugs, lowering blood glucose levels and inactivating the polyol pathway can also significantly increase antioxidant levels. This fact supports our findings because the biguanides group and the Sulfonylureas group were matched for continuous glycemic status (Tessier et al. 1999). We can infer from the results of our study that Bangladesh needs to significantly improve diabetes detection and treatment, particularly among the underprivileged communities.

Conclusion

Diabetes is a chronically progressive global pandemic affecting everyone from children to the elderly, middle-aged to pregnant women. In order to control the disease, early diagnosis is essential. The initial treatment strategy focuses on diet, exercise and then medication. In general insulin, sulfonylureas and biguanides are well tolerated, but some patients cannot tolerate these drugs, as biguanides are associated with nausea and a metallic taste while sulfonylureas cause severe hypoglycemia. Insulin are mostly daily injections apart from newer classes daily or twice a day, which is pretty embarrassing feeling for many patients, also causes hypoglycemia which is dangerous than hyperglycemia, weight gain and local fats blisters at injections sites. Plasma antioxidant status was clearly higher in biguanide-treated type 2 diabetic subjects compared with sulfonylurea-treated subjects, and there was no difference between biguanides and sulfonylureas in their effects on total antioxidant status in type 2 diabetic subjects.

Conflict of interest: The authors hereby state that they have no competing interests with respect to the publication of this paper.

Contribution: Authors contributed equally in the research and writing of this article.

References

Abdulkadir AA and Thanoon IA (2012). Comparative effects of glibenclamide and metformin on C-reactive protein and oxidant/antioxidant status in patients with type II diabetes mellitus. Sultan Qaboos University Medical Journal 12(1): 55.

Adeniyi OV, Yogeswaran P, Longo-Mbenza B and Goon DT (2016). Uncontrolled hypertension and its determinants in patients with concomitant type 2 diabetes mellitus (T2DM) in rural South Africa. PLoS One 11(3): e0150033.

Akbar S, Bellary S and Griffiths HR (2011). Dietary antioxidant interventions in type 2 diabetes patients: a meta-analysis. The British Journal of Diabetes and Vascular Disease 11(2): 62-8.

Baynes JW and Thorpe SR (1999). Role of oxidative stress in diabetic complications: a new perspective on an old paradigm. Diabetes 48(1): 1-9.

Benzie IF and Strain JJ (1996). The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power" the FRAP assay. Analytical Biochemistry 239(1): 70-6.

Chang YC and Chuang LM (2010). The role of oxidative stress in the pathogenesis of type 2 diabetes: from molecular mechanism to clinical implication. American Journal of Translational Research 2(3): 316.

Dario G, Anthonio C and Giuseppe P (1996). Oxidative stress and diabetic vascular complications. Diabetes Care 19(3): 257-67.

De Fronzo RA and Goodman AM (1995). Multicenter metformin study group. Efficacy of metformin in patients with non-insulin-dependent diabetes mellitus. New England Journal of Medicine 333(9): 541-9.

Domínguez C, Ruiz E, Gussinye M and Carrascosa A (1998). Oxidative stress at onset and in early stages of type 1 diabetes in children and adolescents. Diabetes Care 21(10): 1736-42.

Faure P, Rossini E, Wiernsperger N, Richard MJ, Favier A and Halimi S (1999). An insulin sensitizer improves the free radical defense system potential and insulin sensitivity in high fructose-fed rats. Diabetes 48(2): 353-7.

Faure P, Wiernsperger N, Polge C, Favier A and Halimi S (2008). Impairment of the antioxidant properties of serum albumin in patients with diabetes: protective effects of metformin. Clinical Science 114(3): 251-6.

Feinglos MN and Bethel MA (1998). Treatment of type 2 diabetes mellitus. Medical Clinics of North America 82(4): 757-90.

Hossain MA, Hasan MM and Islam SMS (2021a). Effects of probiotic and organic manures for soil amendments on seedling survivability and leaf chlorophyll for crop improvement in wheat (*Triticum aestivum* L.). Journal of Bio-Science 29(2): 61-71. doi: https://doi.org/10.3329/jbs.v29i2.54955.

Hossain MA, Sarkar MK, Mahbub I and Islam SMS (2021b). A study on peripheral neuropathy and its related risk factors associated with HbA1c levels. Journal of Bio-Science 29(2): 123-138. doi: https://doi.org/10.3329/jbs.v29i2.54961.

Hossain MA, Sarkar MK, Mahbub I and Islam SMS (2022). The relation between HbA1c variability and diabetic autonomic neuropathy among type-2 diabetic patients. International Journal of Human and Health Sciences 6(1): 89-95. DOI: http://dx.doi.org/10.31344/ijhhs.v6i1.382.

Luna B, Hughes AT and Feinglos MN (1999). The use of insulin secretagogues in the treatment of type 2 diabetes. Primary Care: Clinics in Office Practice 26(4): 895-915.

Maritim AC, Sanders A and Watkins Iii JB (2003). Diabetes, oxidative stress, and antioxidants: a review. Journal of Biochemical and Molecular Toxicology 17(1): 24-38.

Opara EC, Abdel-Rahman E, Soliman S, Kamel WA, Souka S, Lowe JE and Abdel-Aleem S (1999). Depletion of total antioxidant capacity in type 2 diabetes. Metabolism 48(11): 1414-7.

Reasner CA and Defronzo RA (2001). Treatment of type 2 diabetes mellitus: a rational approach based on its pathophysiology. American Family Physician 63(9): 1687.

Signorini AM, Fondelli C, Renzoni E, Puccetti C, Gragnoli G and Giorgi G (2002). Antioxidant effects of gliclazide, glibenclamide, and metformin in patients with type 2 diabetes mellitus. Current Therapeutic Research 63(7): 411-20.

Song F, Jia W, Yao Y, Hu Y, Lei L, Lin J, Sun X and Liu L (2007). Oxidative stress, antioxidant status and DNA damage in patients with impaired glucose regulation and newly diagnosed Type 2 diabetes. Clinical Science 112(12): 599-606.

Srivatsan R, Das S, Gadde R, Manoj KK, Taduri S, Rao N, Baharani A, Ramesh B, Shah K, Priyatham G, Balakumaran TA, Balakumaran SS, Kamath A, Rao A (2009). Antioxidants and lipid peroxidation status in diabetic patients with and without complications. The Archives of Iranian Medicine 12(2): 121-7.

Tessier D, Maheux P, Khalil A and Fülöp T (1999). Effects of gliclazide versus metformin on the clinical profile and lipid peroxidation markers in type 2 diabetes, Metabolism 48(7): 897-903.

Zaman MS, Parvez Hassan, S M Shahinul Islam, Md. Anayet Ullah and Md. Golam Rabbani (2022). Impact of insulin, biguanide and sulfonylurea treatment on HbA1C in diabetic patients: An interventional study in Rajshahi, Bangladesh. Journal of Bio-Science 30(1): 123-130.

Zimmet PZ, Magliano DJ, Herman WH and Shaw JE (2014). Diabetes: A 21st Century Challenge. The Lancet Diabetes and Endocrinology 2(1): 56-64.

(Manuscript received on 21 January 2023 and revised on 15th March 2023)