A FRAMEWORK FOR STRUCTURED CLINICAL KNOWLEDGE – PCAPS

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Summary

In a quality management system, inherent technology is a basis for high product quality. And the basis for making the best use of inherent technology is to visualize, structure, standardize (optimize) and computerize (IT-systematize) the technology.
We have realized this in the form of the Patient Condition Adaptive Path System (PCAPS). PCAPS describes an overall flow of possible clinical pathways that a patient's disease state may trace, and detailed medical judgment and treatments for each disease state. The application of PCAPS makes it possible to implement proper healthcare interventions according to the disease state. Medical records kept in PCAPS will give useful information on the patient's state, the interventions in that state and the effects of the interventions. Through analysis of these records, it is possible to improve the standard treatment plan. The integrated system of PCAPS, consisting of Builder, Administrator and Analyzer, is introduced, and possibilities and future issues are discussed.

Keywords
Patient Condition Adaptive Path System, PCAPS, structured clinical knowledge, visualization, standardization

1. INTRODUCTION

We are approaching healthcare from a quality-centered aspect. Healthcare is a special service of advanced complex systems that adjusts to the state of the patient. In hospital, diagnosis and treatment service is provided for one patient by many professions. Therefore, a tool to confirm the overall plan and the executed details is necessary for the medical team members. However, the development of methodology and tools appropriate for medical treatment in an adaptive state is lagging behind.

Clinical experience wisdom exists in the doctor's head. It is necessary to extract this experience wisdom and, moreover, to recycle it. That is, a structural framework is needed for the clinical knowledge. We constructed the patient condition adaptive path system (PCAPS) as a structuralizing frame for clinical knowledge. PCAPS links with the Quality-centered Management System for Healthcare (QMS-H), and assures quality and safety.
The PCAPS model adopts "State of the patient" as a base, and the clinical route to "State of the target (aimed-for state of the patient)" reaches the end goal after diverging and uniting. In other words, it can be said that the aspects of the change in the state of the patient that reacted to the medical treatment intervention are made visible.

The unit of each state of the target is formed. The medical service that adjusts the state of the patient is executed until the state of the patient reaches the state of the unit target. A unit ends when it reaches the state of the target. The transition logic navigates, the medical doctor selects the next unit with the best end-point for the state of the patient, and it shifts to the next unit.

The transition logic tracks one after another over the best unit, and the traced medical treatment process history of the patient concerned is built up.

On the other hand, it is possible that the unit is considered not appropriate for the state of the patient while practicing it in the adjusting unit. It is in a certain unit, and when the changing state of the patient exceeds the range of the unit concerned with adjustment of the patient state, a built-in logic function shifts to another unit that adjusts at once. For instance, when the amount of blood generated exceeds the adjustment upper boundary of the unit after an operation, the transition logic shifts to the best unit.

We first describe the basic concept and three types of knowledge base of the PCAPS. Next, we present methodology for standardization and verifying feasibility.

2. PATIENT CONDITION ADAPTIVE PATH SYSTEM (PCAPS)

2.1. Framework for Three Types of Knowledge

Patient condition adaptive path system (PCAPS) is proposed to describe the standard process of healthcare services required in order to take timely and adequate action on the basis of a patient’s state. PCAPS details the healthcare tasks that need to be undertaken according to an individual patient’s state. For this purpose, it is essential to (1) grasp the complete flow of treatment that can be selected for a particular target disease, and (2) manage the change in a patient’s state in order to shift to the next unit safely and effectively. We propose the clinical process chart and the unit sheet to achieve the above requirements, respectively.

The clinical process chart describes the flow of clinical processes according to the patients’ states; this chart comprises several “units.” A healthcare service module is mounted in each unit for carrying out medical treatments, examinations, etc., and for evaluating a patient’s state in order to decide the subsequent unit. Accordingly, a clinical process is modeled by incorporating a module of healthcare services, which is termed a “unit.”

The unit sheet embodies the function of a unit, which is described above. Each unit in the clinical process chart has one unit sheet. The unit sheet serves to manage the patients in a particular unit. All the information necessary for this purpose is provided in the unit sheet. In particular, the unit sheet includes not only healthcare tasks such as medical treatments and examinations but also the patient’s target state in the unit, the unit transition criteria, and so on.
The PCAPS master is also proposed. This is a glossary of the terms used in the unit sheet. It provides the definitions of each term and structured detailed descriptions, if required.

In other words, PCAPS describes the standard process of healthcare using the clinical process chart, unit sheet, and PCAPS master (Fig. 1).

