Achieving Realistic and Interactive Clinical Simulation Using Case Based TheraSim’s Therapy Engine Dynamically

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Abstract—It is almost impossible to represent clinical data and reasons about them without temporal dimensions. This paper is based on the simulation study of TheraSim simulator for patient having diabetes mellitus type 2. TheraSim’s powerful therapy simulation engine uses treatment path analysis to create realistic and interactive simulations based on actual patient cases. Finally, based on the simulation results a new diagnoses and treatment plan has been proposed.

Keywords—temporal database, diabetes mellitus type 2, blood glucose, chronic kidney disease, temporal data mining.

I. INTRODUCTION

Busy medical professional have less time to leave their practice to participate in medical education events. With limited time and increased pressures, clinicians look to medical education for simulating events that directly relate to the improvement of their daily practice.

Time is important when time oriented clinical data are considered as part of various decision support applications, such as determining a diagnosis, prescribing therapy and browsing electronic patient records for management or research purpose. Experienced physicians are able to combine several significant contemporaneous findings, to abstract such findings into clinically meaningful higher-level concepts in a context-sensitive manner, and to detect significant trends in both low-level data and abstract concepts. Thus, it is desirable to provide short, informative, of time-oriented clinical data stored on electronic media, and to be able to answer queries about abstract concepts that summarize the data [1]-[6].

II. DIABETES MELLITUS TYPE-2

Diabetes mellitus is a group of metabolic diseases characterized by high blood sugar (glucose) levels that result from defects in insulin secretion, or action, or both. Type 2 diabetes mellitus occurs when the pancreas (an organ in the abdomen) produces insufficient amounts of the hormone insulin and/or the body’s tissues become resistant to normal or even high levels of insulin. This causes high blood glucose (sugar) levels, which can lead to a number of complications if untreated. Type 2 diabetes is a chronic medical condition that requires regular monitoring and treatment. Treatment, which includes lifestyle adjustments, self-care measures, and sometimes medications, can control blood sugar levels in the near-normal range and minimize the risk of diabetes-related complications.

III. THERASIM SIMULATOR

TheraSim brings all of the advantages of dynamic immersion simulation technology to health care professionals in prescribing new drugs, ordering diagnostic tests and developing new treatment strategies. TheraSim is a fully interactive clinical simulation tool, no checkboxes and no pre-digested choices for the clinician user. TheraSim’s proprietary Therapy Simulation Engine creates an engaging and interactive clinical simulation environment. In this environment, patients come to life and the impact of diagnostic and therapeutic choices are instantly analyzed using an expert knowledge base of best practices and pharmacokinetic data. The resulting feedback is delivered instantly to the user creating an evolving and dynamic learning experience.

TheraSim takes a fresh approach. Using a knowledgebase of thousands of clinical references from guidelines, prescribing information and pharmacologic database, TheraSim’s Therapy Simulation Engine dynamically analyzes each therapy choice and evaluates how fit that therapy path is for a specific patient. This adds a level of feedback and interactivity to the system that has never been seen before in medical education tools [7]-[9].

A. Real Patient Cases

TheraSim simulator is based on actual patient cases which are similar to cases a clinician may encounter in their practice. Cases are enriched with medical images.

B. Clinical Interface

TheraSim simulations present patient data through an electronic medical record with heads up displays for easy assimilation of diagnostic and therapeutic data. Dozens of labs and specialty diagnostic tests are available.

C. Clinical Guidance

TheraSim’s Therapy Simulation Engine is what allows the product to be truly interactive and provide unlimited therapeutic and diagnostic choices to be clinical user. It also provides the user with dynamic clinical guidelines. This instantaneous feedback makes the system fun, engaging and a more effective learning experience.
D. Evaluation

TheraSim is the most advanced clinical assessment tool on the market. The clinician is not limited by the number of diagnostic and therapeutic choices he or she can make so the resulting data is more realistic and relevant. The final therapy decisions are evaluated by the Therapy Simulation Engine in order to provide a detailed session evaluation.

TheraSim’s advanced clinical simulation technology is designed to evaluate reinforce best practices in the diagnoses and treatment of chronic and infectious diseases. TheraSim leverages a smart medical knowledge base of best practices, pharmacokinetics and patient metabolic information to bring actual patient case data to life as advanced medical simulation.

