Keywords: Diabetes mellitus; Drug designing; Hydrophobic activity; Molecular docking

Introduction

Diabetes is a disease in which blood glucose levels are above normal. People with diabetes have problems converting food into energy. It is also defined as chronic disorders of carbohydrate metabolism due to the lack of insulin result in the hyperglycemia and glycosuria. Drug design is the approach of finding drugs by design, based on their biological targets. Drugs may be defined that bind in to active region and inhibit this key molecule.

Diabetes mellitus

Type 1 diabetes is an autoimmune disease. An autoimmune disease results when the body’s system for fighting infection turns against a part of the body. Type 2 diabetes is most often associated with older age, obesity, physical activity and certain ethnicities. In Pre-diabetes, blood glucose levels are higher than normal but not high enough to be characterized as diabetes. Pre-diabetes also increases the risk of heart disease and stroke with weight loss and physical activity. Diabetes mellitus is a complex, Multifactor and polygenic disease likely to be caused by one or more gene alterations action in combination with non-genetic factors (Hamilton et al., 2007).

Insulin is a hypoglycemic hormone and it is composed of two peptide chains referred to as chain A and chain B. These chains are linked together by two disulfide bonds. Insulin is a small protein with a molecular weight of about 6000 Daltons. It is synthesized in significant Quantities only in beta cells of the Pancreas.

Drug designing

Drug designing is the approach of finding drugs based on their targets and typically a drug target is a key molecule involved in a particular metabolism or signaling Pathway that is specific to a disease condition or Pathology or to be infectivity or survival of a microbial Pathogen. Some approaches attempt to stop the functioning of the pathway in the diseased state by causing a key molecule to stop functioning. However these drugs would also have to be designed in such a way as not to affect any other important molecules that may be similar in appearance to the key molecules (Ahmad et al., 2005).

Docking

Docking is a method which predicts the preferred orientation of one molecule to a record when bound to each other to form stable complex knowledge of the preferred orientations in turn may be used to predict the binding strength of association or binding affinity between two molecules. Docking is frequently used to predict the binding orientations of small molecules drug candidates to protein targets in order to in turn predict the affinity and activity of the small molecule. The receiving molecule that primarily binds to a small molecule or another protein or a nucleic acid called receptor. A molecule that forms the complementary partner in the docking process called ligand (Bharatam et al., 2007).

Ligand

Acetohexamide is the first generation sulfonylurea medication used to treat diabetes mellitus type 2, particularly in people whole diabetes cannot be controlled by diet alone. Acetohexamide lowers blood sugar by stimulating pancreas to secrete insulin and helps the body use insulin efficiently. The pancreas must produce insulin for this medication to work. It is an oral anti diabetic agent and is metabolized by the reductive conversion of the acetoxy group to a secondary alcohol metabolite. We tested whether reductase activity for acetohexamide can be found in human erythrocytes. Acetohexamide interact with other drugs such as alcohol, Beta blockers, cisapride, clofibrate, rifampin etc. If we missed to take dose, skip the missed dose and take only the next regularly scheduled dose. If acetohexamide will be a overdose it cause symptoms against a part of the body. Type 2 diabetes is most often associated with older age, obesity, physical activity and certain ethnicities.

Methods

The Protein sequence which is responsible for diabetes mellitus retrieved from NCBI. This IRAK protein has 712 amino acids and 3 hits in the sequence. Then the lists of drugs for diabetes mellitus are retrieved from drug bank and analyzed the hydrophobic activity for
each drugs. Hydrophobic activity is calculated by ALOGPS tool. The distribution of the Log P and Log S values for each drugs shows the highest hydrophobic activity of the drug. The structure of the protein retrieved from Protein data bank and binding sites of the receptor was calculated by PROSITE tool. The structure of the acetohexamide was taken from drug bank and both the structures were docked by Hex 5.1 tool. Finally all the results are compared and discussed.

Results and Discussion

Result for each drug

Acetohexamide:
• mol_N logP logS SMILES
  • mol_1 1.72 -3.83 CC(=O)c1ccc(cc1)S(=O)(=O)NC(=O)=O NC2CCCC2

Metformin:
• mol_N logP logS SMILES
  • mol_1 -1.41 -1.76 CN(C)C(=N)N=C(N)N

Phenformin:
• mol_N logP logS SMILES
  • mol_1 0.30 -3.02 c1ccc(cc1)CCN=C(N)N=C(N)N

Miglitol:
• mol_N logP logS SMILES
  • mol_1 -2.29 0.47 C1C(C(C(C(N1CCO)CO)O)O)O

Tolazamide:
• mol_N logP logS SMILES
  • mol_1 1.40 -3.01 CC1cc(cc1)S(=O)(=O)NC(=O)=O

Gliclazide:
• mol_N logP logS SMILES
  • mol_1 1.52 -3.23 CN(C(C(C(C1(CC)CO)O)O)O)O

Voglibose:
• mol_N logP logS SMILES
  • mol_1 -2.33 -0.15 C1C(C(C(C(C1(CO)O)O)O)O)NC(CO)CO