2.2. Fundamental Structure of the Unit Sheet

As a result of discussion about the role of the unit sheet, we propose five fundamental items:

- **“Target State”**
  The units are separated according to the patients’ states in the clinical process chart. The healthcare service aims to achieve a particular target state for the patients in one unit; if a patient reaches that target state, we can proceed to the subsequent unit. Therefore each unit has a target state that the healthcare service aims to attain. This target state should be defined by the patient’s state in PCAPS. Thus, Target State is one of the fundamental items in a unit sheet.

- **“Healthcare Tasks”**
  For every unit, a set of healthcare services are needed to achieve the target state. Healthcare Tasks, being one of the fundamental items of the unit sheet, are defined therein; the unit sheet comprises a set of healthcare services that aim to achieve the target state.
“Remarkable Patient State” and “Conditional Direction”
Irrespective of whether the same healthcare tasks are done, the change in patients’ states varies. Therefore it is necessary to manage patients who do not make appropriate progress. In the unit sheet, the items for management are Remarkable Patient State and Conditional Direction. The former is a management indicator that judges whether patients are making good progress; if the progress is not satisfactory, additional treatment is provided according to the latter item.

“Unit Transition Criteria”
Since patients have varying states, the processes from hospitalization to discharge also vary. Therefore there are numerous divergences in the clinical process chart, and it is necessary to decide the units that are appropriate for the patient. This is done by the Unit Transition Criteria item.

According to the definition provided above, the unit sheet consists of five items: Target State, Healthcare Tasks, Remarkable Patient State, Conditional Direction, and Unit Transition Criteria. The relations among these are shown in Fig 2.

Figure 2 - Relationships among Fundamental Items of the Unit Sheet

2.3. Functional Structure of Healthcare Tasks
Healthcare Tasks is the most complicated item among the five fundamental items, and this item should be detailed using more particular items.

2.3.1. Essence of Clinical Service
As a result of consideration and analysis, it was concluded that the essential functions of Healthcare Tasks are assessment, intervention, and information provision. An assessment comprises an examination and an observation, and an intervention comprises a medical treatment and nursing care (shown in Table 1).
### Table 1  The Essence of Healthcare Tasks

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Examination</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>Medical Treatment</td>
<td>Nursing Care</td>
</tr>
<tr>
<td>Information Provision</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 2.3.2. Healthcare Treatment Structure

The designed structure of Healthcare Treatment is shown in Table 2.

### Table 2  The Entire Structure of Healthcare Tasks

<table>
<thead>
<tr>
<th>First Layer Items</th>
<th>Second Layer Items</th>
<th>Third Layer Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare Tasks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examination</td>
<td>Specimen Examination</td>
<td>Radiographic Examination</td>
</tr>
<tr>
<td></td>
<td>Physiological Examination</td>
<td>Endoscopic Examination</td>
</tr>
<tr>
<td></td>
<td>Pathological Examination</td>
<td>Other Examinations</td>
</tr>
<tr>
<td>Medical Treatment</td>
<td>Nutrition</td>
<td>Blood Infusion</td>
</tr>
<tr>
<td></td>
<td>Medication(Internal/External Medicine)</td>
<td>Dialysis Treatment</td>
</tr>
<tr>
<td></td>
<td>Medication(Injection)</td>
<td>Radiotherapy</td>
</tr>
<tr>
<td></td>
<td>(Other) Medical Treatment</td>
<td>Rehabilitation</td>
</tr>
<tr>
<td></td>
<td>Operation</td>
<td>Bed Rest</td>
</tr>
<tr>
<td>Observation</td>
<td>Observation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Observation and Diagnosis</td>
<td></td>
</tr>
<tr>
<td>Nursing Care</td>
<td>Nursing Care in Hospital</td>
<td>Nursing Care for maternity</td>
</tr>
<tr>
<td></td>
<td>Nursing Care at Home</td>
<td></td>
</tr>
<tr>
<td>Information Provision</td>
<td>Explanation and Consent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other Information Provision</td>
<td></td>
</tr>
</tbody>
</table>

We structured the unit sheet in three layers, as shown in Table 2. The first layer items include the fundamental items in the unit sheet (Target State, Healthcare Tasks, Remarkable Patient State, Conditional Direction, and Unit Transition Criteria).

The second layer items comprise the functional items of the first layer items. In the second layer items of Healthcare Tasks, we include “Examination,” “Medical Treatment,” “Observation,” “Nursing Care,” and “Information Provision”.

The third layer items comprise the specific items of the second layer items. As a result of discussion, we designed the third layer items of Healthcare Tasks as shown in Table 2.

### 3. POSSIBILITY OF STRUCTURAL VISUALIZATION OF CLINICAL KNOWLEDGE USING PCAPS
PCAPS contents were developed by doctors and nurses working on the clinical front. The clinical process structurally made visible by PCAPS contents was shared, and work was done to convert tacit knowledge into explicit knowledge while exchanging opinions mutually.