In this dynamic clinical environment, practitioners review real patient histories, order laboratory tests and procedures, interpret findings, render diagnoses, and use drug therapies. The clinicians can even receive real time, dynamic clinical feedback. In addition, every action taken in the course of rendering diagnoses, drug selection and dosing is recorded and accessed.

IV. SIMULATION STEPS

The simulation consists of various steps:

A. Intro

It consists of following information like patient profile, physical examination notes, family and social history, chief complaint, current medications, and patient images.

B. History

The information is illustrated using a tabular format consists of diagnosis and current medications. The treatment plan consists of medication, doses, frequency, action, and starting date. The table also shows the type of diagnoses for the patient. For e.g. in case of diabetes the diagnosis may be of Dyslipidemia, Diabetes Mellitus Type 2, Obesity, and Hypertension.

C. Order Tests

It consists of following tests and these tests may be ordered: Chemistry Screen, ECC (Estimated Creatinine Clearance) Fasting Lipid Panel, GFR (Estimated Glomerular Filtration Rate), Hb (Hemoglobin) A1C, Urinalysis, Urine Microalbumin (spot).

D. Graphs

By plotting graphs a comparative study between various parameters can be done. The various parameters are HbA1c, HDL, FPG, and LDL.

E. Diagnosis

A new diagnosis can be added. For e.g. in diabetes a person may be diagnosed with chronic kidney disease. For each diagnosis the simulator also gives clinical guidance. For e.g. chronic kidney disease (CKD) stage 3: You accurately diagnosed the patient with chronic kidney disease (CKD) - Stage 3. If a wrong condition is diagnosed the clinical guidance shows a alert. For e.g. Questionable diagnosis: Diabetic coma (in Diabetes Mellitus Type 1), if one is curing patient with Diabetes Mellitus Type 2.

F. Orders

This section gives the medications given to the patient. In our case the patient is under the medication, which is given in Table IV. Further other procedures or consults may also be added. The procedures consists of, counseling (like smoking cessation, nutrition consultation), schedule follow-up, and other procedures and consults.

G. Result

The result consists of case status and expert remarks.

V. CASE STUDY

60-year-old obese male smoker on metformin for type 2 diabetes, lisinopril-hydrochlorothiazide for hypertension, and invastatin for dyslipidemia returns for a follow-up appointment. He offers no complaints of visual or neurologic problems but admits to not following any diet, and his only exercise is walking from the car to his work or house.

A. Physical Examination Notes

Obese, with normal skin, thyroid, chest, heart, pulses, abdomen, rectal, extremities, and neurologic exams.

B. Family and Social History

Semi-retired insurance agent. Widower with 3 grown children. Smokes 1 pack daily for 42 years and drinks 2 ounces of scotch whiskey every night.

C. Family History

Father and brother died because of myocardial infarctions at ages 57 and 59.

D. Chief Complaint

Return visit for my cholesterol, sugar and blood pressure problems.

E. Current Medications

The current medications and allergies are illustrated in Table II.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Date of First Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>dyslipidemia</td>
<td>07 Jan 08</td>
</tr>
<tr>
<td>diabetes mellitus type 2</td>
<td>07 Jan 08</td>
</tr>
</tbody>
</table>
Table II. Current Medications and Allergies

<table>
<thead>
<tr>
<th>Start Date</th>
<th>Therapy</th>
<th>Dose (mg)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Jan 09</td>
<td>simvastatin</td>
<td>80</td>
<td>qd (daily)</td>
</tr>
<tr>
<td>04 Apr 08</td>
<td>hydrochlorothiazide (HCTZ)</td>
<td>12.5</td>
<td>qd (daily)</td>
</tr>
<tr>
<td>04 Apr 08</td>
<td>metformin</td>
<td>1000</td>
<td>bid (2x/daily)</td>
</tr>
<tr>
<td>07 Jan 08</td>
<td>lisinopril</td>
<td>20</td>
<td>qd (daily)</td>
</tr>
</tbody>
</table>