<table>
<thead>
<tr>
<th>DRUG NAME</th>
<th>DRUG ID</th>
<th>Log P</th>
<th>Log S</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACETOHEXAMIDE</td>
<td>DB00414</td>
<td>1.72</td>
<td>-3.83</td>
</tr>
<tr>
<td>METFORMIN</td>
<td>DB00331</td>
<td>-1.41</td>
<td>-1.76</td>
</tr>
<tr>
<td>PHENFORMIN</td>
<td>DB00614</td>
<td>0.3</td>
<td>-3.02</td>
</tr>
<tr>
<td>MIGLITOL</td>
<td>DB00491</td>
<td>-2.29</td>
<td>0.47</td>
</tr>
<tr>
<td>TOLAZAMIDE</td>
<td>DB00839</td>
<td>-1.4</td>
<td>-3.01</td>
</tr>
<tr>
<td>Gliclazide</td>
<td>DB01120</td>
<td>1.52</td>
<td>-3.23</td>
</tr>
<tr>
<td>Voglibose</td>
<td>DB04878</td>
<td>-2.33</td>
<td>-0.15</td>
</tr>
</tbody>
</table>

Table 1:

These drugs are treated for diabetes mellitus and the smile value for each drugs are retrieved from drug bank and submitted in to ALOGPS 2.1 tool. This tool provides the result with Log P and Log S values for each drug.

In Table 1, we compared Log P and Log S values for each drug. The drug Acetohexamide has the highest Log P value (1.72) when compared with other drugs and it has Log S value (-3.83). So, the hydrophobic activity of the Acetohexamide is higher. The drug Metformin has very low Log P value (-1.41) and Log S values (-1.76). The very low content of hydrophobic effect is present in Phenformin (0.3) but it has negative Log S value (-3.02).

The Log P value is negative in Miglitol (-2.29) and Log S value has (0.47). This shows that hydrophobic activity is very less. The Log P value (1.4) and Log S value (-3.01) for Tolazamide shows that the activity of the drug is very less. The hydrophobic activity of the drug Gliclazide is higher due to Log P value (1.52) and it has Log S value (-3.23). The drug Voglibose has Log P value (-2.33) and it has Log S value (-0.15).

Figure 1 shows that the comparison of Log P values for each drug. From this graph, we can easily understand, the drugs Acetohexamide, Phenformin, Tolazamide and Gliclazide has Positive Log P values and Metformin, Tolazamide and Voglibose has Negative Log P Values. Acetohexamide has highest Log P value (1.72) when compared with rest of the drugs.

Figure 2 from this graph, we can analysed the Log S values for the drugs involved in our analysis. Acetohexamide has very low Log S
value (-3.83) but it has good hydrophobic effect. Miglitol is the only drug which has positive Log S value (0.47) and the rest of the drugs are negative Log s values.

From this Figure 3 we can understand the comparison of Log P and Log S values for each drugs. The red colour shows that the Log P values and the Green colour shows that the Log S values for the drugs Acetohexamide, Metformin Phenformin, Miglitol, Tolazamide, Gliclazide and Voglibose respectively.

Figure 4 shows that both the receptor IRAK protein and the Ligand Acetohexamide ready to bind with each other.

Figure 5 shows that the Ligand Acetohexamide binds with the receptor IRAK Protein through Hex 5.1 tool. The docked Eforce and Etotal values are displayed in this screen.

From this Figure 6, we can easily understand the docked position of the receptor and Ligand. The Green colour shows that the IRAK Protein and the Red colour shows that the Ligand Acetohexamide.

Figure 7 shows that the Atoms and Bonds that are present in the drug Acetohexamide. Here Hydrogen Bond plays a major role between receptor and Ligand. The contribution of carbon, Nitrogen and Oxygen atom is higher in Acetohexamide.

**Prosite result analysis**

The Protein IRAK is responsible for diabetes mellitus and the sequence can be retrieved from NCBI and identifies the binding Site using PROSITE tool. This result from Table 2 shows that 3 hits present in the Protein including 2 patterns and 1 profile. It also shows that the positions of the binding sites present in the IRAK Protein (212-521, 218-239, 336-348). The position 218 and 226 is for NP_BIND and the proton acceptor site is present in the position 340. The ligand Acetohexamide binds in this position.

<table>
<thead>
<tr>
<th>HITS in IRAK Protein</th>
<th>3</th>
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</thead>
<tbody>
<tr>
<td>Position of HITS in Protein</td>
<td>212-521, 218-239, 336-348</td>
</tr>
<tr>
<td>NP_BIND</td>
<td>ATP (by similarity)</td>
</tr>
<tr>
<td>BINDING</td>
<td>239 (ATP by similarity)</td>
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<tr>
<td>ACT_SITE</td>
<td>Proton acceptor (by similarity)</td>
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<td>Protein kinase domain Distinct Patterns</td>
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<tr>
<td>Protein kinase ATP Binding region</td>
<td>PS500107</td>
</tr>
<tr>
<td>Serine/Threonine kinase active site region</td>
<td>PS500108</td>
</tr>
</tbody>
</table>

Table 2:
Conclusion

In this article, we have observed results that the drug acetohexamide has good hydrophobic effect based on Log P value and the IRAK Protein has 3 active sites. The docked results were identified by molecular docking method. The list of drugs are collected from drug bank which are used to treat Diabetes mellitus and identified the best drug based on hydrophobic activity. Finally, we concluded that the ligand acetohexamide has the highest hydrophobic activity.

References