So far, PCAPS contents of 113 clinical process charts have been developed in 19 areas: digestive tract internal medicine, psychiatry department, home nursing visit, living donor liver transplantation, neonatal care, kidney internal medicine department, cancer (operation), cancer (chemotherapy), emergency, department of respiratory surgery, respiratory tract medicine, circulatory organs department, cerebral surgery, nerve internal medicine department, orthopedics department, diabetes, urology, pediatrics department, and digestive organ surgery.

In the contents of about 20 clinical process charts in 12 areas, development proceeded to the unit seat level. As a result, it was suggested that PCAPS has the structure to express clinical knowledge. All PCAPS contents research and development was done by about 200 people. Contents from 5 to 10 clinical process charts are scheduled to be developed in each clinical area. The clinical process charts are designed, and more than half have been verified. In each area, there are several PCAPS contents that have reached the electronic contents level that can be used in the PCAPS application.

4. STANDARDIZATION OF CLINICAL KNOWLEDGE

4.1. Development of methodology

The methodology of the verification survey to standardize PCAPS contents was designed in 2005. The objective of standardization is a clinical process chart that provides a bird’s-eye view of a clinical process. The verification survey is an investigation to follow the clinical process of a patient from the clinical record by using the clinical process chart and the transition logic. The times when the unit began and was passed are investigated from an actual clinical record (Table 3).

Attention was focused on the phenomenon of "Course exit" ("course exit" because there is neither a route nor a unit to the case in reality) as a methodology for analysis and improvement. The "Point of the course exit (position)" and "Reason for the course exit" are specified. The improvement point of contents (position where the clinical process chart is improved) and the corrective strategy (unit addition and route addition) are derived from this information.

Cooperation was received from 15 hospitals, and the above-mentioned verification survey was tried in 2005. Investigation for each single contents item involved cooperation from seven to nine hospitals. It was judged that comparison between the hospitals was possible because 20 cases were investigated at each hospital, taking into consideration the investigation load of each hospital.

Table 3. Verification survey in 2005

<table>
<thead>
<tr>
<th>Ischemic heart</th>
<th>Total prostatectomy</th>
<th>Cerebral infarction</th>
<th>Infant bronchia</th>
<th>Diabetic insulin</th>
<th>Fracture of neck</th>
<th>Total</th>
</tr>
</thead>
</table>
4.2. Verification Survey

In the verification survey, two or more hospitals investigated the case data of 20 cases for the same clinical process chart. The verification survey was carried out 4 times: in 2006, 2007, 2008 and 2009. 185 hospitals cooperated over four years, and the verification survey was made for the standardization of 88 clinical process charts (Table 4). Agreement was reached on standards for 59 clinical process charts because the leakage of the unit and the route detected by the verification survey was improved.

<table>
<thead>
<tr>
<th>Item/Year</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of hospitals</td>
<td>55</td>
<td>51</td>
<td>35</td>
<td>44</td>
</tr>
<tr>
<td>No. of beds</td>
<td>20,033</td>
<td>18,317</td>
<td>15,795</td>
<td>2,009</td>
</tr>
<tr>
<td>No. of PCAPS contents</td>
<td>26</td>
<td>19</td>
<td>32</td>
<td>11</td>
</tr>
</tbody>
</table>

4.3. Standardization and Quality Improvement in the Clinical Process

Figure 3 shows a comparison of the stay days of each unit between two hospitals where the only comparison between the hospitals is long and short stays. When comparison of each process becomes possible between two hospitals, it becomes easy to detect problem processes.

The difference in the unit stay days shown in Figures 4 and 5 has been generated only for hospitalization and before hospital discharge. It is forecast from this that problems with medical treatment and nursing resources in the region are related. There are also other process differences in addition to those regarding hospitalization and pre-discharge in Figure 6. These differences are an unbridgeable gulf apart from the standard, and they suggest a part where improvements can be made. Thus it was confirmed that standardizing the process contributed to increasing the volume of information obtained from benchmarking.
5. CONCLUSION AND FUTURE ISSUES

This paper explained the basics and the significance of PCAPS. Further, we mentioned the activities of our PCAPS research. We are designing a PCAPS integration system, which involves computerization and IT systematization of clinical knowledge. The PCAPS integration system is composed of three subsystems.

- PCAPS content-building support system (PCAPS-Builder)
- PCAPS operation support system (PCAPS-Administrator)
- PCAPS data analysis support system (PCAPS-Analyzer)

We are constructing the PCAPS integration system. The builder is completed, and the administrator will be test-run this year. Development of the analyzer has begun, too. The
PCAPS integration system is an add-on design for EHR.

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REFERENCES