Table III. Hb (Hemoglobin) A1C

<table>
<thead>
<tr>
<th>Date</th>
<th>HbA1C</th>
</tr>
</thead>
<tbody>
<tr>
<td>05 Jul 2009</td>
<td>7.4</td>
</tr>
<tr>
<td>11 Jan 2009</td>
<td>7.6</td>
</tr>
<tr>
<td>20 Jul 2008</td>
<td>7.8</td>
</tr>
<tr>
<td>04 Apr 2008</td>
<td>7.1</td>
</tr>
</tbody>
</table>

A. Diagnosis and Treatment Plan - 1

The patient is currently on the therapy as given in Table IV and the patient is simulated by missing laboratory tests, undiagnosed, and without suggesting the new therapy plan, the simulation results show the following.

1) Diagnoses: Chronic Kidney Disease (CKD) - Stage 3 (Missed diagnosis).

2) Medications: (i) Missing therapy: For this patient, it would have been appropriate to order at least 2 of the Exenatide and Oral Antidiabetic Drugs (serious warning), (ii) Missing therapy: For this patient, it would have been appropriate to order at least 1 of the Lipid-Lowering Agents (potential complication), (iii) Missing therapy: For this patient, it would have been appropriate to order at least 1 of the Aspirin.


4) Other Orders (Procedures, Consults & Patient Education): (i) Missed order: Practitioner did not order the patient to begin Patient Education and Counseling (potential complications), (ii) Missed order: Practitioner did not order the patient to begin Glucose Monitoring (potential complications), (iii) Missed order: Practitioner did not order the patient to begin Exercise (information), (iv) Missed order: Practitioner did not order the patient to begin Special Diet (potential complications), (v) Missed order: Practitioner did not order the patient to begin Smoking Cessation Counseling (potential complications), (vi) Missed consult: Practitioner did not order the patient to consult Ophthalmology (potential complications).

5) Peer Statistics Summary: (i) Therapies- E 86% of peers prescribed metformin, 95% of peers prescribed simvastatin, 93% of peers prescribed lisinopril, 77% of peers prescribed hydrochlorothiazide (HCTZ), 32% of peers prescribed at least 2 of the Exenatide and Oral Antidiabetic Drugs, 2% of peers prescribed at least 1 of the Lipid-Lowering Agents, 2% of peers prescribed at least 1 of the Aspirin. (ii) Diagnoses- 23% of peers diagnosed Chronic Kidney Disease (CKD) - Stage 3.
B. Diagnosis and Treatment Plan-2

By studying the results of previous simulation the following plan has been suggested. Firstly, diagnosis for chronic kidney disease (CKD) stage 3, as given in Table V. Secondly, all the laboratory tests has been ordered, as shown in Table VI. Lastly, A new medicine has been suggested, the details are given in Table VII. While prescribing the new plan the simulator also shows the clinical guidance.

Table V. Clinical Guidance

<table>
<thead>
<tr>
<th>Diagnoses</th>
<th>Clinical Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic Kidney Disease (CKD) -</td>
<td>You accurately diagnosed the patient with Chronic</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Kidney Disease (CKD) - Stage 3.</td>
</tr>
</tbody>
</table>

Table VI. Laboratory Tests

<table>
<thead>
<tr>
<th>Tests</th>
<th>Clinical Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry Screen</td>
<td>You appropriately ordered the Chemistry Screen for this patient.</td>
</tr>
<tr>
<td>Hb (Hemoglobin) A1C</td>
<td>You appropriately ordered the Hb (Hemoglobin) A1C for this patient.</td>
</tr>
<tr>
<td>Fasting Lipid Panel</td>
<td>You appropriately ordered the Fasting Lipid Panel for this patient.</td>
</tr>
<tr>
<td>Urine Microalbumin (spot)</td>
<td>You appropriately ordered the Urine Microalbumin (spot) for this patient.</td>
</tr>
<tr>
<td>Urinalysis</td>
<td>You appropriately ordered the Urinalysis for this patient.</td>
</tr>
<tr>
<td>GFR (Estimated Glomerular Filtration Rate)</td>
<td>You appropriately ordered the GFR (Estimated Glomerular Filtration Rate) for this patient.</td>
</tr>
</tbody>
</table>

Table VII. New Medication Plan

<table>
<thead>
<tr>
<th>Therapy</th>
<th>Dose</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>exenatide (parenteral)</td>
<td>10 mcg</td>
<td>Bid</td>
</tr>
<tr>
<td>hydrochlorothiazide (HCTZ) qd (daily)</td>
<td>12.5 mg</td>
<td>qd (daily)</td>
</tr>
<tr>
<td>lisinopril 20 mg qd (daily)</td>
<td>20 mg</td>
<td>daily</td>
</tr>
<tr>
<td>metformin</td>
<td>1000 mg</td>
<td>bid(2x/day)</td>
</tr>
<tr>
<td>simvastatin (oral)</td>
<td>80 mg</td>
<td>qd (daily)</td>
</tr>
</tbody>
</table>

1) Diagnoses: Practitioner accurately diagnosed the patient with Chronic Kidney Disease (CKD) - Stage 3.

2) Medications: (i) Correctly Ordered: metformin, exenatide, simvastatin, lisinopril, hydrochlorothiazide (HCTZ), (ii) Missing therapy: For this patient, it would have been appropriate to order at least 1 of the Lipid-Lowering Agents, (iii) Missing therapy: For this patient, it would have been appropriate to order at least 1 of the Aspirin.

3) Tests: We have appropriately ordered all the tests.

4) Other Orders (Procedures, Consults & Patient Education): (i) Missed order: Practitioner did not order the patient to begin Patient Education and Counseling. (ii) Missed order: Practitioner did not order the patient to begin Glucose Monitoring. (iii) Missed order: Practitioner did not order the patient to begin Exercise (information), (iv) Missed order: Practitioner did not order the patient to begin Special Diet (potential complications), (v) Missed order: Practitioner did not order the patient to begin Smoking Cessation Counseling (potential complications), (vi) Missed consult: Practitioner did not order the patient to consult Ophthalmology (potential complications).

5) Peer Statistics Summary: (i) Therapies: 86% of peers prescribed metformin, 2% of peers prescribed exenatide, 95% of peers prescribed simvastatin, 93% of peers prescribed lisinopril, 77% of peers prescribed hydrochlorothiazide (HCTZ), 2% of peers prescribed at least 1 of the Lipid-Lowering Agents, 2% of peers prescribed at least 1 of the Aspirin, (ii) Diagnosis: 23% of peers diagnosed Chronic Kidney Disease (CKD) - Stage 3.

C. Diagnosis and Treatment Plan-3

This treatment plan is based on Procedures, Consults & Patient Education. Following plan has been proposed: (i) Patient Education and Counseling, (ii) Glucose, (iii) Monitoring, (iv) Exercise, (v) Special Diet, (vi) Smoking Cessation Counseling, (vii) Special Diet and (viii) Exercise.

1) Diagnoses: All the possible cases have been diagnosed.

2) Medications: Following medications are still missing, so then can be further simulated. (i) Missing therapy: For this patient, it would have been appropriate to order at least 1 of the Lipid-Lowering Agents. (ii) Missing therapy: For this patient, it would have been appropriate to order at least 1 of the Aspirin.

3) Tests: We have appropriately ordered all the tests.

4) Other Orders (Procedures, Consults & Patient Education): Missed consult: Practitioner did not order the patient to consult Ophthalmology.

5) Peer Statistics Summary: (i) Therapies: 86% of peers prescribed metformin, 2% of peers prescribed exenatide, 100% of peers prescribed atorvastatin in amlodipine-atorvastatin, simvastatin, 93% of peers prescribed lisinopril, 77% of peers prescribed hydrochlorothiazide (HCTZ), 32% of peers prescribed amlodipine, 2% of peers prescribed at least 1 of the Lipid-Lowering Agents, 2% of peers prescribed at least 1 of the Aspirin, (ii) Diagnosis:
23% of peers diagnosed Chronic Kidney Disease (CKD) - Stage 3.

VII. CONCLUSION AND SUMMARY

In this paper we have demonstrated the case study of diabetes mellitus type-2 patient based on the simulation of TheraSim simulator. The simulator case also simulated for the BPH prostate, Cardiology, Hepatitis C, HIV, Infectious Disease, Oncology and Psychiatry.

REFERENCES

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